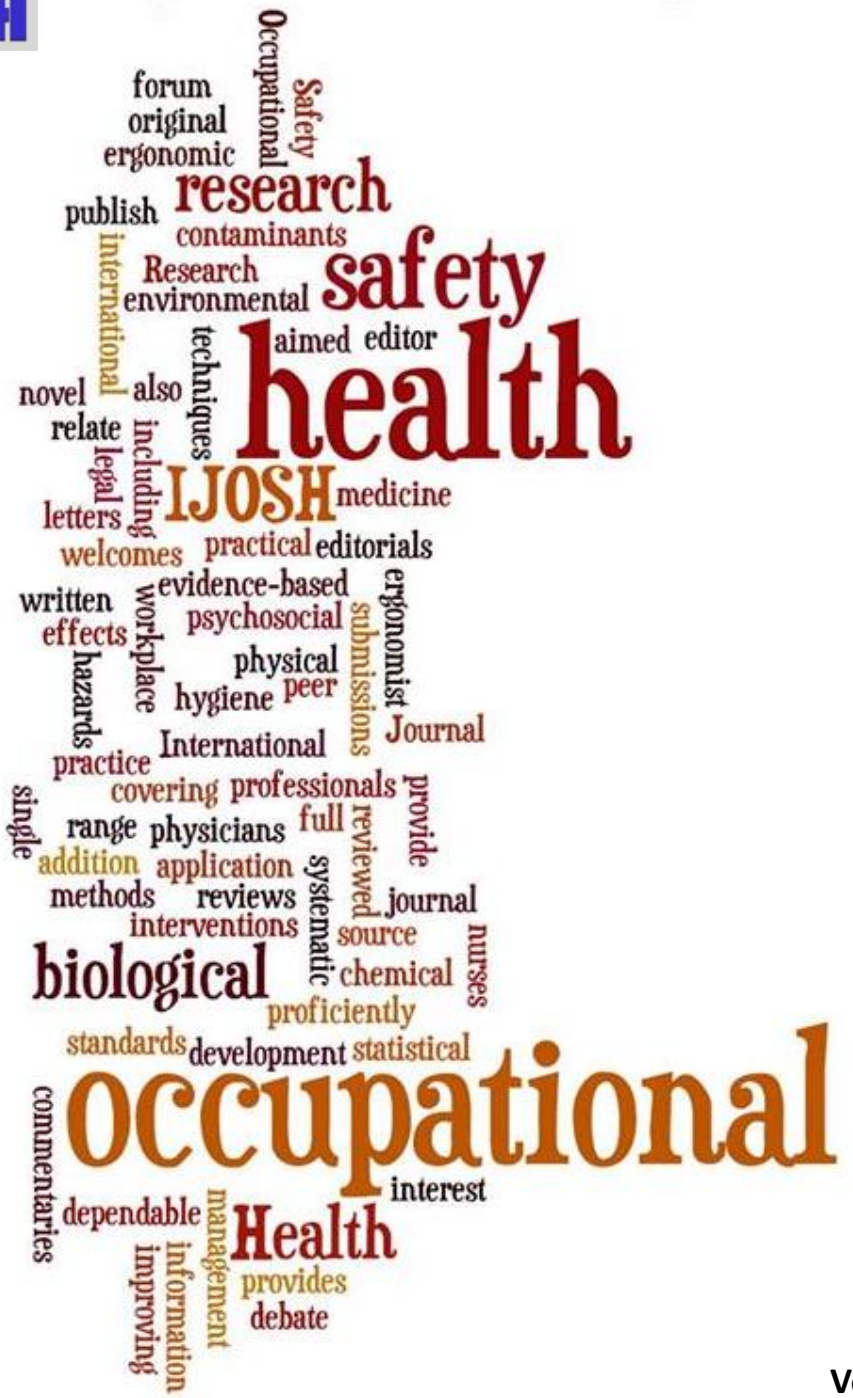
International Journal of Occupational Safety and Health

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



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Vol 13, No 1 (2023)

International Journal of
Occupational Safety and Health

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Original Article

Consequence Modeling and Analysis of Benzene leakage and explosion from a poorly sited gas station in the City of Douala, Cameroon

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Date of submission: 22.02.2022
Date of acceptance: 15.06.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None

DOI:https://doi.org/10.3126/ijosh.v13i1.43091

ABSTRACT

Introduction: Benzene has long been recognized as highly carcinogenic and the most cytotoxic of all air pollutants released by gas stations. Although several studies have been conducted on accidents in the process industry, very little work has been directed toward the modeling of risks caused by the leakage and explosion of toxic substances in gas stations. This knowledge could aid in predicting the vapor concentration inside gas station office buildings and neighboring infrastructures and in developing corresponding safety measures. The purpose of this study was, therefore, to model the consequences of Benzene dispersion following leakage and explosion from gas stations, taking the city of Douala, Cameroon as an example.

Methods: Based on the measured vent emission and meteorological data, the Areal Location of Hazardous Atmosphere (ALOHA v.5.4.7) model was used to predict the hazard radius of leakage and dispersion of benzene from a tank in different seasons. The maps of the toxic and flammable vapor cloud of benzene, evaporation rate from a puddle, and the concentration of toxic and flammable vapor cloud inside and outside of the station were prepared with the aid of MARPLOT and Google Earth software.

Results: The results showed that the maximum average sustained release rate of benzene from a tank was 26 kilograms per minute, with an estimated total amount released of 1,340 kilograms per 60 minutes in the dry season. The puddle spread to a diameter of 19.8 meters. The predicted threat zone distance from the station in the dry season, as compared to the rainy season, had an increase in radius of 12, 20, and 83m for the red, orange, and yellow zones, respectively. The worst hazard level extends primarily in the downwind direction and is predicted to be 31 meters in the rainy season in all directions, covering parts of the adjacent settlements and social infrastructure.

Conclusion: The potential scenarios of benzene dispersion from a poorly sited gas station in the city of Douala have been modeled and the threat zones estimated. Nearby residences and social infrastructures are significantly exposed, with the predicted threat zones being more hazardous for the employees of the gas station. Further research looking at the impact of combined consequences of gasoline emissions may help determine whether the combined effects of benzene with other chemicals are cumulative or synergistic.

Keywords: ALOHA, Benzene, Douala, MARPLOT, Poorly sited Gas station

Introduction

Benzene has long been recognized as a carcinogenic substance, and research has shown that it is one of the most cytotoxic of all the air pollutants released by gas stations and other petrochemical plants. Ambient air at gasoline stations contains volatile organic compounds from fuel vapors and combustions from vehicle engines, including those of benzene, toluene, ethylbenzene, and xylene (BTEX). Other sources of chronic unburned fuel release at gas stations are fuel storage and dispensing: vapor release through the storage tank's vent pipe and vapor emissions from the evaporation of spilled fuel. However small the amount of unburned fuel lost during vehicle refueling and fuel storage might be, the cumulative release of fuel to the environment can be substantial if large amounts of fuel are dispensed at gas stations. The average benzene content of gasoline has been approximately 1%–3% (and up to 5%) in the United States,[1] and 3%–5% in European countries.[2] Recent research shows that gas stations emit ten times the amount of benzene previously recorded.[3]

Concerns about gasoline's health and environmental hazards extend beyond academia, science, and regulation. Benzene exposure has been linked to several blood cancers,[4] including acute myeloid leukemia and acute nonlymphocytic leukemia. Studies in South Korea have found some differences in the median outdoor and indoor concentrations of benzene (9.9 and 6.0 g/m^3 or about 3.1 and 1.9 ppb respectively) at a variety of residences neighboring gas stations. The median indoor concentrations were higher at these sites, reaching 13.1 and 16.5 g/m^3 respectively (about 4.1 and 5.2 ppb, respectively). Another study discovered that benzene and other gasoline vapor releases from service stations can be distinguished from traffic emissions as far as 75 meters away from service stations and that the contribution of service stations to ambient benzene is less significant in high traffic density areas.[5]

The EPA's Toxic Chemical Substance Declaration System reported a dimethyl benzene leak at an unnamed plant in November 2009, a phosgene leak at a chemical complex in December 2009, and a leak at a water purification plant in a chemical complex in December 2009.[6] These leaks had caused physical ailments in the surrounding communities, necessitating medical attention. In light of recent events, if petrochemical plant operators had predicted the magnitude of the impact, it would have facilitated pre-rescue preparations and reduced the extent of the toxic gas's impact on the residents.[7] This raises the question of the consequences of potential benzene dispersion following leakages and explosions from storage devices in gas stations, especially as most of these stations are widely distributed in residential areas and very close to social infrastructures. Predicting the fluid behavior after release and its emissions into the environment is critical for estimating the consequences and potential injuries, as well as being aware of the maximum safe radius of fire, explosion, and toxic substance emissions. Furthermore, it can be extremely useful in dealing with accidents and emergencies.[8]

Several other studies have modeled the consequences of fire, explosion, and toxic dispersion by using different modeling tools such as PHAST (Process, Hazard, Analysis, Software Tool),[9] ALOHA (Areal Locations of Hazardous Atmospheres, U.S. Protection Agency),[10] GIS software,[11] and FLACS (Flame Acceleration Software) modeling programs.[12] Each formal method is founded on a specific mathematical theory. However, researchers, for example,[13] have demonstrated the significance of systematic and analytical methods such as the Bowtie method in shaping the relationship between hazards and their consequences.[14] The Bowtie method has been used to analyze process accidents in refineries,[15] as well as to model the propagation of natural gas leaks. Whether qualitative or quantitative, the method is a useful tool for determining the causes of events as well as specifying critical tasks to ensure the integrity and effectiveness of ongoing controls. However, as a standalone piece of software, it is limited in terms of hazard modeling and simulation.

Previous other studies at the Cameroon level on

this topic are rare and the few that exist have either focused on the consequences of exposure to benzene contamination,[16] or the compliance of gas stations sitting with existing regulations.[17] Though implicit to functional recovery, consequence analysis and modeling has never been a focus for local researchers. Added to the necessity of implementing emergency response planning in this area, this gap overlooks the consequences of benzene leakage from tanks at gas stations and other hydrocarbons storage areas. With these explanations, the purpose of this study was to use the ALOHA (Areal Locations of Hazardous Atmospheres) model has been chosen to simulate the scales of impact (threat zones) in the event of benzene release/ dispersion following leakages and explosion from a storage device and to observe the safety measures required using one of the poorly sited gas stations in the city of Douala, Cameroon as an example. Two failure scenarios were considered:

- A sudden catastrophic failure leading to a Boiling Liquid Expanding Vapor Explosion (BLEVE); and
- A leak leading to a flash fire or a vapor cloud explosion.

The approach consisted in entering source information at a level of concern (LOC) and mapping the footprint on a map to show potential offsite receptors (e.g., schools, roads) using a combination of software (ALOHA, MARPLOT, and Google Earth). The research could be useful in identifying and improving key performance indicators in the areas of health, safety, and the environment.

Methods

The study area is situated on the Wouri estuary, 30 kilometers from the Atlantic Ocean and not far from the Equator, between 4° and 4° 10' North latitude and 9° 35' and 9° 80' East longitude. It is Cameroon's economic hub as well as the country's first city. It is governed by the Douala Urban Community and contains 20,220 hectares. Five urban municipalities (also known as districts) and one rural municipality form the urban community of Douala.[18] (Fig.1)

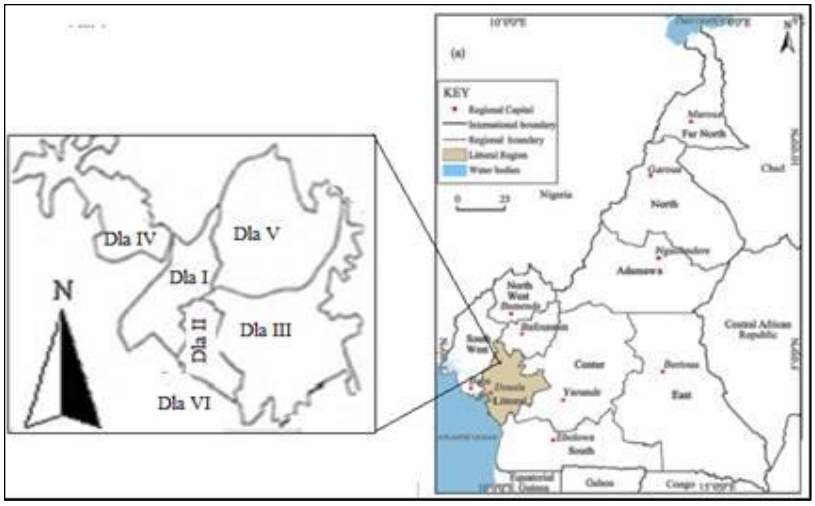


Figure 1: Location of the study area (DLA: Douala)

Douala was chosen for this study because it is the largest city in Cameroon, but also because, it is the commercial and economic capital of Cameroon and the entire CEMAC region comprising Gabon, Congo, Chad, Equatorial Guinea, Central African Republic, and Cameroon. Consequently, any hazard may impact serious economic and environmental loss on the entire region. Douala is also an industrial city and one of the fastest developing urban areas in Africa and ranks first at the national level. According to current estimates from the Douala city council, the population of the municipality is estimated to at 5,000,000 people with an average growth rate of 4.8%. The mean annual rainfall is about 36000.mm, while the mean annual temperature varies between 240C in the rainy season, to about 330C in the dry season. Relative humidity varies between 75 to 100%.

In a previous study,[19] we found that of the one hundred and fifty-two (152) gas stations unevenly

distributed all over the city of Douala, eighty (80) are poorly sited, that is, their locations do not comply with the dictates of existing regulations. These stations have common characteristics in terms of size, products, embedded in human settlements, at close distances (< 400m) from schools, markets, and other social infrastructures, and climatic (weather) conditions. Hence, Total Bonaberi1 (Fig. 2), was conveniently selected for this study.

This gas station, like other poorly sited gas stations, is less than 7m from an always busy-traffic congested major road (Route du Lycee), neighboring many residences, public and private nurseries, primary, secondary, and high schools, and other social infrastructures. Additionally, people typically spend 15 min to 1 hour at this station.

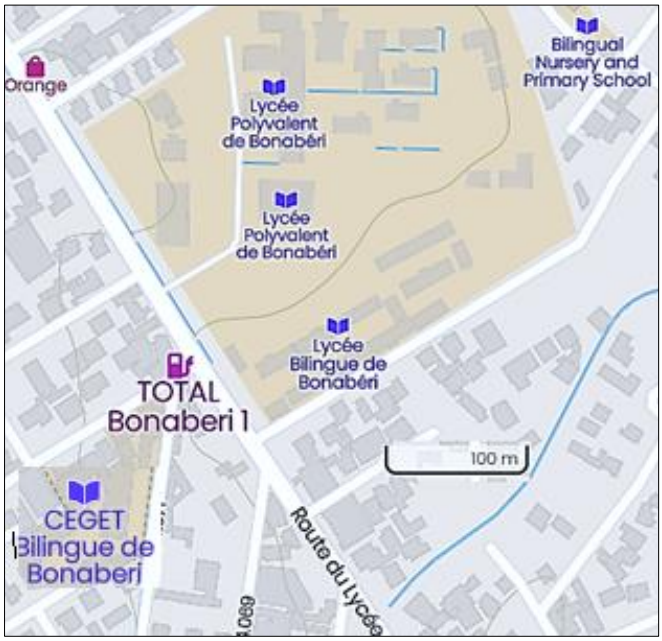
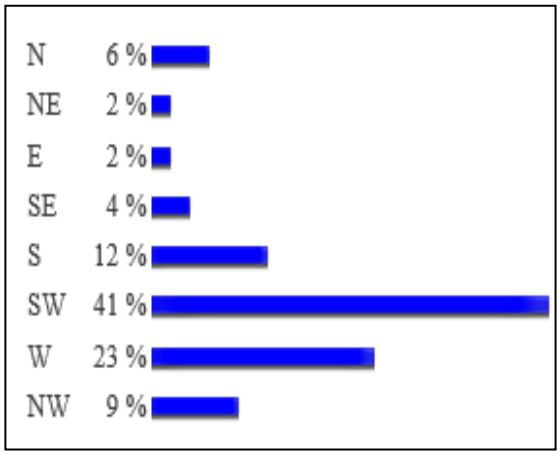


Figure 2: Total Bonaberi1 gas station

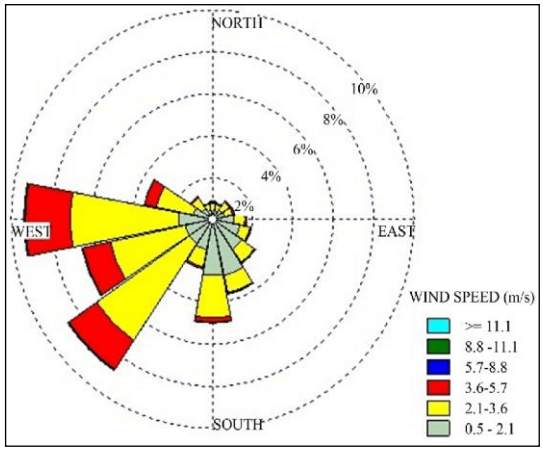
Data Collection

Between December 2020 and January 2021, data were gathered. There was a site walk-through observation, followed by document analysis. Site data (source location and tank geometric information), atmospheric data (temperature, humidity, wind direction and speed, topography, and other meteorological parameters) were gathered

- Atmospheric data: One of the random parameters impacting the dispersion behavior of a leak event is the weather. To account for changing meteorological circumstances over time, leak occurrences should be recreated under various weather settings. Weather data were obtained from field investigations. The wind rose (Fig 3) for Douala shows how many hours per year the wind blows from the indicated direction. Example SW: Wind is blowing from South-West (SW) to North-East (NE).
- Chemical data: For the model to run, the hazardous material released, as well as its physical and chemical properties were specified. The chemical properties released ultimately determined the shape, magnitude, and severity of the plume. The HazMat site was used as a chemical data provider in this study.[20] The data includes product identification, the nature of the danger, physical and chemical properties, security instructions, transportation conditions, etc.



(a) Wind-force per Day (Jan. 2000 – Dec. 2021)



(b) Wind rose for the Douala city

Figure 3: Wind rose derived from both the agency for Aerial Navigation Safety in Africa and Madagascar (ASECNA) and National Oceanic and Atmospheric Administration (NOAA) data for the period of 2008-2012.[18]

- Source data: For this type of data, the exact source characteristics such as geometric properties, storage capacity, and so on were described. This type of information was gathered in this study through field visits and interviews with HSE and engineering experts at gas stations.

A recapitulation of the data collected is summarized as shown in Table 1.

Table 1: Data for the configurations of the release scenario for the seasonal simulations

Parameters	**Season**	
	Dry	Rainy
Air temperature (°C)	33.7	24
Relative humidity (%)	80	95
Wind speed (m/s)	2.8	3.5
Wind direction	SW (225)	SW (225)
Elevation of wind speed measurement (m)	4	4
Atmospheric stability class	E	D
Cloud cover (0–10)	7	7
Total volume released (m^3)	500	500
Model of release	Heavy gas	Heavy gas
Total duration (min)	60	60

Data Analysis

The study employs two scenarios:

- Modeling the domain of benzene toxic vapor cloud formation
- Modeling the domain of benzene flammable vapor cloud formation

It is supposed that the benzene leakage is caused by the creation of a hole with a diameter of 100 mm in the iron wall of a vertical cylindrical tank with a capacity of 5000 liters, in which petroleum products are stored. The benzene storage in the tank is equal to the ambient temperature (25 °C).

In addition to creating maps, the concentration of benzene toxic and flammable vapor cloud in the office building's indoor and outdoor areas was estimated. The American Institute of Chemical Engineers (AIChE) and Det Norske Veritas (DNV) Institute proposed a conventional approach to modeling and assessing the consequences in the chemical process, oil, gas, and transportation industries.[21]

To determine the domain of flammable and toxic vapor cloud Levels of Concern (LOCs), two main criteria were used:

1. The Lower Explosive Limit (LEL): the minimum concentration of a gas or vapor in the air which

can cause a fire in the presence of an ignition source (spark, hear, etc.) and is expressed as the volume percentage of flammable gas in the air.[22] Based on this criterion, we adopted the LOC level for two levels of benzene as stated below.[23]

(1) a concentration of 7200 ppm benzene equivalent to LEL of 60%. In this case, extreme safety precautions against explosion are considered, and,

(2) a concentration of 1200 ppm benzene, equivalent to LEL of 10%. In this case, safety precautions against explosion are considered.

2. Acute Exposure Guideline Levels (AEGLs). AEGLs used in this study are classified into three levels.

- Level 1: AEGL-1 is the airborne concentration (in ppm or mg/m^3) of a substance above which the general population is expected to experience significant discomfort and irritation. The effects, however, are not disabling and are transient and reversible (AEGL-1 (60 min): 52 ppm).
- Level 2: Susceptible individuals may experience adverse and severe effects, as well as irreversible effects, at this concentration. People may lose their ability to escape in this case (AEGL-2 (60 min): 800 ppm). AEGL-2 is the airborne concentration of a substance (expressed as ppm or mg/m^3) above which it is predicted that the general population will suffer irreversible or other serious, long-term adverse health effects.
- Level 3: People may lose their lives at this concentration, or exposure at this concentration may be fatal (AEGL-3 (60 min): 4000 ppm). The airborne concentration of a substance (expressed in parts per million or milligrams per cubic meter) above which the general population is expected to experience life-threatening health effects or death is referred to as AEGL-3.

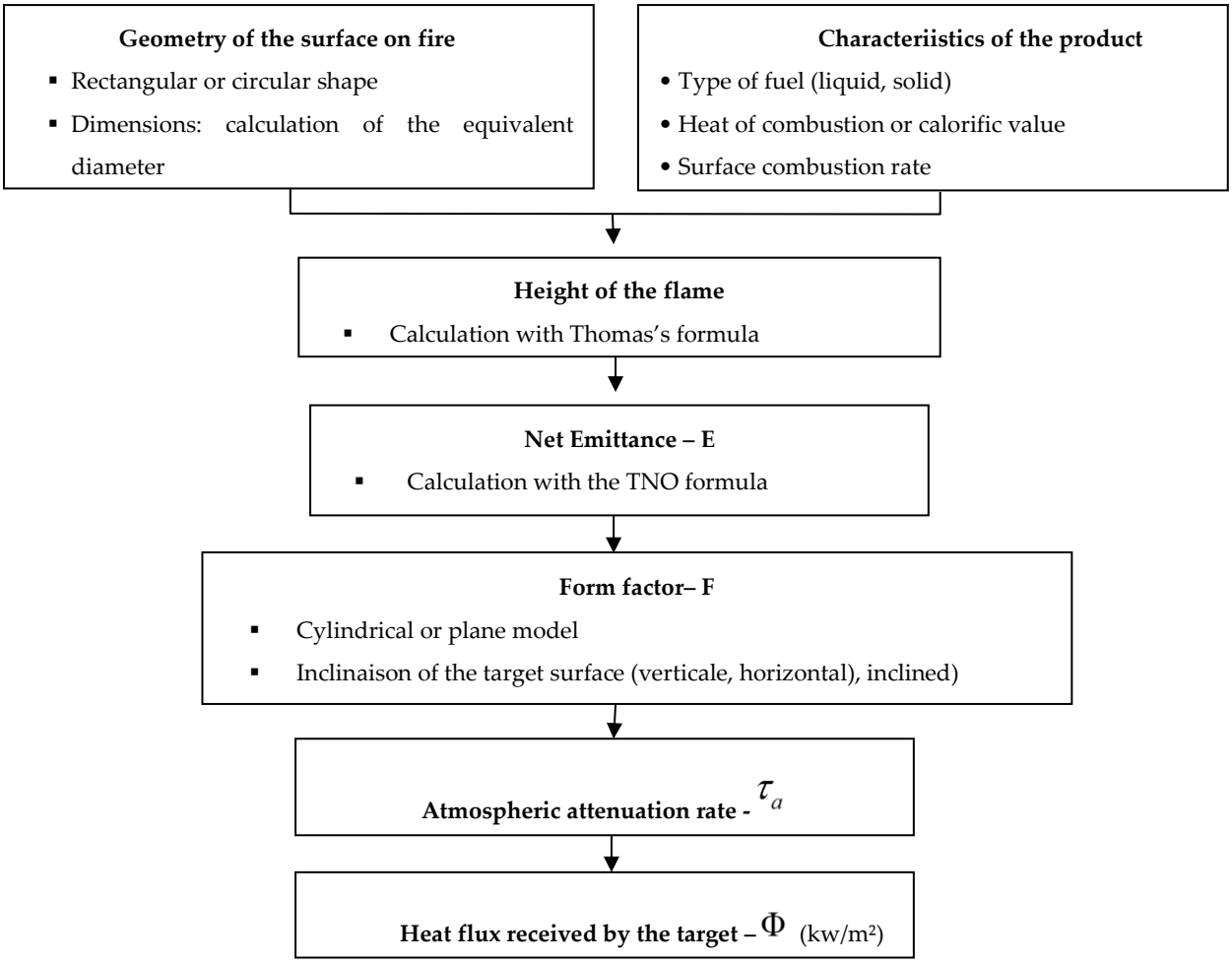


Figure 4: Principle of the method for calculating the thermal effects of fire

ALOHA software (Version 5.4.7), which has been built upon the Gaussian dispersion model of continuous, buoyant air pollution flumes,[25] was then used to model the dispersion maps of benzene toxic and flammable vapor cloud, determination of Max Average Sustained Release Rate averaged over a minute or more, the total amount released, and diameter of the evaporating puddle following the Wiekema's TNO model.[26] (Fig. 4)

The source emission time may vary between limits of one minute to one hour.[27] ALOHA employs solid flame models to compute thermal radiation hazards from bleve fireballs, jet fires, and pool fires. In these three scenarios, the incident radiant heat flux, ϕ(kW/m^2), emitted from a surface is computed, as follows:

$$\phi = E.F.\tau_a$$

Where E is the surface emissive power (kWm^{-2}), F is the geometric view factor, and τ_a is the atmospheric transmissivity. The severity of injuries and the extent of damage caused by thermal radiation from a fire is determined by the intensity of the incident radiation as well as the duration of exposure to that level of heat flux. Because fireballs last only a few seconds, the duration of exposure is commonly set to be the same as the duration of the fireball. ALOHA® threat zone estimates were displayed on a map using the Mapping Application for Response, Planning, and Local Operational Tasks (MARPLOT) software.

The ALOHA model of dispersion is a free application provided by NOAA (National Oceanic and Atmospheric Administration) of the United States and EPA (Environmental Protection Agency) and it is the tool for the assessment of toxic gas cloud threat zones recommended by the USEPA. The model is capable of simulating the dispersion model for over 900 chemicals and is primarily used in the simulation of accidental release of hazardous substances,[28] and the dispersion of chemical vapor.

The ALOHA software was used for this analysis because of its friendly graphical user interface, and because it helps analysts and planners/decision-makers to carefully visualize what may happen.[29] ALOHA can predict source strength for four general classes of chemical releases, or sources:

- Direct. An instantaneous or continuous release of chemical vapors into the air from a single point. This is the only option that allows for an elevated release.
- Puddle. A puddle of constant area, containing either a non-boiling or boiling liquid.
- Tank. A cylindrical or a spherical tank at ground level with a single hole or leaking valve. Tank contents may escape directly into the atmosphere or first form a spreading evaporating pool.
- Gas pipeline. A pressurized pipe containing gas is either connected to a very large reservoir or unconnected to any storage vessel.

The first three classes were considered in this study. Furthermore, ALOHA employs Levels of Concern (LOC) to address the impact of toxic air plumes, fires, and explosions on human populations. For inhalation hazards, ALOHA's LOCs are concentrations of airborne chemicals associated with adverse health effects. It uses two separate dispersion models including the Gaussian plume model,[30] and the heavy gases model,[31] for heavy gases like benzene.

After determining the model for estimating gas dispersion, ALOHA plots the points a concentration higher than Level of Concern, which is used to assess the flammable and toxicity threat of a chemical release.[32] The model assumes that all the combustion energy present in the flammable part of the cloud contributes to the explosion. If the characteristic explosion length is calculated, the blast parameters, such as peak pressure and the duration of the positive pressure phase at a certain distance from the center of the hemisphere are derived from the blast chart.

Results

The study was conducted to simulate the consequence modeling due to toxic materials dispersion from poorly sited gas stations in the city of Douala, Cameroon. In the first scenario considering gas leak, gas station information, and atmospheric information, the outcomes of a gas leak and emissions from the tank are modeled. The predicted averaged release rate during the hour after the release revealed that the release of benzene from the tank and evaporation from the puddle for

up to 60 minutes had a decreasing trend and direction in both seasons (Fig.5).

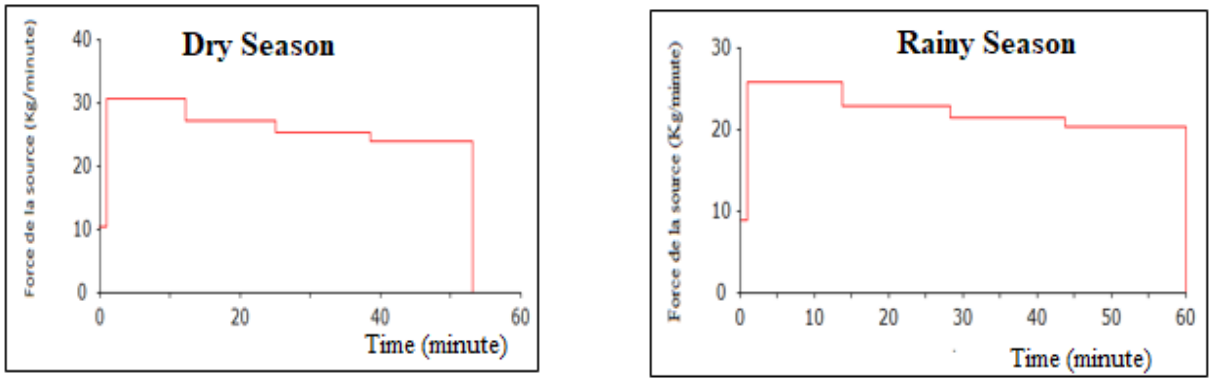
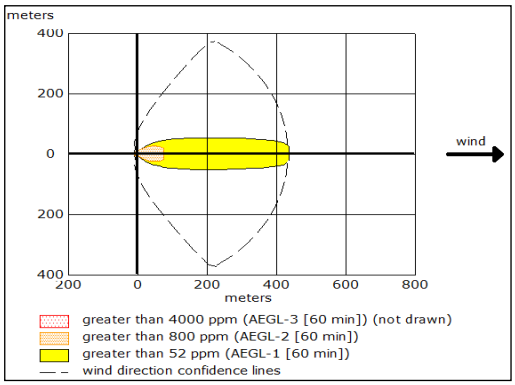
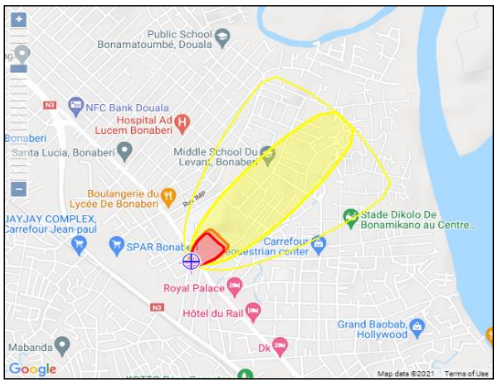


Figure 5: Predicted averaged release rate during the hour after which the release begins

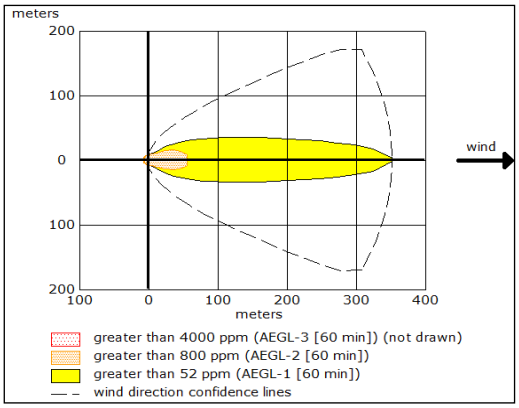
According to ALOHA, the release of vapor into the atmosphere lasts approximately 53 minutes, with a maximum amount of vapor released at any one time of 30.6 kilograms per minute (maximum average sustained release rate). In our study, the evaporation rate of benzene from the puddle formed in the dry season was lower (wind speed of 2.8 m/s, temperature 33.7°C, vapor pressure of the liquid at ambient temperature of 0.12 atm, ambient saturation concentration of 184,216 ppm or 11.9%) than in the rainy season (wind speed of.3.5 m/s, temperature 24°C, vapor pressure of the liquid at ambient temperature of 0.18 atm, ambient saturation concentration of 119,261 ppm or 18.4%). The results related to the domain of formation of the benzene toxic vapor cloud (threat zone) at different distances from the tank in dry and rainy seasons, together with potentially affected areas are shown in Fig.6.



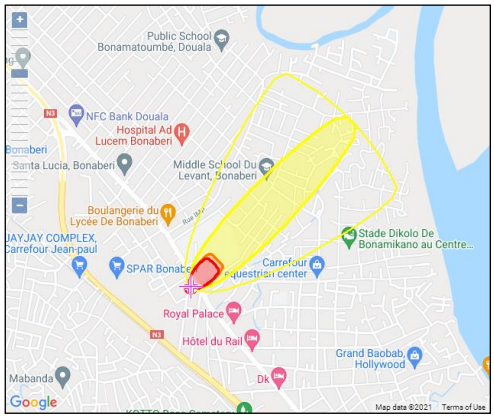
(a) Threat zones in the dry season



(b) Potential affected areas in the dry season



(c) Threat zones in the rainy season



(d) Potential affected areas in the rainy season

Figure 6: Modeling and simulation of the domain of threat zones (a and c), and potentially affected areas (b and d) due to the formation of the benzene flammable vapor cloud at different distances from the tank per season

We observe from figure that, although the toxic vapor threat zone did cover a few sensitive areas with a dense population (the main road that is often traffic-congested and full of students in the morning and afternoon), it could potentially affect surrounding residential areas and school (Government bilingual high school Bonaberi) with a denser population with a change in wind direction in different seasons.

Based on the findings, the threat zone for benzene toxic vapor clouds in the dry and rainy seasons was divided into three layers red, orange, and yellow. The red zone in both seasons represents AEGL-3, which had an exposure concentration of 4000 ppm and was dispersed to 19 and 31 m from the tank, respectively; the orange zone represents AEGL-2, which had an exposure concentration of 800 ppm and was dispersed to 56 and 76 m from the tank, respectively. Ground-level benzene concentrations may exceed the ERPG-2 level within this zone. People may experience serious health effects or have their ability to escape impaired at concentrations above the ERPG-2 level (if they are exposed for about an hour). Finally, the yellow zone represents AEGL-1, which had an exposure concentration of 52 ppm and was dispersed up to 353 m and 436 m from the tank, respectively, during both seasons.

The maximum average sustained release rate was estimated at 26 kilograms/min (averaged over a minute or more), with an estimated total amount of released being 1,340 kilograms. The puddle spread to a diameter of 19.8 meters. The potential consequences of benzene toxic vapor cloud concentrations at different points and times of exposure in the office and outdoor in both seasons vary considerably in the downwind direction (Fig. 7).

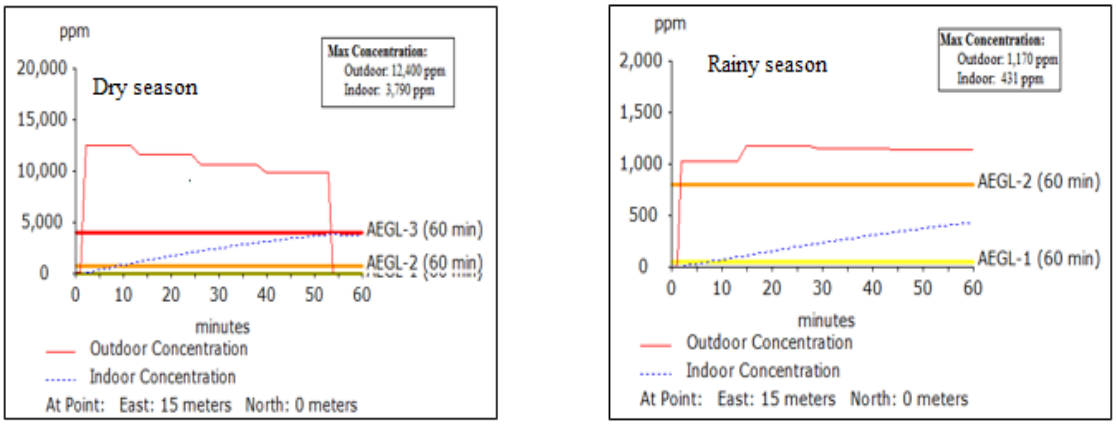


Figure 7: Concentration Estimates at a point of vapor cloud as a function of time in the office building and outdoor

We infer from the figure that, while both AEGL-3 and AEGL-2 levels are likely to be attained at about 54 minutes after the release in the dry season, no such phenomenon is likely to occur in the rainy season. The concentration of benzene flammable vapor cloud in office buildings did not exceed the standard of 10LEL in both seasons. However, the concentration of benzene flammable vapor cloud in the area outside the office building 5 minutes after the start of the accident exceeded the 10% LEL standard. Further, at a point 35mN (across the road from, Government Bilingual High School, Bonaberi), and 35mE of the station, the concentration of benzene toxic vapor cloud exceeded the AEGL-2 standard (800 ppm) only in the dry season after 40 minutes of the accident but was not the case in the rainy season (Fig 8).

In our modeling, ALOHA estimates that the pool fire would last just under 2 and half minutes. The maximum flame length was 25 meters, and the burn duration was about 3 minutes, with a maximum burn rate of 727 kilograms/min. The release followed a decreasing trend in both seasons. The total amount of material burned was1393 kilograms. The chemical escaped as a liquid and formed a burning puddle. The puddle spread to a diameter of 13.5 meters. The increase in burn rate for the first minute and a half could be attributed to

the growing puddle size as the chemical continues to leak from the tank (Fig. 9).

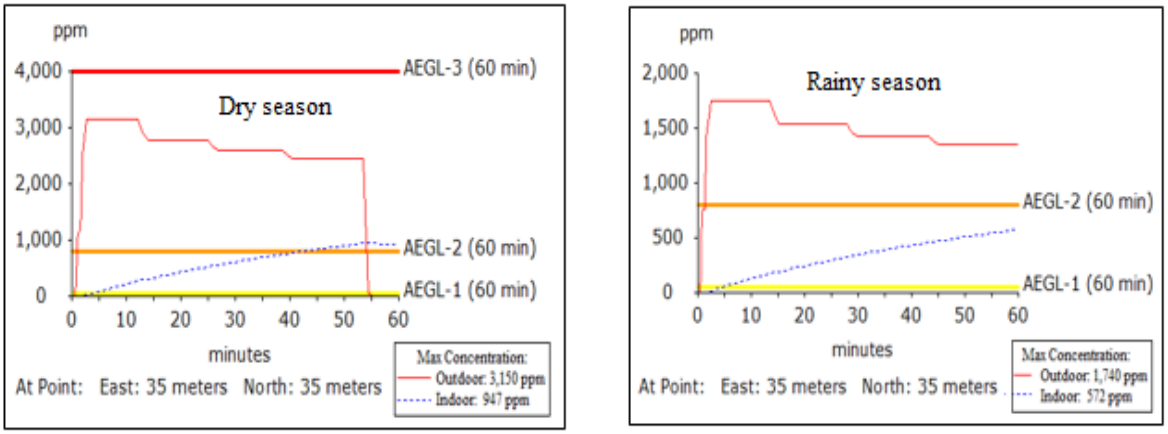
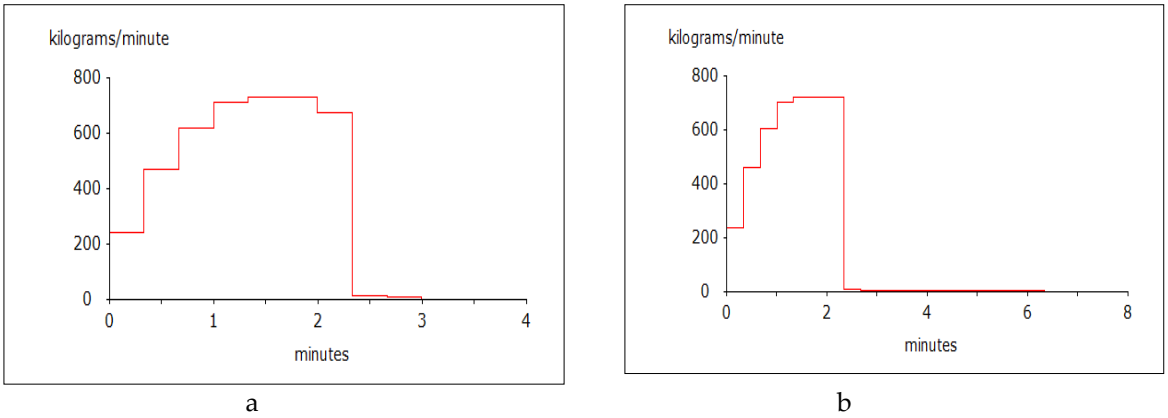


Figure 8: Concentration estimates at a point of vapor cloud as a function of time in & outdoor office building



a b

Figure 9: Evaporation rate of benzene from the puddle formed in dry (a) and rainy (b) seasons

ALOHA's threat zone estimate for this scenario shows three nearly circular thermal radiation threat zones the red threat zone which represents the worst hazard level, and the orange and yellow threat zones which represent areas of decreasing hazard for both seasons (Fig. 10 a & b).

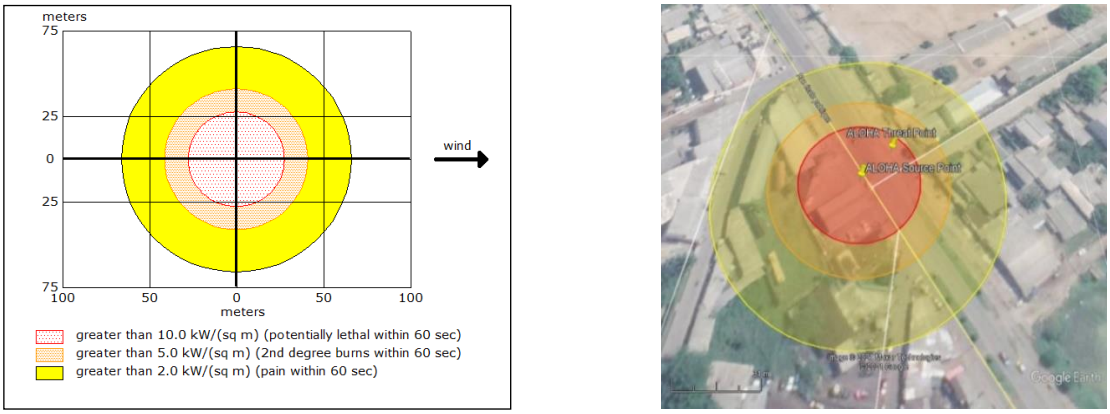


Figure 10a: Thermal radiation threat zone from pool fire in the the dry season

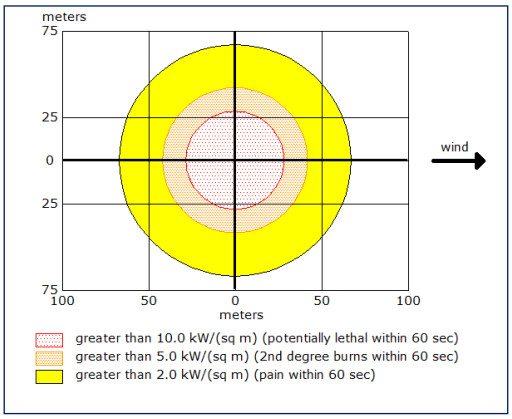
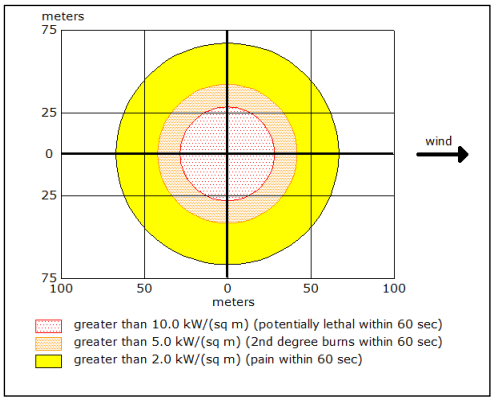
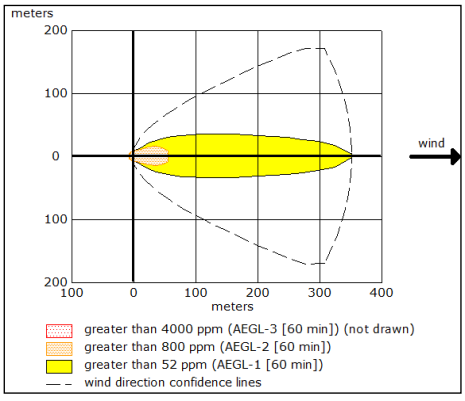


Figure 10b Thermal radiation threat zone from pool fire in the rainy season

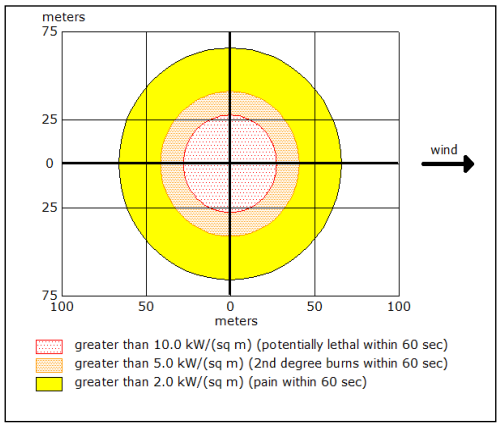
The thermal radiation threat extends a little farther in the downwind direction. In both seasons, the red threat zone was estimated to extend 28 meters (10.0 kW/(sq m) = potentially lethal within 60 seconds) downwind. In the dry season, the orange threat zone extends only about 41 meters (5.0 kW/(sq m) =2nd-degree burns within 60 sec), and in the rainy season, it extends 42 meters in the upwind direction. This slight difference exists probably because the wind tilts the flames in the downwind direction, leading to a greater thermal radiation threat in that direction. The origins (0, 0) on both figures represent the center of the puddle. ALOHA estimates that the red toxic threat zone - the worst hazard level extends primarily in the downwind direction, predicted to extend roughly 31 meters (4000 ppm = AEGL-3 [60 min]) in the dry season, and 19 meters (4000 ppm = AEGL-3 [60 min]) in the rainy season respectively in all directions and a little farther in the downwind direction (Fig 11).



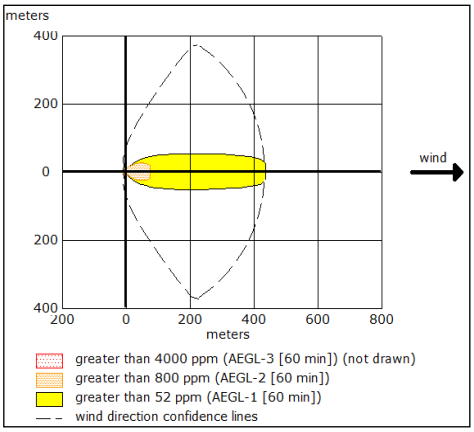
Rainy season pool of fire



Rainy season toxic dispersion



Dry season pool of fire



Dry season toxic dispersion

Figure 11: Comparison of the threat zone estimates from both of the scenarios in dry and rainy seasons

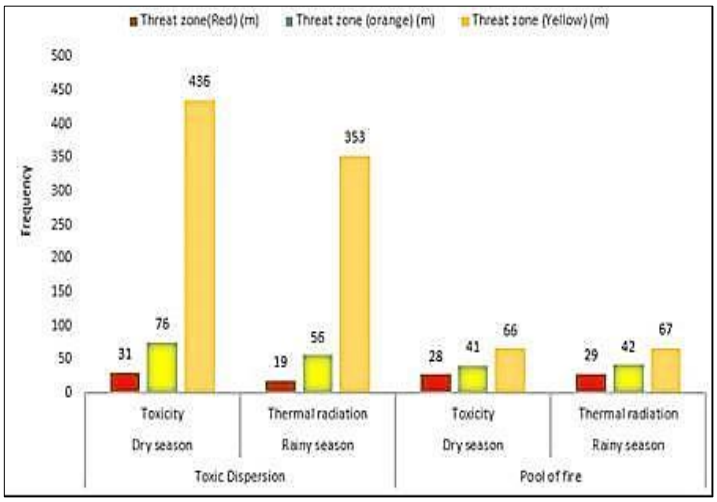


Figure 12: Summary of threat distances from the Text Summary screens

The toxic threat is confined primarily to the area downwind of the release, and even though the thermal radiation threat occurs in all directions is shifted downwind from the origin. The threat distances from both scenarios are summarized as follows (Fig 12).

If operators of petrochemical plants had performed the environmental survey at the initial stage of hazard and simulated the pattern of toxic vapor dispersion using the ALOHA model by plugging in various measurements, the statistics from the simulation would not only serve as a useful reference for rescue operations but also as a basis to notify residents in the affected areas to take necessary safety precautions to ensure the safety of their lives and properties. Considering the threat zone of the toxic vapor cloud, presenting some control strategies for the prevention of human casualties and equipment damage is essential. The most important safety measures to prevent damage to the area are as follows (Table 2).

Table 2: Recommendations based on the results obtained from both scenarios

ID	Prevention barriers	Limitations	Action steps for improvement
1	Operation procedures	Operation procedures are not updated	Regularly review and update operation procedures; establish Management of Change (MOC) procedure
2	Emergency management	No emergency plan to indicate emergency evacuation routes; no oil spill emergency supplies	Need for emergency plan and procedures that will be regularly reviewed and updated; consider emergency procedure updates in the MOC procedure; ensure that first aid equipment and medicine are available per actual needs; ensure that oil spill emergency supplies are in place; conduct desktop exercise once a week and practice once a month
3	Staff training	Insufficient staff ability; insufficient staff training	Develop post-appraisal system; develop training program and plan
4	Routine inspection and monitoring	No specific monitoring plan	Regular foundation settlement assessment
5	Security system	Only one gathering place is set for emergencies; inadequate persons on duty at night	Add an alternative gathering place; increase the site staff on duty at night; strengthen site supervision
6	Fire extinguishing system	Only two fire water tanks of 1500m^3 are available; the quality of fire water is poor	Check fire extinguishers and fire hydrants once a month; add alternative water supply source for fires; forming support groups like firefighting teams in the threat zone in different seasons, ensure that quantity and quality of water conform to the requirements for fire protection; assess the

			effectiveness of fire fighting in case of a large pool fire in an oil transfer pump area
7	Human inspection	Inadequate staff	Periodic inspection in a fixed route
8	Alarm and emergency shutoff	No control system of combustible gas detectors in the central control room; no broadcasting system	Install an acousto-optic alarm system and broadcasting system in threat zones and teaching the personnel how to deal with such situations, providing emergency telephone lines and communication devices for better coordination with the adjacent industries and habitations, and preparing a response plan for emergencies can reduce the harmful impacts of toxic and dangerous substance release.

Discussion

This study was performed on 152 gas stations in the city of Douala and showed that over half of the gas stations were exposed to varying fire risk scenarios. Two failure scenarios were considered: a sudden catastrophic failure leading to a Boiling Liquid Expanding Vapor Explosion (BLEVE); and, a leak leading to a flash fire or a vapor cloud explosion. Both scenarios were considered for both the dry and rainy season inorder to express an opinon on the season that could be riskier to decicion makers.

In the fisrt scenario, the consequences of benzene puddle formed in the dry season due to evaporation were higher (wind speed of 2.8 m/s, temperature 33.7°C, vapor pressure of the liquid at ambient temperature of 0.12 atm, ambient saturation concentration of 184,216 ppm or 11.9%) than in the rainy season (wind speed of.3.5 m/s, temperature 24°C, vapor pressure of the liquid at ambient temperature of 0.18 atm, ambient saturation concentration of 119,261 ppm or 18.4%). Our results suggests that wind speed and atmospheric stability are the primary factors that influence dispersion. Previous research also asserted that air movements can move, disperse, or trap a pollutant cloud.[33] Atmospheric stability is a measure of the mixing or turbulence in the atmosphere, which depends on the amount of solar radiation heating the air near the ground.[34] The dry season corresponds to stability class the slightly stable class, E, while the rainy season corresponds to class D: Neutral (Adiabatic), normally occurs with moderate to dim sunshine, cloudy conditions, and at night, with wind speeds > 3 m/s.[35] Because the topography of Douala is generally flat, the puddle would spread out until it becomes very thin in the dry season with the lesser stable class.

High incoming solar radiation (as would occur on sunny days) and low wind speeds characterize unstable/neutral conditions (e.g. stability class D) and result in high levels of buoyant turbulence. Under such unstable conditions, the air temperature of the atmosphere near the earth's surface declines rapidly with elevation. Warm parcels of air near the surface travel a long distance upward before cooling to the temperature of the air around it. As warmer air rises, the cooler air that is displaced sinks downward. Large-scale, convective motions develop that provide substantial vertical mixing. On the other hand, stable atmospheric conditions (e.g., stability class E), corresponding to the dry season, can occur on clear nights with low wind speeds. The smaller atmospheric temperature gradient that occurs with stable atmospheric conditions limits upward convection and reduces vertical mixing. In this case, ALOHA might have overestimated the real puddle size and evaporation rate given that it assumes a perfectly flat surface which is not the case in the city of Douala. If the puddle were constrained by small depressions in the ground, it would not spread out as far because the liquid flowing away from the tank would fill up the depressions in the ground, and would then be smaller in the area and deeper at a slower rate and it would take longer to completely evaporate.

The predicted threat zone distance from the tank and /or the station in the dry season, as compared to the rainy season, had an increase in radius of 12, 20, and 83m for the red, orange, and yellow zones, respectively. The variation between seasons suggests that meteorology might be influencing dispersion. This hypothesis correlates with the

work of,[36] who concluded that wind speed and atmospheric stability are the primary factors that influence dispersion. Atmospheric stability is a measure of the mixing or turbulence in the atmosphere, which depends on the intensity of solar radiation heating the air near the ground.[37] In this study, the stability classes were D and E in the dry and rainy seasons, respectively. The study's findings revealed that the rate of spread of heavy gases is much higher in an unstable atmosphere than in a more stable atmosphere because airflow movement in the axis perpendicular to the ground is low and the pollutant spreads more in the horizontal axis.[38] As a result, dry-season stability increases the dispersion distance of benzene toxic vapor clouds.

For a low-wind release, the cloud will meander a lot, and we will be unsure of the snakelike path that the cloud will take. Because of the smaller expected cloud meander at high wind speeds, the dashed lines will be close to the footprint. Plume meander refers to the variation of the location of the plume centerline (i.e., plume swings back and forth), due to turbulent velocity fluctuations. The magnitude of the plume meander effect on the time-averaged centerline concentration is a function of averaging time. The time-averaging effect on plume meander dispersion is generally accounted for by the Gifford algebraic expression that relates the horizontal dispersion coefficient (δ_y) for the averaging time of interest (t_a) to a known reference horizontal dispersion coefficient (δ_y, ref) that is associated with a reference averaging time (t_a, ref).[39] This phenomenon was observed during both seasons. However, in the case of low winds, which are more prone to cloud meandering, the area of the dashed lines is a complete circle with a radius equal to the footprint length, indicating that the wind could shift and blow the cloud in any direction. This condition was more prevalent during the dry season than during the rainy season. In Douala, the prevailing wind directions in both seasons are SW, W, ENE, and ESE. However, the direction with the strongest wind speed in both seasons is the SW. For this reason, the approximate direction of the benzene toxic vapor cloud in both seasons was SW. We agree with,[40] that, in general, the prevailing wind direction plays a decisive role in the movement of the benzene toxic vapor cloud. In general, there are two ideal classes of sources: One is an instantaneous source, where the pollutant is released into the atmosphere all at once. The other type of release is a continuous source, where the material is released at an approximately steady rate for a longer period.

ALOHA considers continuous releases lasting up to 60 minutes. Other studies,[6] for example,6 found that benzene and other gasoline vapor releases from service stations can be discerned from traffic emissions as far as 75 m from service stations and that the contribution of service stations to ambient benzene is less important in areas of high traffic density. This is probably because vehicle exhaust is usually the most abundant volatile organic compound (VOC) in urban areas, often followed by gasoline vapor emissions from fuel handling and vehicle operation.

From the foregoing, it appears that the exposures to benzene and other components of refueling vapors and spills experienced by these populations vary based on several factors, including the size and capacity of the refueling station, spatial variation in pollutant concentrations in ambient air, climate, meteorological conditions, time spent at varying locations of the service station, changing on-site activity patterns, physiological characteristics, and the use of vapor recovery and other pollution prevention technologies. Employees at service stations (such as pump attendants, on-site mechanics, garage workers, etc.) are among those with the greatest exposure to benzene originating from gas stations.[41] According to,[42] these receptors spend the most time on site (potentially reflecting approximately 40 h per week, for decades) and intermittently spend time where vapors from the pump are at their highest concentrations, with benzene concentrations measuring between 30 and 230 ppb in the breathing zone. Whether this is significantly affecting the physiological and biochemical processes of humans (which in turn may indirectly affect the productivity potential of the enterprise) or the increased benzene in the atmosphere is directly affecting the output of

workers is difficult to ascertain from this study.

Conclusion

The consequence analysis of potential benzene dispersion following leakages and explosion from storage devices in gas stations in the city of Douala has been modeled in the above discussion. The approach is comparable to other heuristic methods. In some cases, it can be considered as a real-time and reliable detection approach, and offers a strong potential for better understanding and investigating of the environment, especially in regions such as sub-Saharan Africa, where existing petrol station databases are uncommon and often unreliable. Nearby residences and social infrastructures are significantly exposed, with the predicted threat zone being more hazardous for the employees of the gas station. The comparison shows that potential risks could be higher in the dry season than in the rainy season. The results trigger the need for local governments to inculcate the interest of the resident population and employees of petrol stations as a core concern in projects that directly affect local ecosystems. An advantage of this algorithm is that cartography of potential threat zones is provided together with empirical results. The results can be used to help manage facility risks by considering decisions such as siting buildings and specifying appropriate protection against overpressure, thermal radiation, and gas ingress, locating fire and gas detectors and fire hydrants, land use planning restrictions on development around facilities, and emergency response planning. The results could also be applied to other institutions such as airports, local fuel companies, power plants, and large manufacturing facilities such as automobiles and steel plants that also have bulk storage of flammable and combustible liquids. Implementing a risk management system that could evaluate the main causes and consequences of explosions in gas stations, focusing on the identification of prevention and mitigation barriers that could/should be applied by management to avoid and/or mitigate the consequences of explosions caused by gas or fuel leaks, can help achieve more realistic results. In addition, further research on the impact of combined consequences of gasoline emissions could help determine whether the combined effects of benzene with other chemicals are cumulative or synergistic.

Acknowledgments

Through the modernization allowance, the Head of State, His Excellency President Paul Biya has tremendously assisted me in accomplishing this task. Many thanks also go to the enterprises for accepting to cooperate with the research team.

References

1. Hsieh PY, Shearston JA, Hilpert M. Benzene emissions from gas station clusters: a new framework for estimating lifetime cancer risk. Journal of Environmental Health Science & Engineering. 2021 Jun;19(1):273-83. Available from: https://doi.org/10.1007/s40201-020-00601-w
2. Verma DK, des Tombe K. Benzene in gasoline and crude oil: Occupational and environmental implications. AIHA J (Fairfax, Va). 2002; 63(2):225–30. Available from: https://doi.org/10.1080/15428110208984708
3. Hilpert M, Mora BA, Ni J, Rule AM, Nachman KE. Hydrocarbon release during fuel storage and transfer at gas stations: environmental and health effects. Curr. Environ. Health Rep. 2015,2(4),412–22. Available from https://doi.org/10.1007/s40572-015-0074-8
4. IARC working group on evaluation of carcinogenic risks to human. Chemical agents and related occupations. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. 2012;100(Pt F):1-628. Available from:. http://monographs.iarc.fr/ENG/Monographs/vol100F/ (January 13, 2021).
5. Morales Terrés IM, Miñarro MD, Ferradás EG, Caracena AB, Rico JB. Assessing the impact of petrol stations on their immediate surroundings. Journal of environmental management. 2010;91(12),2754-62. Available from: https://doi.org/10.1016/j.jenvman.2010.08.009

6. Yu H, Lee WK, Sohn JR. Risk hotspot of chemical accidents based on spatial analysis in Ulsan, South Korea. Safety Science. 2020;123: 104544. Available from: https://doi.org/10.1016/j.ssci.2019.104544

7. Ho YC, Su BH, Su HJ, et al. The association between the incidence of mumps and meteorological parameters in Taiwan. Human Vaccines and Immunotherapeutics. 2015;11(6),1406-12. Available from: https://doi.org/10.1080/21645515.2015.1029687

8. Darbra RM, Demichela M, Mure S. Preliminary risk assessment of ecotoxic substances accidental releases in major risk installations through fuzzy logic. Process safety and environmental protection. 2008 March;86(2),103-11. Available from: https://doi.org/10.1016/j.psep.2007.10.015

9. Pandya N, Marsden E, Floquet P, Gabas N. Toxic release dispersion modelling with PHAST: parametric sensitivity analysis. In: CISAP - 3rd International Conference on Safety & Environment in Process Industry, Rome, Italy ,11-14 may 2008 (Unpublished).

10. Sanchez, EY, Represa S, Mellado D, et al. Risk analysis of technological hazards: simulation of scenarios and application of a local vulnerability index. Journal of Hazardous Materrial. 2018;352,101–10. Available from: https://doi.org/10.1016/j.jhazmat.2018.03.034

11. Rajeev K, Soman S, Renjith VR, George P. Human vulnerability mapping of chemical accidents in major industrial units in Kerala, India for better disaster mitigation. Int. J. Disaster Risk Reduct. 2019;39:101247. Available from: https://doi.org/10.1016/J.IJDRR.2019.101247

12. Dasgotra A, Teja GVV, Sharma A, Mishra KB. CFD modelling of large-scale flammable cloud dispersion using FLACS. Journal of Loss Prevention in the Process Industries. 2018;56,531-36. Available from: https://doi.org/10.1016/j.jlp.2018.01.001

13. Tekye A, Jafari M, Mortazavi B. Application of Bowtie Techniques in the Analysis of the Accident in SRP Unit of Tehran's Tondgooyan Refinery. In: Seventh National Congress of Occupational Health; 2011; Qazvin. Available from: https://civilica.com/doc/194949/

14. de Ruijter A, Guldenmund, F. The bowtie method: A review. Saf. Sci. 2016;88,211-8, Availabe from: https://doi.org/10.1016/j.ssci.2016.03.001

15. Mountapmbeme PY. Exposition Professionnelle Chronique au Benzene Chez les Pompistes de la Ville de Yaounde et Variations des Concentrations d'acide Trans, Trans-Muconique Dans L'urine [Chronic occupational exposure to benzene among pump attendants in the city of Yaounde and variations in the concentrations of Trans, Trans-muconic acid in urine]. PHARMACY, Faculté de Médecine et des Sciences Biomédicales, Université de YAOUNDE. 2015 Jun 26. French.

16. American Institute of Chemical Engineers, Center for Chemical Process Safety. Guidelines for chemical process quantitative risk analysis. 2nd edition. New York: American Institute of Chemical Engineers;2000. 754p. Available from: http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=589010

17. Batambock S., Ndoh M.I, Bitondo D., Nguemtue W.A.F. Auditing the Siting of Petrol Stations in the City of Douala, Cameroon: Do they fulfill the Necessary Regulatory Requirements? Advances in Science, Technology and Engineering Systems Journal, 2021, 6(1): 493-500. Available from: https://doi.org/10.25046/aj060154

18. Ndoh MI, Bitondo D, Sammy NJ. Modeling the Temporal Variations of Municipal Solid Waste Generation for Future Projection in the Douala Municipality, Cameroon. Journal of Multidisciplinary Engineering Science and Technology. 2016;3(7):5288-95. Available from: https://doi.org/10.25046/aj060154

19. Weather Spark: statistical analysis of historical hourly weather reports and model reconstructions from January 1, 1980, to December 31, 2016 [cited 2021 Mar 20]. Available from: https://weatherspark.com/

20. HazMat database: Chemical data provider, allowing the retrieval of hazardous material description stored [cited 2021 Mar 21]. Available from:

https://www.hazmattool.com

21. Sameti M. The Role of Bowtie Method in the Improvement and Optimization of the Risk Management Process. In: Seventh National Congress of Occupational Health; Qazvin; 2011. Available from: https://civilica.com/doc/194996/

22. Gas L. Lower and upper explosive limits for flammable gases and vapors (LEL/UEL). Matheson. gas. prod. 2013;1-22. Available from: https://www.chrysalisscientific.com/pg443-Lower-LEL-Upper-UEL-Explosive-Limits.pdf

23. Barjoee Shojaee S, Nikbakht M, Malverdi E., Zarei Mahmoud Abadi S, Naghdi MR. Modeling the Consequences of Benzene Leakage from Tank using ALOHA in Tar Refining Industrial of Kerman, Iran. Pollution. 2021,7(1):217-30. Available from: https://doi.org/10.22059/poll.2020.309283.887

24. Beheshti MH, Dehghan SF, Hajizadeh R, Jafari SM, Koohpaei A. Modeling the consequences of an explosion, fire, and gas leakage in domestic cylinders containing LPG. Ann. Med. Health. Sci. Res. 2018,8:83-8. Available from: https://www.amhsr.org/articles/modelling-the-consequences-of-explosion-fire-and-gas-leakage-in-domestic-cylinders-containing-lpg-4291.html

25. Turner DB. Workbook of dispersion estimates. Department on Health Education and Welfare, Cincinnati, Ohio, USA, 1970. Available from: https://www.keysolutionsinc.com/references/Turner%20Workbook.pdf

26. Wiekema BJ. Vapour Cloud Explosion Model. Journal of Hazardous Materials. 1980;3: 221-32. Available from: https://doi.org/10.1016/0304-3894(80)85002-3

27. Jani DD, Reed D, Feigley CE, Svendsen ER. Modeling an irritant gas plume for epidemiologic study. Int. J. Environ. Health. Res. 2016;26(1):58-74. Available from: https://doi.org/10.1080/09603123.2015.1020414

28. Pole IY, Shu CM, Chong CH. Applications of 3D QRA technique to the fire/explosion simulation and hazard mitigation within a naphtha-cracking plant. J. Loss Prev. Process Ind. 2009;22:506–15. Available from: http://doi.org/10.1016/j.jlp.2009.04.002

29. Shamsuddin SD, Omar N, Koh MH. Development of radionuclide dispersion modeling software based on Gaussian plume model. Malays. J. Ind. Appl. Mathematics. 2017;33(2):149-57. Available from: https://doi.org/10.11113/matematika.v33.n2.1003

30. Li Y, Chen D, Cheng S, Xu T, Huang Q, Guo X, et al. An improved model for heavy gas dispersion using time-varying wind data: Mathematical basis, physical assumptions, and case studies. J. Loss. Prev. Process. Ind. 2015;36: 20-9. Available from: https://doi.org/10.1016/J.JLP.2015.05.010

31. Watson JG, Chow JC, Fujita EM. Review of volatile organic compound source apportionment by chemical mass balance. Atmospheric Environment 2001;35(9):1567–84. Available from: https://doi.org/10.1016/S1352-2310(00)00461-1

32. Ilic P, Ilic S, Bjelicc LS. Hazard Modeling of Accidental Release Chlorine Gas Using Modern Tool-Aloha Software. Qual. Life. 2018;16(1-2):38-45. Available from: https://doi.org/10.7251/QOL1801038I

33. Zhang H, Xu T, Zong Y, Tang H, Liu X, Wang Y. Influence of meteorological conditions on pollutant dispersion in a street canyon. Procedia Engineering. 2015;121:899-905. Available from: https://doi.org/10.1016/j.proeng.2015.09.047

34. Lu X, Mao F, Pan Z, Gong W, Zhu Y, Yang J. Enhancement of atmospheric stability by anomalous elevated aerosols during winter in China. Journal of Geophysical Research: Atmospheres. 2020;125(4):1-13. Available from: https://doi.org/10.1029/2019JD031734

35. Turner DB. Workbook of Atmospheric Dispersion Estimates. National service center for environmental publications. Ann Arbor, MI: Lewis Publishers; 1970. 92 p Available from: https://www.keysolutionsinc.com/references/Turner%20Workbook.pdf

36. Pourbabaki R, Karimi A, Yazdanirad S. Modeling the consequences and analyzing the dangers of carbon disulfide emissions using ALOHA software in an oil refinery. J. Health. Field. 2019;6(3):1-9.

Available from: https://doi.org/10.22037/jhf.v6i3.22012

37. Anad AM, , Al-Jiboori MH, Hassoon AF. Simulation effect of stability classes on SO2 concentration in dura refinery and neighboring regions. Al-Mustansiriyah. J. Sci. 2019;30(3):1-8. Available from: https://doi.org/10.23851/mjs.v30i3.611

38. Bhattacharya R, Kumar VG. Consequence analysis for simulation of hazardous chemicals release using ALOHA software. International Journal of ChemTech Research. 2015;8(4):2038-46. Available from: https://sphinxsai.com/2015/ch_vol8_no4/3/(2039-2046)V8N4.pdf

39. Hanna SR, Briggs GA, Hosker JrRP. Handbook on atmospheric diffusion. United States: Technical Information Center, US Department of Energy; 1982. 110p. Available from: https://doi.org/10.2172/5591108

40. Zhao H, Che H, Ma Y, et al. The Relationship of PM Variation with Visibility and Mixing-Layer Height under Hazy/Foggy Conditions in the Multi-Cities of Northeast China. Int. J. Environ. Res. Public Health. 2017;14: 471. Available from: https://doi.org/10.3390/ijerph14050471

41. Karakitsios SP, Papaloukas CL, Kassomenos PA, Pilidis GA. Assessment and prediction of exposure to benzene of filling station employees. Atmospheric Environment. 2007;41(40):9555–69. Available from: http://doi.org/10.1016/j.atmosenv.2007.08.030

42. van Wijngaarden E, Stewart PA. Critical literature review of determinants and levels of occupational benzene exposure for United States community-based case-control studies. Applied Occupational and Environmental Hygiene. 2003;18(9):678–93. Available from: https://doi.org/10.1080/10473220301376

International Journal of Occupational Safety and Health

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

Original Article

Effects of Gasoline and Smoking on Lipid Profile and Liver Functions among Gasoline Exposure Workers in Iraq

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Date of submission: 23.02.2022
Date of acceptance: 12.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None

DOI:https://doi.org/10.3126/ijosh.v13i1.43367

ABSTRACT

Introduction: The rapid and recent rise in the pandemic of cardiovascular disease implies that the environment plays a significant role. Numerous biological systems, such as the cardiovascular, blood-forming organs, liver, and kidneys, can be affected by gasoline and smoking. Because filling station employees, repair service workers, gasoline truck drivers, and refinery workers are all at a greater risk of being exposed to gasoline fumes. Even though gasoline and smoking have been investigated for so many years, few studies have looked into the effects of gasoline exposure combined with smoking on a variety of physiological mechanisms. As a result, we propose that combining gasoline exposure with smoking is a risk factor for cardiovascular diseases and impaired hepatic function.

Methods: The study included 95 male adult volunteers who worked with gasoline and were exposed to different fuel derivatives as study group and age and sex-matched seemingly healthy non-exposed people as the controls. Questionnaire interviews were used to collect socio-demographic data and a standard technique was used to collect the blood samples. The levels of cholesterol, HDL4, LDL-C, triglyceride, and VLDL were measured, as well as for liver enzymes ALP, AST, ALT, indirect bilirubin, direct bilirubin, and total bilirubin were measured.

Results: Our data suggest that smoking with gasoline exposure causes an increase in total and bad cholesterol levels, as well as a significant shift concerning the control group in lipid profile and liver enzymes. the exposed group had higher levels of ALP, and AST and significantly increased. In the nonsmoker exposed group D-bilirubin decreased in comparison to the control and exposed smoker group.

Conclusion: This research concluded that the liver enzymes (ALP, AST, ALT) were higher among workers who smoke and are exposed to gasoline than in control subjects, similarly, the bad cholesterol also increase. Therefore, people who smoke and are handled with gasoline are at a higher risk of having heart and hepatic diseases.

Keywords: Bilirubin, Cardiovascular, Cholesterol, Gasoline, Hepatoxicity.

Introduction

Waste management is identified as one of many severe environmental problems. Waste problems can surely disrupt the environment around the community, such as soil pollution. A polluted environment will also have an impact on public health. There are several causes for the increase in waste, specifically the increase in population, the level of community activity, the socio-economic level of the community, technological advances, and also the pattern of people's lives.[1]

Technological boosts also increase the amount of

waste. It can be seen from the use of personal devices and frequently updating them to the latest ones.[2]

The world population is rapidly increasing Gasoline, a highly flammable liquid mixture, is the primary contaminant in the environment and is mainly utilized for the internal combustion of vehicles.[1] The majority of them are made up of hydrocarbons (aromatic, saturated, and unsaturated) and non-hydrocarbons (N, S, O2, vanadium, and nickel).[2] Because the gasoline vapor concentration in the atmosphere (approximately 2000 ppm) is not healthy when breathed even for a brief time (seconds), filling station personnel, service station attendants, gasoline truck drivers, and refinery workers are all at heightened risk from exposure to gasoline fumes.[3] The most common method of exposure is inhalation, but cutaneous absorption is also possible. It is important to note that production employees, distribution, and gasoline usage are all in danger of acute or chronic toxicity.[4]

Smoking tobacco involves thousands of compounds that have detrimental and poisonous effects on the body. Alterations in lipid profile, increased insulin resistance, decreased nitric oxide (NO) availability, endothelial dysfunction, increased insulin resistance, platelet dysfunction, high blood viscosity, alternations in fibrinolysis, ongoing inflammatory responses with rising inflammatory markers, and more recently free radicals-mediated oxidative stress play a vital role in the mediation of atherothrombosis appear to play an important role in the mediation of atherothrombotic.[5] Smoking cigarettes raises plasma catecholamine levels, which causes lipolysis and the production of free fatty acids, which the liver absorbs. The lipid-driven inflammatory disease of the artery wall is known as atherosclerosis.[6] Low-Density Lipoprotein-Cholesterol (LDL-C) and Very Low-Density Lipoprotein-Cholesterol (VLDL-C) are toxic to cells, while HDL-C (High-Density Lipoprotein-Cholesterol) is a protective factor against coronary atherosclerosis.[5] Tobacco smoking has been linked to higher levels of total cholesterol, triglycerides, LDL–C, VLDL, and lower levels of HDL–C, according to a previous study.[7,8,9] Other research, however, has yielded contradictory outcomes.[10] Cigarette smoking appeared to accelerate atherosclerosis in part due to its effect on lipid profiles.[11,12] It's also been discovered that the amount of cigarettes smoked is closely tied to the chance of developing cardiovascular diseases LDL-C, IDL-C, and VLDL are all potentially atherogenic apoB-containing lipoprotein particles. Non-HDL-C is a progressive measure that includes all possibly atherogenic apoB-containing lipoprotein particles.[13]

The liver is the body's main gland, and it plays a variety of roles in the control of numerous physiological activities. As a result, fatal liver disease could be the major cause of mortality. Drug-induced liver damage would be one of those life-threatening disorders that necessitate extensive clinical and surveillance assessments.[14] Breathing small quantities of gasoline fumes can cause nasal and throat irritation, as also headaches, dizziness, nausea, vomiting, confusion, and breathing difficulties. Dermal contact with gasoline can cause rashes, redness, and swelling, along with many other symptoms. Although allergic reactions (hypersensitivity) have been observed, they are uncommon.[15] Long-term exposure to gasoline can cause hepatotoxicity, and the severity of benzene poisoning is dependent on the amount, route, and length of time of exposure, as well as the exposed person's age and pre-existing medical condition.[16]

The most typically requested tests for heart and liver investigations are lipid profile and liver function tests (LFTs).[17] As a result, the goal of this study was to determine the impact of gasoline exposure combined with smoke on the lipid profile parameters and liver function tests in gasoline station workers in Zakho, Duhok City, Kurdistan Region, Iraq.

Methods

The study included 95 male adult volunteers from Zakho city, who worked with gasoline and were exposed to different fuel derivatives and provided

informed consent to participate in the research. Age and sex-matched seemingly healthy non-exposed people from various locations in Zakho served as the controls. Participants with the following criteria were excluded from the study: people diagnosed with cardiovascular disorders, those with a family history of malignancies, subjects with chronic renal and respiratory disease, individuals on corticosteroid therapy, radiotherapy or chemotherapy, liver damage or disease, and those who were already taking medication that affected their cardiovascular and liver functions.

Questionnaire interviews were used to collect data over three months, concentrating on socio-demographic information, periods of exposure, time of working (hours/day), health conditions, and habits of smoking. A standard technique was used to collect the blood. To reduce errors, the blood sample container was tagged with the participant's name. A blood sample was collected from the peripheral vein on the arm of each of the volunteers by venipuncture using a sterile 10ml needle and syringe. 7mls of venous blood was taken and 4mls were transferred immediately into a sterile labeled plain vial while 3mls were transferred into well-label potassium EDTA anticoagulant vials. The blood in the plain vial was allowed to clot and retract. It was centrifuged at 18000g, serum extracted, for heart and liver enzyme assay.

This investigation was carried out after the research and ethical committee of Zakho University's Department of Biology Faculty of Science proved (5/238) its permission. To get authority to conduct biochemical analysis in the central laboratories, an official letter of request was issued to Bedare Hospital. After describing the study's goal, all research participants gave their written informed consent to participate willingly.

Data obtained were presented as median ± S.E.M. One-way ANOVA followed by Bonferroni post hoc test comparison was used to compare among control, non-smoking exposure, and smoking exposure groups. All statistical tests were two-tailed and a ($P \leq 0.05$) was considered statistically significant. All the calculations and statistical analyses were performed using GraphPad Prism 7 (GraphPad Software, San Diego, California, USA).

Results

The information about the participants' demographics was acquired from a record based on the service station employees. The participants' ages ranged from 23 to 53 years for nonsmokers (mean 33.43 years), 31.82 for smokers in the exposed group, and 20 to 53 years for the unexposed group (mean 40.03 years). Workers were employed for 3 to 35 years and were exposed to various fuel derivatives for at least 10 hours per day (Table 1).

Figures 1, 2, and Table 2 show the mean level of cholesterol (mg/dl), HDL-4 (mg/dl), LDL-C (mg/dl), Triglyceride (mg/dl), VLDL (mg/dl), and Liver enzymes of workers exposed to gasoline including smokers and non-smokers in comparison to the unexposed group. The mean results of the exposed non-smoker group provided the following values for cholesterol (161.9 ± 2.95), HDL-4 (39.03 ±1.23), LDL-C (120.2 ±1.16), Triglyceride (177.9 ±37.54), and VLDL (20.08 ±1.12). Whereas, in the case of the exposed smoker group, mean values of (165.7 ± 3.19), (39.38 ±1.26), (118.7 ±2.41), (121.2 ±6.55), and (23.38±1.39) were obtained for cholesterol (mg/dl), HDL-4 (mg/dl), LDL-C (mg/dl), Triglyceride (mg/dl), and (VLDL (mg/dl), respectively. For Control were cholesterol (126.9 ± 6.01), HDL-4 (44.98 ±0.64), LDL-C (102.2 ±2.28), Triglyceride (107.3 ±2.597), VLDL (22.11 ±1.288). Comparing the two sub-groups with the control indicated, the (cholesterol, HDL-4, and LDL-C) parameters were significantly different, whilethe parameters for (Triglyceride and VLDL) were insignificant.

Table 1. Some of the demographic Criteria for Participation

Demographic Criteria	control	Non-Smoker Exposure	Smoker Exposure
Age	40.03	33.43	31.82
Weight	75.33	79.64	75.61
Years/work	-	11.43	16
Exposure hours	-	10	10
packet	-	NO	1-4 packet

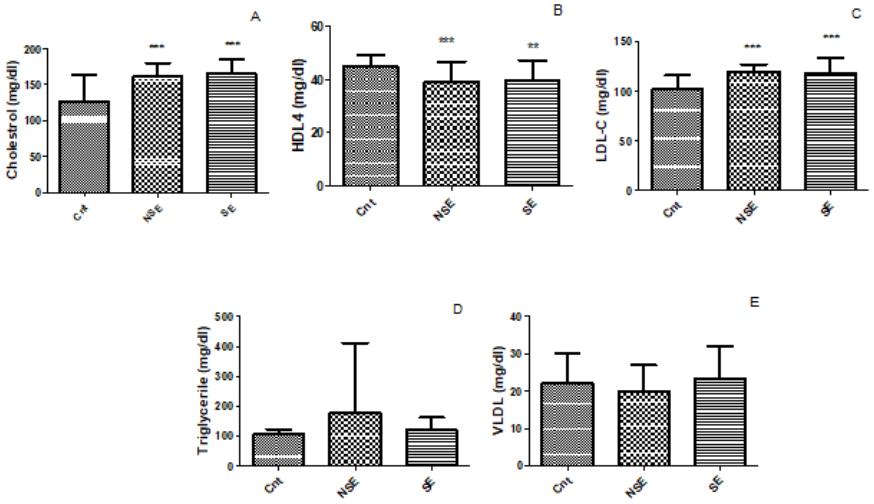

Figure 2. Comparison graph for levels of total plasma cholesterol (A), LDL-4 (B), HDL-C (C), triglycerides (D), and VLDL (E) in the Non-smoker (NSE) and smoker (SE) group compared with non-exposed controls (cnt); *: $p<0.05$.

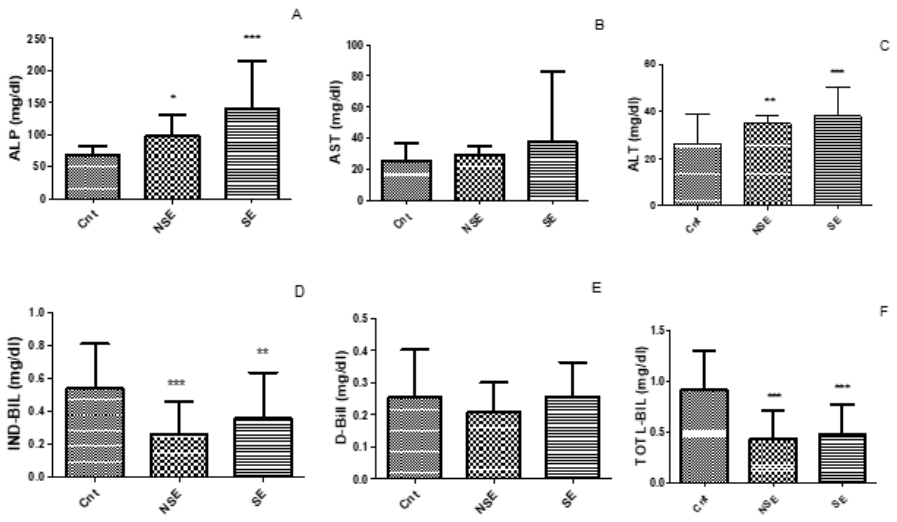

Figure 2. Comparison graph for levels of Liver enzyme: ALP (A), AST(B), ALT (C), IND-BIL(D), D-BIL (E), Total Bill (F) in the Non-smoker and smoker group compared with non-exposed controls; *: $p<0.05$

Table 2. The effect of gasoline inhalation on lipid profile parameters among smoker and nonsmoker gasoline exposure workers

Parameter	control	Non-Smoker Exposure	Smoker Exposure	P-value
Cholesterol (mg/l)	126.9 ± 6.01	161.9 ± 2.95 ***	165.7 ± 3.19 ***	< 0.0001
HDL4 (mg/l)	44.98 ±0.64	39.03 ±1.23 ***	39.38 ±1.26 **	< 0.0001
LDL-C (mg/l)	102.2 ±2.28	120.2 ±1.16 ***	118.7 ±2.41 ***	< 0.0001
Triglyceride (mg/l)	107.3 ±2.597	177.9 ±37.54	121.2 ±6.55	0.0603
VLDL (mg/l)	22.11 ±1.288	20.08 ±1.12	23.38±1.39	0.1829

Values are means±SEM (n=96), a P<0.05, significant change concerning the control group, ***changes between P<0.01 and P<0.001, SEM: Standard error of the mean, HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol, VLDL: Very-low-density lipoprotein cholesterol.

The blood ALP level for the exposed group of smokers was 140.7± 11.85 mg/l higher than the exposed group of non-smokers which was 98.14 ± 4.99 mg/l, both of them were significant when compared with the control. On the other hand, the AST concentration for the exposed group of smokers was 38.1 ± 1.95 mg/l which was insignificantly higher than the mean value for the non-smokers exposed group 34.93 ±0.49 mg/l, both of them were insignificant when compared with control. The mean levels of alanine transaminase (ALT) of all participants were evaluated. The result revealed a significant (P=0.05) increase in ALT in the smoker and non-smoker exposed groups (34.93±0.49 and 38.1±1.95 mg/l), respectively, when compared with the control (26.54 ± 1.98 mg/l). However, the D-BILL concentration for the exposed group of smokers was 0.2556 ± 0.017 mg/l which was insignificantly higher than the mean value for non-smokers in the exposed group (0.2082 ±0.02 mg/l). The result of the study revealed a significant decrease (P≤0.001) in the mean IND-BILL in the nonsmoker-exposed group. A significant decrease was noted between both control and non-smokers exposed groups for both total bilirubin and indirect bilirubin. Data from Table 3 indicated indirect bilirubin in the exposed group of smokers increased significantly in comparison to the control. On the other hand, the mean of total bilirubin decreased significantly in the non-smoker smoke-exposed group in comparison to the control (0.911± 0.062 control, 0.4369± 0.044 non-smokers, and 0.4805± 0.046 smokers). (Figure 2, Table 3).

Table 3. The effect of gasoline inhalation on liver function among smoker and nonsmoker gasoline exposure workers.

Parameter	Control	Non-Smoker Exposure	Smoker Exposure	P-value
ALP (mg/l)	66.92 ± 2.38	98.14±4.99 *	140.7± 11.85 ***	< 0.0001
AST (mg/l)	25.67 ± 1.81	29.45 ± 0.89	37.69 ± 7.24	0.1391
ALT (mg/l)	26.54 ± 1.98	34.93 ±0.49 **	38.1 ± 1.95 ***	< 0.0001
D-BILL (mg/l)	0.254 ± 0.02	0.208 ±0.015	0.256 ± 0.017	0.1444
IND-BILL (mg/l)	0.5385± 0.04	0.2628 ± 0.03 ***	0.3626 ± 0.04 **	< 0.0001
TOT-BILL (mg/l)	0.911± 0.062	0.4369± 0.044 ***	0.4805± 0.046 ***	< 0.0001

Values are means ± SEM, a P<0.05, significant change concerning the control group, *, ** and *** changes between P<0.01 and P<0.0001, SEM: Standard error of the mean, ALP: Alkaline phosphatase, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, D-BILL: direct bilirubin, IND-BILL indirect bilirubin, TOT-BILL: Total bilirubin.

Discussion

The risks of gasoline exposure are caused by chemicals in the gasoline mixture, such as xylenes toluene, ethylbenzene, benzene, and methyl tertiary butyl ether (MTBE). The CNS is the most common systemic impact of acute gasoline exposure, but respiratory tract irritation and hematological effects such as anemia and hypothermia can also occur at high concentrations. Chronic sniffing of gasoline has been linked to cardiac problems, as well as gasoline being a hepatotoxic substance.[17] Recently, it has been indicated by Rahimi et al (2020), that gasoline elevated proteinuria, liver enzymes, and fatty liver changes among exposed workers.[18] Through an oxidative process known as CYP450 2E1, gasoline hydrocarbons that are inhaled are digested in the liver, releasing free radicals and quinine metabolites such as hydroquinone, benzoquinone, phenol, and 1,2,4 benzenetriol. By these free radicals and hazardous metabolites, lipid peroxidation and damage to the hepatic plasma membrane are caused.[19] Assessment of cardiac parameters and liver enzymes may provide significant information regarding the effects of gasoline and smoke products on the heart cells and liver in Iraq because there are no legal guidelines or supervision for fuel components.[2]

Because of the predictive relationship between blood lipids and cardiovascular disorders, particularly coronary artery disease, measuring blood lipids in the clinical laboratory has become increasingly relevant. Total cholesterol, triglycerides, HDL cholesterol, and LDL cholesterol are frequently measured in lipid profiles during health screenings. The total cholesterol, LDL-C, increased statistically significantly as a result of this investigation. Smoking is linked to significantly higher total cholesterol and low-density lipoprotein levels in the blood (LDL). Triglycerides were found to be greater in the non-smoker exposure group. Smoking, on the other hand, lowers HDL cholesterol levels in the blood, which is a strong preventive factor against the development of atherosclerosis. These findings could be linked to exposure and inhalation of the hydrocarbon component of gasoline and cigarette smoke, both of which can produce oxidative stress due to reactive oxygen species (ROS). Tobacco smoke contains around 5000 hazardous chemical constituents, including polycyclic aromatic hydrocarbons (PAHs), free radicals, and oxidative gases.[20] As a result, in addition to inducing ROS intracellularly, the components of cigarette smoke suppress intracellular antioxidant systems, resulting in oxidative stress.[21] Pollutants in the environment, such as gasoline fumes, have been shown to increase oxidative stress in cells. When breathed, fumes from petroleum products can be degraded as xenobiotics through a sequence of reactions and biotransformations. During these reactions and biotransformations, ROS are created as undesirable by-products. Free radicals, which are produced by cigarette smoke, are thought to have harmful consequences, causing oxidative stress.[22]

Oxidative stress occurs when the cell's ROS and antioxidant systems are out of equilibrium. Under healthy settings, the cell produces ROS through oxygen metabolism, which is crucial for cellular signaling and is also harmless. Excessive formation of reactive oxygen species (ROS) causes lipid peroxidation, DNA strand breakage, and other impairments to the structure and functionality of cells when oxidative stress is present.[23] Extrinsic and intrinsic ROS can accumulate inside cells. Inhaled hazardous gases are the principal source of exogenous ROS (e.g., cigarette smoke, car exhaust fumes, and environmental pollutant). Peroxisomes, mitochondrial respiration, the NADPH oxidase system, and inflammatory cells, among other sources, create endogenous ROS.[24] The findings of this study, like those of many others, showed that cigarette smoke contributes to oxidative stress. In a case-control study involving 78 smoking and 82 nonsmoking men, Karademirci et al.(in press) found that the total antioxidant status (TAS), vitamin C, and vitamin E values were considerably higher in the nonsmoker group than in the smoker group. The smokers had increased total oxidant status and oxidative stress index values.[25] Other animal investigations have shown that cigarette smoke intake results in diminished and faulty antioxidant defense (decreased glutathione

peroxidase and superoxide dismutase activity, increased lipid peroxidation, and mitochondrial dysfunction) that causes a rise in H_2O_2 production.[26] As a result of this imbalance, oxidative stress caused by tobacco smoking causes greater heart damage.[27] The communication of NO with free radicals in smoke reduces NO's bioactivity, influencing its vasodilatory, antithrombotic, antioxidant, and anti-inflammatory effects, as well as its effects on endothelium permeability and myocardial function.[18,28]

In recent years, academics have been particularly interested in the physiological impacts of gasoline and smoking. In four primary studies, demographic data, smoking status, and other background information were gathered.[19] In five investigations, the frequency of cigarette smoking was recorded in both exposed and unexposed groups.[29] In terms of liver function measures, our findings revealed that non-smokers and smoke-exposed individuals had higher ALP, AST, and ALT levels than unexposed workers. Furthermore, the average levels of ALP and ALT were considerably higher in the smoker group, with no significant variations in AST levels between the exposed and unexposed groups. Smoking has been linked to an increase in liver enzymes and the development of chronic renal disease.[30] Furthermore, smoking has been linked to liver cancer and chronic renal disease, as well as an increase in liver enzymes.[31] Nicotine's poisonous components (CO, cyanide, potassium nitrate, cadmium, chloroform, vinyl chloride, and copper) are to be regarded.[32]

Some components of the smoke can inhibit the establishment of intracellular junctions, which can lead to tissue damage.[33] The rates of IND BILL and Total BILL were increased, according to the findings. Even though D-BILL was not statistically significant, it did indicate a little rise in the smoking exposure group, suggesting that environmental hazardous chemicals may hurt the liver. This data can be attributed to enzyme leakage, primarily as a result of enhanced cell membrane permeability. In addition, the liver is responsible for the metabolism of hazardous chemical compounds, which explains why the organ is susceptible to metabolic-induced hepatotoxicity.[34]

In addition, multiple investigations found that employees subjected to organic solvents had much higher liver enzymes than controls, supporting the current findings. Similar to our data, two of the investigations have reported an elevation in ALT and AST among the exposed than the unexposed group.[35] Furthermore, another study reported an increase in ALT and AST among the exposed group and similar concentrations in direct bilirubin and ALP in both exposed and unexposed persons.[36] While, on the other hand, Akinosun et al. record lower concentrations of ALT, AST, total protein, total albumin, and total bilirubin in both exposed and unexposed groups.[37] Workers in refueling stations had higher levels of ALT and AST enzymatic activity than those in the control group.[38] Contrary to popular belief, exposure to a variety of organic solvents does not affect the levels of liver enzymes such as ALT and AST.[39] Some investigations, however, have found that exposure to a mixture of organic solvents did not affect the levels of liver enzymes like ALT and AST.[40] Furthermore, the hallmark liver alterations (e.g., elevated ALP, ALS, and ALT) are depending on the method of administration (e.g., inhalation vs. cutaneous absorption), dose, and exposure period.[41] Another study conducted by Mohammed in Sulaimaniya City (Iraq) discovered changes in the hematological and biochemical profiles of gasoline station personnel, smokers, and non-smokers who were occupationally exposed to gasoline in connection to the observed lead levels.[42]

Conclusion

Based on the findings of this study, we can conclude that the harmful effects of gasoline, particularly when combined with smoking, are linked to negative health effects such as lipid profile parameters and liver, and that people who smoke are at a higher risk of having heart and hepatic diseases.

Acknowledgments

We'd like to express our gratitude to the participants in the study for their involvement. The

administration of the Zakho city gasoline offices and the Bedare specialized hospital were also acknowledged.

References

1. Ahmed F, Fakhruddin A. A Review on Environmental Contamination of Petroleum Hydrocarbons and its Biodegradation. Int J 068 Environ Sci Nat Res. 2018; 11(3):63-9. Available from: https://doi.org/10.19080/IJESNR.2018.11.555811
2. Bahadar H, Mostafalou S, Abdollahi M. Current understandings and perspectives on non-cancer health effects of benzene: a global concern. Toxicol Appl Pharmacol. 2014.15;276(2):83-94. Available from: https://doi.org/10.1016/j.taap.2014.02.012
3. Mohammed S. Hematological, Biochemical and Blood Lead Level Profile among Gasoline Exposed Station Workers in Sulaimaniya City. ARO-The Scientific Journal of Koya University. 2014. 2(1):6-11. Available from: http://dx.doi.org/10.14500/aro.10036
4. Asefaw T, Wolde M, Edao A, Tsegaye A, Teklu G, Tesfay F. Assessment of liver and renal function tests among gasoline exposed gas station workers in Mekelle city, Tigray region, Northern Ethiopia. PLoS ONE. 2020;15(10): e0239716. Available from: https://doi.org/10.1371/journal.pone.0239716
5. Rashan MA, Dawood T, Abdul Razzaq A, Hassali A. The Impact of Cigarette Smoking on Lipid Profile among Iraqi Smokers., International Journal of Collaborative Research on Internal Medicine & Public Health. 2016; 8(8), 491-500. Available from: https://www.iomcworld.org/articles/the-impact-of-cigarette-smoking-on-lipid-profile-among-iraqi-smokers.
6. Tabas I, Williams KJ, Boren J. Subendothelial lipoprotein retention as the initiating process in atherosclerosis update and therapeutic implications. Circulation. 2007; oct 16; 116(16): 1832-44. Available from: https://doi.org/10.1161/circulationaha.106.676890
7. Mouhamed DH, Ezzaher A, Neffati F, Gaha L, Douki W, Najjar MF. Association between cigarette smoking and dyslipidemia. Immuno-analyse & Biologie Spécialisée. 2013; 28: 195-200. Available from: https://doi.org/10.1016/J.IMMBIO.2013.03.004
8. Neki NS. Lipid profile in chronic smokers - a clinical study. Journal, Indian Academy of Clinical Medicine. 2002; 3: 51-4.
9. Prabha V, Waheeda S, Meriton Stanly A. Effect of Tobacco Smoking on Lipid Profile. Indian Journal of Applied Research 2015; 5: 562-4. Available from: https://www.worldwidejournals.com/indian-journal-of-applied-research-(IJAR)/article/effect-of-tobacco-smoking-on-lipid-profile/NjA5NA==/?is=1
10. Yan-Ling Z, Dong-Qing Z, Chang-Quan H, Bi-Rong D. Cigarette smoking and its association with serum lipid/lipoprotein among Chinese nonagenarians/centenarians. Lipids in health and disease. 2012 jul 24; 11: 94. PMID: 22828289 Available from https://lipidworld.biomedcentral.com/articles/10.1186/1476-511X-11-94
11. Devaranavadgi BB, Aski BS, Kashinath RT, Hundekari IA. Effect of cigarette smoking on blood lipids - A study in Belgaum, Northern Karnataka, India. Global Journal of Medical Research. 2012; 12(6):57-61. Available from https://globaljournals.org/GJMR_Volume12/9-Effect-of-Cigarette-Smoking-on-Blood-Lipids
12. Afshan A, Sugoor M, Swati IA, Patil RB. A hospital based study on lipid profile in smokers and non-smokers- A comparative study. Journal of Evolution of Medical and Dental Sciences. 2012; 1: 662-7. Available from: https://doi.org/10.14260/jemds/103.
13. Burns DM. Epidemiology of smoking-induced cardiovascular disease. Progress in cardiovascular diseases. 2003; 46: 11-29. Available from: https://doi.org/10.1016/s0033-0620(03)00079-3
14. Hassani MK. Role of Vitamin D as Protective Agent against Induced Liver Damage in Male Rats. Archives of Razi Institute. 2021; 76 (6) 1815-22. Available from: https://doi.org/10.22092/ari.2021.356611.1881
15. Neghab M, Hosseinzadeh K, Hassanzadeah J. Hematological study of petrol station workers exposed to unleaded petrol, Toxicological & Environmental Chemistry. 2014; 96:6, 951-61.

Available from: https://doi.org/10.1080/02772248.2014.979828

16. Soderland P, Lovekar S, Weiner DE. Brooks DR, Kaufman JS. Chronic kidney disease associated with environmental toxins and exposures. Adv Chronic Kidney Dis. 2010; 17(3):254–64. Available from: https://doi.org/10.1053/j.ackd.2010.03.011
17. Hall P, Cash J. What is the real function of the Liver 'function'tests? Ulster Med J. 2012. 81(1):30-6. PMID: 23536736
18. Rahimi Moghadam S, Afshari M, Ganjali A, Moosazadeh M. Effect of occupational exposure to petrol and gasoline components on liver and renal biochemical parameters among gas station attendants, a review and meta-analysis. Rev Environ Health. 2020;35(4):517-30. Available from: https://doi.org/10.1515/reveh-2019-0107
19. Rahul NG, Vyas S, Sankhla M, Punjabi P. Biochemical assessment of the hepatic functions of the petrol pump workers of Jaipur city.Natl. J Physiol Pharm Pharmacol 2017;7:1–6. Available from: https://doi.org/10.5455/njppp.2017.7.0516622052017
20. Kuranchie FA, AngnunavuriPA, AttiogbeFK, Nerquaye-TettehEN,YunGY. Occupational exposure of benzene, toluene, ethylbenzene and xylene (BTEX) to pump attendants in Ghana: Implications for policy guidance. Cogent Environmental Science. 2019; 5(1),1-18. Available from: https://doi.org/10.1080/23311843.2019.1603418
21. Borgerding M, Klus H. Analysis of complex mixtures Cigarette smoke. Experimental and Toxicologic Pathology. 2005;57(Suppl 1):43-73. Available from: https://doi.org/10.1016/j.etp.2005.05.010
22. Das A, Dey N, Ghosh A, Das S, Chattopadhyay DJ, Chatterjee IB. Molecular and cellular mechanisms of cigarette smoke-induced myocardial injury: Prevention by Vitamin C. PLoS One. 2012;7: e44151. Available from: https://doi.org/10.1371/journal.pone.004415
23. Carnevale R, Cammisotto V, Pagano F, Nocella C. Effects of Smoking on Oxidative Stress and Vascular Function. Smoking Prevention and Cessation. Springer New York, NY, 2018; 25-47. Available from: https://doi.org/10.5772/intechopen.78319
24. Holmström KM, Finkel T. Cellular mechanisms and physiological consequences of redox-dependent signaling. Nature Reviews. Molecular Cell Biology. 2014;15:411-21. Available from: https://doi.org/10.1038/nrm3801
25. Karademirci MM, Kutlu R, Kilinc I (in press). Relationship between smoking and total antioxidant status, total oxidant status, oxidative stress index, vitamin C, vitamin E. The Clinical Respiratory Journal. 2017 ; 12(6); 2006-12 . Available from: https://doi.org/10.1111/crj.12757
26. Talukder MAH, Johnson WM, Varadharaj S, Lian J, Kearns PN, El-Mahdy MA, et al. Chronic cigarette smoking causes hypertension, increased oxidative stress, impaired NO bioavailability, endothelial dysfunction, and cardiac remodeling in mice. American Journal of Physiology. Heart and Circulatory Physiology. 2011;300:H388-96. Available from: https://doi.org/10.1152/ajpheart.00868.2010
27. Santos PP, Oliveira F, Ferreira VCMP, Polegato BF, Roscani MG, Fernandes AA, et al. The role of lipotoxicity in smoke cardiomyopathy. PLoS One. 2014;9: e113739. Available from: https://doi.org/10.1371/journal.pone.0113739.
28. Barua RS, Ambrose JA, Eales-Reynolds LJ, DeVoe MC, Zervas JG, Saha DC. Dysfunctional endothelial nitric oxide biosynthesis in healthy smokers with impaired endothelium-dependent vasodilatation. Circulation. 2001; 104:1905-10. Available from: https://doi.org/10.1161/hc4101.097525
29. Shankar A, Klein R, Klein BE. The association among smoking, heavy drinking, and chronic kidney disease. Am J Epidemiol 2006; 164:263–71. Available from: https://doi.org/10.1093/aje/kwj173
30. Kim KY, Lee Y-J, Chung BC, Hong J, Jung BH. Relations between toxicity and altered tissue distribution and urinary excretion of nicotine, cotinine, and hydroxycotinine after chronic oral administration of nicotine in rats. Drug Chem Toxicol 2010;33:166–72. Available from: https://doi.org/10.3109/01480540903196832
31. Oshima A, Tsukuma H, Hiyama T, Fujimoto I, Yamano H, Tanaka M. Follow-up study of HBS Ag-

positive blood donors with special reference to effect of drinking and smoking on development of liver cancer. Int J Cancer. 1984; 34:775–9. Available from: https://doi.org/10.1002/ijc.2910340607

32. Ayanian JZ, Cleary PD. Perceived risks of heart disease and cancer among cigarette smokers. JAMA 1999; 281:1019–21. Available from: https://doi.org/10.1001/jama.281.11.1019
33. Knishkowy B, Amitai Y. Water-pipe (Narghile) smoking: an emerging health risk behavior. Pediatrics 2005;116: e113–9. Available from: https://doi.org/10.1542/peds.2004-2173
34. Bae JC, Seo SH, Hur KY, Kim JH, Lee MS, Lee MK. Association between Serum Albumin, Insulin Resistance, and Incident Diabetes in Nondiabetic Subjects. Endocrinology and metabolism. 2013; 28(1):26-32. Available from: https://doi.org/10.3803/EnM.2013.28.1.26
35. Nwanjo HU, Ojiako OA. Investigation of the potential health hazards of petrol station attendants in Owerri Nigeria. J Appl Sci Environ Manag. 2007; 11:197–200. Available from: https://doi.org/10.4314/jasem.v11i2.55040
36. Saadat M, Ansari-Lari M. Alterations of liver function test indices of filling station workers with respect of genetic polymorphisms of GSTM1 and GSTT1. Cancer Lett. 2005;227(2):163-7. Available from: https://doi.org/10.1016/j.canlet.2005.03.044
37. Akinosun OM, Arinola OG, Salimonu LS. Immunoglobulin classes and liver function tests in Nigerian petrol attendants. Indian J Occup Environ Med. 2006;10 (2):58-61. DOI: 10.4103/0019-5278.27300.Available from: http://www.bioline.org.br/pdf?oe06012
38. Eltom A, Taj Elsir Hamd H. Assessment of liver Enzymes level among Sudanese Gasoline Station Workers, Sch. J. App. Med. Sci.2017; 5(3A):738-43. Available from: https://saspublishers.com/article/6756/
39. Kim S, Vermeulen R, Waidyanatha S, Johnson BA, Lan Q, Smith MT, et al. Modeling human metabolism of benzene following occupational and environmental exposures. Cancer Epidemiol Biomarkers Prev. 2006; 15(11):2246-52. Available from: https://doi.org/10.1158/1055-9965.EPI-06-0262.
40. Qafisheh N, Mohamed OH, Elhassan A, Ibrahim A, Hamdan M. Effects of the occupational exposure on health status among petroleum station workers, Khartoum State, Sudan. Toxicol Rep. 2021; 8:171-6. Available from: https://doi.org/10.1016/j.toxrep.2020.12.025
41. Mohamme S. Hematological, Biochemical and Blood Lead Level Profile among Gasoline Exposed Station Workers in Sulaimaniya City. ARO-The Scientific Journal of Koya University. 2014. 2(1):6-11. Available from: https://doi.org/10.14500/aro.10036
42. Mohammed C, Al-Habib O. Mechanisms Underlying the Relaxation Induced by Bradykinin in Rat Aorta. International Journal of Medical Research & Health Sciences. 2018, 7(6): 105-13. Available from: https://www.ijmrhs.com/medical-research/mechanisms-underlying-the-relaxation-induced-by-bradykinin-in-rat-aorta.pdf

International Journal of Occupational Safety and Health

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

Original Article

Identification of Musculoskeletal Disorder among Eco-Brick Workers in Indonesia

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Date of submission: 21.04.2022
Date of acceptance: 02.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: UAD grant, PDD-301/SP3/LPPM-UAD/VI/2021
DOI: https://doi.org/10.3126/ijosh.v13i1.44575

ABSTRACT

Introduction: Plastic waste is considered one of the common vital waste problems in developing countries such as Indonesia. One proposed alternative way to reduce plastic waste is by reusing and recycling it into bricks. Eco-bricks are a form of recycled plastic waste that can be used as an alternative building construction material. Unfortunately, manufacturing workers do not ergonomically perform this work during their working hours. Therefore, it causes inappropriate body postures and leads to musculoskeletal disorders easily. This study intends to identify the posture of workers in the manufacture of eco-bricks in Indonesia

Methods: A cross-sectional study was done with purposively selected 32 eco-bricks workers from 10 waste bank communities in Central Java and Yogyakarta. Sampling was done by snowball method. This research was conducted by interviewing and collecting data on body complaints using a Nordic Body Map (NBM) questionnaire.

Results: All respondents (100%) experienced musculoskeletal disorder complaints while producing eco-bricks. Based on the results gained from the Nordic Body Map Questionnaire, the common complaints perceived by eco-bricks workers are upper neck, lower neck, back, waist, buttock, and bottom. In addition, workers also perceived complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand

Conclusion: Working postures that are not well-organized in terms of ergonomics during the production process of eco-bricks will provoke complaints on the limbs caused by the continuous load on the muscles on the right side of the body.

Keywords: Eco-brick, Nordic Body Map, MSDs, Plastic waste

Introduction

Waste management is identified as one of many severe environmental problems. Waste problems can surely disrupt the environment around the community, such as soil pollution. A polluted environment will also have an impact on public health. There are several causes for the increase in waste, specifically the increase in population, the level of community activity, the socio-economic level of the community, technological advances, and also the pattern of people's lives.[1] Technological boost also increases the amount of waste. It can be seen from the use of personal devices and frequently updating them to the latest ones.[2] The world population is rapidly increasing that it produces waste more and getting worrying. Various types of waste have been generated in various countries, and also numerous 3R programs (Reuse, Reduce, and Recycle) have been proposed to reduce waste that can affect the environment.[3]

Reduce, reuse, and recycle are now recognized as important waste management principles around

the world to avoid high tipping fees due to a scarcity of landfill sites. The significant increase in the amount of waste in developing countries has led to an increase in environmental impacts and health problems.[4] Waste reduction in the community can be controlled by the community setting into a useful product that has economic value.[1]

Plastic waste is identified as a prominent problem in developing countries such as Indonesia. In this instant era, plastic wrappers are easily found everywhere. Plastic packaging is widely used in everyday life because of its high-performance features and low production costs.[5] Besides, plastics are also made of chemical polymers that cannot be degraded naturally so that plastic will not decompose even if buried.[6] Combinations of synthetic polymers such as polyethylene, polyamide, polypropylene, polystyrene, polyethylene terephthalate, and polyvinyl chloride are often used as packaging materials.[7] Polymer waste such as post-consumption plastic is the main component of solid waste that creates a very large environmental burden because it is not easily degraded.[8] Plastic waste can pollute the environment caused by carbon bonds, both primary carbon and secondary carbon in plastic packaging.[9] Therefore, it is necessary to manage plastic waste into new and valuable products.

Most of the plastic waste in the community is only dumped in rivers and the sea. The study found around 10 million tons of plastic waste was dumped into the sea which ultimately had an impact on marine life.[10] High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE) and Polyethylene (PET) are the most widely used materials for plastic packaging and plastic bottles. The process of recycling plastic waste is one way to reduce the amount of waste in the community. One form of recycling is to make a useful product from plastic waste. The products produced from inorganic waste processing include wallets, bags, plastic flowers, and other forms of crafts.[11]

In addition to crafts, plastic waste can also be used for various mixtures in the manufacture of asphalt, road construction, paving blocks, bricks, and eco-bricks.[12-17] Recycling is one of the technologies that can be adopted in waste management after the process of preventing, minimizing,g and reusing waste [18,19.] There are 3 types of low-cost construction developed in the construction sector, namely social-based low-cost construction consisting of 3 materials like wood plastic composite, tetra pack chip panels, and PET eco brick.

One environment-friendly alternative is to use PET plastic bottles to be used as bricks.[20]Plastics have properties that are durable and corrosion resistant. Besides, they are also energy efficient, economical, have long life spans, and are also lightweight. In short, the eco-brick concept might be used as an alternative building construction material. Those contemplate the reasons why eco-bricks might be utilized as a choice for building construction materials.[6,21-23] Furthermore, the reuse of PET plastic bottles as building materials will have a good effect on energy savings and also will reduce CO2 emissions.[20] The performance of eco-brick as a construction alternative depends on the material used and the power to fill the bottle. Construction materials using eco-bricks have been used by Rohingya refugees in Bangladesh to be adopted as houses. [22-24]

Waste management in Indonesia is mostly carried out by waste banks. The waste bank becomes of the activities to reduce waste by implementing community-based of 3Rs. The basic principle of waste banks in all provinces in Indonesia is collecting, storing, producing, changing behavior, and enjoying a clean environment. In the other concept of a waste bank, plastic waste can be reused for an economic transaction. In the waste banks, all PET bottles make some eco-bricks to reduce plastic waste to be disposed of in a landfill.

The eco-bricks have some advantages. Besides their strength and durability, eco-bricks are also long-lasting because of the original nature of the plastic which is water-resistant and does not decompose easily. However, it takes a long time to produce eco-bricks. Based on the observations addressed, it can be seen that the average time required to compact plastic pieces into 1 full bottle is approximately 27 minutes. Factors that affect its time-consuming compacting process are the location of the empty bottle holder and placing the filled bottle beyond the working range. The basin used for the small plastic piece container is only able to accommodate as many as 300 grams of plastic pieces so you have to repeatedly fill the material into the container and scatter tools.

In addition, during the plastic compacting process, most workers complained of pain, including back and neck pain due to a half-bent working position for a long and constant time. They also complained of leg cramps due to sitting on the floor with legs folded or cross-legged for a continued period.

Besides, the area around the palms of workers also experiences calluses (callus). This makes workers uncomfortable in carrying out activities. Poor work posture will cause disorders of the skeleton or disorders of musculoskeletal disorders. Musculoskeletal disorders (MSDs) are injuries to the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs. Continuous work and improper posture will also increase the possibility of MSD risk factors for workers.[25]

Several former studies have assessed MSDs in various construction fields as well as in material handling. Galuh Sista, et al analyzed work posture and MSD complaints in batik workers. while Widyanti, et al also conducted an ergonomic analysis on mothering and child activities. In addition, Ijaz, et al conducted a quantitative and qualitative assessment of MSD disorders in the brick industry in Pakistan.[25,26,27] The method used in this study is the standard Nordic Body Map Questionnaire and RULA. The use of the Nordic Body Map Questionnaire method was also conducted by Okka, et al. [28] This study was carried out by analyzing the body posture of workers in SMEs. In addition, Ismayenti, et al also applied the Nordic Body Map to analyze fatigue and MSD complaints on garment sewing operators.[29]

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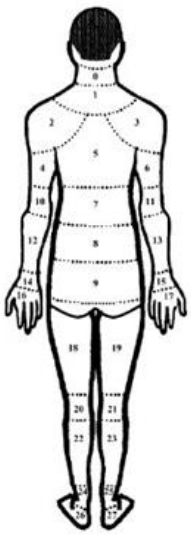
However, there has been no former study evaluating the body posture in eco-bricks manufacturers. Therefore, this study aims to analyze the body posture of workers in the manufacture of eco-bricks as many complaints felt by operators of eco-bricks.

Methods

This research was conducted in Yogyakarta and Central Java. There were 32 respondents from 10 waste bank communities in Central Java and Yogyakarta incorporated in this study. This study purposively selects 32 respondents by using the Slovin method with an acceptable error of 10 percent. Sampling in this study by snowball sampling. The type of research used in this study is observational with a cross-sectional study approach. This research was conducted by interviewing and collecting data on body complaints using a Nordic Body Map (NBM) questionnaire. The NBM questionnaire is used for the identification of musculoskeletal disorders, the detailed questionnaire used can be observed in Figure 1.



No	Location	Grade of complaints			
0	Pain/stiff in the upper neck	A	B	C	D
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Figure 1: Nordic Body Map Questionnaire (Source: https://pei.or.id/)

The respondents filled in personal data before doing the questionnaire such as name, age, height, weight, years of service, and average working hours per day. In addition, the researchers explained the implementation of the research. Then the respondents were asked to fill out an agreement to take part in the study. Furthermore, respondents were asked to fill out a Nordic Body Map (NBM) questionnaire containing 28 extremities that experienced musculoskeletal complaints by placing a checkmark on one of the MSD complaints options, namely no pain, mild pain, pain, and very painful. Measurement of Body Mass Index (BMI) is done by calculating height and weight. According to WHO

BMI was categorized into severely underweight (BMI < 18.5), normal (BMI 18.5-24.9), overweight (BMI 25-29.9), and obese (BMI 30).[32,33] To calculate Body Mass Index (BMI), respondents were required to measure their height and weight. BMI is computed as body weight in kilograms divided by the square of height in meters (kg/m2) and is categorized into four groups according to WHO. The division of BMI according to WHO is determined as underweight (BMI < 18.5), normal (BMI 18.5-24.9), overweight (BMI 25-29.9), and obese (BMI 30).

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Results

The respondents of this research are 32 eco-brick craftsmen in Central Java and Yogyakarta. The respondent's character data were analyzed based on age, weight, height, working years, operational time, and also BMI.

Subject character data was summarized in mean and standard deviation. The measurement of age is based on the date of birth written on their national ID card, gender is a phenotypic feature that can be seen. Detailed data on the characteristics of the respondent might be observed in Table 1. While the age and gender data are displayed in Table 2.

Table 1: The characteristics data of the respondents

Description	Average (n=32)	StdDev (n=32)
Age	44.4	7.8
Height (cm)	162.0	4.0
Weight (kg)	67.4	12.8
experience (year)	3.4	1.0
Working hours/day	3.1	0.7
BMI	25.7	5.1

Table 2: The age and genders of the respondents

Variable	Characterization	Frequency	Percentage (%)
Age	20-30	1	3%
	31-40	9	28%
	41-50	16	50%
	51-60	6	19%
Gender	Male	6	19%
	Female	26	81%

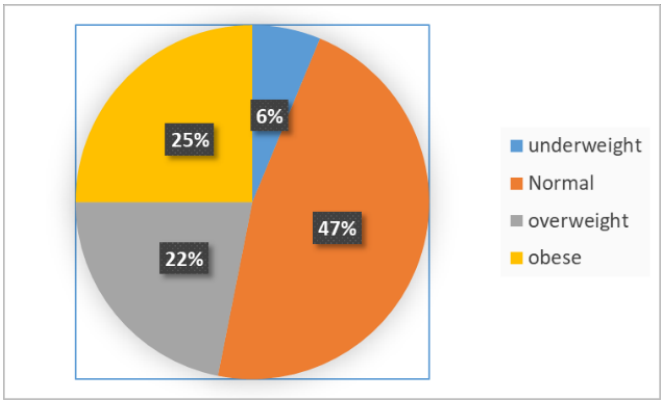

Figure 2: Distribution of Body Mass Index of respondents according to WHO

The results of the BMI distribution show that 6% of respondents are underweight, 47% of respondents are in the normal category, the overweight category of respondents has a value of 22%, and 25% of

respondents are in the obese category Figure . The BMI of each population has a different value, this depends on environmental factors, such as the amount of physical activity and diet. A high percentage of BMI reflects a higher risk of disease.[34] The Body Mass Index of eco-bricks makers ranges from 17.15 to 36.51.

Furthermore, the results of the grouping of all respondents might be observed in Table 3. Table 3 presents the complaints experienced by respondents. Most of those who belong to the category of underweight, normal, overweight, and obese had complaints in 3 parts of the body. They are the neck, shoulders, and back. Meanwhile, most workers who belong to the normal category have complaints about the right shoulder.

Table 3: Classification of complaints experienced by the respondent

BMI	Neck		Shoulder		Back
	Upper	Lower	Left	Right	
Underweight (n = 2)	2	2	0	2	2
Normal (n = 15)	4	15	0	15	15
Overweight (n = 7)	7	7	0	7	7
Obese (n = 8)	8	8	0	8	8

Based on the results of the Nordic Body Map questionnaire filled up by the respondents, it was also found that there are several complaints about the members of the workers' bodies can be seen in Table 4. The detailed prescribed complaints might be seen and analyzed in Figure 3.

Table 4: Distribution of complaints by respondents

No	Part of body	Complaints									
		Not Pain		Moderate pain		Pain		Very Painful		Total	
		N	%	N	%	N	%	N	%	N	%
1.	Upper neck	0	0	6	19	26	81	0	0	32	100
2.	Lower neck	0	0	1	3	31	97	0	0	32	100
3.	Right Shoulder	0	0	2	6	30	94	0	0	32	100
4.	Back	0	0	1	3	31	97	0	0	32	100
5.	Right Lower arm	1	3	3	9	28	88	0	0	32	100
6.	Waist	0	0	1	3	31	97	0	0	32	100
7.	Buttock	0	0	2	6	31	97	0	0	32	100
8.	Bottom	0	0	2	6	30	94	0	0	32	100
9.	Right Elbow	1	3	28	88	3	9	0	0	32	100
10.	Right Upper arm	2	6	1	3	29	91	0	0	32	100
11.	Right wrist	1	3	3	9	28	88	0	0	32	100
12.	Right hand	0	0	1	3	31	97	0	0	32	100

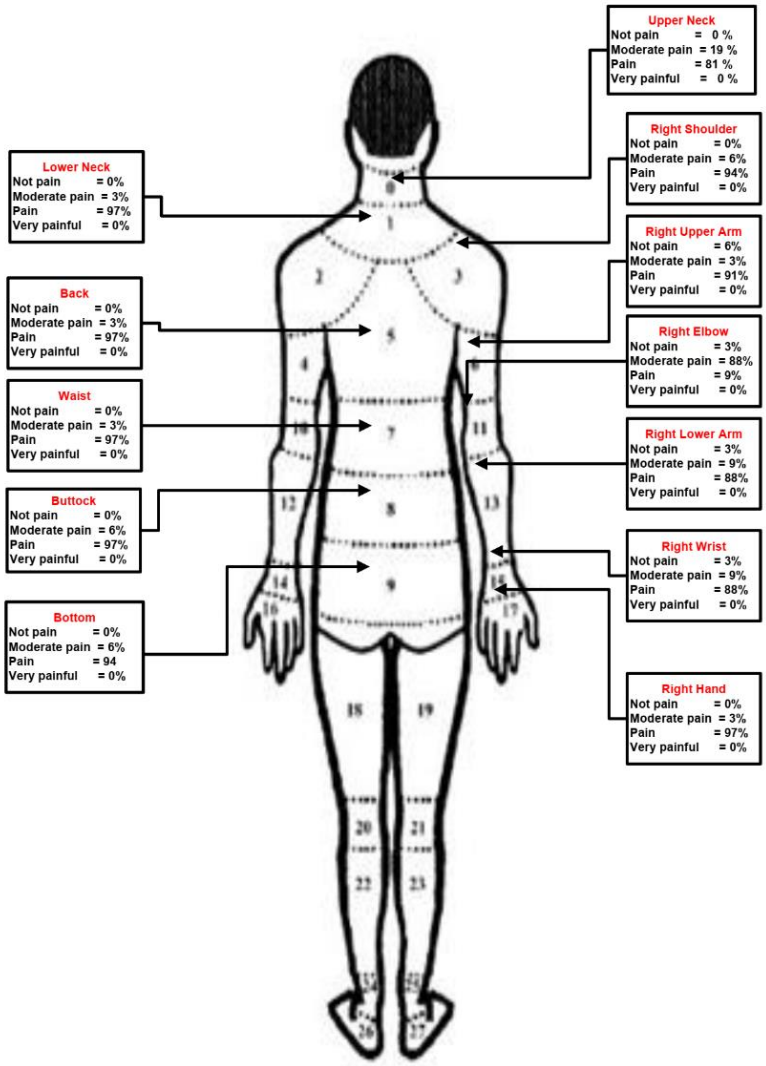

Figure 3: Nordic Body Map questionnaire results

Statistical analysis was assessed using the chi-square test. The statistical analysis was done using SPSS produced p value >0.05, which means that there is no relationship between gender with body parts grievance. It is also possible that it is the result of a habit of working with a workload that exceeds the limit of muscle strength. Also, their work posture is unusual, and their body part moves away from their natural position on a continuous and long-term basis because the space for movement is limited and the equipment used is still traditional.

The p-value > 0.05 means that there is no relationship between gender with body parts grievance. It is also possible that it is the result of a habit of working with a workload that exceeds the limit of muscle strength. Also, their work posture is unusual, and their body parts move away from their natural position on a continuous and long-term basis because the space for movement is limited and the equipment used is still traditional.

The p-value is more than 0.05 which indicates that the BMI is not as significant with body parts grievance. But in the back, waist, and right-hand p-value is less than 0.05 which means BMI was significant with pain in the back, waist, and right hand. Eco-brick workers have several complaints Around the palms. Workers also experience calluses that cause discomfort in carrying out activities Figure 4. The body position of the ecobrick maker can be seen in Figure 5.

Table 5: The association between Gender and pain in body parts

Variables	Gender	Body grievances				p-values
		Yes		No		
		N	%		%	
Upper neck	Male	5	16	1	3	0.885
	Female	25	78	1	3	
Lower neck	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Right Shoulder	Male	6	19	0	0	0.483
	Female	24	75	2	6	
Back	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Right Lower arm	Male	6	19	0	0	0.304
	Female	22	69	4	13	
Waist	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Buttock	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Bottom	Male	6	19	0	0	0.483
	Female	24	75	2	6	
Right Elbow	Male	1	3	5	16	0.497
	Female	2	6	24	75	
Right Upper arm	Male	6	19	0	0	0.382
	Female	23	72	3	9	
Right wrist	Male	5	16	1	3	0.732
	Female	23	72	3	9,4	
Right hand	Male	6	19	0	0,0	0.625
	Female	25	78	1	3,1	

Table 6: The association between the BMI and pain in body parts

Variables	Body grievances		BMI				p-values
			underweight	Normal	Overweight	Obese	
Upper neck	Yes	N	2	11	5	8	0.338
		%	6	34	16	25	
	No	N	0	4	2	0	
		%	0	13	6	0	
Lower neck	Yes	N	2	14	7	8	0.760
		%	6	44	22	25	
	No	N	0	1	0	0	
		%	0	3	0	0	
Right Shoulder	Yes	N	1	14	7	8	0.057
		%	3	44	22	25	
	No	N	1	1	0	0	
		%	3	3	0	0	
Back	Yes	N	1	15	7	8	0.001

		%	3	47	22	25	
	No	N	1	0	0	0	
		%	3	0	0	0	
Right Lower arm	Yes	N	1	12	7	8	0.139
		%	3	38	22	25	
	No	N	1	3	0	0	
		%	3	9	0	0	
Waist	Yes	N	1	15	7	8	0.001
		%	3	47	22	25	
	No	N	1	0	0	0	
		%	0	0	0	0	
Buttock	Yes	N	2	15	7	7	0.377
		%	6	47	22	22	
	No	N	0	0	0	1	
		%	0	0	0	3	
Bottom	Yes	N	2	14	7	7	0.768
		%	6	44	22	22	
	No	N	0	1	0	1	
		%	0	3	0	3	
Right Elbow	Yes	N	0	1	0	2	0.339
		%	0	3	0	6	
	No	N	2	14	7	6	
		%	6	44	22	19	
Right Upper arm	Yes	N	1	14	7	7	0.185
		%	3	44	22	22	
	No	N	1	1	0	1	
		%	3	3	0	3	
Right wrist	Yes	N	1	14	7	6	0.159
		%	3	44	22	19	
	No	N	1	1	0	2	
		%	3	3	0	6	
Right hand	Yes	N	1	15	7	8	0.001
		%	3	47	22	25	
	No	N	1	0	0	0	
		%	3	0	0	0	

Figure 2: Callus in the hand worker

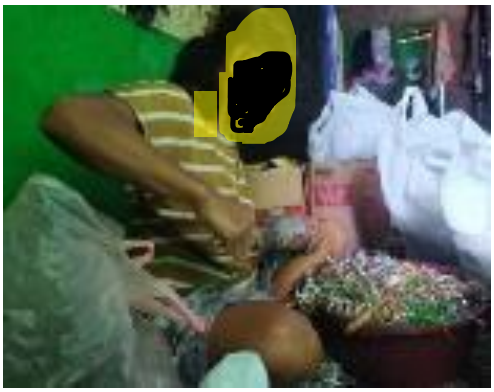

Figure 3: Body Position of eco-brick worker

Discussion

The findings from the Nordic body map survey revealed that there is no relationship between gender and body parts grievances. But the relationship between BMI and body parts grievances was statistically significant with pain in the back, waist, and right hand. Being overweight and obese are some of the common health problems that greatly affect medical conditions. Elevated BMI conditions have been identified as an independent risk factor that can lead to musculoskeletal disorders (MSDs).[35] Research from Viester, et al illustrates that BMI conditions affect several body parts, including the neck, shoulders, and back.[36] In this study, the complaints of respondents who answered moderate pain, pain, and very painful were grouped as complaints of having overall musculoskeletal symptoms, while those who answered not pain were classified as having no musculoskeletal symptoms. It is well known that people with a higher body mass index (BMI) have more musculoskeletal pain than people with a lower BMI. BMI is an independent risk factor for the development of MSDs, as well as an increase in MSD prevalence over 12 months.[37]

When the body moves, it uses ATP (adenosine triphosphate) and calcium energy to contract muscles. When muscles use ATP for contraction, it is directed by anaerobic metabolism, or fuel metabolism without oxygen, which causes fuel damage and the formation of lactic acid. Muscle pain is caused by an accumulation of lactic acid. Muscle complaints occur when the muscles continue to contract without the possibility of relaxation.[38]

Several studies on MSDs complaints experienced by workers showed its impact on the back and shoulder muscles. This complaint is often experienced by workers who carry out constant movements without taking a rest for several hours. In this study, out of 32 respondents from waste bank workers, it was found that 100% of the respondents experienced MSDs complaints. This questionnaire was filled out by asking for complaints for 1 year doing the same job.

Musculoskeletal disorders (MSDs) are a major health problem in the working community, with low back pain (LBP) being one of the most common MSDs. MSDs have a high impact on individual workers, due to problems such as pain and limitations in daily activities. This MSDs' complaint is the result of repetitive movements that are carried out continuously.[30]

Based on Figure 3, the most common complaints felt by eco-brick workers are on the upper neck, lower neck, back, waist, buttock, and bottom. In addition, workers also feel complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand. The complaint on the right is due to the rest on the right side of the body while working on the waste banks.[39,40] Besides, the back is one of the body parts that are vulnerable because of the mechanism of the human body, the tissues, structures of the vulnerable spine, and bring in the weight-bearing muscle aspect. Work postures that are not ergonomic will drive workers to do a coercive attitude during their work. The working position of eco-brick workers is less ergonomic and there is a continuous load on the muscles on the right side of the body. This will result in trauma and a form of injury that is manifested by pain or tingling, swelling, and muscle weakness.[37,41] There is a possibility that waste bank workers experience MSDs due to the habit of doing work with a workload that exceeds the limit of muscle strength. This study can be used as a surveillance program for risk implications for eco-brick workers. However, the prevention of MSDs can be performed by attending ergonomic training programs and doing starching breaks in the muscles so that workers get more comfort in their workplace.

Conclusions

The results of the analysis showed that all eco-brick workers experienced MSDs complaints. Besides, based on the results of the Nordic Body Map Questionnaire, the common complaints felt by eco-brick workers are on the upper neck, lower neck, back, waist, buttock, and bottom. In addition,

workers also feel complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand. in addition, the BMI analysis showed the complaints experienced by 32 respondents can be categorized into 4 BMI categories, namely underweight, normal, overweight, and obese. Eco-brick workers who are included in the normal category have complaints in the form of a right shoulder. In short, workers categorized as underweight, normal, overweight, and obese have neck, shoulder, and back complaints. Further detailed research is warranted for this area of study using detailed ergonomic assessments.

Acknowledgments

This research is fully supported by UAD grant, PDD-301/SP3/LPPM-UAD/VI/2021. The authors fully acknowledged Universitas Ahmad Dahlan and Universiti Teknikal Malaysia Melaka for the approved fund which makes this important research viable and effective.

References

1. Boysan F, Özer Ç, Has M, Murat M. Project on Solid Waste Recycling Plant in Sakarya University Campus. Procedia Earth Planet Sci. 2015;15:590–5. Available from: https://doi.org/10.1016/j.proeps.2015.08.108
2. Malinauskaite J, Jouhara H, Czajczyńska D, Stanchev P, Katsou E, Rostkowski P, et al. Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe. Energy. 2017;141:2013–44. Available from: https://doi.org/10.1016/j.scitotenv.2020.139038
3. Rehman MU, Ahmad M, Rashid K. Influence of fluxing oxides from waste on the production and physico-mechanical properties of fired clay brick: A review. J Build Eng. 2020;27(July 2019):100965. Available from: https://doi.org/10.1016/j.jobe.2019.100965
4. Sharma B, Goswami Y, Sharma S, Shekhar S. Inherent roadmap of conversion of plastic waste into energy and its life cycle assessment: A frontrunner compendium. Renew Sustain Energy Rev. 2021;146(April):111070. Available from: https://doi.org/10.1016/j.rser.2021.111070
5. Liliani, Tjahjono B, Cao D. Advancing bioplastic packaging products through co-innovation: A conceptual framework for supplier-customer collaboration. J Clean Prod. 2020;252:119861. Available from: https://doi.org/10.1016/j.jclepro.2019.119861
6. Adiyanto O, Mohamad E, Abd Razak J. Systematic Review of Plastic Waste as Eco-Friendly Aggregate for Sustainable Construction. International Journal of Sustainable Construction Engineering and Technology. 2022 May 9;13(2):243-57. Available from: https://doi.org/10.30880/ijscet.2022.13.02.022
7. Dixit S, Yadav VL. Optimization of polyethylene/polypropylene/alkali modified wheat straw composites for packaging application using RSM. J Clean Prod. 2019;240:118228. Available from: https://doi.org/10.1016/j.jclepro.2019.118228
8. Li X, Ling TC, Hung Mo K. Functions and impacts of plastic/rubber wastes as eco-friendly aggregate in concrete – A review. Constr Build Mater. 2020;240:117869. Available from: https://doi.org/10.1016/j.conbuildmat.2019.117869
9. Dabaieh M, Heinonen J, El-Mahdy D, Hassan DM. A comparative study of life cycle carbon emissions and embodied energy between sun-dried bricks and fired clay bricks. J Clean Prod. 2020;275:122998. Available from: https://doi.org/10.21660/2021.84.j2195
10. Fapohunda TM. Towards Effective Team Building in the Workplace. Int J Educ Res. 2013;1(4):1–12. Available from: https://www.researchgate.net/publication/258344173_Towards_Effective_Team_Building_in_the_Workplace
11. Wulandari D, Hadi Utomo S, Narmaditya BS. Waste bank: waste management model in improving local economy. Int J Energy Econ Policy. 2017;7(3):36–41. Available from: https://www.econjournals.com/index.php/ijeep/article/view/4496
12. Movilla-Quesada D, Raposeiras AC, Silva-Klein LT, Lastra-González P, Castro-Fresno D. Use of plastic scrap in asphalt mixtures added by dry method as a partial substitute for bitumen. Waste Manag. 2019;87:751–60. Available from: https://doi.org/10.1016/j.wasman.2019.03.018
13. Köfteci S. Effect of HDPE Based Wastes on the Performance of Modified Asphalt Mixtures. Procedia Eng. 2016;161:1268–74. Available from: https://www.nepjol.info/index.php/IJOSH

https://doi.org/10.1016/j.proeng.2016.08.567.

14. Agyeman S, Obeng-Ahenkora NK, Assiamah S, Twumasi G. Exploiting recycled plastic waste as an alternative binder for paving blocks production. Case Stud Constr Mater. 2019;11:e00246. Available from: https://doi.org/10.1016/j.cscm.2019.e00246
15. Arulrajah A, Perera S, Wong YC, Horpibulsuk S, Maghool F. Stiffness and flexural strength evaluation of cement stabilized PET blends with demolition wastes. Constr Build Mater. 2020;239:117819. Available from: https://doi.org/10.1016/j.conbuildmat.2019.117819
16. Limami H, Manssouri I, Cherkaoui K, Khaldoun A. Study of the suitability of unfired clay bricks with polymeric HDPE & PET wastes additives as a construction material. J Build Eng. 2020;27(June 2019):100956. Available from: https://doi.org/10.1016/j.jobe.2019.100956
17. Akinwumi II, Domo-Spiff AH, Salami A. Marine plastic pollution and affordable housing challenge: Shredded waste plastic stabilized soil for producing compressed earth bricks. Case Stud Constr Mater. 2019;11:e00241. Available from: https://doi.org/10.1016/j.cscm.2019.e00241
18. Bundhoo ZMA. Solid waste management in least developed countries: current status and challenges faced. J Mater Cycles Waste Manag. 2018;20(3):1867–77. Available from: https://doi.org/10.1007/s10163-018-0728-3
19. Paihte PL, Lalngaihawma AC, Saini G. Recycled Aggregate filled waste plastic bottles as a replacement of bricks. Mater Today Proc. 2019;15:663–8. Available from: https://doi.org/10.1016/j.matpr.2019.04.135
20. Jayaprakash M., Deeksha I, Soumya M. PET Bottles for Eco-friendly Building in Sustainable Development. Int J Curr Trends Eng Res. 2016;2(5): 318-26 Available from: https://www.researchgate.net/publication/328019707_PET_Bottles_for_Eco-friendly_Building_in_Sustainable_Development
21. Safinia S, Alkalbani A. Use of Recycled Plastic Water Bottles in Concrete Blocks. Procedia Eng. 2016;164(June):214–21. Available from: https://doi.org/10.1016/j.proeng.2016.11.612
22. Antico FC, Wiener MJ, Araya-Letelier G, Retamal RG. Eco-bricks: A sustainable substitute for construction materials. Rev la Constr. 2017;16(3):518–26. Available from: https://doi.org/10.7764/RDLC.16.3.518
23. Singhal A, Netula O. Utilization of Plastic Waste in Foundry Sand Bricks. Int J Res Appl Sci Eng Technol. 2017;5(4):977–82. Available from: https://doi.org/10.22214/ijraset.2017.4178
24. Haque MS. Sustainable use of plastic brick from waste PET plastic bottle as building block in Rohingya refugee camp: a review. Environ Sci Pollut Res. 2019;26: 36163–83. Available from: https://doi.org/10.1007/s11356-019-06843-y
25. Ramesh N, Kannan R. Work-related musculoskeletal disorders among pesticide sprayers of tea plantations in South India. International Journal of Occupational Safety and Health. 12 (1), 23–28. Available from: https://doi.org/10.3126/ijosh.v12i1.41034
26. Halkai KR, Halkai RS, Sulgante S, Sanadi RM, Ara SA, Zainab H, et al. Work-related musculoskeletal disorders among dentists and their prevention through ergonomic interventions - A systematic review. International Journal of Occupational Safety and Health, 12(2), 125–39. Available from: https://doi.org/10.3126/ijosh.v12i2.39195
27. Sunny S, Fathima FN, Joy J, Passah BL, Thomas JC, Agrawal T. Occupational risk assessment and selected morbidities among cement brick unit workers in a rural area of Bangalore District, India. International Journal of Occupational Safety and Health, 12(1), 17–22. Available from: https://doi.org/10.3126/ijosh.v12i1.41033
28. Prabarukmi GS, Widajati N. Relationship between working tenure and working posture with musculoskeletal grievance in batik Madura workers. Indian J Forensic Med Toxicol. 2021;15(1):79–86. Available from: https://doi.org/10.37506/ijfmt.v15i1.13379
29. Widyanti A, Ramadhiar A, Fista B, Rahmawati N. The ergonomics of mothering and child care activities (ErgoMOMics) in Indonesia: Indivi and social factors influencing musculoskeletal symptoms. Work. 2020;65(3):625–33. Available from: https://doi.org/10.3233/WOR-203117
30. Adiyanto O, Effendi M, Jaafar R, Razak JA, Faishal M, Mulaicin M. Integrated self-report and observational risk assessment for work-related musculoskeletal disorder in small and medium enterprises. Eng Appl

Sci Res. 2022;49(1):73–80. Available from: https://doi.org/10.14456/easr.2022.8

31. Ismayenti L, Suwandono A, Denny HM, Widjanarko B. Reduction of Fatigue and Musculoskeletal Complaints in Garment Sewing Operator through a Combination of Stretching Brain Gym ® and Touch for Health. Int J Environ Res Public Health. 2021 Aug 25;18(17):8931. Available from: https://doi.org/10.3390/ijerph18178931
32. Lim JU, Lee JH, Kim JS, Hwang Y Il, Kim T, Yong S, et al. Comparison of World Health Organization and Asia-pacific body mass index classification in COPD patients. Int J COPD. 2017;12:2465–75. Available from: https://doi.org/10.2147/copd.s141295
33. Nuttall FQ. Body mass index: Obesity, BMI, and health: A critical review. Nutr Today. 2015;50(3):117–28. Available from: https://doi.org/10.1097/NT.0000000000000092
34. Corbel MJ, Tolari F, Yadava VK. Appropriate body-mass index for Asian populations and its implications. The Lancet. 2004 Jan 10;363(9403):157-63. Available from: https://doi.org/10.1016/S0140-6736(03)15268-3
35. Onyemaechi NOC, Anyanwu GE, Obikili EN, Onwuasoigwe O, Nwankwo OE. Impact of overweight and obesity on the musculoskeletal system using lumbosacral angles. Patient Prefer Adherence. 2016;10:291–6. Available from: https://doi.org/10.2147/PPA.S90967
36. Viester L, Verhagen EA, Hengel KMO, Koppes LL, Van Der Beek AJ, Bongers PM. The relation between body mass index and musculoskeletal symptoms in the working population. BMC Musculoskelet Disord [Internet]. 2013;14:238. Available from: https://doi.org/10.1186/1471-2474-14-238
37. Collins JD, O'Sullivan LW. Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions. Int J Ind Ergon. 2015;46(January 2015):85–97. Available from: https://doi.org/10.1016/J.ERGON.2014.12.013
38. Thamrin Y, Pasinringi S, Darwis AM, Putra IS. Relation of body mass index and work posture to musculoskeletal disorders among fishermen. Gac Sanit. 2021;35:S79–S82. Available from: https://doi.org/10.1016/j.gaceta.2020.12.022
39. Budiyanto T, Astuti RD, Purwani A. Pelatihan Dan Pendampingan Pengolahan Sampah Menjadi Produk Bernilai Ekonomi Pada Bank Sampah Bersih Bersama Karanganom, Sitimulyo, Piyungan, Bantul. SPEKTA (Jurnal Pengabdian Kepada Masyarakat: Teknologi Dan Aplikasi). 2020 Nov 10;1(2):49-54. Available from: https://doi.org/10.12928/spekta.v1i2.3044
40. Sokhibi A, Primadasa R. Analisis Resiko Musculosceletal Disorder Pada Tata Letak Lcd Proyektor Ruang Kuliah Fakultas Ekonomi & Bisnis Universitas Muria Kudus. Spektrum Industri. 2019 Oct 1;17(2):99. Available from: https://doi.org/10.12928/si.v17i2.13705
41. Mallapiang F, Azriful, Nildawati, Syarfaini, Muis M, Adriansyah. The relationship of posture working with musculoskeletal disorders (MSDs) in the weaver West Sulawesi Indonesia. Gac Sanit. 2021;35:S15–8. Available from: https://doi.org/10.1016/j.gaceta.2020.12.005

International Journal of Occupational Safety and Health

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

Original Article

Evaluation of Root Cause Analysis from Occupational Health and Safety Data in a Hospital: A Retrospective Study

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Date of submission: 21.04.2022
Date of acceptance: 02.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v13i1.42418

ABSTRACT

Introduction: Occupational accidents are increasing every year around the world. The fact that accidents will be repeated as a result of not learning the lessons is constantly forgotten. Occupational accidents should be examined based on the "Root Cause" approach. Within the scope of the information obtained as a result of the analysis studies on the causes of occupational accidents, the institutions need to make a plan to prevent the reoccurrence of the accidents. This study was carried out retrospectively to examine the root cause analysis process of occupational accidents that occurred in a state hospital and to examine how it was applied in the health facility.

Methods: The population of the research consists of occupational accident records that occurred in a state hospital between January 2018 and April 2021. (N=156). In the analysis of the data; Root cause analysis forms and number-percentage distributions were used to identify all factors that could cause a particular problem.

Results: Of those who had occupational accidents, 67.94% were women, 45% were nurses, 25 were cleaning staff and 3% were physicians. Fifty percent of the accidents occurred in inpatient services, 15% in emergency services, and 15% in intensive care units. Causes of accidents; needle-stick injuries (71.8%) are the most common occupational accidents. These injuries are followed by slipping and falling (14.7%).

Conclusion: By establishing a safety culture that monitors occupational accidents at the institutional level, evaluates their consequences, and develops precautions, the probability of occupational accidents will decrease. And the costs and compensations that will occur after the accident will decrease, and labor and service/production losses will be prevented.

Keywords: Accident, Health employee, Root-cause analysis, Safety

Introduction

Occupational health and safety is the systematic and scientific work carried out to determine the conditions that affect health and safety caused by various reasons during the performance of the work and to protect employees from the harmful effects of these conditions.[1] Negative states such as occupational accidents and occupational diseases are the situations that arise as a result of the ineffective implementation of occupational health and safety.

Post-accident investigations are as important as preventing work-related accidents. It is important to investigate occupational accidents, identify and eliminate hazards, reveal the deficiencies in the materials and equipment used, reduce the treatment and compensation costs that will occur after the accident, prevent labor losses, to prevent the events that may cause accidents in the future and to improve the morale of the employees.

Various methods such as five cause analysis, root cause analysis, fault tree analysis, event tree analysis, step (time-ordered stages of complex events),

barrier analysis, and bowtie analysis are used in accident and incident investigations.

Root cause analysis covers the determination of the main reason for the origin of the errors and the measures to be taken to prevent the errors from recurring.[2] It is a problem-solving process to investigate an incident, problem, error, accident, or noncompliance that has occurred. In all standards of quality management systems and problem-solving approaches related to the extent and depth of corrective and preventive measures, the realization of root cause analysis has been emphasized.[3]

The subject of root cause analysis is the event and its causes, not individuals. In this approach, the aim is not to find out who is negligent, but to make improvements in the system by reviewing all the events.[4] With the analysis studies to be carried out, it is aimed to find the root causes of the problems, learn the source of the problems, ensure the correct understanding of the problems and ensure positive behavior changes at the knowledge level, and prevent time loss due to corrective and preventive actions taken before reaching the source of the problems.

The root-cause analysis benefits the organization by identifying the underlying causes of a problem encountered. This approach offers a long-term perspective for improving management processes. If an effective root cause analysis and subsequent improvement studies are not carried out, the probability of recurrence of the error is high. Root cause analysis also prevents the same problem from repeating itself in the future. It should also be noted that a problem may often have more than one related or unrelated cause.[5] Root Cause Analysis is the most widely used analysis tool to investigate health care safety-related incidents, either as a technique or as part of continuous improvement efforts.[6]

Fishbone diagram (Ishikawa diagram), brainstorming, Pareto diagram, scatter diagram, flowcharts, histogram, tree diagram, control charts, etc. are some of the analysis tools used.[7] The fishbone diagram is the most widely used in health care.

Root cause analysis is used to identify possible causes of a particular problem or condition. It can visually present the causes of the problem by using statistical methods and based on the results of the analysis, in a way that can reach the causes of the event and reveal the cross-relationship between the resulting results and the causes that give rise to them.[8-10]

In this context, the research was conducted to examine the root cause analysis and process after an occupational accident in a state hospital and to examine how it was applied in the health facility and the causes of occupational accidents.

Methods

The hospital-based retrospective study was carried out by evaluating the occupational accident records that occurred in a state hospital and reported to the Provincial Directorate of Social Security. The population of the research consists of 156 health workers who had an occupational accident between January 2018 and April 2021.

Data were obtained by using the occupational accident notification forms and root cause analysis forms used in the institution. Occupational groups, the place where the injury occurred, the event that caused the injury, and the tool that caused the injury were included in the evaluation. The collected data were evaluated using percentage calculation.

In the study, the "fishbone" method, which is a root cause analysis method for detecting all factors that may cause a particular problem and confirming the factor that will affect the problem the most, was used.[11]

The problems were determined and the important reasons causing the problem were listed, and primary causes and sub-causes were studied.

To carry out the research, its ethical suitability was approved and evaluated by the Social and Human Sciences Ethics Committee of Tokat Gazi-osmanpaşa University, and written permissions were obtained from the Ministry of Health and the Tokat Provincial Health Directorate.

Results

The percentage distribution of occupational accidents by year is shown in Table 1. The reasons stated in the occupational accident and root-cause analysis form were examined, and the source of the problem was searched by giving priority to the findings. Of those who applied to the occupational health and safety unit due to a work accident; 67.94% were women, 45% were nurses, 25% were cleaning staff and 3% were physicians. Looking at the location of the accident, 50% occurred in inpatient services, 15% in emergency services, and 15% in intensive care units.

In the way, the accidents occur; needle stick injuries (71.8%) are the most common occupational accidents, followed by slipping and falling (14.7%). When the tools that cause sharps and stab wounds are examined; needle tip (45.5%) is in the first place, followed by branule (19.6%) and lancet (14.2%).

Considering the causes of needle stick injuries according to occupational groups; it was seen that the

nurses were trying to close the needle tip, the patient moved during the procedure, and the needles on/inside the sharps box were full during waste separation. The reason for the injury of the cleaning personnel is; that it was seen as throwing a sharp tool into a medical waste bag and forgetting a sharp tool in the environment during cleaning operations.

It was determined that the fall-collision accidents reported in the second rank occurred mainly in the cleaning personnel, caused the most loss of workforce, and the most common reason was due to the slippery floor. When the causes of work accidents are examined, it is seen that the main reason is inattention (37.18%). This is followed by non-compliance with the rules (27.56%).

Table I: Distribution of employees by socio-demographic characteristics and application periods

	Employees (n)	Percentage (%)
Gender		
Woman	106	67.94
Man	50	32.06
Marital status		
Married	102	65.38
Single	54	34.62
Title		
Doctor	5	3.21
Nurse	71	45.52
Midwife	12	7.69
Cleaning staff	40	25.64
Health officer	5	3.21
Security worker	3	1.92
Anesthesia Technician	3	1.92
Laboratory Technician	4	2.56
Other*	13	8.33
Educational Status		
Primary education	20	12.83
High school	31	19.87
Associate degree	18	11.53
Licence	87	55.77
Accident cause tool		
Needle tip	55	35.26
Branule	22	14.11
Lancet	16	10.27
Bistoury	2	1.28
Suture needle	2	1.28
Insulin shot	7	4.48
Other**	12	7.72
Work Place		
Inpatient Service	78	50
Intensive care	24	15.38
Emergency	24	15.38
Operating room	7	4.48
Policlinic	6	3.84
Hospital Garden	5	3.21
Laboratory	5	3.21
Other **	10	6.4
Causes of the accident		
Carelessness	58	37.18
disobeying the rules	43	27.56
Tiredness	8	5.12
Lack of maintenance	3	1.92
Irregularity	5	3.22

Inexperience	1	0.65
Other ****	38	24.35

* Computer operator, servant, clinical support staff, etc.)
** Microtome, spiral, scissors, glass etc.)
*** Corridor, machine shop, laundry
**** Insufficient lighting, visual impairment, slippery floor etc.

Discussion

Healthcare workers are a professional group that interacts a lot with patients and their relatives during the diagnosis and treatment processes. Unfortunately, they encounter many work accidents and occupational diseases while carrying out these procedures.

In our study, most of those who had occupational accidents were women. In this situation; it is thought that nurses form the main frame of the health care services process and the majority of nurses are women. In some studies, it was observed that the gender with the most occupational accidents was female.[12-15] Needle stick injuries were the most common occupational accident (71.8%). In another study, this rate was found to be 82.2%.[16]

The second most common occupational accident was slip-fall injuries. Contrary to our study, in the study of Wåhlin et al., threat and violence (18.6%) were the second most common injuries. Slip-fall (8.1%) occurred less frequently.[14] In the study conducted by İnci et al., 13% of occupational accidents were found to be falls and 36% to be sharp injuries. The rate of falls and injuries is similar to our study.[17]

According to the data obtained by the CDC, the number of the needle tip and percutaneous injuries increases every year in healthcare workers, and 385,000 injector injuries occur in hospital workers every year and an average of 1000 needle-stick injuries per day. In the USA, it is estimated that there are around 600-800 thousand applications for similar injuries per year, half of which are not reported.[18]

Our study determined that the most common type of injury was needle tip injuries (45.5%). Similarly, in the study of Kurttekin and Taçgın, it was found that the most common injury was caused by the needle tip.[19] Similarly, a study conducted in India revealed that the nurses' most common occupational injury is needle syringe injuries and it occurred commonly during needle recapping.[20]

In a study investigating the behaviors that cause needle-stick injuries in nurses, trying to close the caps of the injectors and the inability to remove the needles stand out as the most important problems. Similarly, in our study, it was observed that most of the needlestick injuries occurred while trying to close the needle tip.[21]

Insufficient questioning of the post-injury approach makes it challenging to reach healthy data. Therefore, this study aims to prevent or reduce accidents by determining which occupational accidents the employees are most exposed to and the leading causes of these accidents.

Conclusions

If an effective root cause analysis and subsequent improvement studies are not carried out, the probability of recurrence of the error is high. Incorrect determination of root cause will lead to incorrect determination of corrective actions and this will not be the definitive solution of corrective action. Thus, the probability of the problem reoccurring will continue. Performing root cause analysis also prevents repetition of the same determination by repeating it in case the same problem occurs. Instead of masking the problem, permanent solutions are produced to prevent the problem from becoming chronic.

More than one factor is likely to cause a single problem to occur. In this case, the reasons that may be the source of the problem should be listed. After the causes are determined, the subparts or branches of each cause, if any, should be named. For example, what could the reason for 'Personnel' also be listed? Problem-based data and information should be collected. Then, after all the sub-causes are sorted, all the data is analyzed by brainstorming and so on.

Meaningless reasons and ideas are eliminated and the cause or reasons that are the source of the problem are reached. While a 5-cause analysis may be sufficient to find the source of any problem, this method will not be sufficient in a complex and multi-factorial process. In this case, the fishbone diagram provides a useful framework for revealing the factors and causes that simultaneously affect a problem within the framework of the cause-effect relationship.

Today, although the rate of needle-stick injuries has decreased significantly with approaches such as the use of disposable medical equipment (injector, scalpel, lancet, etc.), blood collection with the vacuum tube, and the use of puncture-proof waste boxes for sharps, it is still at a very high rate of 50-70% in our country maintains its importance.[22]

Post-occupational accident investigation is important. According to the provisions of the Regulation on Occupational Health and Safety Committees, one of the principles of meeting Occupational Health and Safety Committees in workplaces is occupational accidents.[23] With this meeting, the cause of the work accident is investigated, and the cause of this accident is tried to be found and solutions specific to the cause are suggested. In this way, it is tried to prevent the recurrence of the accident. If the same errors/ınfolence ıs repeated;

1- Why the root found may be faulty.

2- Both the root cause and the action may be wrong.

It is thought that if the board meetings are carried out in parallel with the cause-precaution by removing the necessity of creating the documents and making them effective after the work accident, the probability of repetition of work accidents will decrease, and the costs and compensations that will occur after the accident decreases, and the loss of labor and service/production will be prevented.

Also, Occupational health and safety professionals investigating occupational accidents should be given in-service training to determine the root causes of the accidents and eliminate the root causes, select field-specific personnel or increase their knowledge and experience.

Acknowledgments

M. Solmaz contributed to the study conception and design, acquisition of data, interpretation of data; drafting of the article or reviewing it critically for important intellectual content; and giving final approval of the version to be published. T.Solmaz contributed to the study conception and design, analysis, and interpretation of data.

References

1. Erol S. İş Sağlığı ve Güvenliği Konusunda İşveren, Çalışan ve Devletin Rolü [The role of employer, employee and state about occupational health and safety]. ASSAM International Refereed Journal. 2015;2(4):86-103. Turkish. Available from: https://dergipark.org.tr/en/pub/assam/issue/32281/358441

2. Kaya ŞD. Root Cause Analysıs: Examples of Scenario. Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi. 2017;6(4):247-51. Available from: https://dergipark.org.tr/tr/download/article-file/388852

3. Mülayim Y, İntepeler S. Bir Üniversite Hastanesinde Düşmelerin Sıklığı Ve Kök Neden Analizi [Root cause analysis and frequency of fallings in a university hospital]. Ege Üniversitesi Hemşirelik Yüksek Okulu Dergisi. 2011; 27(3), 21-34. Turkish. Available from: https://dergipark.org.tr/tr/pub/egehemsire/issue/49352/630394

4. Hand M, Seibert S. Linking Root Cause Analysis To Practice Using Problem-Based Learning. Nurse Educ. Wolters Kluwer Health. 2016; 41(5): 225-7. Available from: https://doi.org/10.1097/NNE.0000000000000256

5. Tunca F, Utlu Z. İş Güvenliğinde Kök, Neden - Sonuç İlişkisi [Root cause effect relationship in occupational safety]. İstanbul Aydın Üniversitesi Dergisi. 2016;8(31): 1-14. Turkish.. Available from: https://dergipark.org.tr/tr/pub/iaud/issue/40585/487714

6. Jones RW, Despotou G. Root Cause Analysis and Health Informatics. 14th International Conference on Informatics, Management and Technology in Healthcare (ICIMTH); 2016 Jul 1-3; Athens. Amsterdam: IOS Press; 2016; 226:131–134. Available from: https://doi.org/10.3233/978-1-61499-664-4-131

7. Ineci E. Hastane Yöneticilerinin Toplam Kalite Yönetimine İlişkin Algılarının Belirlenmesi Konusunda Bir Araştırma [A Research on determining the perceptions of hospital managers related to total quality management] [master's thesis]. Nicosia (Cyprus): Near East University; 2018. 119p. Turkish.

8. Eraydın C, Tezcan B, Koç Z. Hasta Düşmelerinin Değerlendirilmesinde Balık Kılçığı Yöntemi ile Kök Neden Analizi [Root Cause Analysis For Evaluating The Patient Falling With Fishbone Method]. Journal of Health and Nursing Management. 2019; 6(3):267-72. Turkish. Available from: https://doi.org/10.5222/SHYD.2019.82905

9. Ilie G, Ciocoiu CN. Application of Fishbone Diagram to Determine the Risk of an Event with Multiple Causes. Manage Res Prac. 2010;2(1):1–20. Available from: https://mrp.ase.ro/no21/f1.pdf

10. Akansel N, Palloş A. Hemşirelik Öğrencilerinin Bakım Planı Hazırlamada Yaşadıkları Güçlüklerin Kök Nedenlerinin İncelenmesi [Dificulties experienced by nursing students in the development of nursing care plans: Root cause analysis]. ACU Sağlık Bil Derg. 2020; 11(2):269-75. Turkish. Available from: https://doi.org/10.31067/0.2020.265.

11. Wong KC. Using An Ishikawa Diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature. Journal of Medical Case Reports. 2011;5:120-3. Available from: https://doi.org/10.1186/1752-1947-5-120

12. Alamgir H, Yu S, Drebit S, Fast C, Kidd C. Are Female Healthcare Workers At Higher Risk Of Occupational İnjury? Occup Med (Lond). 2009; 59(3):149-52. Available from: https://doi.org/10.1093/occmed/kqp011

13. Solmaz M, Solmaz T. Experiences With Needle-Stick And Sharp Object İnjuries For Healthcare Workers İn A State Hospital İn Tokat Province, Turkey. Int J Occup Hygiene.2017,9(3):142-8. Availble from: https://ijoh.tums.ac.ir/index.php/ijoh/article/view/269

14. Uğurlu Z, Elbaş HNÖ, Günay A. Hemşirelik Hizmetlerine Bağlı Çalışan Sağlık Personelinin Maruz

Kaldığı İş Kazalarının İncelenmesi [Investigation of Occupational Accidents Health Workers in Nursing Services Are Exposed To]. FLORA. 2020;25(2):220-7. Turkish. Available from: https://doi.org/10.5578/flora.68792

15. Wåhlin C, Kvarnström S, Öhrn A, Strid EN. Patient And Healthcare Worker Safety Risks And İnjuries. Learning From İncident Reporting. European Journal of Physiotherapy. 2020;22(1),44-50. Available from: https://doi.org/10.1080/21679169.2018.1549594

16. Engin DÖ, İnan A, Demir ZA, Dağlı Ö, Karagül E, Özyürek S. Occupational Exposures Among Healthcare Workers: A Teaching Hospital Sample. Journal of Microbiology and Infectious Diseases. 2014;4(2):64-8. Available from: https://dergipark.org.tr/en/pub/jmid/issue/9946/123040 doi: https://doi.org/10.5799/ahinjs.02.2014.02.0129

17. İnci E, Bilişli Y, Hizay D. İş Kazalarına Maruz Kalan Sağlık Çalışanlarının Bildirimlerinin Değerlendirilmesi: Üniversite Hastanesi Örneği. Sağlık Akademisyenleri Dergisi [Assessment of notifications by healthcare staff suffering from occupational accidents: case of university hospital]. 2016;3(3),83-8. Turkish. Available from: https://dergipark.org.tr/en/pub/sagakaderg/issue/46736/586245 doi: https://doi.org/10.5455/sad.13-1477513701

18. Akgün S. Sağlık Sektöründe İş Kazaları [Work accidents in health sector]. Health Care Acad J. 2015;2(2),67-75. Turkish. Available from: https://dergipark.org.tr/tr/pub/sagakaderg/issue/46750/586379 doi: https://doi.org/10.5455/sad.2015131442264595

19. Kurttekin A, Taçgın E. Sağlık Hizmetlerinde İş Kazaları ve Kesici-Delici Alet Yaralanma Araştırmaları Üzerine Bir Değerlendirme [An Evaluation on Occupational Accidents in Health Services and Cutter-Drilling Instrument Injury Investigations]. Sağlıkta Performans ve Kalite Dergisi. 2020;17(2),135-82. Turkish. Available from: https://dergipark.org.tr/tr/pub/spkd/issue/53376/540078

20. Lalrinzuala, Elizabeth H. Risks and Safety of Women Healthcare Workers in Aizawl District, Mizoram, India. International Journal of Occupational Safety and Health. 2022;12(2),111–6. Available from: https://doi.org/10.3126/ijosh.v12i2.39794

21. Pournaras S, Tsakris A, Mandraveli K, Faitatzidou A, Douboyas J, Tourkantonis A. Reported Needlestick And Sharp İnjuries Among Health Care Workers İn A Greek General Hospital. Occup Med (Lond). 1999; 49(7): 423-6. Available from: https://doi.org/10.1093/occmed/49.7.423

22. Demirdağ H, Yılmaz M, Gündüz O. Bir Devlet Hastanesinde Kesici Delici Alet Yaralanmalarında Öğrencilerin Yaralanma Sıklığı ve Kök-Neden Analizi [Injury frequency and root cause analysis of students in sharp injuries in a state hospital]. Ege Üniversitesi Hemşirelik Fakültesi Dergisi. 2018;34(2):23-9. Turkish. Available from: https://dergipark.org.tr/en/pub/ege-hemsire/issue/38978/365684

23. İş Sağlığı ve güvenliği kurulları hakkında yönetmelik [Regulation on Occupational Health and Safety Boards]. Resmî Gazete Tarihi: 18.01.2013 Resmî Gazete Sayısı: 28532. Turkish. Available from: https://www.resmigazete.gov.tr/eskiler/2013/01/20130118-3.htm

International Journal of Occupational Safety and Health

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

Original Article

Postural stress and risk conditions in manual load handling of Chilean industrial workers

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Date of submission: 07.12.2021
Date of acceptance: 26.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:
https://doi.org/10.3126/ijosh.v13i1.41264

ABSTRACT

Introduction: Although, there is a current regulatory framework for optimal manual handling of loads to preserve health conditions in the industrial sector, technical assessment and the use of certain instruments are still required for the diagnosis of occupational hazards. This study aimed to identify the occupational hazards associated with manual load handling in industry workers and estimate those resulting from postural stress.

Methods: Fifty-two (52) industry workers took part in this cross-sectional study. All participants were evaluated using the Manual Handling Guide and the Reba assessment tool. Subjects were characterized, and risks associated with different tasks were detected.

Results: 59.6% of workers were between 18 and 45 years old. Lifting, lowering, and transporting loads activities had a repetitive task risk of 94%, exceeding the weight limit in 85.7% of cases. Pushing and pulling activities, mostly showed a working postural risk of 82% and a high perception of initial effort (Borg> 8). Reba score warned to intervene immediately in both types of tasks.

Conclusion: Risk from the manual handling of loads found in this study constitutes an alert that suggests reviewing compliance with the current regulation, as well as effective use of working pauses and the improvement of strategies to minimize physical efforts used by workers.

Keywords: Ergonomic assessment, occupational health, posture load, work risk

Introduction

Important work procedures and processes are associated with manual load handling (MLH), most of which are involved in productive sectors such as agriculture, construction, and industry.[1] An important aspect that has caught the attention of occupational health units, ergonomics departments, and public health centers is the collection of data that relate risks associated with MLH with postural load and the prevalence of musculoskeletal disorders in workers.[2,3]

Although the approach to occupational health includes various disciplines, the study of the workplace continues to be a powerful diagnostic tool, as work in the industrial area continues to present serious problems about the adoption of poor harmful postures to carry out productive tasks.[4] In fact, there are several instruments and methods available for the assessment of risk because of postural stress, including its application in different working environments[5,6] to identify forced postures adopted by workers and use this information to design workplace adjustments as well as to promote hazard management strategies to minimize stress on the locomotor system.[7]

In Chile, management derived from the analysis regarding load handling hazards in workers allowed the incorporation of new regulations about maximum weight to be lift by humans into the labor code in 2005 by law 20.001, which is ruled by the guide of manual handling risk assessment, however, it was modified through law 20,949;

which reduced to only 25-20 kilos for maximum MLH limit in adult men and those under 18 years of age and /or women respectively since 2016 through the technical guide for assessment and control of risks associated with manual load handling.[8] Despite the existence of current regulations on risk assessment in MLH; recent studies have shown that the working population is exposed to work overload variables, physical-biomechanical factors, and perception of musculoskeletal discomfort;[9] and in other cases it is noted that the maximum legal load limit should not be interpreted as a safety health value.[10]

This study aimed to evaluate the risk present in tasks that include manual load handling, as well as postural load in industrial workers.

Methods

This is a cross-sectional study that took place in a furniture and mattress factory in the metropolitan region (Santiago de Chile) between April and August 2019 and by request of the Occupational Safety and Health Administration (Law 16.744).

The company has 180 workers with an indefinite employment contract and the investigation was carried out in a branch office that included 80 workers (the biggest of this company).

Workers in this area primarily perform mattress manufacturing activities through quilting, edge definition, and assembly processes. Finally, they carry out the closure and the product is packaged to distribute to commercial stores for later sale. The manufacturing and assembly areas included in this study require manual load handling activities through lifting, lowering, transporting, pushing and dragging tasks. 20 workers were excluded from this study due to administrative work activities.

The study included 60 male workers. To calculate the sample size of a finite population, the following formula was used:

$$n = \frac{N \times z_{\alpha}^{2} \cdot p \; x \; q}{e^{2} \times (N-1) + z_{\alpha}^{2} \; x \; p \; x \; q}$$

Where: n: Sample size to consider; N: Population size; Z: Statistic that depends on N; p: Probability of occurrence of the occupational risk t; q: Probability that the event does not occur q = (1-p) and e: Error. For this study, a significance level of 5% was considered, so that Z corresponds to: 1.96. Finally, a margin of error of 5% was used. Calculations established a size sample of 51.7. Therefore, the sample finally consisted of 52 subjects. Workers were separated into two groups according to their functions and tasks performed after the evaluation (interview and job observation); 35 subjects performed lifting, lowering and transportation tasks, while 17 performed pushing and pulling activities.

Subject selection considered the following inclusion criteria: men between 18 and 65 years old, subjects who worked 44 hours a week, presented an indefinite employment contract, and whose tasks included lifting, lowering, transporting, pushing, and pulling actions. Subjects perform functions for 8 hours a day and a 1-hour break was established for rest and feeding. Exclusion criteria involved working in the administration department or those with jobs outside the branch office. Tasks performed by workers were mostly carried out manually and physically, however, some of them used the help of machinery.

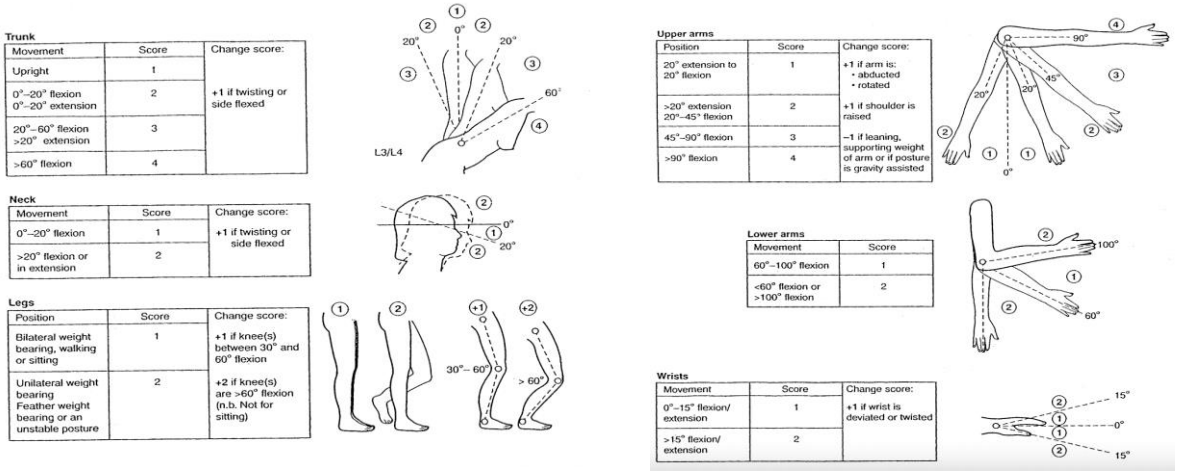
The assessment involved a technical visit by a professional with training in ergonomics and 3 years of experience in assessing risks associated with work and in the implementation of the current technical standard for manual load handling. The evaluation considered the Reba observational method, based on the observation of postures used in the execution of the task in the subject's workplace. The observation is captured by images. In addition, a 20-minute interview was conducted with each worker in which a structured questionnaire was applied on basic aspects related to age, sex, type of tasks performed, number of hours and breaks during the working day, and exposure times. The questionnaire was reviewed by experts in job evaluation. In addition, the technical guide for the evaluation and control of risks associated with manual handling of the load was applied. The information collected was recorded in an excel spreadsheet for later analysis. This made it possible to analyze the jobs individually.

Additionally, according to the type of tasks performed by the workers, the advanced ergonomic instrument Reba[11] was used to specify the risk associated with the postural load. This tool includes a systematic full body assessment of the postural risk to which the worker is exposed and involves dynamic and static postural load factors as well as person-load interaction by examining separately; right and left upper and lower extremities, trunk position, and variation of posture in the cervical region.[12] Later, the data collected were compared and analyzed.

The work was reviewed by the university's ethics committee and was approved according to the ethical criteria, instruments applied, and protection of the information. Confidentiality certificates were used for each of the participants authorizing the subsequent use of the data resulting from the evaluation with full protection of the information of the company and each of its workers.

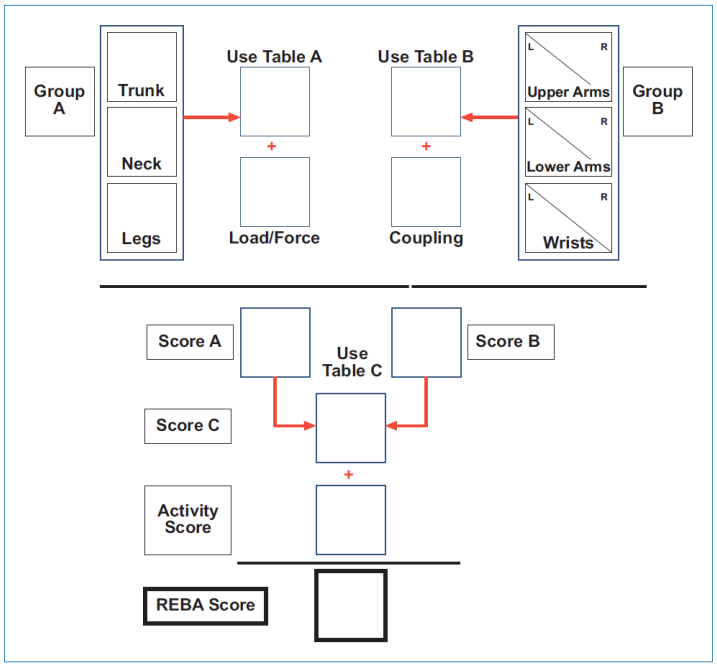
Data of the number of workers by type of task, the percentage of vertebral asymmetry, and the deficit in maintaining the vertical position during lifting, lowering and transportation tasks were described as discrete variables. Likewise, for the tasks of pushing and pulling, the Borg scale was described as the percentage of poor posture. On the other hand, the comparison of the repetition of the activity between both types of tasks was analyzed according to the student's test.

The Reba method was used to evaluate the observation of the posture of each body segment of both hemibodies during a task from the analysis of the images obtained in the workplace. Based on observation and image analysis, Reba suggests scores, and the sum of them gives a final score for each hemibody, which will be categorized according to the level of risk suggested by the method (Fig 1 A - B). Data obtained from the Reba score suggested levels of intervention for each hemibody and was compared according to the student's test.



Group A **Group B**

Figure 1A. Reba group A and B body diagrams



REBA Score	Risk level
1	Negligible
1 -3	Low
4 -7	Medium
8 -10	High
11 - 15	Very High

Figure 1B. Reba Scoring Sheet

Results

A total of 52 persons participated in this study. The largest number of workers were engaged in activities involving lifting, lowering, and carrying loads in comparison to pushing and pulling activities. For both activities, there was greater involvement of workers between 18 and 45 years of age. Regarding task description, evidence showed a greater number of tasks evaluated, involving lifting, lowering, and transporting loads, which also presented a lower average time duration corresponding to 40.64 seconds. However, the longest exposure time was longer for the tasks that involved pushing and pulling activities, reaching an average of 84.27 minutes. Regarding the presence of observed risk conditions, repetitiveness in both activities was positive, reaching 94% for lifting, lowering, and load transport activities. In its counterpart, the highest static load was observed in 82% of pushing and pulling activities. However, there are no significant differences in repeatability between these two types of tasks (t-test, p> 0,05). The postural instability factor was only observed in two-thirds of the workers during lifting, lowering, and carrying loads, meanwhile, it was absent in pushing and pulling activities (Table 1).

Table I: Characterization of the activity carried out by a worker

Workers characterization	**Lifting, lowering, transport**	**Pushing and pulling**
	n	**n**
Total number of workers	35	17
Age 18 to 45 years	20	11
Age> 45 years	15	6
Task characterization	**n**	**n**
Number of tasks	10	7
	Mean ± SD	**Mean ± SD**
Task duration (seconds)	40.64±38.57	96.36±73.11
Exposure time (minutes)	41.58±35.13	84.27±52.90
Risk conditions present in workers	**% (n)**	**% (n)**
Repeatability factor	94 (49)	58 (30)
Static postural load on one or more parts of the body	65 (34)	82 (43)
Postural instability	65 (34)	0 (0)

When examining the weight load limit according to the current regulation, 85.7% of subjects developed their task with excess load, being more prominent in lifting, lowering, and transportation activities. Between 70 and 100% of subjects evaluated experienced risk conditions associated with their type of task. For the lifting, lowering, and transportation activities, asymmetry of the spine and the deficit in maintaining the vertical position were observed.

For pushing and pulling activities, showed a high perception of initial effort (Borg> 8), and poor posture. When comparing both types of tasks, the duration of the work cycle and time exposure were considered for analysis. Using these data, the average number of repetitions for each worker estimated according to their performed activities was 103 times for lifting, lowering, and transport, and 86 times for pushing and pulling (Fig 2).

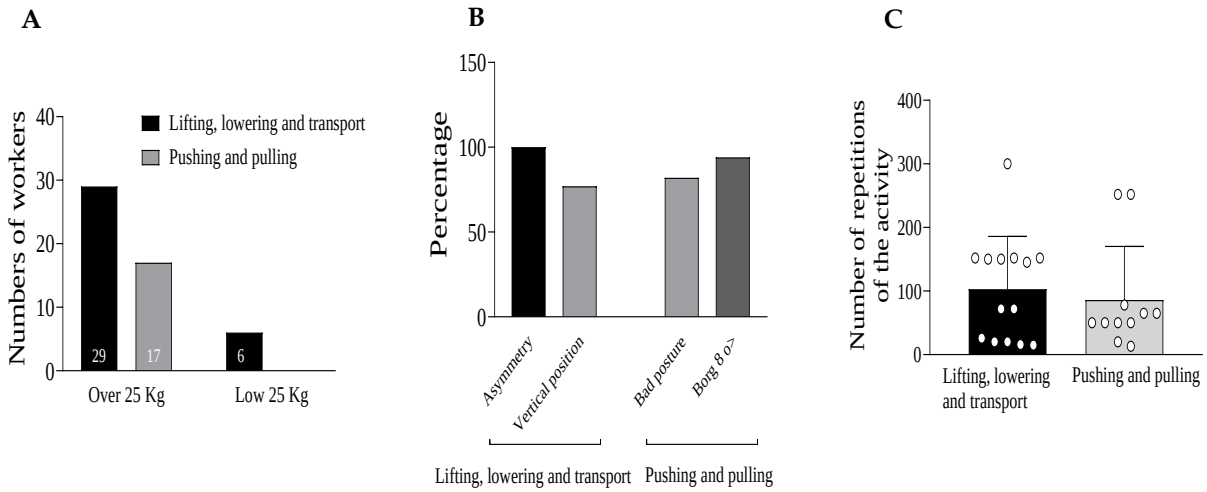


Figure 2. Load limit, risk conditions and repeatability of the activity.

A. 85.7% of the workers who carry out lifting, lowering, and transport are over the load limit, while 100% of the workers who carry out the push and pull activity are over the load limit. B. Presence of asymmetry (100%) and vertical position (77%) in lifting, lowering and carrying and presence of poor posture (82%) and effort (94%) in pushing and pulling. C. Repeatability in work activity both for lifting, lowering and transporting (103 times) and for pushing and pulling (86 times). Data are represented as means ±SEM.

When analyzing the risk estimation for postural load using the Reba assessment tool when applied to both hemibodies, the same trend was observed in terms of the achieved score and suggested levels of action for lifting, lowering and transportation activities as well as for pushing and dragging. A slightly higher score out of 12 points was recorded for lifting, lowering, and carrying compared to the pushing and pulling activities, which cataloged risk as "very high". Regarding the level of action suggested when comparing the two groups of tasks, the same trend was observed on both sides of the body, suggesting an "immediate intervention" (Fig 3).

When analyzing and comparing the breakdown of the scores obtained by applying the Reba method for each body segment and the variables of load/strength and type of grip in each group of evaluated tasks, it was evidenced that for lifting, lowering and transporting the highs Overall scores were derived from the higher contribution made by the referred score of the arm segment, while for pushing and pulling activities the higher score is due to the higher estimate of trunk load, and levels of load/force used. In both types of tasks, the load estimation turned out to be homogeneous for each right and left half body (Fig. 4).

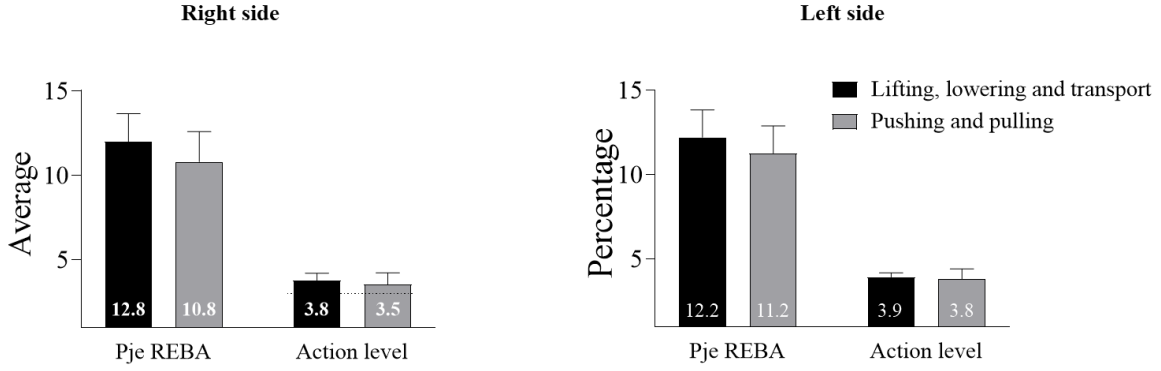


Figure 3. REBA score and level of action by laterality.

The evaluation of the risk estimates for postural load determined that, for the activity of lifting, lowering and transport, both for right and left laterality it obtained a score out of 11 with a level higher than 3, which suggests immediate intervention. For the push and pull activity, the REBA score (10,8 right laterality and 11,2 left laterality) associated with action levels 3,5 and 3,8 respectively indicate the need for immediate intervention. Data are represented as means ±SEM.

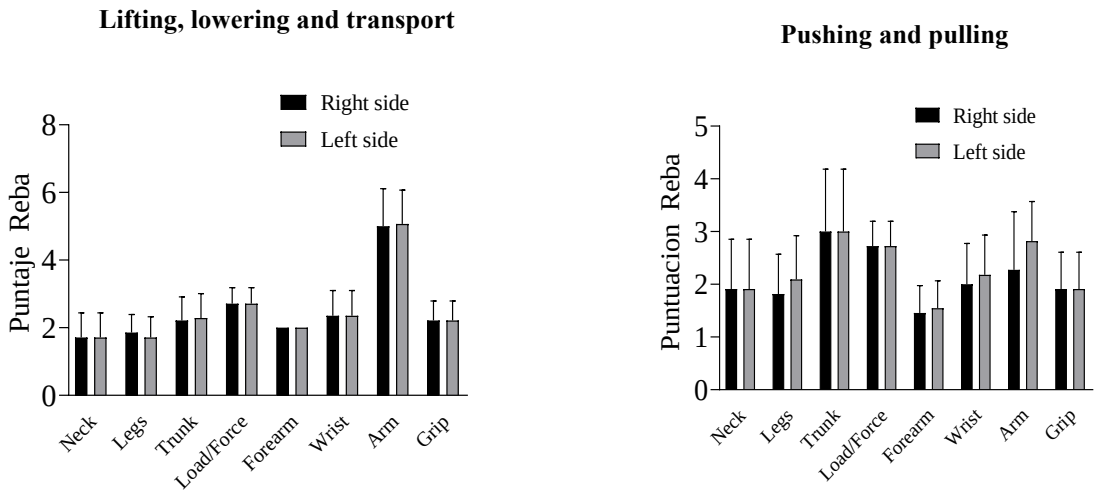


Figure 4. Scoring of the REBA method by the task group

A. Higher scores were observed in the arms, forearms, and wrist, while for group B the segments that gave the highest score in the assessment correspond to the trunk, neck, and legs, in both considering the level of load/force exerted and type of grip. Data are represented as means ±SEM.

Discussion

The novelty of this study is that a highly variable and versatile work system is assessed in terms of the tasks performed by the subjects and allowed each of them to be specifically evaluated. The foregoing was based on the difference and specificity of the tasks performed by the subjects, where not all perform the same activity in the same work circuit, and also the tasks performed by each of the workers vary during the work circuit. The selected instruments were appropriate in characterizing the sample and in investigating the risk conditions present in both groups of tasks examined. In the first place, although there is repetitiveness both in lifting, lowering and transportation, as well as for pushing and pulling activities, the differences found may be related to the different productive rhythms, whereas in the case of lifting, lowering, and transportation, the duration of work cycle is practically double.[13] A second relevant aspect, common for both types of activities, is the presence of risk as a result of postural load, static load, and/or unstable posture. In this sense, the risk conditions were related to the asymmetry of the spine, the difficulty to maintain a vertical cervical position and the adoption of poor posture and/or functional compensation during a task [14], fringes were also found in other studies in which the main issue originates from poor technique and/or training for workers regarding the use of mechanical advantage for their body segments to perform motor skills.[15]

On the other hand, for pushing and pulling activities, considerate is worth noting that most workers scored initial effort with the Borg scale> 8, while 85.7% of subjects who participated in lifting, lowering and transportation activities reported having approached the human load limit (25 kilograms). Although workloads used for both activities are within the norm, they require a great effort from the worker to put a load into motion [16,17].

Regarding evaluation using the Reba assessment tool for both types of activities for each hemibody, data revealed different score contributions according to the body region involved in the process. Once again, the score resulting from the load magnitude and/or the exerted force stands is highlighted in both activities. For lifting, lowering and transportation, the highest score by body segment was observed in the arms, forearms, and wrists, which could be explained to a greater extent by working angles of 45 and/or 90 degrees in the lateral and frontal planes, in addition to movements in another plane such as rotations [18], working angles that are responsible for imposing greater load and stress on the tissues involved.[19]. In its counterpart, for pushing and dragging, the topographic regions mostly involved in the scoring were the trunk, neck, and legs, which are regions commonly implicated in maintaining a posture in a flexing, antigravity pattern and/or used for coupling between the body and load.[20] A study on ergonomics evaluation of manual lifting task on biomechanical stress conducted in India showed that heavier weights produced higher stresses than lower weights, and the loading rate was found to be same at waist or knee level. It was observed to be linear-

ly increasing after waist level.[21]

The study proposes the following measures which should be adopted by occupational health units to improve working conditions: a) evaluate and train the best technique to perform different tasks to make more efficient use of biomechanics and mechanical advantage[22], b) evaluate mechanical assistance to push loads of greater magnitude or the conformation of task teams to minimize the initial push and/or drag effort [23], c) review and incorporate the use of working pauses combined with the rotation of workers in different jobs to reduce the repetitiveness component and improve the recovery of tissues and joint structures involved in the execution of activities, and by reducing the stress imposed on the musculoskeletal system in the tasks performed.[24]

A limitation of this study was not to consider or preliminarily assess clinical aspects such as signs and symptoms associated with musculoskeletal disorders and organizational aspects, including those that determine the productive rhythms, criteria that would have allowed to clarify if the detected risks compromise occupational health as well as the development of sustainable work [25].

Another limitation was the size of the sample (n=52), however, this study considers it important for future or continuity work to increase the sample by assessing other company branches and the inclusion of women to improve representativeness, and be able to transfer the obtained results to other productive sectors with more statistical significance.

In this sense, the main implications and applications of the study show that in terms of risk prevention associated with the manual handling of loads, the implementation of the technical guide for the evaluation and control of risk factors could include sections in which variables are established. of risk for different tasks because not all present the same risks, for example in the observed variables of postural load, and repetitiveness. A better application could be to separate and classify the type of tasks and from this categorize the risks as well as their evaluation, management, and control measures.

Conclusion

This work concludes the presence of associated risks derived mainly from the postural load in the manual load handling, as well as indicators that constitute an alert, including the absence of pauses/rest times or a change of activity during the work cycle. Although there is a current regulation on the weight limit for of loads, it is wise to review its compliance through audits and by finding ways to minimize the physical efforts used by workers.

References

1. Ortiz-Hassang C. Biomechanical occupational risk Associated with manual load handling in the construction industry. Scientific Journal of the Specialized University of the Americas. 1(8):44-61.
2. Sánchez Medina AF. Prevalence of musculoskeletal disorders in workers of a pharmaceutical products trade company. Rev Cienc salud [Internet]. 2018 [cited20th July 2021];16(2):203. Available from: http://www.scielo.org.co/scielo.php?pid=S1692-72732018000200203&script=sci_abstract
3. Paredes-Rizo M, Vásquez-Verdugo M. Descriptive study on the working conditions and musculoskeletal disorders in the nursing staff (nurses and AAEE) of the Pediatric and Neonatal Intensive Care Unit at the Hospital Clínico Universitario de Valladolid. Med Segur Trab. 64(251):161-99. Available from: https://www.cabdirect.org/cabdirect/abstract/20193180720
4. Am-Eam N, Jankaew P, Ninthappho K, Noosom T. An Evaluation of Work Posture by REBA: A Case Study in Maintenance Department. Advances in Physical Ergonomics and Human Factors [Internet]. [Cited 20th July 2021]; 967:106-14. Available from: http://link.springer.com/10.1007/978-3-030-20142-5_11
5. Kong Y-K, Lee S, Lee K-S, Kim D-M. Comparisons of ergonomic evaluation tools (ALLA, RULA, REBA and OWAS) for farm work. International Journal of Occupational Safety and Ergonomics [Internet]. [Cited 20th July 2021]; 24(2):218-23. Available from: https://www.tandfonline.com/doi/full/10.1080/10803548.2017.1306960
6. Kirci BK, Ensari Ozay M, Ucan R. A Case Study in Ergonomics by Using REBA, RULA and NIOSH Methods: Logistics Warehouse Sector in Turkey. Hittite J Sci Eng [Internet]. [Cited 20th July 2021] 7(4):257-64. Available from: https://dergipark.org.tr/en/pub/hjse/issue/59994/866434
7. Hita-Gutiérrez M, Gómez-Galán M, Díaz-Pérez M, Callejón-Ferre Á-J. An Overview of REBA Method Applications in the World. IJERPH [Internet]. 12th April 2020. [Cited 20th July 2021];17(8):2635. Available from: https://www.mdpi.com/1660-4601/17/8/2635
8. Undersecretary of social security. Technical guide for the evaluation and control of risks associated with the handling or handling of cargo. Government of Chile; 2018.
9. Rodríguez-Herrera C, Cerda-Díaz E, Rodríguez-Tobar

J, Díaz-Canepa C, Besoain Saldaña A, Olivares-Péndola G, et al. Pilot Study: Description of the Global Workload, the Physical-Biomechanical Factor and Perception of Musculoskeletal Discomfort in Pregnant Workers. Cienc Trab [Internet]. [Cited 20th July 2021]; 19(58):1-6. Available from: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-24492017000100001&lng=en&nrm=iso&tlng=en

10. Navarrete-Espinoza E, Saldías-Lizama E. Perception of the Weight of a Load According to Body Composition in Interurban Bus Assistants. Cienc Trab [Internet]. [Cited 20th July 2021]; 20(61):7-13. Available from: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-24492018000100007&lng=en&nrm=iso&tlng=en

11. Rizkya I, Syahputri K, Sari RM, Anizar, Siregar I. Evaluation of work posture and quantification of fatigue by Rapid Entire Body Assessment (REBA). IOP Conf Ser: Mater Sci Enf [Internet]. [Cited 20th July 2021]; 309:012051. Available from: https://iopscience.iop.org/article/10.1088/1757-899X/309/1/012051

12. Mahmood S, Aziz S, Abdul H, Zulkifli M, Marsi N. Rula and Reba Analysis on Work Postures: A Case Study at Poultry Feed Manufacturing Industry. Journal of computacional and heoretical nanoscience. 17(2-3):755-64. Available from: https://doi.org/10.1166/jctn.2020.8716

13. Pinto-Retamal R. Participatory Ergonomics Program for the Prevention of Musculoskeletal Disorders. Application in a Company of the Industrial Sector. 2015. 17(53):128-36.

14. Khoddam-Khorasani P, Arjmand N, Shirazi-Adl A. Effect of changes in the lumbar posture in lifting on trunk muscle and spinal loads: A combined in vivo, musculoskeletal, and finite element model study. Journal of Biomechanics [Internet]. [Cited 20th July 2021]; 104:109728. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0021929020301445

15. Concepción-Batiz E, Dos-Santos A, Berretta-Hurtado A, Macedo M, Schmitz-Mafra E. Assessment of postures and manual handling of loads at Southern Brazilian Foundries. Rev Fac Ing Antioquia [Internet]. [Cited 20th July 2021]; (78):21-9. Available from: https://revistas.udea.edu.co/index.php/ingenieria/article/view/21817

16. Brandt M, Madeleine P, Samani A, Ajslev J, Jakobsen M, Sundstrup E, et al. Effects of a Participatory Ergonomics Intervention With Wearable Technical Measurements of Physical Workload in the Construction Industry: Cluster Randomized Controlled Trial. J Med Internet Res [Internet]. [Cited 20th July 2021]; 20(12):e10272. Available from: https://www.jmir.org/2018/12/e10272/

17. Ibarra C, Astudillo P. Manual handling of bovine quarters between delivery operators in a slaughterhouse in Chile: a case study with an ergonomic approach. En Srpinger, Cham; 2021.

18. Huysamen K, Bosch T, de Looze M, Stadler K, Graf E, O'Sullivan L. Evaluation of a passive exoskeleton for static upper limb activities. Applied Ergonomics [Internet]. [Cited 20th July 2021]; 70:148-55. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003687018300334

19. Conforti I, Mileti I, Del Prete Z, Palermo E. Assessing ergonomics and biomechanical risk in manual handling of loads through a wearable system. [Internet]. 2019. [Cited 20th July 2021]; p. 388-93. Available from: https://ieeexplore.ieee.org/document/8792843/

20. Julianus H. Work Posture Analysis by Using Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) Methods (Case Study: Rice Milling In Malang - East Java of Indonesia). IOP Conf Ser: Mater Sci Eng [Internet]. [Cited 20th July 2021]; 469:012012. Available from: https://iopscience.iop.org/article/10.1088/1757-899X/469/1/012012

21. Vijaywargiya A, Bhiwapurkar MK, Thirugnanam A. Ergonomics Evaluation of Manual Lifting Task on Biomechanical Stress in Symmetric Posture. International Journal of Occupational Safety and Health. [Internet]. 2022; [Cited 20th July 2021]; 12(3): 206–14. Available from: https://doi.org/10.3126/ijosh.v12i3.40903

22. Nakić J, Kovačević E, Abazović E. Occupational Kinesiology - Manual Handling. En Croatia..[Internet]. 2017. [Cited 20th July 2021]; p. 631-4. Available from: https://www.researchgate.net/publication/319538490_OCCUPATIONAL_KINESIOLOGY-MANUAL_HANDLING

23. Egger G, Riedl M, Rauch E, Matt D. Design of a low-cost loading/unloading mechanism for processing stations in an automated production environment. En: Puik ECN, Foley JT, Cochran DS, Betasolo ML, editores. MATEC Web of Conferences [Internet]. Italia; 2018. [Cited 20th July 2021]; p. 01001. Available from: https://www.matec-conferences.org/10.1051/matecconf/201822301001

24. Diego-Mas J. Designing Cyclic Job Rotations to Reduce the Exposure to Ergonomics Risk Factors. IJERPH [Internet]. [Cited 20th July 2021]; 17(3):1073. Available from: https://www.mdpi.com/1660-4601/17/3/1073

25. Cournut S, Chauvat S, Correa P, Santos-Filho J, Diéguez F, Hostiou N, et al. Analyzing work organization on livestock farm by the Work Assessment Method. Agron Sustain Dev [Internet]. [Cited 20th July 2021]; 38(6):58. Available from: http://link.springer.com/10.1007/s13593-018-0534-2

International Journal of Occupational Safety and Health

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

Original Article

Risk factors of sleep-disordered breathing among Public Transport Drivers of Kochi, India

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ABSTRACT

Introduction: Sleep-disordered breathing (SDB) appears to be a major occupational health concern among transport drivers as it increases the chance of road traffic crashes. The study aimed to determine the prevalent risk factors of sleep-disordered breathing in public transport drivers of Kochi, India.

Methods: A descriptive cross-sectional study was performed among 50 public transport drivers who satisfied the inclusion criteria and were categorized as high and low-risk groups using the STOP-BANG questionnaire. Physical examination recorded neck circumference, waist-hip ratio, body mass index, blood pressure, and facial profile. Excessive daytime sleepiness was evaluated using the Epworth sleepiness scale. Mann Whitney and Chi-square tests were used to test for significance. Logistic regression was also done by including the significant variables.

Results: The high risk (n= 27) and low-risk groups (n=23) were identified. Among the high-risk group; age, body mass index, neck circumference, blood pressure, snoring, and tiredness showed statistically significant results ($p<0.05$) when compared to the low-risk group. Excessive daytime sleepiness was present among 29.6% of high-risk subjects. Logistic regression confirmed that age (OR=1.176; p=0.001) and body mass index (OR=1.348; p=0.050) were independent predictors of developing a high risk of SDB.

Conclusion: Among public transport drivers in Kochi, India; older age and increased body mass index were significant contributing factors for developing sleep-disordered breathing. Obstructive sleep apnea (OSA), whether diagnosed or undiagnosed, is a major public health concern and a proven risk factor for vehicle crashes. Applicants for public transport driver's licenses should be thoroughly examined for the risk of OSA/SDB. A standardized screening protocol for OSA risk assessment should be advisable for public transport drivers to ensure road safety.

Keywords: Obstructive sleep apnea, Public transport drivers, Sleep-disordered breathing, STOP-BANG questionnaire.

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Date of submission: 12.03.2022
Date of acceptance: 22.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:
https://doi.org/10.3126/ijosh.v13i1.43759

Introduction

Obstructive sleep apnoea (OSA) is a disease characterized by collapsed upper airway with restricted or full cessation of airflow. Characteristic features of OSA include disruptive snoring, nocturnal hypoxemia, and excessive daytime sleepiness due to recurrent episodes of full/partial pharyngeal blockage during sleep.[1] OSA could be due to sleep-disordered breathing (SDB) and has been correlated with negative cardiovascular health

outcomes, risk of vehicle crashes, and impaired quality of life and social living.[2]

Obesity and associated factors like high body mass index (BMI), altered neck circumference (NC), and waist-to-hip ratio (WHR) are all considered risk factors for OSA.[3] Polysomnography which is the gold standard in diagnosing OSA is an expensive, time-consuming test which cannot be routinely done among the public which necessitates the need for screening tests like the STOP-BANG questionnaire and Epworth Sleepiness scale for evaluating the risk factors for OSA.[4]

Driving is a complex process that requires constant interaction with the road and the environment.[5] Excessive daytime sleepiness (EDS) may be described as a situation wherein the subject is unable to keep themselves fully awake during the wakeful period of the sleep-wake cycle. Recent years have seen a gradual increase in the number of fatal and non-fatal motor vehicle crashes in the country. Tregear et al and Huhta et al reported persons with undiagnosed OSA have an increased risk of falling asleep during driving and may cause crashes when compared to healthy individuals.[6,7] This warrants the need to identify the high-risk factors for developing SDB among drivers. Thus, the study aimed to determine the prevalent risk factors of SDB among public transport drivers of Kochi, India.

Methods

A descriptive cross-sectional study was conducted among 50 male public transport drivers in Kochi, Kerala, India from June to August 2021. Based on the results of percentage predicted neck circumference and BMI among OSA by Agrawal et al and with 10% relative precision and 95% confidence, the minimum sample size came to 17 and 2 respectively.[8] Since the highest value was 17, the minimum sample size would be 50 subjects, which would give an estimated 99% confidence.

Male public transport drivers in the age group of 18-60 years with professional driver's licenses and enrolment at any local transportation enterprise in Kochi, Kerala were selected for the study. Of the 68 individuals approached for the study, 50 consented to participate (response rate of 73.5%). Subjects who denied voluntary participation, and who had any recent upper airway surgery, respiratory malignancy, congestive heart failure and renal failure were excluded from the study.

The Institutional ethical committee at Amrita Institute of Medical Sciences, Kochi (IRB-AIMS-2020-161) approved the study protocol. Participants who gave consent and satisfied the inclusion criteria were selected for the study. Their demographic details, medical history, and years of working as professional drivers were recorded.

A previously validated Modified STOP-BANG questionnaire[4,9] was used as a screening tool for assessing the risk factors of SDB. Physical examination was done to record neck circumference (NC), waist-hip ratio (WHR), Body mass index (BMI), blood pressure and facial profile.

The STOP-Bang questionnaire is a simple, reliable screening tool, which can be effectively used for identifying the risk factors for OSA in a cost-effective manner. This questionnaire includes eight screening criteria such as a history of snoring, daytime tiredness, observed apnea, high blood pressure, body mass index $>30\ kg/m^2$, Age >50, Neck circumference >40 cm, and male Gender. Patients with a score of <3 were categorized as the low-risk group and patients with scores ≥ 3 were classified as a high-risk group.[9]

Excessive daytime sleepiness was assessed using the Epworth Sleepiness scale (ESS).[4] ESS is a self-administered questionnaire that measures daytime sleepiness based on the chances of falling asleep in eight different situations. The final score of 11 or more indicates excessive and severe daytime sleepiness.

Using standardized processes and equipment, anthropometric data were collected. The height was measured to the closest half-centimeter. The weight was measured in barefooted subjects to the nearest 0.1 kilograms. BMI calculation was done with the equation: BMI = weight in Kg / (height in meters)^2

Based on BMI categorization, participants were classified into: normal weight ($\leq 24.99\ kg/m^2$),

overweight (25 - 29.99 kg/m^2), and obese (≥30 kg/m^2).[10] Measurement of circumferences to the closest 0.5 cm was done with a non-stretch measuring tape. NC was measured between the mid-cervical spine and the mid-anterior neck, with the individual standing erect, face in the Frankfort horizontal plane, and shoulders relaxed.[11] The midpoint between the highest point of the iliac crest and the last floating rib was used to calculate the WC. The circumference of the hips was measured at their widest point. The WHR was computed (cm) by dividing the waist circumference (cm) by the hip circumference (cm).[12] According to the World Health Organization, a WHR of 1.0 or above increases heart diseases risk and other illnesses connected to obesity in both men and women, so they were categorized into two groups; the no-risk group with a WHR of less than 1 and a risk group with WHR >/= 1. The participant's blood pressure (BP) was measured while the patient was seated in a comfortable position with proper back support. Standardized mercury sphygmomanometers were used. The systolic and diastolic BP (SBP and DBP respectively) above 140 mm Hg and 95 mm Hg respectively were classified as risk categories. The facial profile was recorded clinically. Glabella, subnasale and soft tissue pogonion were evaluated. Based on the facial profile participants were categorized as convex, straight and concave.

Statistical analysis was done with IBM SPSS version 20.0 software. Frequency and percentage were used to express categorical variables. The mean and SD as well as the median and interquartile range were used to depict numerical variables. The statistical significance of the mean value difference of all continuous variables between groups in terms of risk was tested using the Mann-Whitney test. Chi-Square with continuity correction was used to examine the statistical significance of the relationship between Profile, Snoring, Tiredness and risk. To find the significant predictors of SDB, logistic regression analysis was applied. Statistically significant values had a p-value of less than 0.05.

Results

In the study, 50 participants were screened using the modified STOP-BANG questionnaire. Then they were categorized as high-risk and low-risk groups based on their score. A score of more than >3 indicates high risk and <3 as low-risk subjects.

Out of the 50 participants, 23 subjects (46%) were grouped as high-risk and 27 subjects (54%) in a low-risk group. The mean age and BMI of the high-risk group were 48.96±7.01 and 24.91±3.77 respectively; whereas for the low-risk group the mean age and BMI were 39.96±7.40 and 23.15±1.44. EDS was identified in 29.6% of high-risk subjects using ESS. By comparing the two groups (low and high risk) age, BMI, neck circumference, and Systolic and diastolic blood pressure showed statistically significant results (p<0.05). (Table 1 & figure1)

Table 1: Comparison between high and low-risk groups

Variable	Risk	Median (Q1, Q3)	p-value
Age	Low Risk	40(34,45)	0.001*
	High Risk	52(46,54)	
Body Mass Index	Low risk	23.5(23.07,24.02)	0.006*
	High risk	24.5(23.5,26.06)	
Neck circumference	Low risk	39(38,40)	0.003*
	High risk	40(39,41)	
Waist hip ratio	Low risk	0.98(0.98,0.99)	0.224
	High risk	0.98(0.97,0.99)	
Systolic BP	Low Risk	125(122,127)	0.004*
	High risk	131(128,145)	
Diastolic BP	Low risk	82(81,84)	0.045*
	High risk	85(82,87)	

*p<0.05 statistically significant

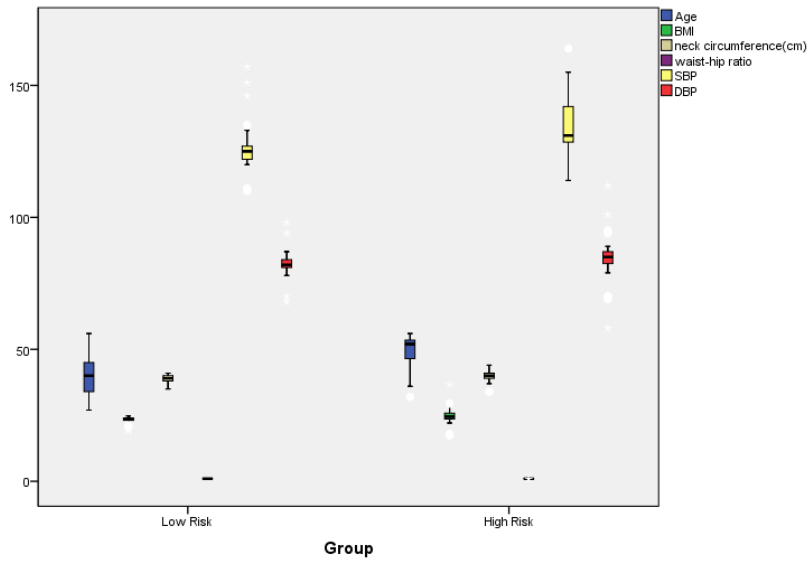

Fig.1: Risk factors in low and high-risk groups

Out of the 50 participants, snoring was present in 10 subjects and 40 were non-snorers. All the 10 snorers identified were grouped into the high-risk group based on the scores. Among the 40 non-snorers,13 were high-risk subjects and 27 were low-risk subjects.

Tiredness was also reported among 10 participants who were grouped as high-risk subjects and among 40 participants who reported an absence of tiredness, 16 were grouped into high risk and 24 were grouped into low-risk. The comparison showed that both snoring and tiredness were statistically significant parameters ($p<0.05$) (Table 2). The comparison of facial profile and Waist Hip ratio among the two groups did not show a statistically significant difference.

Table 2: Association of the profile, snoring and tiredness among low and high-risk groups.

Risk factor		Low-risk n (%)	High risk n (%)	p-value
Profile	**Convex**	16 (51.6)	15 (48.4)	0.665
	Straight	11(57.9)	8 (42.1)	
Snoring	**Absent**	27 (67.5)	13 (32.5)	0.001*
	Present	0 (0)	10 (100)	
Tiredness	**Absent**	24 (60)	16 (40)	0.037*
	Present	0(0)	10 (100)	

*p<0.05 statistically significant

The variables showing significant differences were included in the logistic regression model and the odds ratio was obtained (Table 3). Older age and increased BMI were associated with OSA. The risk of being in the high-risk group of OSA was 1.17 times more in participants with >50 years of age ($p=0.001$) and 1.35 times more when BMI was >30kg/m^2 ($p=0.05$). Other variables were NC (OR 1.65), systolic BP (OR 1.06), and diastolic BP (OR 1.03) were not independent risk factors.

Table 3: Univariate analysis of risk factors of OSA

Variable	Odds Ratio (OR)	95% of CI of OR	p-value
Age	1.176	1.070-1.292	0.001*
Body Mass Index	1.348	0.994-1.827	0.050*
Neck Circumference	1.650	1.121-2.428	0.011
Systolic BP	1.066	1.007-1.129	0.028
Diastolic BP	1.030	0.962-1.103	0.397

*p<0.05 statistically significant

Discussion

In this study, the predictive risk factors for OSA identified among the high-risk group of public transport drivers were age and BMI.

Road traffic crashes have become a significant public health issue since they are a preventable cause of mortality.[13] Among the various factors causing motor vehicle crashes, excessive sleepiness as a result of OSA has a significant position.[14] It is often characterized by a partial or complete collapse of the upper airway during sleep leading to hypoxemia and sleep fragmentation. Thus, these patients with OSA have abnormal neurocognitive and psychomotor abilities, excessive drowsiness and fatigue, which all affect their driving skills.[14,15] Previous studies have shown that drivers with untreated OSA have a 1.2 to 4.9 times higher risk for road crashes and adequate treatment using CPAP therapy reduces this risk.[16] Hence, to ensure the safety of drivers there exists an increased need to identify and screen the possible risk factors of OSA.

The study was performed among male public transport drivers as previous literature on the Indian population has shown three times higher prevalence of OSA among males when compared to females and the majority of the public transport drivers were male. According to Reddy et al and Dubey et alprevalence of high-risk OSA increases with age.[17,18] This was in accordance with our study in which the median age was 52 years (p<0.05) in the high-risk group as opposed to the low-risk group, which had a median age of 40 years. The odds of developing OSA were higher as age increases (OR 1.17) and has emerged as a strong risk factor.

The results of the present study also showed increased BMI (OR 1.348) causing obesity as another important independent risk factor for developing OSA. Neck circumference even though was increased in the high-risk group when compared to the low-risk group and was not found to be an independent risk factor (OR 1.65) for OSA. A previous study by Basoglu et al. identified a proportional relationship in OSA patients with increased neck circumference to greater daytime sleepiness leading to more chances of road traffic crashes.[19] The increased NC has also been reported as a predictor of severe OSA severity, with marked central fat deposition.[11] Many theories have been proposed to explain how fat accumulation increases the risk of OSA. As fat deposits around the pharyngeal region (neck region) it leads to an increased risk for upper airway collapsibility and central obesity (abdominal fat) also causes a decrease in lung volume and residual functional capacity leading to weakened caudal traction causing pharyngeal collapse.[20]

Blood pressure records of the study population revealed a significantly higher value (p<0.05) for systolic and diastolic BP among high-risk subjects but were not found to be an independent risk factor. Phillips et al also have previously reported elevated blood pressure as an important risk factor for OSA, and that OSA can be an important secondary cause of hypertension.[21] Elevated systolic and diastolic

pressure caused by apnea-hypopnea episodes keeps the mean blood pressure levels high at night and also during the daytime even when the breathing is normal.

A facial profile also could be an important component in diagnosing risk factors of OSA. Banabihl et al postulated in their study that a convex profile was more common in patients with OSA.[22] Convex profile because of mandibular retrognathism has an increased chance of upper airway collapse. The subjects in the high-risk group in our study also predominantly demonstrated a convex profile (48.4%) but were not statistically significant. Also, all those participants who reported snoring and tiredness were identified to be in the high-risk category. Berger et al found that patients with snoring had an increase in the apnoea/hypopnoea index over time which led to OSA.[23] Conversely, Chotinaiwattarakul et al reported a substantial reduction in patients' complaints of tiredness with good adherence to Continuous positive air pressure (CPAP) for OSA.[24]

There is a higher prevalence rate of crashes among SDB patients and they have an increased risk of morbidity and mortality, particularly due to excessive daytime sleepiness and cardiovascular diseases. EDS assessed subjectively by the Epworth sleepiness scale showed 29.6% among high-risk individuals. The results of the study indicate a marked overall association of SDB with high-risk factors for OSA. OSA patients are often tired and sleepy during the daytime and also contribute to neurocognitive deficits which can further impair their driving performance leading to road traffic crashes.[25] Additionally, a drowsy driver fails to assess the hazardous situations while driving due to impaired decision-making. The alarming higher percentage of high-risk group subjects in a smaller study sample of public transport drivers of the Kochi population necessitates screening of larger samples of public transport drivers. Proper awareness and screening of public transport drivers in coordination with transport authorities and health agencies regarding SDB may ensure the safety of both drivers and passengers. Thus, it is important to conduct systematic screening procedures among public transport drivers for identifying sleep-disordered breathing while driving license is being issued or renewed for ensuring road safety.

Conclusion

Sleep disorders are highly prevalent among public transport drivers leading to poor quality of sleep and motor vehicle crashes. In this study, older age and increased BMI indicating obesity were shown to be significant independent risk factors for developing OSA. Thus, the study findings emphasize the need to conduct screening protocols and awareness programs for identifying sleep disorders among public transport drivers for improving their general and psychological well-being and thus reducing road traffic crashes.

Acknowledgment: The support of all staff and colleagues of the Department of Orthodontics, Amrita School of Dentistry and Department of Biostatistics, Amrita Institute of Medical Sciences is gratefully acknowledged.

References

1. Garbarino S. Excessive daytime sleepiness in obstructive sleep apnea: implications for driving licenses. Sleep Breath. 2020;24(1):37-47. Available from: https://doi.org/10.1007/s11325-019-01903-6
2. Collen J, Lettieri C, Wickwire E, Holley A. Obstructive sleep apnea and cardiovascular disease, a story of confounders. Sleep Breath. 2020;24(4):1299-1313. Available from: https://doi.org/10.1007/s11325-019-01945-w
3. Burks SV, Anderson JE, Bombyk M, Haider R, Ganzhorn D, Jiao X, Lewis C, et al. Nonadherence with Employer-Mandated Sleep Apnea Treatment and Increased Risk of Serious Truck Crashes. Sleep. 2016;39(5):967-75. Available from: https://doi.org/10.5665/sleep.5734
4. Sebastian SK, Vaghela JF. Clinical use of STOP-BANG and ESS questionnaires in the evaluation of obstructive sleep apnoea-related risk factors for motor vehicle accidents among public transport drivers in Delhi, India. Sleep Breath. 2021;25(3):1461-6. Available from:

https://doi.org/10.1007/s11325-020-02277-w

5. Hein M, Lanquart JP, Loas G, Hubain P, Linkowski P. Prevalence and risk factors of moderate to severe obstructive sleep apnea syndrome in insomnia sufferers: a study on 1311 subjects. Respir Res. 2017;18(1):135. Available from: https://doi.org/10.1186/s12931-017-0616-8

6. Tregear S, Reston J, Schoelles K, Phillips B. Obstructive sleep apnea and risk of motor vehicle crash: systematic review and meta-analysis. J Clin Sleep Med. 2009;5(6):573-81. PMID: 20465027

7. Huhta R, Hirvonen K, Partinen M. Prevalence of sleep apnea and daytime sleepiness in professional truck drivers. Sleep Med. 2021;81:136-43. Available from: https://doi.org/10.1016/j.sleep.2021.02.023

8. Agrawal S, Sharma SK, Sreenivas V, Lakshmy R. Prevalence of metabolic syndrome in a north Indian hospital-based population with obstructive sleep apnoea. Indian J Med Res. 2011;134(5):639-44. Available from: https://doi.org/10.4103/0971-5916.90988

9. Evans KA, Yap T, Turner B. Screening Commercial Vehicle Drivers for Obstructive Sleep Apnea: Tools, Barriers, and Recommendations. Workplace Health Saf. 2017;65(10):487-92. Available from: https://doi.org/10.1177/2165079917692597

10. Romero-Corral A, Caples SM, Lopez-Jimenez F, Somers VK. Interactions between obesity and obstructive sleep apnea: implications for treatment. Chest. 2010;137(3):711-9. Available from: https://doi.org/10.1378/chest.09-0360

11. Ghosh P, Sapna Varma NK, Ajith VV, Suresh A. Upper Airway and its Association with Neck Circumference and Hyoid Position in OSA Subjects – A Cephalometric Study. Int J Cur Res Rev. 2021;13(6):167-71. Available from: https://doi.org/10.31782/IJCRR.2021.13610

12. Chan DC, Watts GF, Barrett PH, Burke V. Waist circumference, waist-to-hip ratio and body mass index as predictors of adipose tissue compartments in men. QJM. 2003;96(6):441-7. Available from: https://doi.org/10.1093/QJMED/HCG069

13. Purtle MW, Renner CH, McCann DA, Mallen JC, Spilman SK, Sahr SM. Driving with undiagnosed obstructive sleep apnea (OSA): High prevalence of OSA risk in drivers who experienced a motor vehicle crash. Traffic Inj Prev. 2020;21(1):38-41. Available from: https://doi.org/10.1080/15389588.2019.1709175

14. McNicholas WT, Rodenstein D. Sleep apnoea and driving risk: the need for regulation. Eur Respir Rev. 2015;24(138):602-6. Available from: https://doi.org/10.1183/16000617.0049-2015

15. Yusoff MF, Baki MM, Mohamed N, Mohamed AS, Yunus MR, Ami M, Othman I, Ishak AI. Obstructive sleep apnea among express bus drivers in Malaysia: important indicators for screening. Traffic Inj Prev. 2010;11(6):594-9. Available from: https://doi.org/10.1080/15389588.2010.505255

16. Ozoh OB, Okubadejo NU, Akanbi MO, Dania MG. High risk of obstructive sleep apnea and excessive daytime sleepiness among commercial intra-city drivers in Lagos metropolis. Niger Med J 2013; 54(4):224–9. Available from: https://doi.org/10.4103/0300-1652.119607

17. Reddy EV, Kadhiravan T, Mishra HK, Sreenivas V, Handa KK, Sinha S, et al. Prevalence and risk factors of obstructive sleep apnea among middle-aged urban Indians: A community-based study. Sleep Med. 2009;10(8):913–8. Available from: https://doi.org/10.1016/j.sleep.2008.08.011

18. Dubey A, Bajaj DK, Mishra A, Singh BP, Gupta V, Kant S, Dixit S. Obstructive sleep apnea risk for driving license applicants in India - A community-based study. Int J Occup Med Environ Health. 2018;31(1):25-36. Available from: https://doi.org/10.13075/ijomeh.1896.01021

19. Basoglu OK, Tasbakan MS. Elevated risk of sleepiness-related motor vehicle accidents in patients with obstructive sleep apnea syndrome: a case-control study. Traffic Inj Prev. 2014;15(5):470-6. Available from: https://doi.org/10.1080/15389588.2013.830213

20. Lam JCM, Sharma SK, Lam B. Obstructive sleep apnoea: Definitions, epidemiology & natural history. Indian J Med Res. 2010;131:165–70. PMID: 20308741

21. Phillips CL, O'Driscoll DM. Hypertension and obstructive sleep apnea. Nat Sci Sleep. 2013;10;5:43-52.

Available from: https://doi.org/10.2147/NSS.S34841

22. Banabilh SM, Samsudin AR, Suzina AH, Dinsuhaimi S. Facial profile shape, malocclusion and palatal morphology in Malay obstructive sleep apnea patients. Angle Orthod. 2010;80(1):37-42. Available from: https://doi.org/10.2319/011509-26.1

23. Berger G, Berger R, Oksenberg A. Progression of snoring and obstructive sleep apnoea: the role of increasing weight and time. Eur Respir J. 2009;33(2):338-45. Available from: https://doi.org/10.1183/09031936.00075408

24. Chotinaiwattarakul W, O'Brien LM, Fan L, Chervin RD. Fatigue, tiredness, and lack of energy improve with treatment for OSA. J Clin Sleep Med. 2009;5(3):222-7. PMID: 19960642.

25. Antonopoulos CN, Sergentanis TN, Daskalopoulou SS, Petridou ET. Nasal continuous positive airway pressure (nCPAP) treatment for obstructive sleep apnea, road traffic accidents and driving simulator performance: a meta-analysis. Sleep Med Rev. 2011;15(5):301-10. Available from: https://doi.org/10.1016/j.smrv.2010.10.002

International Journal of Occupational Safety and Health

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

Original Article

Sharp injuries during clinical training among medical students in the University of Peradeniya, Sri Lanka

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ABSTRACT

Introduction: Medical students are exposed to blood and body fluids during their clinical training which increases the risk of transmission of blood-borne infections. The objective of the study is to assess the prevalence, knowledge, attitude and practices regarding sharp injuries among final medical students of the University of Peradeniya, Sri Lanka

Methods: A survey was done among 210 final-year medical students of the University of Peradeniya with a self-administered online questionnaire including demographic information, experience, knowledge and reporting behavior following sharp injuries.

Results: Response rate was 80% (n=168). Sharp injuries were experienced by 22.6%. Most of the sharp injuries were sustained during venepuncture (39.5%). The majority (58.9%) did not adhere to universal precautions as they did not anticipate the event. One-third of the students (31.6%) did not know about universal precautions. Most of the students (68.4%) who had a sharp injury did not seek post-exposure assistance or prophylaxis. The majority of this group thought there is no risk (64%). Twenty-five students have not completed the full course of the hepatitis B vaccine. More than half (51.8%) of the fully vaccinated group were unaware of their immune status. The majority (67.3%) believed that their knowledge is not adequate regarding the prevention and management of needle stick injuries. The majority (97%) believed more emphasis should be given to knowledge and practice regarding sharp injuries.

Conclusion: The knowledge, attitude and practices of medical students regarding the prevention and management of sharp injuries were unsatisfactory. Poor awareness was observed regarding immune status following hepatitis B vaccination among medical students.

Keywords: Blood-borne infections, Health care workers, Medical students, Sharp injuries, Sri Lanka

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Date of submission: 29.06.2022
Date of acceptance: 15.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI: https://doi.org/10.3126/ijosh.v13i1.46260

Introduction

Healthcare workers (HCWs) including medical students are at a higher risk of exposure to infectious agents during clinical work. This includes exposure to contaminated sharp instruments which increases the risk of transmission of various blood-borne infections including HIV, Hepatitis B and C and many others.

Sri Lanka has a low level of HIV epidemic, with HIV prevalence below 0.1% which is well below other South Asian countries including India.[1]

Prevalence of Hepatitis B is less than 2% and Hepatitis C has an intermediate level prevalence in Sri Lanka.[2-4] But this recent change in social structure and proximity to India makes Sri Lanka very vulnerable to blood-borne infections.[5]

The health system in Sri Lanka is free for all and it caters ever-increasing number of patients with various medical conditions. The recent Covid 19 pandemic and an increasing number of dengue and leptospirosis patients have saturated the capacity in health care. HCWs are overburdened with the increasing patient numbers and the high number of clinical procedures carried out. The risk of occupational exposure to blood and blood products is invariably increased in HCWs who are overworking with many patients. The use of universal precautions before a clinical procedure and recommended practices after a possible exposure to blood or body fluids are practices at a lower level in developing countries.[6-8] This could be multifactorial including a lack of knowledge, lack of supervision, or unavailability of necessary personal protection equipment (PPE).

Medical students in their clinical years are expected to carry out many hands-on clinical procedures as a part of their curriculum. They are involved in clinical procedures such as blood draws, intravenous cannulation, and surgical procedures in the theatre and labor room. During these procedures, students are vulnerable to getting exposed to blood and body fluids. There are many factors contributing to this including, lack of practice and experience, and poor knowledge and practice about universal precautions.[9,10] After an exposure, practice of post-exposure prophylaxis and proper notification to relevant bodies are also not commonly seen.

The objective of this study is to assess the prevalence of exposure to blood and body fluids among final-year medical students at the University of Peradeniya. In addition, we have assessed knowledge, attitudes, and practices of universal precautions practiced and post-exposure prophylaxis. Knowledge of infections in occupational exposures and vaccinations to prevent infections were assessed.

Methods

A cross-sectional descriptive study of final-year medical students was carried out in 2022. Ethical clearance for the study was obtained by the Ethical Review Committee of the Faculty of Medicine, University of Peradeniya. The students in the sample were in the final year doing the second 8-week rotation of professorial appointment. There were 210 students registered in the batch. The link for the google form containing the questionnaire was forwarded to all the final year medical students via email. Along with the google form, an information sheet was forwarded explaining the purpose of the study. The questionnaire contained 102 items in the form of multiple-choice questions (MCQs) and short answer questions. English medium was used in the questionnaire. These questions assessed different domains of the objectives including prevalence, knowledge, attitude and practices regarding the prevention and management of sharp injuries. The frequencies, percentages and prevalence rate were calculated. Chi-square test was used to assess the significance when relevant.

Results

The response rate was 80% (n=168) and among them 54% were females. All participants were in the age group of 25-30 years (mean age 26.3). More than one-third (44.6%) reported not having any formal teaching and training on the prevention of needle stick injuries as a part of the curriculum. Among participants, 22.6% had sustained a sharp injury during clinical procedures. There is no statistically significant difference in exposure to blood or body fluids between males and females (P=0.2).

Most of the exposure to blood-borne infections was in the form of percutaneous injury by sharp instruments (86.8%). Others (13.2%) had exposure to body fluids and potentially infective material. Most of the needle stick injuries were sustained during venepuncture (39.5%). Nearly one-fourth of needle stick injuries were during performing or assisting surgery. More than one-fifth (21%) had a percutaneous injury during suturing of episiotomies (Figure 1).

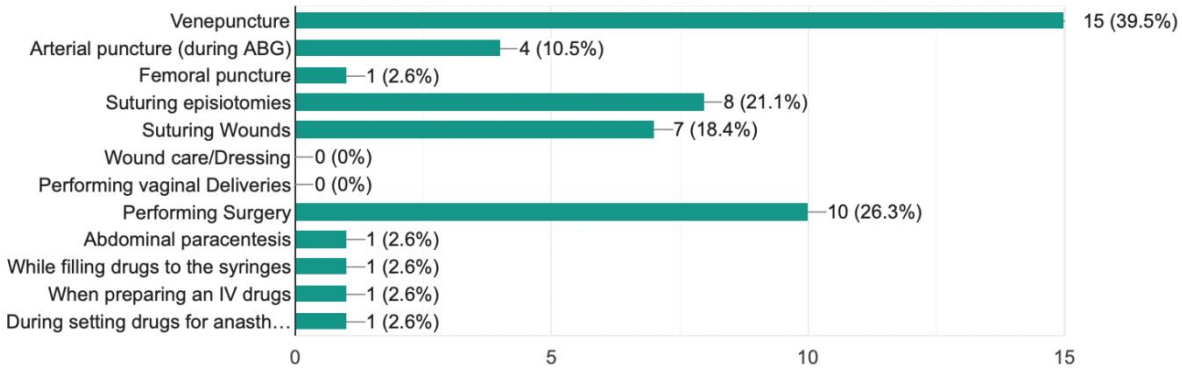

Figure 1- Type and frequency of sharp injuries

Attitude and practices regarding preexposure precautions

Only 52.6% of students who had a sharp injury believed that they practiced universal precautions during the clinical procedure. Most of the students (89.5%) used gloves during the procedure. Among this group, 58.9% reported not using universal precautions as they did not anticipate the event. One-third of the students (31.6%) in this group did not know about universal precautions. Reasons that the student provided for non-adherence to universal precautions are summarized in figure 2

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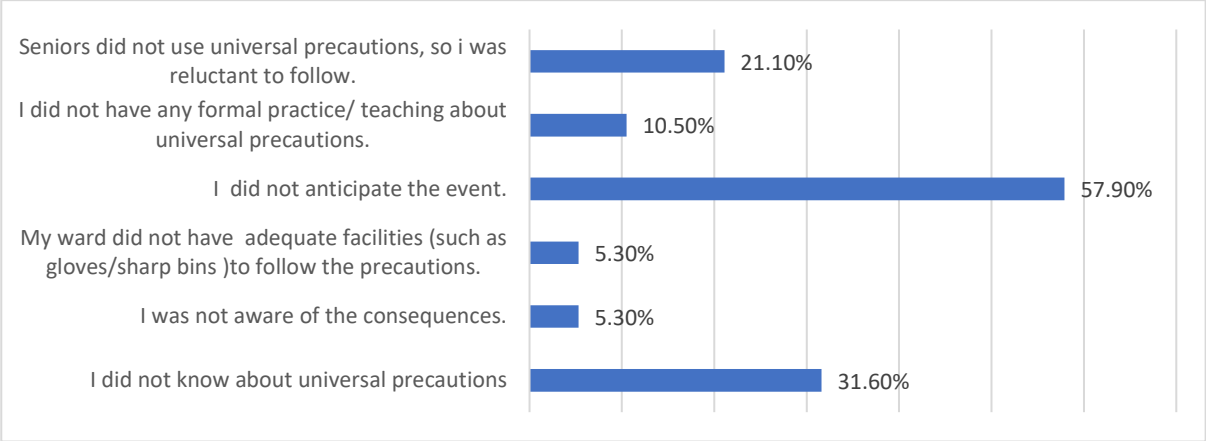

Figure 2- Reasons for not following universal precautions

Attitude and practices regarding postexposure prophylaxis

Among the students who had a sharp injury, 84.2% washed the prick site with runny water. Two students did not do anything specific. A small per cent of the exposed group followed measures that are not recommended such as scrubbing, squeezing, and applying antiseptics.

Most of the students (68.4%) who had a sharp injury did not seek post-exposure assistance or prophylaxis. The majority of this group thought there is no risk (64%). Eight students have taken a detailed history from the source person and decided that there is no additional risk (Figure 3).

Among students who have sought post-exposure assistance, the majority informed ward sister (n=16) and the infection control unit (n=15). But only 11 students had their exposure documented and notified. Three students were started on post-exposure prophylaxis (PEP) for HIV after the exposure.

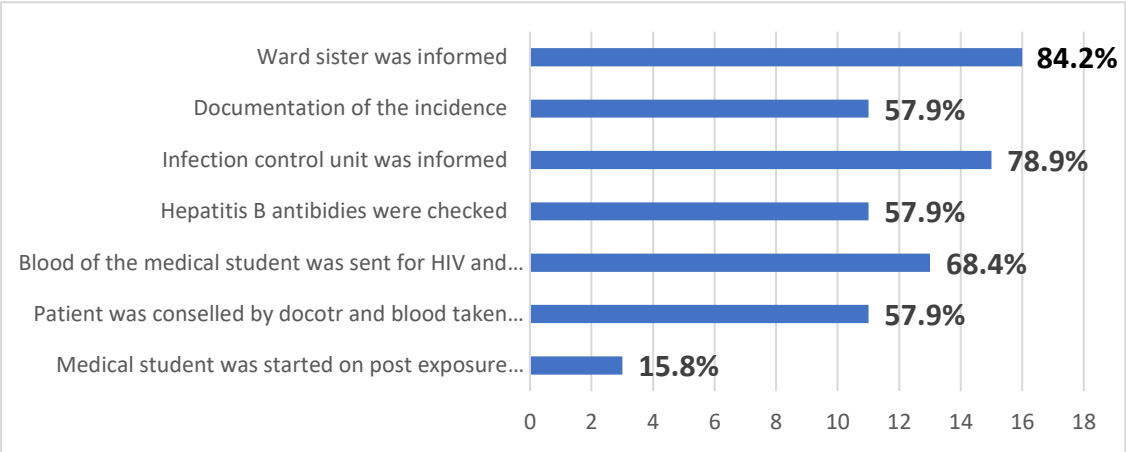

Figure 3- Actions occurred after sustaining a needle stick injury

Knowledge about blood-borne infections

Most of the students were aware that Hepatitis B (n=167) and HIV (n=165) can be transmitted through sharp injuries. But only 73.2% of the study group were aware that Hepatitis C can be transmitted by a needle prick injury.

Among final-year medical students, 14.9% (n=25) have not completed the full course of the hepatitis B vaccine although most of them (97%) were aware that the hepatitis B vaccine is recommended for HCWs. More than half (51.8%) of the students who had the full course of hepatitis B vaccine, were not aware of the hepatitis B antibody status and 41.1% did not know where to go to get their antibody levels checked. Twenty-nine students (17.3%) were not aware or had heard of post-exposure prophylaxis.

Only one-third of the students (32.7%) believed that their knowledge is adequate regarding the prevention and management of needle stick injuries. The majority of the students (95%) believed that more emphasis on improving the knowledge and practice regarding sharp injuries should be given in the clinical curriculum

Discussion

The medical students are having a hands-on exposure to a wide variety of clinical procedures during their clinical appointments as a part of the medical curriculum. Some of the procedures were directly supervised by the doctors such as assisting in major surgery, but some are not directly supervised such as suturing episiotomies or venepuncture. Some clinical procedures are taught to medical students by junior doctors (e.g. house officers) or nurses in informal ways such as venepuncture and episiotomy suturing. Lack of experience and practice makes them more vulnerable to getting exposed to blood and body fluids during these procedures. This mainly involves sustaining sharp injuries leading to an increased risk transmitting of blood-borne infections. This study showed a significant proportion of medical students getting exposed to sharp injury during clinical procedures and unsatisfactory pre-exposure precautions and post-exposure prophylaxis.

In a study done in Sri Lanka in 2008 among medical students at the University of Colombo, 95% of the students had one or more sharp injuries.[11] But among 168 final-year medical students at the University of Peradeniya, only 22.6% had a sharp injury during their clinical training. An in-depth analysis needs to be done to identify factors for this difference. But the final year medical student batch we studied in 2022 completed their 3rd and 4th clinical years amidst the Covid Pandemic, which probably affected their clinical exposure. A reduction in the number of clinical procedures a student carries out would invariably lead to a reduction in sharp injuries sustained. But this needs to be supported with further data and research.

Most of the sharp injuries sustained by students were during venepuncture. A significant number of students had sharp injuries during episiotomy

suturing and assisting surgery. Most medical students gain the skill of venepuncture through junior doctors or nurses and episiotomy suturing through junior doctors. They do not have any formal teaching or hands-on skills training sessions in a skills laboratory on these procedures. After minimal training, they tend to perform these procedures unsupervised.[12] Therefore, they carry a high risk of sustaining sharp injuries inadvertently.

Universal precautions during a clinical procedure should be taught, supervised, and reinforced among medical students. It should be an essential component of the medical curriculum.[13] Skills laboratories available in the universities and hands-on training sessions on universal precautions can be easily introduced and students can be trained. Among the medical students who sustained sharp injuries nearly one-third were not aware of the universal precautions. Among those who did not use universal precautions, many did not anticipate sharp injury. And some reported that they were reluctant to use universal precautions as they were not practiced by the seniors.

Most of the students (97%) were aware of hepatitis B vaccination is recommended for HCWs, but 15% of the students in the final year have not completed the full course of vaccine. Among students, 58.9% knew that only some people develop protective antibodies against the Hepatitis B vaccine, and more than half of the students did not have their hepatitis B antibody level checked. This is significant as vaccination induces antibodies only in 85% of people and it may give a false sense of security to the student about security.[14] Among these students, 41.1% did not know where to go to get the antibodies checked. This is an important aspect that needs to be addressed and students should be motivated to get their hepatitis B immune status checked.

Post-exposure prophylaxis is known to significantly reduce the transmission of blood-borne viral infections such as hepatitis B and HIV, provided that they are started promptly after a risk assessment.[15,16] In this study, we found a significantly low level of reporting and seeking assistance after a sharp injury. The vast majority (68.4%) did not seek any post-exposure assistance or prophylaxis. The main reason was the perception of the medical students that there is no additional risk. Some students have talked with the source patient and reassured themselves as no risk. Reporting to ward sister and infection control unit remained at a low level and low level of notification and documentation were noted among students.

Conclusions

We found that the knowledge, attitude, and practices of medical students regarding the prevention and management of sharp injuries are not satisfactory. Poor awareness was observed regarding confirming immunity following hepatitis B vaccination among the medical students.

The study emphasizes that medical students should receive comprehensive pre-clinical training on universal precautions and post-exposure management of sharp injuries. Universities can use skill laboratories to improve student's hands-on skills to give confidence and competence before dealing with patients. Adopting a strategy to improve hepatitis B vaccination and assessing the immune status during the pre-clinical years of the medical student would minimize the risk of hepatitis B transmission.

Limitations

Clinical exposure of the studied student batch was somewhat compromised due to the Covid pandemic in Sri Lanka and this might have affected the lower incidence of sharp injuries.

References

1. UNAIDS Data 2019. Geneva: UNAIDS, 2020. Available from: https://www.aidsdatahub.org/resource/unaids-data-2019

2. Senevirathna D, Amuduwage S, Weerasingam S, Jayasinghe S, Fernandopulle N. Hepatitis C virus in healthy blood donors in Sri Lanka. Asian J of Transfus Sci. 2011 Jan;5(1):23-5. Available from: https://doi.org/10.4103/0973- 6247.75976

3. Niriella MA, Hapangama A, Luke HP, Pathmeswaran A, Kuruppuarachchi KA, de Silva HJ. Prevalence of hepatitis B and hepatitis C infections and their relationship to injectable drug use in a cohort of Sri Lankan prison inmates. Ceylon Med J. 2015 Mar;60(1):18-20. Available from: https://doi.org/10.4038/cmj.v60i1.7288

4. Noordeen F, Pitchai FN, Rafeek RA. A Review of Hepatitis B Virus Infection in Sri Lanka. Sri Lankan Journal of Infectious Diseases 2015;5(2):42-50. Available from: https://doi.org/10.4038/SLJID.V5I2.8087

5. Rodrigo C, Rajapakse S. Current Status of HIV/AIDS in South Asia. J Glob Infect Dis. 2009 Jul;1(2):93-101. Available from: https://doi.org/10.4103/0974-777X.56249

6. Simonsen L, Kane A, Lloyd J, Zaffran M, Kane M. Unsafe injections in the developing world and transmission of blood-borne pathogens: a review. Bull World Health Organ. 1999;77(10):789–800. Available from: https://pubmed.ncbi.nlm.nih.gov/10593026/

7. Elmiyeh B, Whitaker IS, James MJ, Chahal CA, Galea A, Alshafi K. Needle-stick injuries in the National Health Service: A culture of silence. J R Soc Med. 2004;97(7):326–7. Available from: https://doi.org/10.1177/014107680409700705

8. Musa S, Peek-Asa C, Young T, Jovanovic N. Needle Stick Injuries, Sharp Injuries and other Occupational Exposures to Blood and Body Fluids among Health Care Workers in a general hospital in Sarajevo, Bosnia and Herzegovina. Int J Occup Saf Health. 2014;4(1):31-7. Available from: https://doi.org/10.3126/ijosh.v4i1.9847

9. Elliott SK, Keeton A, Holt A. Medical students' knowledge of sharps injuries. J Hosp Infect. 2005Aug;60(4):374-7. Available from: https://doi.org/10.1016/j.jhin.2005.01.033.

10. Varsou O, Lemon JS, Dick FD. Sharps injuries among medical students, Occup Med (Lond). 2009;59(7):509-11. Available from: https://doi.org/10.1093/occmed/kqp103

11. Liyanage IK, Caldera T, Rwma R, Liyange CK, De Silva P, Karunathilake IM. Sharps injuries among medical students in the faculty of medicine, Colombo, Sri Lanka. Int J Occup Med Environ Health. 2012;25(3):275-280. Available from: https://doi.org/10.2478/S13382-012-0036-4

12. Shen C, Jagger J, Pearson RD. Risk of needle stick and sharp object injuries among medical students. Am J infect control. 1999 Oct;27(5)435-7. Available from: https://doi.org/10.1016/s0196-6553(99)70010-6

13. Ankita B, Ipsa M. First year medical students and standard precautions: The need for change. Clin Epidemiol Glob Health. 2021;9:221-6. Available from: https://doi.org/10.1016/j.cegh.2020.09.002

14. Salisbury D, Ramsay M, Noakes K. Immunisation against infectious disease. London: TSO; 2006. Available from: https://www.hug.ch/sites/hde/files/structures/pharmacologie_et_toxicologie_cliniques/documents/utilisation_vaccins.pdf

15. Ingerslev J, Mortensen E, Rasmussen K, Jorgensen J, Skinhoj P. Silent hepatitis-B immunization in laboratory technicians. Scand J Clin Lab Invest. 1988;48(4):333–6. Available from: https://doi.org/10.3109/00365518809167504

16. Gerberding JL. Management of occupational exposures to blood-borne viruses. N Engl J Med. 1995;332:444–51. Available from: https://doi.org/10.1056/NEJM19950216332070

International Journal of Occupational Safety and Health

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

Original Article

Assessment of noise-induced hearing loss (NIHL) of weaving factory workers in West Bengal, India - a pilot study

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ABSTRACT

Introduction: Excessive noise exposure is one of the majorly considered occupational stressors for industrial workers. The operation of steel weaving machinery producing a high level of noise such as weaving machines, crimping machines, and hydraulic press machines for a prolonged period increases the risk of developing noise-induced hearing loss (NIHL). The main aim of the study was to assess the auditory health of the workers exposed to a high level of noise in a steel weaving factory and the prevalence of NIHL among workers.

Methods: Twenty six (26) subjects in the age group of 25-55 years from a steel weaving industry of Chinsurah town, Hooghly district of West Bengal were randomly selected with 5 years of exposure for the study. The control group was selected from the same age group, socioeconomic status and geographical location and had no history of such exposure. The physiological parameters of the workers, noise levels in the workplace and auditory functions and the risk of NIHL were assessed by standardized protocol and statistically analyzed.

Results: The study indicated that steel weaving factory workers had significantly reduced hearing functionality at 4000Hz and 6000Hz in the left ear respectively. It also revealed that the workers were exposed to high noise exposure of 131dB near the weaving machine, 113dB at the crimping machine, and 84dB at the hydraulic press machine respectively.

Conclusion: A high level of noise exposure leads to deterioration in the hearing capabilities of steel-weaving industrial workers. Implementation of ergonomic interventions in the workplace and the use of personal protective equipment (PPE) may decrease the prevalence of NIHL and can help to prevent hearing loss in workers.

Keywords: Auditory health, NIHL, occupational stress, steel weaving factory workers

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Date of submission: 12.01.2022
Date of acceptance: 08.07.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None

DOI:
https://doi.org/10.3126/ijosh.v13i1.42281

Introduction

Hearing loss is ranked the fourth highest cause of disability across the globe estimating 466 million people having disabling hearing loss.[1] Occupational noise exposure is the major stress undergone by industrial workers and is the second major self-reported occupational illness having social, functional and economic impacts on industrial workers.[2-3] Noise harm the health of individuals and the community exposed. It disturbs the work-rest cycle and biological rhythm of the individuals leading to damaged hearing and eliciting physiological, psychological and pathological reactions.[4] Occupational hearing loss is considered one of the majorly occurring occupational diseases.

It is found about 49% of male miners undergo hearing loss at the age of 50. The figure rises to 70% by the age of 60. Occupational hearing loss is faced by a large sector of the working force.[5] It is estimated about 16% of the disabling hearing loss in adults develops on exposure to occupational noise.[6]

Hearing loss developing from chronic noise exposure leads to the gradual disruption of hearing sensitivity which on being unaware later develops into NIHL.[7]

The occupation having a high risk of NIHL includes heavy engineering, quarrying, tunneling, mining and textile machinery.[2] NIHL is defined as an incurable and irreversible disease with prevention being of primary importance. The early signs of occupational hearing loss can be detected by simple audiometric evaluations. A periodic audiometric examination can be considered the principal medical prevention of excessive noise exposure.[8-9] According to OSHA if the noise level in the workplace is 85 dB(A) or above for an average period of eight hours the employers must organize a hearing conversation program for the employees.[10]

Occupational health diseases often have a long latency period, making it difficult to diagnose at the primary stage. [11] It is important to assess workers hearing functionality for preventing the risk of developing NIHL.[12] Periodic hearing conservation program with audiometric screening tests in the workplace for the workers can increase the effectiveness of the hearing protection protocol and proper education for increasing awareness of risks of noise exposure. The present study was made to assess the auditory health of the workers exposed to the high level of noise in a steel weaving factory and the prevalence of NIHL among workers and to compare the auditory health (at varied frequencies) in both the ears of the workers working in steel weaving factory with the control group.

Methods

The study was conducted on workers of a steel weaving factory in Chinsurah town, Hooghly district of West Bengal. Twenty-six steel weaving factory workers were randomly selected for the prevailing study as the experimental group. All the selected workers were having a minimum working experience of 5 years of their present occupation and were in the age group of 25-55 years. The control group was selected from the same socioeconomic and geographical locations. The consent of the workers was taken verbally before the study.

A study was made based on the auditory complaints of the workers of a steel weaving factory for the study period. The questionnaire comprised of series of polar questions on hearing discomfort and using of PPEs- "Do you recently have difficulty in hearing words clearly?", "Are you having difficulty in hearing while working- yes or No?", "Do you feel frustrated when you do not get words clear- yes or no?"," Do you experience tinnitus after working with the machine- yes or no?", " Do you experience pain during working with noise-producing machine- yes or no?","Do you use PPE while working- yes or no?- if No then "Do you think of using PPEs while working – yes or no?"

The physiological parameters involving blood pressure, pulse rate, and mid-arm circumference of the steel weaving factory workers and the control group were assessed using a standardized protocol. The noise levels at the different areas of the steel weaving factory were taken during the working period using Cel-231 Type 2A sound level meter. Three readings were taken near the operation of machinery in the beginning hours, in the middle and at the end of the working day. The locations from where the readings were taken were near the weaving machine, crimping machine and Hydraulic press machine respectively.

All the audiograms were assessed using Arphi audiometer. Bone and air conductance for both ear were performed from 1000Hz to 8000Hz respectively.

Hearing loss can be categorized into five types.[13]

Mild HL: hearing threshold between 26-40 dB HL.
Moderate HL: hearing threshold between 41-55 dB HL.
Moderately severe HL: hearing threshold between 56-70 dB HL.
Severe HL: hearing threshold between 71-90 dB HL.
Profound HL: hearing threshold more than +90 dB HL

Student "t" test was performed among the steel weaving factory workers and the control group to find out whether there is any significant difference between the physical parameters and thresholds of hearing for frequencies 1000 Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz respectively for the chosen level of significance($p< 0.05$). Statistical analysis was performed using SPSS version 17 (Chicago, Illinois, USA).

Results

Table 1 represents the demographic information of the male steel weaving factory workers denoted as the exposed group and the control group showing the mean age of the exposed group is 31.10 years, height and weight to be 162.93 cm and 64.62 cm while the mean age of the control group is 32.35 years, height and weight is 161.69 cm and 64.50 cm respectively. From Table 1 it was observed that there was no significant change in age, stature, and weight between the exposed and control groups.

The mean values of the physiological parameters including systolic pressure,diastolic pressure, pulse rate and Mid arm circumference of the noise exposed group and control group is represented in Table-2. It was observed that there was significance change in systolic pressure between exposed and control group.

We have observed sound levels at various workplaces where different machineries (weaving machine, cramping machine and Hydraulic press machine) are operated. The mean noise levels near weaving machine, cramping machine and Hydraulic press machine is found to be 131.83 dB, 113dB and 84.16 dB respectively as shown in Table 3.

Table 1. Demographic information about the noise Exposed group and Control group

Parameters	Exposed Group	Control Group	t value	P value
Age(years)	31.10(±7.92)	32.35(±7.73)	0.58	0.57
Height (cm)	162.93(±7.23)	161.69(±7.87)	0.59	0.57
Weight (cm)	64.62(±9.52)	64.50(±9.11)	0.04	0.96

Table 2. Physiological parameters of the Noise exposed group and control group

Parameters	Exposed Group	Control Group	t value	P value
Systolic pressure(mm Hg)	133.46(±10.89)	121.62(±5.66)	4.91	P<0.0001
Diastolic pressure(mm Hg)	79.04(±7.06)	80.08(±0.69)	0.75	0.46
Pulse rate(bpm)	76.73(±6.84)	72.19(±4.14)	2.89	P=0.005
Mid arm circumference(cm)	28.15(±2.18)	25.77(±2.09)	4.01	P=0.0002

Table 3. Noise levels in selected workplaces

Workplace areas	Noise level(dBA)
Near weaving machine	131.83±1.25
Cramping machine	113±10
Hydraulic press machine	84.16±0.76

About 73% of the steel weaving factory workers responded to having difficulty hearing words clearly. 69% of the exposed population faced difficulty in hearing properly. From the study, it was observed that about 62% of the workers responded to being frustrated when do not get the words clear. 58 % of the workers agreed on experiencing tinnitus after working with machines and ear pain during working with noise-producing machines. Only 31% of the study population used PPEs while working and 38% of the steel weaving factory workers responded to not thinking of using PPEs while working as mentioned in Table 4.

The mean hearing threshold level of both the right and left ear of the exposed group and control group at a varied frequencies of 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz respectively is shown in Table 5. It was observed that there was a significant difference in hearing threshold levels at varied tested frequencies in the exposed and control group.

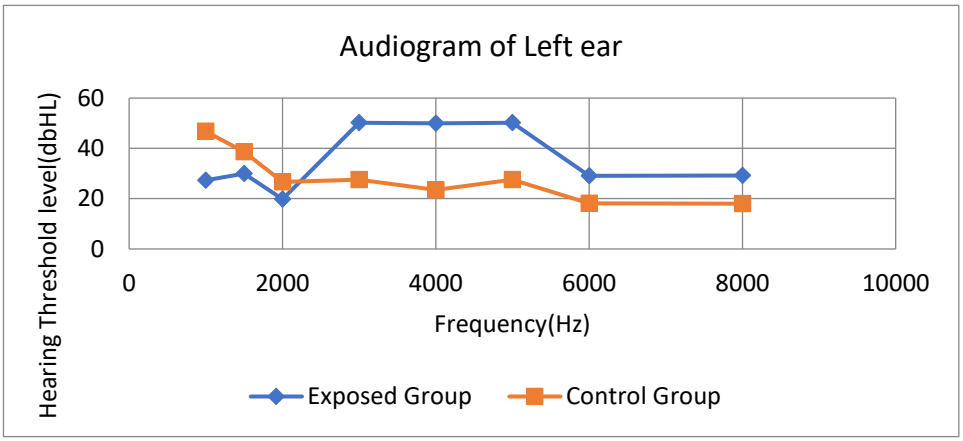
Table 4. Frequency distribution of Auditory complaints and practices

Auditory complaints and Practices	**Steel weaving factory workers**
Do you recently having difficulty in hearing words clear?	19 (73%)
Are you having difficulty in hearing while working?	18 (69%)
Do you feel frustrated when you do not get words clear?	16 (62%)
Do you experience tinnitus after working with machine?	15 (58%)
Do you experience ear pain during working with noise producing machine?	15 (58%)
Do you use PPE while working?	08 (31%)
Do you think of using PPEs while working?	10 (38%)

Table 5. Hearing Threshold of the noise exposed group and control group for the tested frequency

Frequency(Hz)	**Ear**	**Exposed group**	**Control group**	**t value**	**P value**
1000	Left	27.31(±2.54)	46.73(±4.89)	17.97	P<0.0001
1000	Right	27.50(±2.55)	50.58(±4.08)	24.46	P<0.0001
1500	Left	30(±4.00)	38.65(±5.20)	6.72	P<0.0001
1500	Right	29.81(±4.11)	39.62(±5.81)	7.02	P<0.0001
2000	Left	19.81(±3.86)	26.73(±5.46)	5.27	P<0.0001
2000	Right	17.50(±2.55)	27.31(±6.20)	7.46	P<0.0001
3000	Left	50.19(±4.57)	27.50(±2.91)	21.35	P<0.0001
3000	Right	54.23(±3.65)	29.23(±5.03)	20.51	P<0.0001
4000	Left	50.00(±5.2)	23.46(±3.67)	21.26	P<0.0001
4000	Right	47.31(±5.51)	24.23(±3.92)	17.40	P<0.0001
5000	Left	50.19(±4.57)	27.50(±2.91)	21.35	P<0.0001
5000	Right	54.04(±3.74)	29.23(±5.03)	24.81	P<0.0001
6000	Left	29.04(±3.47)	18.08(±3.76)	10.92	P<0.0001
6000	Right	28.46(±5.43)	18.65(±3.62)	7.66	P<0.0001
8000	Left	29.23(±5.94)	18.00(±3.67)	8.20	P<0.0001
8000	Right	28.46(±5.43)	18.69(±3.62)	7.63	P<0.0001

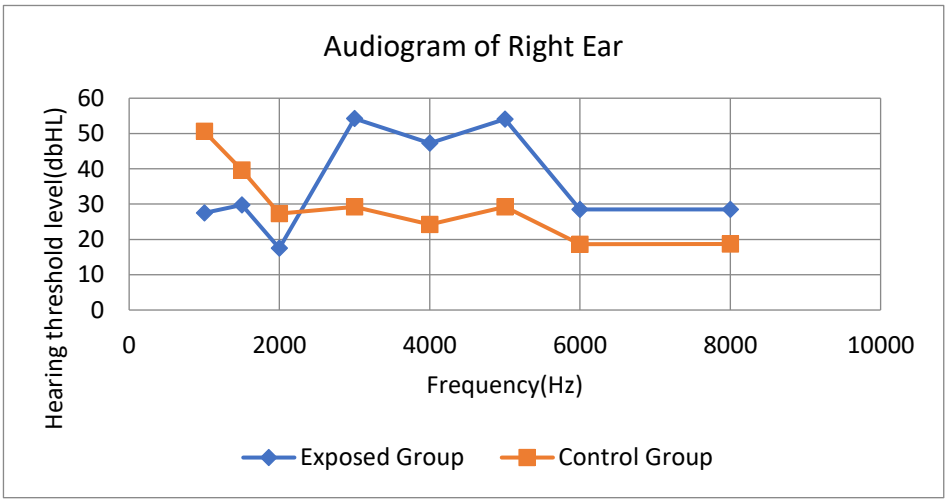
Figure 1. Mean hearing threshold levels of left ear of exposed group and control group for various tested frequency



The mean hearing threshold level of the left ear of the noise-exposed group and control group at different tested frequencies (1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz) is shown in fig 1. A significant change in hearing threshold level in the left ear is observed in the exposed and control group.

The mean hearing threshold level of the right ear of the noise-exposed group and control group at different tested frequencies (1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz, 5000Hz, 6000Hz and 8000Hz) is shown in fig 2. A significant change in hearing threshold level in the right ear is observed in the exposed and control groups.

Figure 2. Mean hearing threshold levels of the right ear of the exposed group and control group for various tested frequency



Discussion

NIHL is considered one of the completely preventable hearing losses having significant health coupled with economic consequences primarily observed in southeast Asian countries.[14] The present study showed the mean age of the steel weaving factory workers was 31.10 years within the age group of 25-55 years as shown in Table 1. The result was found to be consistent with the studies that prevailed in Thailand and Pakistan with mean ages of 33.8 years and 34.3 years respectively. [15-16] Most of the studies conducted in industrial workers in Bhutan, Thailand belong to the age group of 31-40 years.[17-19] The workers of the steel weaving factory work in 8 hours shift duration. According to the Factories act 1951 and standardized by International Labour Organization the working hours for continuous processes in Myanmar should not

exceed 8 hours a day or 44 hours or 48 hours. In the study, a significant increase in blood pressure (systolic blood pressure) was found in the noise-exposed group than the control group shown in Table 2.

Dzhambov et al. in their study showed a significant increase in the blood pressure of the workers who were exposed to occupational noise.[20] The study showed similar results in a Taiwan study showing a positive correlation between blood pressure level and noise level.[21] The noise levels in the workplaces where various types of machinery involving weaving machines (121.83 dbA), cramping machines (113 dbA), and Hydraulic machines (84.16 dBA) were measured as shown in Table 3. The study showed the workers are exposed to highly hazardous noise levels for a prolonged period of 8 hours of work shift which may lead to hearing loss. Kerdonfag P et al. mentioned in their study one time or prolonged period of exposure to loud noise can lead to hearing loss. Continuous exposure to loud noise for a prolonged period increases the risk of progressive and irreversible hearing loss in both ears.[22] The NIOSH denotes 85dB(A) and more noise level as the restricting level for preventing hearing loss. The study made in Thailand [19] stated a significant increase in the risk of developing hearing loss among workers who are exposed to high noise levels above 85db(A). The noise-exposed group of the present study can be at higher risk of hearing loss development than the control group. The noise level measurements were made on A weighted network based on the simplicity and accuracy of the scale in evaluating hearing hazard. The scale has been internationally adopted for the assessment of noise exposure.[23-24] From the study it was found that only 31% of the steel weaving workers used PPE while working with weaving machinery shown in Table 4. This may be due to poor awareness of NIHL risk and protective measures of PPE at the workplace. A United States study has shown increased reporting of hearing loss in unprotected workers.[25] A study on industries showed the implementation of noise-reduction measures and the use of hearing PPE reduced hearing damage in young workers.[26] Use of hearing protectors such as earmuffs, ear canal caps and ear plugs to reduce the noise level to a safer level should be promoted when engineering controls and work methods cannot be under feasibility.[27] In the present study about 69% of the noise-exposed group have difficulty in hearing the words clearly. Studies mentioned a loss of clarification of perceived speech and difficulty in distinguishing particular words is observed among individuals having NIHL.[28-29] Among the 26 noise-exposed subjects 58% experience tinnitus after working in a noisy environment. Teixeira et al. stated the development of tinnitus from exposure to loud noise. The workers having hearing loss fails to mark hearing ability changes till the occurrence of a large threshold shift. The irreversible characteristic of tinnitus and severity increased with continued exposure.[30] About 62% of the exposed group feel frustrated due to poor perception of the words. This may be due to the development of tinnitus which leads to the development of annoyance and poor mood. Tinnitus is considered one of the major problems for noise-exposed workers, primarily affecting mood, sleep, concentration, and quality of life.[31] Sheppard et al. stated inability to get speech properly in the everyday situation due to hearing loss have a severe social impact.[32] In the present study we found from the audiometric results shown in Table 5 the steel weaving factory workers significantly differed from the control group and were at significantly higher risk of developing bilateral NIHL than the control group in varied tested frequencies of 1000 Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz,6000Hz and 8000 Hz respectively. Narasimhan et al. mentioned 4000Hz frequency to be severely affected by chronic noise exposure along with higher frequency (3 kHz-6KHz) than the lower frequencies (500Hz- 2KHz).[33] Based on the hearing threshold level of the exposed group and control group at higher frequencies of 3kHz- 8kHz shown in Table 3, referring to the Olusanya et al. categorization of hearing loss the noise-exposed group has the probability of developing mild hearing loss As the noise-exposed workers of the steel weaving factory are exposed to chronic noise level for a prolonged period and not using PPE for convenience while working can have a cumulative effect on the increased risk of developing bilateral NIHL.

Conclusion

From the results and analysis of the study, it can be concluded that the steel weaving factory workers are exposed to hazardous noise levels in the workplace for an extended period of 8 hours of work shift, which may result in hearing loss. About 69% of the noise-exposed populations reported complaints of difficulty in hearing and more than 58% of the workers complained of tinnitus showing the probability of the development of hearing loss. Only 31% of the steel weaving workers use PPE while exposed to chronic noise indicating poor awareness of noise exposure effect and NIHL risk in the workplace. The audiometric results showed the noise-exposed workers have the highest mean hearing threshold levels in 3KHz -5KHz than the control group suggesting the probability of developing mild hearing loss which gradually can develop into bilateral NIHL. Significant increases in blood pressure observed in the noise-exposed workers increase the risk of the development of hypertension. Occupational NIHL is considered one of the completely preventable hearing losses with significant health and economic consequences mostly occurring in developing countries. Since noise levels in the workplace are uncontrollable, the use of PPE while working on steel weaving machinery can help workers avoid hearing loss. Strict enforcement of the self-protective measures-use of noise-canceling earmuffs, ear canal caps, and ear plugs should be encouraged and periodic hearing conservation with audiometric screening tests can help to check the risk of NIHL.

Acknowledgments

We authors acknowledge all the workers of the steel weaving factory in Chinsurah town, Hooghly district of West Bengal for their support and assistance throughout the research work.

References

1. World Health Organization. Addressing the prevalence of hearing loss.[Internet] Geneva: World Health Organization; 2018 February. p. 3e10. [Accessed on 05-05-22]
2. Masterson EA, Bushnell PT, Themann CL, Morata TC. Hearing impairment among noise-exposed workers—United States, 2003–2012. Morbidity and Mortality Weekly Report. 2016 Apr 22;65(15):389-94. Available from: https://doi.org/10.15585/mmwr.mm6515a2
3. Murphy E, King EA. Environmental noise pollution: Noise mapping, public health, and policy. Elsevier; 2022 Apr 9.ISBN: 9780124115958
4. Meetham AR, Bottom DW, Cayton S. Atmospheric pollution: its history, origins and prevention. Elsevier; 2016 Jan 21. ISBN: 9780128166932
5. Nyarubeli IP, Tungu AM, Bråtveit M, Sunde E, Kayumba AV, Moen BE. Variability and determinants of occupational noise exposure among iron and steel factory workers in Tanzania. Annals of work exposures and health. 2018 Nov 12;62(9):1109-22. Available from: https://doi.org/10.1093/annweh/wxy071
6. Graydon K, Waterworth C, Miller H, Gunasekera H. Global burden of hearing impairment and ear disease. The Journal of Laryngology & Otology. 2019 Jan;133(1):18-25. Available from: https://doi.org/10.1017/S0022215118001275
7. Ding T, Yan A, Liu K. What is noise-induced hearing loss?. British Journal of Hospital Medicine. 2019 Sep 2;80(9):525-9. Available from: https://doi.org/10.12968/hmed.2019.80.9.525
8. Prokopenko LV, Courierov NN, Lagutina AV, Pochtariova ES. Calculation and assessment noise induced hearing loss excess risk in group of population. Russian Journal of Occupational Health and Industrial Ecology. 2019 May 20(4):212-8. Available from: https://doi.org/10.17116/otorino20208506127
9. TSha SH, Schacht J. Emerging therapeutic interventions against noise-induced hearing loss. Expert opinion on investigational drugs. 2017 Jan 2;26(1):85-96. Available from: https://doi.org/10.1080/13543784.2017.1269171
10. Hemmativaghef E. Exposure to lead, mercury, styrene, and toluene and hearing impairment: evaluation of dose-response relationships, regulations, and controls. Journal of occupational and environmental hygiene. 2020 Dec 1;17(11-12):574-97. Available from: https://doi.org/10.1080/15459624.2020.1842428
11. Rabinowitz P, Cantley LF, Galusha D, Trufan S, Swersey A, Dixon-Ernst C, Ramirez V, Neitzel R. Assessing hearing conservation program effectiveness. Journal of Occupational and Environmental Medicine. 2018 Jan 1;60(1):29-35. Available from:

https://doi.org/10.1097/JOM.0000000000001125

12. Abraham Z, Massawe E, Ntunaguzi D, Kahinga A, Mawala S. Prevalence of noise-induced hearing loss among textile industry workers in Dar es Salaam, Tanzania. Annals of global health. 2019;85(1). Available from: https://doi.org/10.5334/aogh.2352
13. Olusanya BO, Davis AC, Hoffman HJ. Hearing loss grades and the International classification of functioning, disability and health. Bulletin of the World Health Organization. 2019 Oct 10;97(10):725. Available from: https://doi.org/10.5334/aogh.2352
14. Davis AC, Hoffman HJ. Hearing loss: rising prevalence and impact. Bulletin of the World Health Organization. 2019 Oct 10;97(10):646. Available from: https://doi.org/10.2471/BLT.19.224683
15. Aljunid SM, Tahir NB. Noise Induced Hearing Loss in Manufacturing Industries: How Much Does It Cost to the Workers, Families and Society?. Partridge Publishing Singapore; 2020 Apr 24. (Accessed on 15-05-22)
16. Sheikh MS, Majeed S, Ali S. Noise induced hearing loss among industrial workers of South Punjab, Pakistan. The Professional Medical Journal. 2020 May 10;27(05):1022-6.Available from: https://doi.org/10.29309/TPMJ/2020.27.05.4115
17. Wangchuk P, Dendup P. Prevalence of Occupational noise induced hearing loss (ONIHL) among industrial workers in Bhutan. Bhutan Health Journal. 2020;6(1):25-31. Available from: https://doi.org/10.47811/bhj.96
18. Jhanwar D. Noise pollution: a review. Journal of Environment Pollution and Human Health. 2016;4(3):72-7. Available from: https://doi.org/10.12691/jephh-4-3-3
19. Sriopas A, Chapman RS, Sutammasa S, Siriwong W. Occupational noise induced hearing loss in auto part factory workers in welding units in Thailand. J Occup Health 2016:15e291. Available from: https://doi.org/10.1539/joh.15-0291-OA
20. Dzhambov AM, Dimitrova DD, Dzhambov A. Association between noise pollution and prevalent ischemic heart disease. Folia Med (Plovdiv). 2016 Dec 23;58(4):273-81. Available from: https://doi.org/10.1515/folmed-2016-0041
21. Lu S-Y, Lee C-L, Lin K-Y, Lin Y-H. The acute effect of exposure to noise on cardiovascular parameters in young adults. J Occup Health 2018. 2017-0225-OA. Available from: https://doi.org/10.1539/joh.2017-0225-OA
22. Kerdonfag P, Wadwongtham W, Taneepanichskul S. Hearing threshold levels among steel industry workers in Samut Prakan, Thailand. Risk Manage Health Policy 2019;12:57. Available from: https://doi.org/10.2147/RMHP.S166042
23. Zaw AK, Myat AM, Thandar M, Htun YM, Aung TH, Tun KM, et al. Assessment of noise exposure and hearing loss among workers in textile mill (Thamine), Myanmar: a cross-sectional study. Safety and Health at Work. 2020 Jun 1;11(2):199-206. Available from: https://doi.org/10.1016/j.shaw.2020.04.002
24. Smolensky MH, Reinberg AE, Sackett-Lundeen L. Perspectives on the relevance of the circadian time structure to workplace threshold limit values and employee biological monitoring. Chronobiology International. 2017 Nov 26;34(10):1439-64. Available from: https://doi.org/10.1080/07420528.2017.1384740
25. Neitzel RL, Swinburn TK, Hammer MS, Eisenberg D. Economic impact of hearing loss and reduction of noise-induced hearing loss in the United States. Journal of speech, language, and hearing research. 2017 Jan;60(1):182-9. Available from: https://doi.org/10.1044/2016_JSLHR-H-15-0365
26. Frederiksen TW, Ramlau-Hansen CH, Stokholm ZA, Grynderup MB, Hansen ÅM, Kristiansen J, et al. Noise-Induced Hearing Loss–A Preventable Disease? Results of a 10-Year longitudinal study of workers exposed to occupational noise. Noise & health. 2017 Mar;19(87):103. Available from: https://doi.org/10.4103/nah.NAH_100_16
27. Basu S, Aggarwal A, Dushyant K, Garg S. Occupational noise induced hearing loss in India: A systematic review and meta-analysis. Indian Journal of Community Medicine. 2022 Apr 1;47(2):166. Available from: https://doi.org/10.4103/ijcm.ijcm_1267_21
28. Weier MH. The Association Between Occupational Exposure to Hand–Arm Vibration and Hearing Loss: A Systematic Literature Review. Safety and health at work. 2020 Sep 1;11(3):249-61. Available from: https://doi.org/10.1016/j.shaw.2020.04.003
29. Kurabi A, Keithley EM, Housley GD, Ryan AF, Wong

AC. Cellular mechanisms of noise-induced hearing loss. Hearing research. 2017 Jun 1;349:129-37. Available from: https://doi.org/10.1016/j.heares.2016.11.013

30. Teixeira LR, Azevedo TM, Bortkiewicz A, Da Silva DT, De Abreu W, De Almeida MS, et al. WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of exposure to occupational noise and of the effect of exposure to occupational noise on cardiovascular disease. Environment international. 2019 Apr 1;125:567-78. Available from: https://doi.org/10.1016/j.envint.2018.09.040

31. Møller AR. Sensorineural tinnitus: its pathology and probable therapies. International journal of otolaryngology. 2016 Oct;2016. Available from: https://doi.org/10.1155/2016/2830157

32. Sheppard A, Ralli M, Gilardi A, Salvi R. Occupational noise: auditory and non-auditory consequences. International journal of environmental research and public health. 2020 Dec;17(23):8963. Available from: https://doi.org/10.3390/ijerph17238963

33. Narasimhan S, Rajagopalan R, Justin Margret J, Visvanathan G, Jayasankaran C, Rekha K, Srisailapathy CS. Audiometric notch as a sign of noise induced hearing loss (NIHL) among the rice and market flour mill workers in Tamil Nadu, South India. Hearing, Balance and Communication. 2022 Jan 2;20(1):21-31. Available from: https://doi.org/10.4103/0971-7749.10343

International Journal of Occupational Safety and Health

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

Original Article

Morbidity profile of migrant workers attending health camps in Bangalore urban during the Covid-19 pandemic

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Date of submission: 10.02.2022
Date of acceptance: 11.07.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v13i1.43081

ABSTRACT

Introduction: Global pandemic of COVID-19 resulted in a nationwide lockdown which affected the migrants in terms of healthcare service accessibility. This led to an increase in the prevalence of various morbidity. Objective of this study was to assess the morbidity profile of camp attendees in Bangalore urban conducted during the lockdown period of the COVID-19 pandemic.

Methods: During the pandemic lockdown, health camps were conducted in selected urban under-privileged areas of Bangalore city targeting the migrant workers and these records were reviewed and relevant data were analyzed. Variables included age, gender, residential address, occupation and morbidity.

Results: Among the 484 participants who had attended the medical camp, the youngest patient was 1 year old and the oldest was 75 years with a median age of 27 years (IQR: 20 – 35). The majority of the camp attendees were males (78%) and migrants (77%). Common morbidities noted were hypertension (5%) followed by musculoskeletal pain (4%). The other illnesses were anemia (3%), gastritis (2.5%), pre-diabetes (1.7%) and combined diabetes and hypertension (1.5%). There was no significant relationship between migrant status and the presence of any morbidity.

Conclusion: Hypertension and musculoskeletal pain are the most common morbidity among the camp attendees.

Keywords: Health camp, lockdown, migrants, urban underprivileged area

Introduction

A nationwide lockdown was announced on 24th March 2020 for the first time in India as a preventive step against the COVID-19 pandemic. All the essential services were made available including the health care services. The overall response to the lockdown was positive.[1] But due to the fear of contracting the infection and strict lockdown measures that were implemented, people who needed medical attention either for their chronic noncommunicable diseases or for any acute onset illness, preferred to skip their routine hospital visits.[2] This was evident with a drop in outpatient cases seen in every department of a hospital setting. There are no estimates as yet to know the non-COVID health-related morbidity and mortality. The community is expected to experience a surge in non-communicable diseases (NCD), lack of antenatal and postnatal care, mental illnesses, substance abuse, and domestic violence and in the long run the pandemic might have an impact on health-seeking behavior.[3,4,5,6,7]

Due to fear, stigma and lack of awareness, the healthcare-seeking behavior during the pandemic decreased leading to the reduced footfall of outpatients in hospitals.[8,9] These 'missing patients' who failed to visit a health care center were encountered in the camp. The most affected were the migrant population facing difficulty in accessing health services.

NCDs are estimated to account for 63% of all deaths in India and Karnataka has a big burden of ischemic heart disease, diabetes and hypertension.[10,11] NCDs were one of the neglected entities during the lockdown.[3] Reviewing the records that capture the morbidity profile of the camp attendees is a reflection of the health needs of the population during a lockdown particularly due to an outbreak. This information will help us plan and deliver health care services (emergency and non-emergency) on time ultimately reducing mortality other than the unfortunate COVID-19 losses. The primary objective of the study was to assess the morbidity profile of camp attendees in Bangalore urban conducted during the first lockdown period of the COVID-19 pandemic.

Methods

A medical health camp was conducted by the Department of Community Health to cater to the health needs of the urban communities, especially the migrants in Bangalore. As a part of the outreach activity of the Division of Occupational Health Services, Department of Community Health, St. John's Medical College Hospital health camps were conducted in partnership with the company, Enquero Global (India) under their Corporate Social Responsibility (CSR) activity, Poorna Swasta Mitra. The target population examined during the camp was mainly migrant workers. Migrant workers were identified to be the most vulnerable in terms of making ends meet or having adequate meals which also meant that their health care needs had also taken a back foot.[12]

A record was maintained capturing the socio-demographic and medical details of the camp attendees which were recorded manually in the field. According to World Health Organization guidelines, all participants above the age of 30 were screened for diabetes (using Accu-chek Instant glucometer) and hypertension (using Omron HEM 7121 digital Blood Pressure monitor).[13] Migrants with random blood sugar levels of 200 mg/dL or more were considered to have diabetes. Blood pressures were monitored using the standard protocol and those with consistently high readings even on the third reading (systole > 140 mm of Hg and diastole > 90 mm of Hg) were considered to have hypertension.

After obtaining clearance from the Institutional Ethical Committee, these records were reviewed, and data were extracted using a structured instrument that included age, gender, residential address, occupation and morbidity. All the 484 patients enlisted in the record were included. The data was then extracted to Microsoft Excel for data entry and 10% of the data was verified for accuracy and reliability by the second investigator. Data analysis was done using percentages, mean and median wherever necessary. The Chi-square test was used to find associations between migrant status with existing morbidities.

Results

This was a retrospective study, with records of 484 people who had attended the medical camp. The youngest patient was 1 year old and the oldest was 75 years with a median age of 27 years (IQR: 20 – 35). The majority of the camp attendees were males (78%) and had migrated to Bangalore (77%).

Most of the male participants were employed in the construction and garment sectors while a majority of the females were homemakers (Figure – 1). The migrants were involved in different activities on construction sites (Figure – 2). The non-migrants were farmers, having their own small businesses and/or delivery executives. Almost all the non-migrants were from Bangalore urban areas whereas the majority of the migrants hailed from Bihar (19%) and Jharkhand (19%) followed by Orissa (11%) and West Bengal (8%).

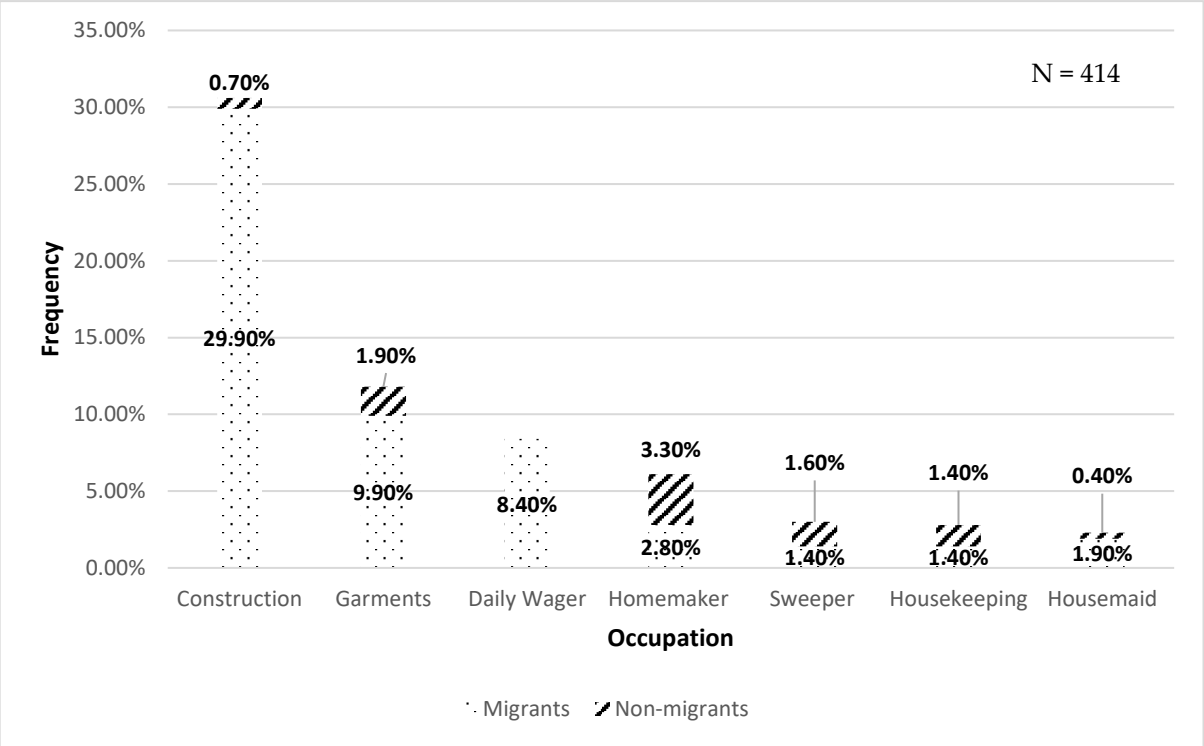

Figure 1: Occupation of Camp attendees – 1

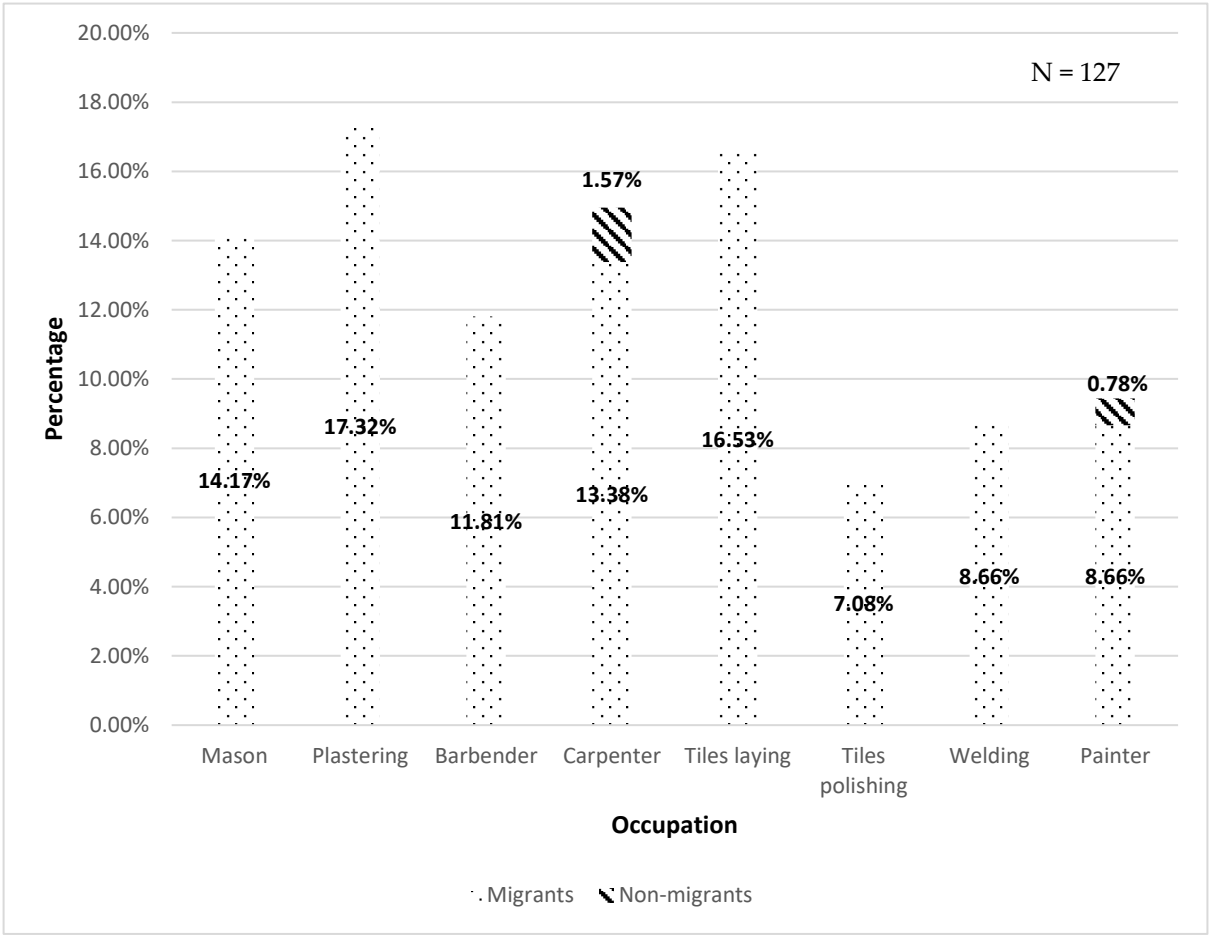

Figure 2: Occupation in Construction of Camp Attendees – 2

Almost three-fourths of the camp attendees (72%) did not have any known morbidities. Among those with co-morbidity, the majority were diagnosed with hypertension (5%) followed by musculoskeletal pain (4%) (Figure – 3). The other illnesses were pallor (3%), gastritis (2.5%), pre-diabetes (1.7%) and a combination of diabetes and hypertension (1.5%). Other conditions like tinea, urticaria, dry eyes, allergic rhinitis and dysmenorrhoea were also managed during the camp including the provision of antenatal care (1%).

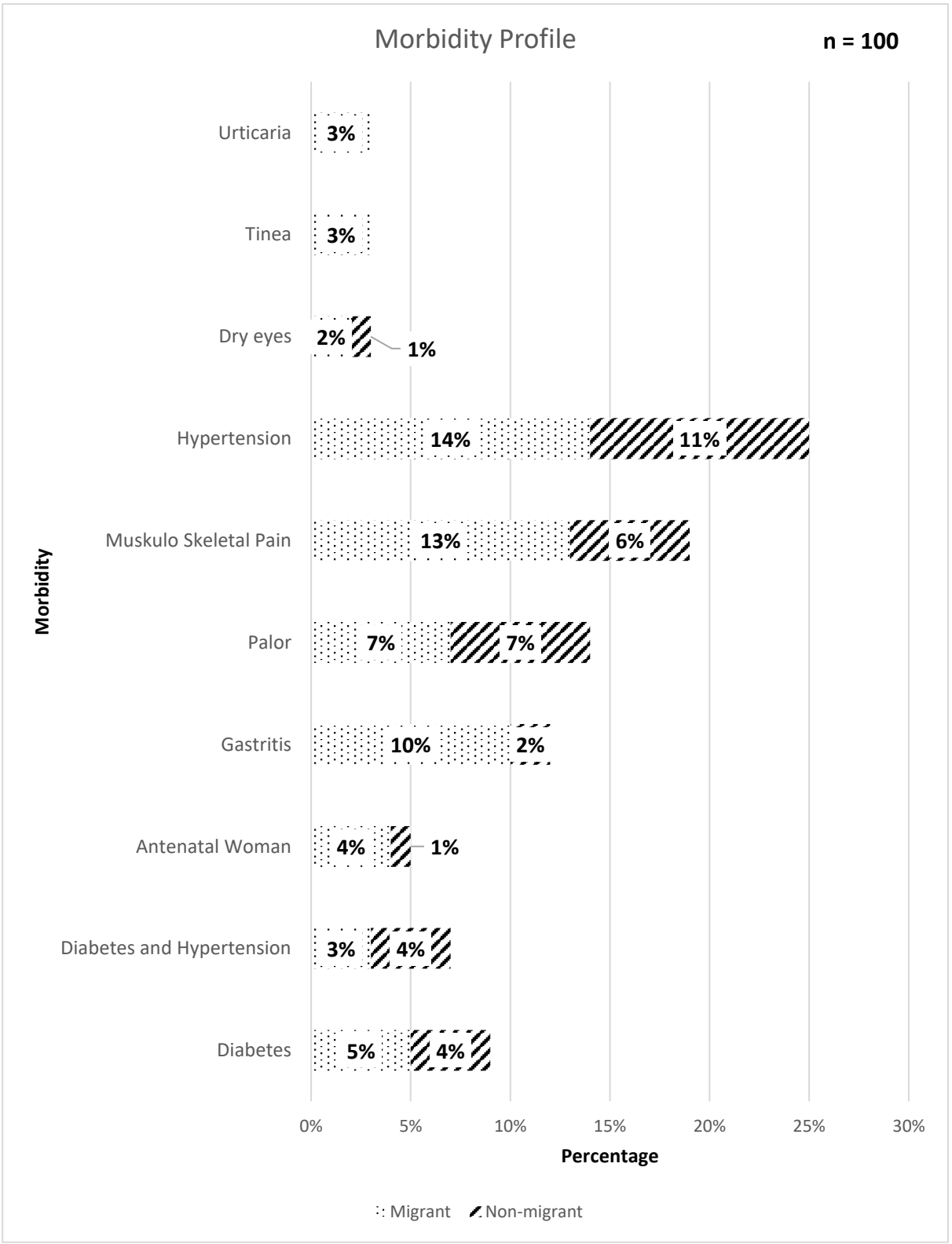

Figure – 3: Morbidity Profile of the Camp Attendees

All the camp attendees who were above the age of 30 years were screened for diabetes and hypertension and we found that 3.5% had elevated sugar levels and 16% had elevated blood pressure. The prevalence of the common diseases among the non-migrants and migrants is depicted in Table – 1.

Gastritis was more prevalent among migrants whereas hypertension and anemia are more common among the non-migrants. There was no significant difference in the mean age between males and females or between migrants and non-migrants in the independent samples t-test. On doing the chi-square test, there was no significant association between elevated sugar and blood pressure levels with the migrant status (Table – 2).

Table 1: Prevalence of common diseases between natives and migrants

Disease	Non-Migrants (112) N (%)	Migrants (372) N (%)
Hypertension	11 (9.5%)	14 (3.79%)
Musculoskeletal Pain	6 (5.2%)	13 (3.52%)
Gastritis	2 (1.7%)	10 (2.7%)
Anaemia	7 (6.08%)	7 (1.89%)

Table 2: Association between Migrant status and elevated Blood pressures and sugar levels.

Variable		Elevated Blood Sugar levels		p value
		Yes	No	
Migrant Status	Yes	10 (2.7%)	359 (97.3%)	p = 0.141*
	No	7 (6.1%)	108 (93.9%)	
		Elevated Blood Pressure levels		
		Yes	**No**	
Migrant Status	Yes	53 (14.4%)	316 (85.6%)	p = 0.147*
	No	23 (20%)	92 (80%)	

*chi-square test

Discussion

The median age of the migrant population was 27 years and the majority were males which is similar to other studies on migrants.[14–16] This is because the 20 – 30 years age group is the ripe age for a demographic dividend, and they travel in search of a job. Also, this is the younger generation who realised the plight of the failed farming in their hometowns and shift with their families for better life and opportunities for their children.

Migration is gendered and categorized. According to Census 2001, among all the migrants, females are twice the number of males probably because when a family migrates, the women also shift places.[17] The data shows that 14.7% migrated for work/employment among which 37.6% were men and 3.2% were women. Among the 43.8% who migrated for marriage, almost 65% were women. The trends are almost the same as with the 2011 census which also shows that the highest out-migrants are from Uttar Pradesh and Bihar.[18] The top states for in-migration are Delhi and Maharashtra. The proportion of interstate migration in India was 55% before the 2001 census which came down to 33% in the 2011 census.

A report shows that 47% of the migrants work in the construction sector whereas our study shows 33.6% in different sectors of construction.[19] This is because the metropolitan cities provide ample opportunities for the construction of newer buildings which creates demand for workers. The uneven growth and development of cities lead to urbanization, expansion and infrastructure development. Even though many native workers are also in construction, most are in technical roles whereas the migrants take up different roles under them. In many families, the women either were homemakers and took care of children or were employed as housemaids in the nearby apartments.

A study done among migrants in Mangalore showed that two-thirds are men and the rest are women which is similar to our study.[15] The major illnesses in previous studies were musculoskeletal pain and skin issues among migrants.[14,16] Our camp results show that the prevalence was high for elevated blood pressure and sugar levels followed by musculoskeletal pain. The main reason for this pain is because of increased work hours, inadequate training in handling heavy objects and also uncomfortable living/ sleeping conditions. Gastritis which was prevalent may be due to the source of food and cooking environment or the cheap spicy food which is easily available.

Mortality in 60%-90% of the Covid-19 cases is attributed to either one or more comorbidities like diabetes mellitus, hypertension, respiratory and heart disease, particularly among the elderly.[20,21] Temporary closure of outpatient health facilities in some of the secondary and tertiary care hospitals has deprived millions of NCD patients of their regular medication and diagnostic health needs. Due to the lack of robust primary healthcare facilities and ineffective public health interventions, socioeconomically vulnerable patients are more likely to become non-adherent to their routine medications thereby increasing their risk of disease complications.[22]

Patients living with obesity and NCDs are at increased risk of health impacts of emergencies such as COVID-19. NCD health-care staff and associated workers and volunteers should be centrally involved in the planning of COVID-19 response strategies to ensure that the needs of patients and caregivers are addressed. A streamlined response to COVID-19 in the context of NCDs is important to optimize public health outcomes and reduce the impacts of this pandemic on individuals, vulnerable groups, key workers, and society. Loss of job coupled with fear of contracting COVID on visiting a healthcare facility may have led to decreased adherence to medications and elevated blood pressure and sugar levels. It is advised to prioritize and ensure continued community-level services in a safe way to cater to NCD patients' needs.[23]

The global pandemic of COVID-19 and the resultant lockdown put a dent in the job opportunities and income of these migrant workers. Combined with being displaced from home, reduced options to visit the hospital, and the

inability to go back home strained the mental health of the migrant families.[24] The main stressors of COVID-19 with increased IES-R score were not staying with family members, and influence of social media.[25] They burnt through their savings and are on the verge of poverty in different parts of the country.[26] Even though lockdown was implemented successfully which slowed down the disease transmissions, it hurt the economy of the country and especially migrant workers who are dependent on weekly wages for their livelihood.[27] These factors not only impacted the physical health but strained the mental health of the migrant population.

Migrant workers were scared and anxious about the pandemic and their ability to go home. In this dire circumstance, health took a backseat and regular medications are a luxury that they can skip. Despite all these, migrants turned up in good numbers at the medical camp even if it is to check their temperature, blood pressure and oxygen saturation. Migration is always associated with marginalization, fragmentation, vulnerabilities, lack of social support, exploitation and exclusion.[28] Many a time, the onus is on their employers to provide support financially, providing groceries, or even organizing travel services.

Conclusion

The most prevalent morbidities among the migrant population were elevated blood pressure, elevated sugar levels, musculoskeletal pain and gastritis. Migrant populations are facing many challenges among which the most pressing issue is food and travel. Health is in the backseat mainly because of the access to healthcare coupled with the fear of contracting the disease on visiting a healthcare facility. Priority measures should be concentrated on providing basic amenities like groceries, drinking water, and shelter for these people until they can travel back to their hometowns.

References

1. Barkur G, Vibha, Kamath GB. Sentiment analysis of nationwide lockdown due to COVID 19 outbreak: Evidence from India. Asian J Psychiatr. 2020;51. Available from: https://doi.org/10.1016/j.ajp.2020.102089
2. Singh P. Non-COVID-19 Patients Are Paying the Price of India's Efforts Against the Coronavirus - The Wire Science. Science by The Wire. https://science.thewire.in/health/healthcare-non-coronavirus-patients/ Published 2020 [Accessed July 3, 2021]
3. Nikoloski Z, Alqunaibet AM, Alfawaz RA, Almudarra SS, Herbst CH, El-Saharty S, et al. Covid-19 and non-communicable diseases: evidence from a systematic literature review. BMC Public Health. 2021;21(1):1-9. Available from: https://doi.org/10.1186/S12889-021-11116-W/TABLES/1
4. Tadesse E. Antenatal Care Service Utilization of Pregnant Women Attending Antenatal Care in Public Hospitals During the COVID-19 Pandemic Period. Int J Womens Health. 2020;12:1181. Available from: https://doi.org/10.2147/IJWH.S287534
5. Townsend R, Chmielewska B, Barratt I, Kalafat E, Van der Meulen J, Gurol-Urganci I, et al. Global changes in maternity care provision during the COVID-19 pandemic: A systematic review and meta-analysis. EClinicalMedicine. 2021;37:100947. Available from: https://doi.org/10.1016/J.ECLINM.2021.100947
6. Nair VS, Banerjee D. "Crisis Within the Walls": Rise of Intimate Partner Violence During the Pandemic, Indian Perspectives. Front Glob Women's Heal. 2021;0:29. Available from: https://doi.org/10.3389/FGWH.2021.614310
7. Krishnakumar A, Verma S. Understanding Domestic Violence in India During COVID-19: a Routine Activity Approach. Asian J Criminol. 2021;16(1):19. Available from: https://doi.org/10.1007/S11417-020-09340-1
8. Saah FI, Amu H, Seidu AA, Bain LE. Health knowledge and care seeking behaviour in resource-limited settings amidst the COVID-19 pandemic: A qualitative study in Ghana. PLoS One. 2021;16(5):e0250940. Available from: https://doi.org/10.1371/JOURNAL.PONE.0250940
9. Xiao H, Dai X, Wagenaar BH, Liu F, Augusto O, Guo Y, et al. The impact of the COVID-19 pandemic on health services utilization in China: Time-series analyses for 2016–2020. Lancet Reg Heal - West Pacific.

2021;9:100122. Available from: https://doi.org/10.1016/J.LANWPC.2021.100122

10. World Health Organization (WHO). Noncommunicable Diseases Country Profiles. Geneva, Switzeland: World Health Organization; 2018. https://www.who.int/publications/i/item/ncd-country-profiles-2018. [Accessed July 3, 2021]

11. Indian Council of Medical Research and Public Health Foundation of India and Institute for Health Metrics and Evaluation. India: Health of the Nation's States. The India State-Level Disease Burden Initiative Disease Burden Trends in the States of India 1990 to 2016. New Delhi, India; 2017. https://www.healthdata.org/sites/default/files/files/policy_report/2017/India_Health_of_the_Nation%27s_States_Report_2017.pdf

12. Rao M. When Bengalureans decided they couldn't simply watch hungry migrants trudge helplessly | Citizen Matters, Bengaluru. Citizen Matters. https://bengaluru.citizenmatters.in/covid-lockdown-individuals-plunge-relief-migrant-workers-highways-46181 . Published 2020. Accessed July 3, 2021.

13. World Health Organization (WHO). Noncommunicable diseases. Health Topics. https://www.who.int/health-topics/noncommunicable-diseases#tab=tab_1 Published 2021. [Accessed May 18, 2021]

14. Maiya GR, Nesan GSCQ, Badiger S, Kiran KG, Jain T. Study of Morbidity Pattern and Its Associated Factors among Migrant Workers Residing in the Field Practise Area of a Tertiary Care Hospital in Mangalore: A Cross-Sectional Study. Indian J Public Heal Res Dev. 2020;2(6):244-9. http://medicopublication.com/index.php/ijphrd/article/view/10590/9924 [Accessed May 17, 2021]

15. Kiran KG, Swathi N, Kumar N, Uday Kiran N, Swathi AB, Badiger S. Study of Morbidity Pattern Among Migrant Workers In A Coastal City Of Study Of Morbidity Pattern Among Migrant Workers In A Coastal City Of Karnataka. Int J Curr Res. 2016;8(7):34078-80. https://www.journalcra.com/sites/default/files/issue-pdf/15372.pdf [Accessed May 17, 2021]

16. Mohankumar P, Gopalakrishnan S, Muthulakshmi M. Morbidity Profile and Associated Risk Factors among Construction Workers in an Urban Area of Kancheepuram District, Tamil Nadu, India. J Clin Diagnostic Res. 2018;12(7):LC06-09. Available from: https://doi.org/10.7860/JCDR%2F2018%2F34678.11773

17. Ministry of Home Affairs, India G of I. Census of India 2001. Office of the Registrar General & Census Commissioner, Government of India; 2001.

18. Ministry of Home Affairs. Data on Migration. Office of Registrar General & Census Commissioner, Government of India; 2011. https://censusindia.gov.in/2011census/migration.html [Accessed May 17, 2021]

19. Rao AK, Sriraman P. Leaving the City Behind: A Rapid Assessment with Migrant Workers in Maharashtra. Chennai; 2020. https://www.habitat.org/sites/default/files/documents/Leaving-the-City-Behind_Rapid-assessment-with-migrant-workers-Maharashtra.pdf [Accessed May 17, 2021]

20. Palmer K, Monaco A, Kivipelto M, Onder G, Maggi S, Micheal J, et al. The potential long-term impact of the COVID-19 outbreak on patients with non-communicable diseases in Europe: consequences for healthy ageing. Aging Clin Exp Res 2020 327. 2020;32(7):1189-94. Available from: https://doi.org/10.1007/S40520-020-01601-4

21. Cuschieri S, Pallari E, Hatziyianni A, Sigurvinsdottir R, Sigfusdottir ID, Sigurðardóttir K. Mortality comparisons of COVID-19 with all-cause and non-communicable diseases in Cyprus, Iceland and Malta: lessons learned and forward planning. Public Health. 2022;202:52-7. Available from: https://doi.org/10.1016/J.PUHE.2021.03.025

22. Basu S. Non-communicable disease management in vulnerable patients during Covid-19. Indian J Med Ethics. 2020;V(2):103-5. Available from: https://doi.org/10.20529/IJME.2020.041

23. Kluge HHP, Wickramasinghe K, Rippin HL, Mendes R, Peters D, Kontsevaya A, et al. Prevention and control of non-communicable diseases in the COVID-19 response. Lancet. 2020;395(10238):1678-80. Available from: https://doi.org/10.1016/S0140-6736(20)31067-9

24. Kumar R. The long march of migrant workers in India

during the COVID-19 pandemic 2020—Failure of postcolonial governments to decolonize Bihar and rebuild Indian civilization after 1947. J Fam Med Prim Care. 2020;9:5087-5091. Available from: http://dx.doi.org/10.7860/JCDR/2018/34678.11773

25. Bala S, Pandve H, Katkuri S, Nikhil T. Measurement of risk and stressors of post-traumatic stress disorder during the first lockdown period of COVID-19 among Industrial workers, Hyderabad, India. International Journal of Occupational Safety and Health. 2022; 12(2): 104–10. Available from: https://doi.org/10.3126/ijosh.v12i2.40601

26. Pillai DDM, Nagappan N, Dharani SV, Subramanian K, Champakesan B, Maridasan D'Cruz T. Socio-economic impact of coronavirus disease 2019 (COVID-19) – An Indian outlook Dinesh. J Fam Med Prim Care. 2020;9:5103-5106. Available from: https://doi.org/10.4103/jfmpc.jfmpc_835_20

27. Yadav AK. Impact of lockdown to control over Novel Coronavirus and COVID-19 in India. J Fam Med Prim Care.2020;9:5142-5147. Available from: https://doi.org/10.4103/jfmpc.jfmpc_692_20

28. Rajan SI, Sumeetha M. Handbook of Internal Migration in India. New Delhi: SAGE India; 2020. https://in.sagepub.com/en-in/sas/handbook-of-internal-migration-in-india/book271344#preview [Accessed May 17, 2021]

International Journal of Occupational Safety and Health

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

Original Article

Epidemiological pattern of corneal foreign bodies and utilization of protective eye devices: a hospital-based cross-sectional study

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Date of submission: 15.05.2022
Date of acceptance: 26.07.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: The study was partially funded by the Provincial Health Research Grant of Nepal Health Research Council, 2021.

DOI:https://doi.org/10.3126/ijosh.v13i1.45153

ABSTRACT

Introduction: A corneal foreign body (CFB) is the most common occupational ocular injury that can cause secondary infection or scars on the visual axis, decreasing vision. This study aimed to find-out practices of wearing protective eye devices in the workplace and the factors influencing the utilization of such devices among patients with CFB injury.

Methods: A cross-sectional study was conducted in a tertiary eye hospital in Bhaktapur from April to August 2021. All patients with CFB attending the hospital were included in the study. CFB was removed with ocular examination under a slit lamp biomicroscope, and a face-to-face interview was conducted.

Results: Among 142 patients, only one was female, and 41.5% had a previous history of CFB. The most common CFB particle was metallic (n=124, 87.3%). Three-fourths (75.1%) of patients were not using eye-protective devices at the time of injury, and 45.1% tried physically removing the CFB in a harmful way. Nearly one-fifth (19.7%) had used topical antibiotic eye drops before presenting for CFB removal. Nearly half of the participants (46.5%) reported never wearing any protective eye devices, and the main reason for it was the unavailability of such devices at their workplace. The awareness of the need for protective eye devices ($p<0.001$) was significantly associated with using protective eye devices during work.

Conclusion: The workers should be made aware of the consequences of harmful practices following CFB injury. The workers should wear protective eye devices to minimize the risk of ocular injury and consequent visual impairment.

Keywords: Cornea, Foreign Body, Protective Device, Workplace.

Introduction

Ocular injuries are a major cause of preventable blindness worldwide.[1] Work-related eye injuries constitute a public health problem responsible for significant morbidity, disability, and socioeconomic damage.[2,3] A corneal foreign body is the most common occupational ocular injury, which occurs across several occupations like metallic and construction workers, electricians, carpenters, etc.[4,5]

It causes multiple ocular symptoms, including red-eye, foreign body sensation, pain, blurred vision, etc.[6] It can also cause secondary infection or scars on the visual axis, decreasing vision.[7] These injuries account for a significant amount of time taken off work for hospital visits, increasing healthcare costs.[8]

The Bhaktapur Eye Study showed that the prevalence of ocular injuries in Nepal is 3.7%,[9] and the incidence varies from 2.2% to 4.9% each year, according to one study in Western Nepal.[10] The corneal foreign body comprises 20.4% to 22.5%

of ocular injuries cases in Nepal.[11, 12]

Industrialization and urbanization have increased eye injuries worldwide, and similar is the situation in Nepal with an increase in the number of patients with OPD with corneal foreign body (CFB) injuries.[13,14] The proper use of protective equipment would prevent 60–66% of eye injuries at the workplace.[13] However, lack of use of protective equipment, poor health-seeking behavior of patients due to lack of education, or negligence create a worse prognosis, especially in developing countries.[14] Hence this study was conducted to determine the etiologic factors, level of awareness, and utilization of eye protective equipment among the workers presenting with a CFB.

Methods

A cross-sectional study was conducted in the Hospital for Children, Eye, ENT, and Rehabilitation Services (CHEERS), Bhaktapur, Nepal. All the consecutive patients aged 18 years and above presenting with a complaint of foreign body in the Eye Outpatient Department of the Hospital from April to August 2021 were included in the study.

Each patient underwent a careful, comprehensive slit lamp bio-microscopic examination by the attending Ophthalmologist to find the location, type of foreign body, complications, and corneal scars to determine past injuries and was recorded in OPD Cards. Corneal foreign bodies were removed using a 26-gauge needle under topical anesthesia, and topical antibiotics were prescribed for a week.

Each patient was offered to participate in the study by an accompanying Ophthalmic Assistant who was oriented about the study and trained for data collection. The patients and their companions were briefed about the study objective, the information needed, and the expected duration of the interview. Only those patients or companions (for illiterate patients) who gave written consent to participate were selected for the study and interviewed for data collection using a semi-structured questionnaire. At the same time, the location, type, complications, and previous history of the foreign body were recorded from OPD Cards. The patients who had CFB at places other than workplace settings were excluded from the study. The corneal foreign body was marked as central, paracentral, and peripheral, taking into account a 3 mm radius as central, 3 to 6 mm radius as paracentral, and beyond that as peripheral.[15]

The study team developed the study tool from literature review and finalized it after inputs from the expert advice of fellow Ophthalmologists, Public Health, and Health Promotion experts. The tool in the Nepali language was pre-tested in City Eye Clinic, Thimi, Bhaktapur, among 10 patients with CFB and modified for the structure and tone of the questions. Permission for the study was taken from the study site, CHEERS Hospital, and ethical approval was obtained from the Ethical Review Board of Nepal Health Research Council (Ref. No. 2778, ERB Protocol No. 109/2021P).

The interviewers entered all the data from the questionnaire in Google Sheets on the same day of data collection. The data entered were checked and cross-checked for completeness by the researchers every day. The analyses were done using IBM Statistical Package for the Social Sciences (SPSS) version 26.0 (Released 2019. IBM Corp., Armonk, New York, United States). The frequencies and percentages were computed to assess the distribution of population characteristics, including age group, educational status, occupational settings, awareness about protective eyewear, history of foreign bodies in the eye, etc. To identify the associations between explanatory variables and the use of protective eye devices, bivariate logistic regression analyses was applied. Those variables with p-values <0.05 were included in a multivariate logistic regression analysis to determine the effect adjusted for each potential explanatory variable. A p-value of <0.05 denoted statistical significance.

Results

Among 149 patients approached for the study, 142 (95.3%) participated and completed the interview session.

Socio-demographic characteristics of the patients

More than four-fifths (83.8%) of participants were aged 18-40 years old, and only one female participant was in the study. More than two-thirds (67.6%) worked in the metallic and grill industry, as shown in Table 1.

Table 1. Socio-demographic profile of the study participants (n=142)

Characteristics		Frequency	Percentage
Age-group	18 – 40 years	119	83.8
	41 – 70 years	23	16.2
Gender	Male	141	99.3
	Female	1	0.7
Permanent residence	Kathmandu valley	20	14.1
	Outside of Kathmandu valley	122	85.9
Education	Illiterate	28	19.7
	Literate	25	17.6
	Primary level	37	26.1
	Secondary level	35	24.6
	Intermediate	13	9.2
	Bachelor's and above	4	2.8
Type of Workplace	Metallic & grill	96	67.6
	Carpentry	11	7.8
	Building & constructions	30	21.1
	Others	5	3.5

Foreign body injury and complications

Two patients visited for consultation within half an hour of foreign body injury, whereas 4.9% consulted after more than one week of the injury. The mean time before presenting for consultation was 44.52 (±46.97) hours. The average working days lost due to foreign body injury was 1.17 (±1.16).

More than half (53.5%) had a foreign body in their right eye, and 87.3% of study participants had a metallic foreign body. None had open globe injury, and the most common location of the foreign body was the paracentral (57.7%). More than one-fourth (26.1%) of the study participants had already developed complications following injury, and keratitis was the most common (62.2%), as shown in Table 2. Less than one-fourth (24.6%) of study participants reported wearing or using eyewear during the injury, and 24 of them were wearing goggles or sunglasses.

History of foreign body injury

More than two-fifths (41.5%) reported a history of previous foreign body injury in at least one of their eyes. On slit-lamp examination, 26.1% had scars in at least one eye suggestive of the previous history. Nearly two-fifths of (38.7%) study participants' colleagues also had similar foreign body injuries in the past.

Practices following foreign body injury

More than two-fifths (45.1%) of the study participants physically tried to remove the foreign body either by self (n=45) or with the help of friends, colleagues, or family members (n=16) or with the help of non-eye health workers (n=2). Among those who tried to remove the foreign body, the most used material was handkerchiefs and other clothes (n=41). More than three-fifths (62.0%) of participants reported trying several remedies, like washing their eyes with clean water and using human milk, as shown in Table 3.

Table 2. Foreign body injury among participants (n=142)

Characteristics		Frequency	Percentage
Injured Eye	Right	76	53.5
	Left	66	46.5
Location of Foreign Body	Central	29	20.4
	Paracentral	82	57.7
	Peripheral	31	21.8
Type of Foreign body	Metallic particles	124	87.3
	Wooden particles	4	2.8
	Sand & stone particles	10	7.1
	Others (plastics & carbon particles)	4	2.8
Complications following injury	None	105	73.9
	Keratitis	23	16.2
	Epithelial defect	9	6.4
	Corneal ulcer	4	2.8
	Iritis	1	0.7
Use of any protective eyewear during injury	None	107	75.4
	Goggles or sunglasses	24	16.9
	Glasses or spectacles	4	2.8
	Protective eye wears	6	4.2
	Metallic shield	1	0.7

Less than half (47.9%) of the participants directly reported to our eye hospital. Among the remaining 74 participants, 85.1% visited the nearby local pharmacy, 6.8% visited local clinics, 5.4% visited local eye clinics, and 2.7% reported visiting a general hospital (with no eye care services) to seek treatment before presenting to our eye hospital with an injury. Nearly three-fifths (59.9%) of participants reported using eyedrops before presenting to our eye hospital with a foreign body injury. Among them, one participant reported using topical steroids, none reported using eye ointment, and we could not verify the 29 medicines as depicted in table 3.

Awareness and practices on Occupational Eye Health

Two-fifths (40.8%) of participants had not received formal health and safety education on occupational eye health. However, more than two-thirds (72.5%) knew that a foreign body could cause visual impairment. But nearly one-third (32.4%) of participants were unaware of the need for protective eyewear at their workplace.

Practices of using protective eye devices at the workplace (n=142)

More than two-fifths (46.5%) of participants reported never using protective eye devices primarily due to the unavailability of such devices at their workplace, as presented in table 4.

Factors influencing use of protective eye devices

The bivariate analysis showed that literacy status (p=0.016), health education on occupational eye hazards (p=0.004), awareness about visual impairment from foreign body injury (p=0.044), history of the previous injury among self or colleagues (p=0.006), and awareness of the need of protective eye devices (p<0.001) were significantly associated with the use of protective eye devices during work. However, the multivariate logistic regression model suggested that the awareness of the need for protective eye devices (p=0.005, OR=18.883, 95% CI: 2.432-146.636) was the only variable significantly associated with the use of protective eye devices, as depicted in table 5.

Table 3. Practices following foreign body injury (n=142)

Characteristics		Frequency	Percentage
Physically tried	No	78	54.9
Removing	Using handkerchiefs and other clothes	41	28.9
	Using coins	9	6.4
	Using paper note	7	4.9
	Using nails or needles	2	1.4
	Others (threads, pieces of cotton)	3	2.1
	Irrigation and syringes (at health center)	2	1.4
Self-	None	54	38.0
Remedy tried	Cleaning with cold water	67	47.2
before	Use of old eye drops	15	10.6
visiting Eye	Use of unprocessed herbal products	3	2.1
Hospital or other health	Use of human milk	2	1.4
Facilities	Cleaning with lukewarm water	1	0.7
Eye	None	57	40.1
medicines used	Topical antibiotics eye drops	28	19.7
before	Lubricating eye drops	19	13.4
presenting to Eye	Naphazoline+ Phenylephrine	8	5.7
Hospital	Topical steroids eye drops	1	0.7
	Don't know	29	20.4
	Eye ointment	0	0.0

Table 4: Practices of using protective eye devices at workplace

Characteristics		Frequency	Percentage
Practices of	Never	66	46.5
using	Goggles or Sunglasses	55	38.7
Protective Eye Wear at	Special protective eyewear	10	7.1
Workplace (n=142)	Simple glasses	9	6.3
	Metallic shield	2	1.4
Reason for not wearing	Not available	32	48.4
protective eye gear (n=66)	Felt unnecessary	15	22.8
	Uncomfortable	15	22.8
	Poor visibility	3	4.5
	Damaged or lost wear	1	1.5

Table 5: Association between patient's characteristics and use of protective eye devices

Characteristics		Wearing Protective Eye Devices		p-value	COR (95% CI)	p-value	AOR (95% CI)
		Yes n (%)	No n (%)				
Age-Group	41 years and above	6 (26.1)	17 (73.9)	0.861	1.095 (0.395 – 3.039)	NA	NA
	18 – 40 years	29 (24.4)	90 (75.6)				
Literacy status	Literate or with formal education	33 (28.9)	81 (71.1)	0.016*	5.296 (1.189 – 23.597)	0.101	3.757 (0.773 - 18273)
	Illiterate	2 (7.1)	26 (92.9)				
Ever received health education on occupational eye health hazards	Yes	28 (33.3)	56 (66.7)	0.004*	3.643 (1.465 – 9.059)	0.118	2.350 (0.804 – 6.866)
	No	7 (12.1)	51 (87.9)				
Awareness about Foreign Body can cause Visual Impairment	Yes	30 (29.1)	73 (70.9)	0.044*	2.795 (0.997 – 7.832)	0.444	1.519 (0.444 – 5.192)
	No	5 (12.8)	34 (87.2)				
History of similar injury in past year with self or colleague	Yes	27 (33.3)	54 (66.7)	0.006*	3.313 (1.380 – 7.948)	0.072	2.418 (0.923 – 6.333)
	No	8 (13.1)	53 (86.9)				
Awareness on need of Protective Eye devices	Yes	34 (35.4)	62 (64.6)	<0.001*	24.667 (3.256 – 187.012)	0.005*	18.883 (2.432 – 146.636)
	No	1 (2.2)	45 (97.8)				

*: Statistically significant at p<0.05; CI: Confidence Interval, COR: Crude Odds Ratio, AOR: Adjusted Odds Ratio

Discussion

In this study, CFBs occurred predominantly in-migrant male workers, especially those working in the metallic and grill industries. The metallic foreign particles were the most common CFB.

Despite being aware of protective eye devices, the majority were not using them at the time of injury. Even after the injury, they indulged in unhealthy practices like self-medication or attempting to

remove the foreign body by themselves or friends. The awareness of the need for protective eye devices ($p<0.001$) was significantly associated with using protective eye devices during work.

In our study, most of the patients (83.8%) were in the age group 18 to 40 years. The mean age of the participants was 31.15 (±9.78) years, similar to the study done by Dass et al., where the mean age was 31 years, and most of the patients were below 40 years of age.[16] In this study, 99.3% of the patients were male, similar to the study by Agrawal et al., where 99% were male.[5] Male preponderance was also seen in several other studies.[15,17] This shows that young males are more prone to such injuries. This might be due to the predominance of young and inexperienced males in metallic and grill industries, carpentry, and other high-risk jobs without occupational safety awareness and practices.

About three-fourths (75.4%) of patients were not using protective eyewear at the time of injury. In a similar study in India, 86% of patients were not wearing glasses at the time of injury.[5] In a study by Tuladhar et al., only 6.6% gave a history of wearing protective devices while working.[11] In another study done in the United Kingdom, 39.33% of the patients with corneal foreign body injury were using some kind of eye protection while working.[18] The workers with awareness of the need for protective eye devices were about eighteen times more likely to use protective eye devices than those who were not in our study. Even though our study showed that 67.6% were aware of the need for protective eye devices, they were not wearing protective eye devices because of their unavailability (33.8%) at their workplace. The Labour Act of 2017 in Nepal clearly defines the employee's duty towards the workers in making workplaces safe by providing personal safety and provisions as required, which seems to be missing in Nepal in such small-scale industries or informal occupational settings.[19] Hence there should be regular supervision and monitoring from the concerned authorities regarding such provisions for laborers' health and safety.

Metallic and grill workers were most commonly affected (67.6%), followed by construction workers (21.1%) and carpenters (7.7%), and the most common foreign body material was metallic (87.3%) in our study. These findings resonated with the study done by Reddy et al., where industrial workers were most commonly affected, followed by the construction workers, and the metallic foreign body was the commonest,[8] as with the construction and metal industry workers in another study in Washington D.C.[20] In the older studies with ocular trauma, we could see that most corneal injuries were due to agricultural work and mainly occurred during harvesting seasons.[10] However, rapid urbanization and industrialization seem to have increased the shift in ocular injuries to mainly foreign bodies in Kathmandu valley.

The mean duration between injury and the first visit to an ophthalmologist was 44.52 (±46.97) hours which was almost similar to the other study conducted in Turkey, where the mean duration between the injury and the presentation for consultation was 2.16 (±0.26) days.[21] In our study, the most common location of CFB was the paracentral (57.7%) which was similar to other studies.[8, 15] Due to this, the central vision was not affected in most cases, which might be the reason for the late presentation at the hospital. Even though 72.5% replied that they were aware of CFB causing visual impairment, they were late in presenting to visit Ophthalmologists. This indicates that they were not well aware or have not internalized the consequences (severity) of CFB, which might be due to fewer workers in such workforces with higher education, as shown in our study, where only 36.6% had completed secondary education or above. Besides, our study showed that 41.5% had reported a history of previous corneal foreign bodies, and 26.1% had corneal scars suggesting past foreign body injury on slit-lamp examinations, implying that the participants had not internalized the consequences of CFB. Another reason for late presentation at the hospital could be the larger number (85.1%) of patients visiting local over-the-counter pharmacies after injury, and 59.9% used topical ocular medications. They might have waited for the medicine to have an effect on their

eye and only presented to us after the pain or discomfort did not subside. In addition, the time off from work to reach a nearby eye hospital in the first place could also have played a role in the late presentation to the eye hospital. In a study of ocular trauma in Nepal, 35% of patients had sought medical assistance before presenting to the hospital, and 41.9 % had been to pharmacies.[12] As the pharmacies are seen as the first point of contact, it is important to educate the health workers of such drugstores about the need for early contact at the eye center for CFB removal and appropriate eye drops.

We found that 41.5% of patients attempted CFB removal by themselves. In the study conducted by Ozkurt et al., 52% of patients attempted CFB removal on their own, which can cause further injury.[21] In this study, the most frequently used material was cloth or handkerchief (64%), followed by currency notes (10%). In contrast, the most commonly used materials for the removal were currency notes (31%), followed by napkins (7%) and cloth (4%) in a study done in Turkey.[21] Although our study showed that 59.2% reported receiving health education on occupational eye health hazards, unhealthy self-removal practices were still prevalent, leading to further complications and secondary infection. Hence, comprehensive eye health care education and training are advised, which is also the employer's role according to Nepal Labor Act 2017.[19]

Our study showed that the literacy status of the workforce was three to five times associated with the use of protective eye devices at the workplace. Similarly, a study done in South India among welders showed that workers with higher literacy levels had a higher protective eye device use.[22] Literacy is an important factor as literate workers are more likely to be aware of the visual impairment from CFB injury or their workplace safety rights.

Our study revealed that the workforce with a previous injury history among self or colleagues was two to three times more likely to use protective eye devices. The treating health workers mostly counsel about the consequences of CFB injury and the use of protective eye devices for patients with foreign body injury, which might have led to the use of protective eye devices in the future. Health promotion in hospital settings could educate the patients and reduce the incidence of visual impairment by encouraging workers to use protective eye devices in workplaces with a higher risk of ocular injuries. In a study, behavioral change was noted among the workers after an injury, and 66% of the workers were using eye protection since they had been treated for work-related eye injuries.[23]

Limitation of the study

The study was limited to the urban setting and only accommodated the patients coming to a tertiary level eye hospital. Hence this study cannot be generalized. Besides, this study only included patients coming for OPD checkups and did not include emergency care settings.

Conclusion

CFB occurs predominantly in young males working in the metallic and construction industries. Though most of the injuries are minor, it results in loss of days' work leading to economic loss. Even though relatively cost-effective protective measures exist, the lack of compliance limits their effectiveness and results in corneal foreign bodies. Besides, workers should be educated about such eye injuries and encouraged to use eye-protective devices properly during their work through regular and comprehensive educational workshops in high-risk workplaces. Protective eye devices use should be strictly supervised and enforced at high-risk workplaces.

Acknowledgments

The authors would like to acknowledge the dedication of Ms. Kalpana Deuba, Ms. Sabitra Khawas, and Ms. Shreeya Manandhar, without whom the data collection could never have been possible. We would also like to thank the study participants. This study would not have been possible without their compliance.

References

1. Fiebai B, Awoyesuku E. Ocular injuries among industrial welders in Port Harcourt, Nigeria. Clinical ophthalmology (Auckland, NZ). 2011;5:1261-3. Available at: https://doi.org/10.2147/opth.s20297
2. Nicaeus T, Erb C, Rohrbach M, Thiel HJ. An analysis of 148 outpatient treated occupational accidents. Klinische Monatsblatter fur Augenheilkunde. 1996;209(4):A7-11. Available at: https://pubmed.ncbi.nlm.nih.gov/9044956/
3. Lipscomb HJ. The importance of observational methods for evaluation of interventions to prevent occupational injuries. Occupational and environmental medicine. 2005;62(12):819-20. Available at: https://doi.org/10.1136/oem.2005.022228
4. Cai M, Zhang J. Epidemiological Characteristics of Work-Related Ocular Trauma in Southwest Region of China. International journal of environmental research and public health. 2015;12(8):9864-75. Available at: https://doi.org/10.3390/ijerph120809864
5. Agrawal C, Girgis S, Sethi A, Sethi V, Konale M, Lokwani P, et al. Etiological causes and epidemiological characteristics of patients with occupational corneal foreign bodies: A prospective study in a hospital-based setting in India. Indian J Ophthalmol. 2020;68(1):54-7. Available at: https://doi.org/10.4103/ijo.ijo_623_19
6. Guier CP, Stokkermans TJ. Cornea Foreign Body Removal. StatPearls. Treasure Island (FL): StatPearls. Publishing LLC. 2022. Available at: https://www.ncbi.nlm.nih.gov/books/NBK554478/
7. DeBroff BM, Donahue SP, Caputo BJ, Azar MJ, Kowalski RP, Karenchak LM. Clinical characteristics of corneal foreign bodies and their associated culture results. The CLAO journal : official publication of the Contact Lens Association of Ophthalmologists, Inc. 1994;20(2):128-30. Available at: https://pubmed.ncbi.nlm.nih.gov/8044979/
8. Reddy PS, Nirmala K, Radhika S, Ravi S, Paul C. Incidence of ocular surface foreign body and its correlation with specific occupation and preventive measures. Global journal for research analyses. 2016;5(12):56-8. Available at: https://doi.org/10.18535/jmscr/v6i11.149
9. Upadhyay MP, Karmacharya PC, Koirala S, Shah DN, Shakya S, Shrestha JK, et al. The Bhaktapur eye study: ocular trauma and antibiotic prophylaxis for the prevention of corneal ulceration in Nepal. British Journal of Ophthalmology. 2001;85(4):388-92. Available at: https://doi.org/10.1136/bjo.85.4.388
10. Adhikari RK, Pokherel H, Chaudhari LB, Sharma M, Chaudhari B, Sharma SR, et al. Ocular Trauma in Rapti Eye Hospital, Dang 1993 (2049-2050). Journal of Nepal Medical Association. 2003;32(109):5-9. Available at: https://doi.org/10.31729/jnma.2070
11. Tuladhar S, Dhakal S, Poudel S, Poudel B. Profile of Ocular Trauma in a Tertiary Centre in Western Nepal. Journal of Gandaki Medical College-Nepal. 2018;10:6. Available at: https://doi.org/10.3126/jgmcn.v10i2.20801
12. Karki DB. Ocular Morbidity due to Trauma. Post-Graduate Medical Journal of NAMS. 2008;8. Available at: https://pmjn.org.np/index.php/pmjn/article/view/26/22
13. Fong LP, Taouk Y. The role of eye protection in work-related eye injuries. Australian and New Zealand journal of ophthalmology. 1995;23(2):101-6. Available at: https://doi.org/10.1111/j.1442-9071.1995.tb00137.x
14. Yadav H, Rai V, Chanchlani M. A study of profile of patients with ocular trauma in tertiary care center. Journal of Evolution of Medical and Dental Sciences. 2014;3(25):6891-6. Available at: https://doi.org/10.14260/jemds/2014/2834
15. Kar AS. Different Types of Corneal Foreign Bodies Post Injury and it's Correlation with Specific Occupation. International Journal of Contemporary Medical Research. 2020;7(12):L1-5. Available at: https://doi.org/10.21276/ijcmr.2020.7.12.1
16. Dass RI, Gohel DJ. Ocular surface foreign body: Its incidence and correlation with specific occupations. GCSMC J Med Sci. 2012;2:42-5. Available at: http://www.gcsmc.org/xadmin/myaccount/upload/resource/ocular-surface-foreign-body-its-incidence-and-correlation-with-specific20181005172323032126O.pdf
17. Ramakrishnan T, Constantinou M, Jhanji V, Vajpayee RB. Corneal Metallic Foreign Body Injuries Due To Suboptimal Ocular Protection. Archives of Environmental & Occupational Health. 2012;67(1):48-50. Available at:

https://doi.org/10.1080/19338244.2011.573023

18. Alexander MM, MacLeod JD, Hall NF, Elkington AR. More than meets the eye: a study of the time lost from work by patients who incurred injuries from corneal foreign bodies. British Journal of Ophthalmology. 1991;75(12):740-2. Available at: https://doi.org/10.1136/bjo.75.12.740

19. The Labour Act. 2017 (2074); 14. Available at: https://www.lawcommission.gov.np/en/wp-content/uploads/2021/03/The-Labor-Act-2017-2074.pdf

20. Welch LS, Hunting KL, Mawudeku A. Injury surveillance in construction: eye injuries. Appl Occup Environ Hyg. 2001;16(7):755-62. Available at: https://doi.org/10.1080/10473220117500

21. Ozkurt ZG, Yuksel H, Saka G, Guclu H, Evsen S, Balsak S. Metallic corneal foreign bodies: an occupational health hazard. Arquivos brasileiros de oftalmologia. 2014;77(2):81-3. Available at: https://doi.org/10.5935/0004-2749.20140020

22. Prabhu M, Rokhade R, Chandra KP, Kakhandaki A. A study of awareness and use of personal protective eyewear among welders in a tier 2 city in South India. Indian Journal of Clinical and Experimental Ophthalmology. 2017;3(3):356-60. Available at: https://www.ijceo.org/article-download/full-text/4991

23. Blackburn JL, Levitan EB, MacLennan PA, Owsley C, McGwin Jr G. Changes in eye protection behavior following an occupational eye injury. Workplace health & safety. 2012;60(9):393-400. Available at: https://doi.org/10.1177/216507991206000904

International Journal of Occupational Safety and Health

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

Original Article

Workplace Well-Being in Manufacturing Organizations in Nigeria: Do Employee Green Behavior, Core Self-Evaluations and Empowering Leadership Matter?

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ABSTRACT

Introduction: Workplace well-being has become a key issue in organizational behavior literature because of the impact it has on various outcomes in the organization. A plethora of studies have explored well-being among employees across various work settings. However, little is known about the predictors of workplace well-being in manufacturing organizations. Thus, this study examined employee green behavior, core self-evaluation, and empowering leadership as predictors of workplace well-being.

Methods: A cross-sectional study was carried out in the Apapa area of Lagos State, Nigeria. Data were collected from 201 employees working in manufacturing organizations using a systematic random sampling technique. Approval was obtained from the institutional ethical committee. Four standardized and psychometrically sound instruments (on a five-point Likert format) were used for collecting data while regression analysis was used in testing the hypotheses via the IBM-SPSS version 25.

Results: The participants comprised 124(61.7%) males and 77(38.3%) females with a mean age of 31.43 years and a standard deviation of 5.87. The individual regression values indicated that the predictive relationship between employee green behavior and workplace well-being (R= .43, p < .01), core self-evaluations and workplace well-being (R= .14, p < .05), and empowering leadership and workplace well-being (R= .19, p < .01) were positive and statistically significant. Based on the dimensions of employee green behavior; green learning (B= .15, p < .01), individual practice, (B = .21, p < .01), and influencing others (B= .12, p < .01) significantly predicted workplace well-being.

Conclusion: This study provides valuable contributions to occupational health literature by bringing to light new evidence linking employee green behavior, core self-evaluations, and empowering leadership to the experience of well-being at work. Hence, manufacturing organizations should encourage policies that offer rewards for green behavior, personal development, and managerial empowerment.

Keywords: Core self-evaluations, employee green behavior, empowering leadership, manufacturing organizations; workplace well-being.

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Date of submission: 10.01.2022
Date of acceptance: 11.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None

DOI:https://doi.org/10.3126/ijosh.v13i1.42236

Introduction

Organizations worldwide have increasingly felt the need to contribute to the well-being of employees and contribute to the sustainability of the environment. Organizational and employee practices related to the environment have a consequence for varieties of workplace outcomes. Well-being in and outside the workplace is a common pursuit for individuals and organizations all around the world.[1] Well-being among employees promotes various workplace behaviors leading to an increase in performance both on the part of the individuals and the organization.[2] Therefore, it becomes pertinent to carry out research that will help in understanding the complexities of well-being and other factors that can promote well-being in manufacturing organizations.

Researchers have given considerable attention to mental well-being both within and outside the work environment. Workplace well-being is a vital construct for employees in manufacturing organizations. Literature indicates that the well-being of employees in the workplace is very important to the work process, hence, unhealthy

workers can create a significant cost burden on the organization.[2]

The absence of well-being among employees in manufacturing organizations could be detrimental to organizational processes because reduced well-being has been associated with low productivity, errors in the production process, conflicts among colleagues, grievances and disciplinary incidents, low morale, and a negative work atmosphere.[2,3] Individuals spend a huge amount of time either in the workplace or being involved in work-related activities, therefore, it is not surprising that the quantity of time spent in the workplace and the workplace activities influence the overall health of an employee.[4]

Workplace well-being is pivotal to understanding employees' general health and workplace behaviors.[5] Based on this, employee well-being in the workplace influences other areas of their lives, hence, organizations need to ensure that workers' well-being in the workplace is prioritized. Researchers have explored the impact of various individual and organizational variables that are likely to affect employee well-being. For example, Anwarsyah and Salendu studied job demand and workplace well-being in manufacturing companies while Hussain et al studied abusive supervision and the psychological well-being of employees in service organizations. [6,7] Hence, it is important to study employees' discretionary behavior toward the environment, their core self-evaluations, and their leaders' empowering behaviors and how it impacts their well-being at work.

Literature on the antecedents of workplace well-being in the Nigerian manufacturing sector is dearth as most studies have been focused on exploring antecedents of psychological well-being such as management safety practices and workplace spirituality.[8,9] Little is known about how individual discretional behaviors, self-evaluations, and leaders' behavior influence employees' experience of well-being at work. Consequently, employee green behavior, core self-evaluations, and empowering leadership were used in this study as possible antecedents of workplace well-being. The core self-evaluations theory which proposed that the multidimensional core self-evaluations construct consisting of self-esteem, generalized self-efficacy, locus of control, and emotional stability influences various workplace outcomes informed the choice of core self-evaluations as a predictor variable.[10] The utilization of empowering leadership as a possible prediction variable was put forward by Weiss and Cropanzano's affective event theory.[11] The affective event theory is the notion that events and individual experiences in the organization cause emotional reactions which have consequences for workplace attitudes and behaviors. In application to this study, empowering leadership can steer positive emotions which could in turn positively influence employee behaviors and their well-being. Thus, to fill these research gaps, the main objectives of the study are: (1) to examine the direct relationship between employee green behavior and workplace well-being, (2) to examine the relationship between core self-evaluations and workplace well-being, and (3) to explore the relationship between empowering leadership and workplace Well-being.

Employee Green Behavior and Workplace Well-Being

Well-being is one of the salient factors in all areas of life and well-being in the work environment is not an exception. Well-being is defined as the combination of cognitive and emotional aspects experienced by individuals based on subjective evaluations of their lives. The individual's subjective evaluations include cognitive judgments about life, satisfaction, and affective reactions to life events.[12] Well-being is a state that is characterized by stable, good, and satisfactory conditions in all areas of a person's life. Workplace Well-being simply refers to an employee's positive feelings regarding all areas of work life. Zheng et al. described workplace Well-being as an employee's positive assessment of work and job-related experiences.[13] The literature supports the claim that workplace well-being promotes behaviors that are beneficial to the organization. For example, workplace well-being has been found to increase organizational performance.[14]

On the other hand, employee green behaviors are environmentally sustainable behaviors carried out by employees in an organization.[15] Kim et al defined employee green behavior as voluntary behaviors carried out by employees to protect the work environment through the reduction of the negative impact of the activities of employees.[16] Employee green behavior is a series of behavior carried out by an employee in the organization to reduce negative environmental impact and contribute to the sustainability of the environment, such as completing tasks in an environmentally friendly way, reducing and utilizing waste, and promoting environmentally conscious behavior among colleagues.[1,17] Employee green behavior is regarded as a positive organizational behavior aimed at solving environmental and sustainable development issues at the micro-level.[1] The four-dimensional measurement framework of employee green behavior developed by Zhang et al. is adopted in this study.[1] Four dimensions are

identified: green learning, individual practices, influencing others, and organizational voices. Hence, employee green behavior is conceptualized in this study as the act of learning, practicing, encouraging others and ensuring that environmentally safe practices are implemented by colleagues in the workplace, and suggesting safer environmental practices to the organization.

Employee green behavior is a relatively new construct in the management literature and there is a lack of research concerning how it influences other workplace variables. Therefore, the literature review is based on related empirical studies that offer support for the current study. Empirical studies indicate that the experiences and feelings of individuals influence employee well-being. For example, helping behavior, and organizational citizenship behavior towards the environment have been positively linked with employee psychological well-being.[18,19]

Employee green behavior- a positive and deliberate workplace behavior towards the sustainability of the work environment and the organization in general- has implications for employee well-being. This is supported by the empirical literature which indicates that employee green behavior is beneficial to the implementers. For example, Su and Swanson found that supportive green behavior has a positive and significant impact on employee well-being.[20] While Zhang et al. proposed that employee green behavior enables employees to actively cope with work-related pressures and challenges, which in turn helps the employee achieve well-being.[1] Based on the above empirical literature, it is hypothesized that:

Hypothesis one (H_1): *Employee green behavior has a significant and positive relationship with workplace well-being.*

Core Self-Evaluation and Workplace Well-Being

According to Judge et al. core self-evaluation is defined as an individual's subconscious and fundamental traits of self-evaluations and belief in one's ability and control.[10] The construct of core self-evaluation consists of an individual's self-esteem, general self-efficacy, locus of control, and emotional stability.[21] Core self-evaluations have an impact on how individuals perceive what happens around them including job-related events. Individuals who have positive core self-evaluations can cope in various situations and adapt to the situation around them better than those who have negative core self-evaluations.[22]

Core self-evaluations is an individual's fundamental appraisal regarding their self-worth and capabilities. It has been empirically linked to various well-being indicators in the workplace. As proposed by the core self-evaluations theory, the construct is multidimensional and has been found to influence individual and organizational outcomes. Sudha and Shahnawaz conducted a study on the relationship between core self-evaluations and subjective well-being among special educators.[23] The indicators of subjective well-being used in the study include life satisfaction, positive affect, and negative affect. Core self-evaluations correlate positively with life satisfaction and positive affect and correlate negatively with negative affect. Also, Gibson and Hicks found that core self-evaluations have a positive impact on psychological well-being which is in support of the view that a positive perception of the self influences satisfaction with life and other indicators of well-being at work.[24] Some aspects of the multidimensional construct have also been linked to employee well-being. These include self-efficacy and Self-esteem.[25,26] These were all identified as predictors of work-related well-being. Based on the above review, it is hypothesized that:

Hypothesis Two (H_2): *Core self-evaluations have a significant and positive relationship with workplace well-being.*

Empowering Leadership and Workplace Well-Being

Leadership is an essential factor in the organization because, through leadership, tasks in the organization are organized, and employees are directed and motivated to achieve optimum performance. This brings us to the fact that the leadership style implemented in an organization is vital and has certain implications for workplace behavior. One such leadership behavior that could influence employee behavior in the organization is empowering leadership. Srivastava et al. defined empowering leadership as a leadership type that is centered on a commitment to performance implementation, giving subordinates the chance to participate in the decision-making process, and holding work orientation to achieve increased work performance.[27] In empowering Leadership, power is shared with team members which in turn raises their performance and levels of motivation.[27]

Empirical findings indicated that empowering leadership positively influences voice behavior, taking charge, creativity, and job performance.[28] In a meta-analysis conducted by Kim et al. empowering leadership was found to positively influence a range of positive employee outcomes such as psychological empowerment, self-efficacy, organizational-based self-esteem, job satisfaction, goal orientation, job effort, role clarity, employee motivation and resources, and positive attitude and

emotions in the workplace.[29] This is an indication that empowering leaders brings out the best in employees and empower them toward their goal attainment while also promoting a positive work environment that is salient to workplace well-being. Conger and Kanungo asserted that when employees experience empowerment in their jobs, it can directly influence their psychological state.[30]

A positive psychological state is necessary for workplace well-being. A study carried out by Premchandran and Priyadarshi positively linked empowering leadership to psychological, and subjective well-being among information technology sector employees in India.[31] The proposed relationship is further supported by the affective event theory which suggests that events occurring in the organization i.e. employee experiences in the workplace influence various workplace outcomes.[11] It has been reported that empowering leadership has a positive effect on individual well-being and relevant behavioral outcome in the organization (e.g., life satisfaction and meaningful work) while it has an adverse effect on negative affectivity and emotional exhaustion in the workplace.[32] As indicated in the literature, through empowering leadership, positive affectivity is promoted in the organization. Therefore, employees' emotional reaction to workplace events when they are working under an empowering leader is likely to be positive thereby increasing workplace well-being. Based on the empirical and theoretical evidence, it is hypothesized that:

Hypothesis Three (H_3): *Empowering leadership has a significant and positive relationship with workplace well-being.*

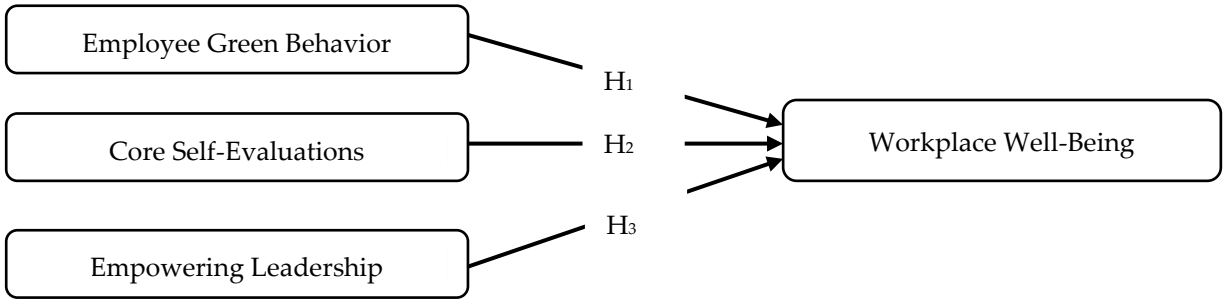

Figure 1: Conceptual framework showing the proposed relationships

Methods

A cross-sectional study was carried out among employees in two manufacturing organizations in the Apapa area of Lagos State, Nigeria. A cross-sectional study was adopted. The cross-sectional study was considered necessary because of the sample size, inadequate resources, and time constraints. It was also deemed necessary because it can adequately address multiple research questions and hypotheses. Based on the report gotten from the human resources departments, an estimated 450 employees were currently working in both organizations. Sloven's formula was used for estimating the required sample size for this study. The sloven's formula is given below:

$n = N/ (1 + N e^2)$,

Where n is the desired sample size

N= represents the total population (450)

e = level of error tolerance (0.05)

Based on the aforementioned formula, the appropriate sample size was 211.76. This was evenly distributed across both organizations. The researchers could only utilize 201 participants after the questionnaire sorting process. Some questionnaires were not properly filled out. This could either be a result of the participant's unwillingness or lack of motivation to continue participating after consenting to the study. Consequent to this, 201 questionnaires were used for the statistical analysis. The questionnaire for the collection of data contained four established instruments and items eliciting socio-demographic information such as gender, age, marital status, organizational tenure, and educational qualification. The mean scores for each participant were utilized for the final analysis.

Ethical clearance was obtained from the institutional ethical committee of the researchers' institution (Nnamdi Azikiwe University, Awka, Nigeria) before the commencement of the study. Also, confidentiality was strictly adhered to throughout the process of data collection. The researchers sought the permission of the participating manufacturing organizations

(through the letter of introduction stating the purpose of the research) before the administration of the questionnaires. The employees consented to participate in the study. This was achieved through verbal confirmation. The selection was done using a type of probability sampling. The participants were selected through a systematic random sampling technique using an *nth* case of one (1). In line with this, every second individual using a count of 1 was selected for the study. Participants were selected from the technical, operations, production, quality control, and human resources departments. The researchers ensured that the manufacturing organizations have these departments for the sake of homogeneity and replication of the study. Two hundred and twenty-five (225) questionnaires were distributed to employees in the participating organizations. Two hundred and eleven (211) questionnaires were retrieved; consisting of a return rate of 93.78%. However, after sorting out the questionnaire, 201 were used for the analysis of data.

Four standardized instruments were utilized in the data collection process while a 5-point Likert format (1 = strongly disagree to 5 = strongly agree) was utilized for all the measures. Workplace well-being was measured using the 6-item subscale.[13] Sample items from the workplace well-being scale include: "work is a meaningful experience for me" and "I feel satisfied with my work achievements in my current job." Higher scores on the scale indicate higher employee workplace well-being. A Cronbach's alpha of .92 was reported for the scale.

Employee green behavior was measured with a 13-item scale.[1] The scale which has four dimensions is aimed at measuring employees' behaviors toward protecting the work environment and ensuring environmental sustainability in the organization. Four dimensions used in the scale are; green learning (measured using three items e.g., I actively participate in environmental protection-related training provided by my organization), individual practice (measured by four items e.g., I complete the task assigned by my organization in an environmentally friendly way), influencing others (measured by three items e.g., I encourage my colleagues to adopt more environmentally conscious behavior), and organizational voices (also measured by three items e.g., I try to draw management's attention to potentially environmentally unfriendly activities). The composite score when each dimension is added together represents an employee's green behavior. Higher scores indicate higher green behavior in the organization. The Cronbach's alphas as reported by the developers were .84, .84, .93, and .87 respectively for each of the subscales while a Cronbach's alpha of .90 was found for the overall scale.

Core self-evaluations were measured with a 12-item scale.[33] Sample items include: "I determine what happens in my life" and "I am capable of coping with most of my problems". A Cronbach's alpha ranging from .81 to .87 was found across four samples.[33] Empowering leadership was measured with a 12-item scale.[34] Sample items for the scale include: "my manager helps me understand how my objectives and goals relate to that of the company" and "my manager solicits my opinion on decisions that may affect me". The developers reported a Cronbach's alpha of .89 for the scale.

The three hypotheses were tested with the simple regression analysis while multiple regression was used to assess the influence of the four dimensions of employee green behavior on workplace well-being. Preliminary analyses such as the normality test, Cronbach's alpha, correlation coefficient, and common method variance (CMV) tests were carried out. Since regression was adopted, it became necessary to adhere strictly to the assumption surrounding the use of parametric tests. Hence, the assumptions surrounding the use of parametric tests were well observed in the study. For example, the data used were normally distributed, and the scatter plot produced by the IBM-SPSS showed a linear relationship between the variables. The data were analyzed with version 25 of the IBM-SPSS Statistics.

Results

The demographic profiles of the participants are given in table 1. The sample consisted of 124(61.7%) males and 77(38.3%) females; 109(54.2%) unmarried, 86(42.8%) married, and 6(3%) separated. The age range of the respondents was between 20-60 with a mean of 31.43 years (SD, 5.87; Age range, 40). All the participants had a formal education with a minimum of O' Level certification comprising 83(41.3%) of the participants. The majority of the respondents, 115(57.2%) had a first-degree certification. Also, 75.6% of the participants have spent between 1 to 7 years while 18.9% have spent between 8 to 13 years in their respective organizations. Table 1 indicates that most of the research participants were male. Also, participants between 20 to 30 years of age, and those who have spent less than 7 years in their various organizations made up a large proportion of the sample.

Table 1: Demographic profiles of the research participants

	N	Frequency	Percent
Gender	201		
Male		124	61.7
Female		77	38.3
Age	201		
20-30years		100	49.8
31-40years		83	41.2
41-50years		16	8.0
51-60years		2	1.0
Marital Status	201		
Married		86	42.8
Unmarried		109	54.2
Separated/Divorced		6	3.0
Organizational Tenure	201		
1-7 years		152	75.6
8-13 years		38	18.9
14-19 years		6	3.0
20-25 years		5	2.5
Educational Qualification	201		
Less than a Bachelor's degree		83	41.3
Bachelor's degree/equivalent certificate		115	57.2
Postgraduate		3	1.5

The Cronbach's alphas, mean, standard deviation, and correlation results are shown in Table 2. The internal consistency of the scales as measured by Cronbach's alpha ranged from .72 to .90. Specifically, Cronbach's alpha values for employee green behavior, workplace well-being, core self-evaluations, and empowering leadership were .85, .78, .89, and .80 respectively. The Cronbach's alpha values for the dimensions of employee green behavior were appropriate. Table 2 also indicates that the mean and standard deviation values were modest for all the variables. Also, the table showed that all the main relationships tested in this study are significant, employee green behavior (r = .43, p < .01), core self-evaluations (r = .17, p < .05), and empowering leadership (r = .14, p < .05) were all positively correlated with workplace well-being. Also, green learning was positively associated with core self-evaluations (r = .20, p < .01), and workplace well-being (r = .24, p < .05), while organizational voices dimension of employee green behavior positively correlates with workplace well-being (r = .17, p < .05), core self-evaluations (r = .16, p < .05), and empowering leadership (r = .16, p < .05).

Table 2: Descriptive statistics, correlation coefficient, and Cronbach's alpha of the variables

	Mean	*SD*	EGB	GL	IP	IO	OV	WWB	CSE	EL
EGB	3.48	.44	[.85]							
GL	3.93	.71	.49**	[.77]						
IP	3.46	.70	.61**	.09	[.75]					
IO	3.34	.74	.62**	.06	.27**	[.72]				
OV	3.18	.75	.56**	08	.15**	.40**	[.83]			
WWB	3.73	.54	.43**	.24**	.35**	.28**	.17*	[.78]		
CSE	3.58	.72	.17*	.20**	-.02	.11	.16*	.14*	[.89]	
EL	3.59	.50	.14*	.11	-.03	.15*	.16*	.20**	15*	[.80]

Note: **p < 0.01; *p < 0.05; SD = standard deviation; EGB= employee green behavior; GL = green learning; IP = individual practice; IO = influencing others; OV = organizational voices; WWB = workplace well-being; CSE = core self-evaluations; EL = empowering leadership; Cronbach's alphas are given in parenthesis.

Table 3: Simple regression analysis of workplace well-being predicted from employee green behavior, core self-evaluations, and empowering leadership

	R	R^2	*Adjusted* R^2	*B*	*SE*	*F*
Employee green behavior	.43**	.19	.18	.53	.07	46.60
Core self-evaluations	.14*	.02	.01	.10	.05	3.96
Empowering leadership	.19**	.04	.03	.21	.08	7.33

Note: **p < 0.01; *p < 0.05

The hypotheses were tested with regression analysis. Table 3 shows the simple linear regression performed for the three hypotheses. As indicated by the individual regression values, the relationship between employee green behavior and workplace well-being (R= .43, P < .01), core self-evaluations and workplace well-being (R= .14, P < .05), and empowering leadership and workplace well-being (R= .19, P < .01) were positive and statistically significant. The analysis of variance (ANOVA) test for employee green behavior was F (1; 200) = 46.60, P < .01; core self-evaluations, F (1; 200) = 3.96, P < .05; and empowering leadership, F (1; 200) = 7.33, P < .01 were all statistically significant. The R^2 indicated that employee green behavior accounted for 19%, variance, core self-evaluations accounted for 2% variance, and empowering leadership accounted for a 4% variance in workplace well-being.

The contributions of each dimension of employee green behavior (green learning, individual practice, influencing others, and organizational voices) to workplace well-being were tested with multiple regression analyses. Table 4 shows the multiple regression analysis of workplace well-being predicted from the dimensions of employee green behavior. The results indicated that green learning, B(201) = .15 p < .01, individual practice, B(201) = .21 p < .01, and influencing others, B(201) = .12 p < .01 significantly predicted workplace well-being while organizational voices, B(201) = .03 p >.05 did not. As revealed by the B-values, workplace well-being increases by 15%, 21%, 12%, and 3% for every one-unit increase in green learning, individual practice, influencing others, and organizational voices. β values show that workplace well-being was largely influenced by individual practice, accounting for a 28% variance.

Table 4: Multiple regression analysis of workplace well-being predicted from the dimensions of employee green behavior

	B	β	T	Part correlation	95% CI	VIF
Green learning	.15	.19**	3.06	.19	[.05, .24]	1.01
Individual practice	.21	.28**	4.26	.27	[.11, .32]	1.08
Influencing others	.12	.17**	2.38	.15	[.02, .23]	1.25
organizational voices	.03	.04	.53	.03	[-.07, .12]	1.19
F = 12.35, R = .45**, R^2 = .29, Adj. R^2 = .18 (DW, 1.56)						

Note: **p < 0.01; DW = Durbin-Watson; VIF = Variance Inflation Factor

The statistics at the base of Table 4 present the combined contribution of the four dimensions of employee green behavior on workplace well-being, R = .45, R^2 = .29, p < .01. The R^2 value indicates that employee green behavior as a composite explained a 29% variance in workplace well-being.

Discussion

This study examined employee green behavior, core self-evaluations, and empowering leadership as predictors of workplace well-being among employees in manufacturing organizations. It is apparent from the literature that employee green behavior, core self-evaluations, and empowering leadership have not been well explored in the Nigerian work setting, especially in manufacturing organizations. It is important to understand well-being in manufacturing organizations, as this will help inform managerial practice. Hence, this study is timely and highly necessary. Three hypotheses were developed and tested in this study. The descriptive statistical output revealed a moderate level of employee green behavior, workplace well-being, core self-evaluation, and empowering leaders for the employees who participated in the study.

The Cronbach's alphas were satisfactory as they were above 0.70.[35] Regarding the validity of the scales, the content validity was achieved through the adoption of scales that have been consistently adopted across various management-related studies. The correlation values were within the acceptable range (0.2 to 0.5), while the inter-item correlation values showed evidence of convergent validity.[36] Since a parametric test was adopted to

test the research hypotheses, it was necessary to check if the data are normally distributed. The normality test (using skewness and Kurtosis) showed that the indicators were within the acceptable values that indicate normality. The statistical analysis showed that the values for the skewness and Kurtosis were below 2; this is an indication that the data are normal.[37] The observed correlation values were below .80 indicating that multicollinearity and common method variance were not an issue in the study.[38]

Based on Cohen's d criterion,[39] from the linear regression conducted to test the hypotheses, the R^2 of .19 indicates a large effect size while R^2 of .02, and .04 indicate small effect sizes. The small difference in the effect sizes indicates good cross-validation, meaning that the model can be adopted for other samples in a similar population. Also, the *B*-indicates that, a unit increase in employee green behavior, core self-evaluations, and empowering leadership will lead to an increase in workplace well-being by .53, .10, and .21 respectively. The Durbin-Watson values were within the acceptable range. The three hypotheses developed for the study were supported.

The first hypothesis which stated that employee green behavior will positively and significantly predict workplace well-being was supported. Employee green behavior was found to positively and significantly predict workplace well-being. This implies that engaging in green behavior fosters well-being in the workplace. Therefore, as employee green behavior increases, workplace well-being also increases. This finding is in line with previous studies that have explored environmental factors and employee general well-being. For example, the literature indicates that organizational citizenship behavior towards the environment positively influences the psychological well-being of employees, while supportive green behavior is positively linked to employee well-being.[19,20] Thus, through employee green behavior, employees can easily cope with pressures and challenges related to their work environment, helping them find more meaningful experiences, and in the process increasing their well-being at work.[1]

The second hypothesis which states that core self-evaluations will positively and significantly predict workplace well-being was supported. The findings indicated that the core self-evaluations of an employee predicted well-being at work. This implies that as employees' core self-evaluations increase by one unit, their well-being at work also increases by one unit. This finding is in congruence with the extant literature.[23,24,25,26] For example, Gibson and Hicks found a positive significant relationship between core self-evaluations and psychological well-being which gives support to the notion that having a positive perception and evaluation of one's abilities is a salient indicator of well-being in the workplace.[24] This further suggests that when an employee has a positive perception or evaluate themselves positively, this is likely to influence their experience in the workplace, especially with regard to their well-being. The core self-evaluation theory put forward by Judge et al. justifies the observed positive relationship.[10] The theory holds that the four factors in core self-evaluations (self-esteem, self-efficacy, locus of control, and emotional stability) can serve as positive resources that can facilitate the well-being of an individual both within and outside the workplace. Core self-evaluation can help employees deal with the challenges and demands emanating from task-related activities in the workplace. Positive core self-evaluation denotes higher levels of efficacy, control, and stability-all of which are essential to well-being in the workplace.[10, 24]

The third hypothesis which states that empowering leadership will positively and significantly predict workplace well-being was also supported by the results of the study. The findings indicated that empowering leadership was positively linked to the experience of well-being in the workplace. This is an indication that when employees are exposed to leaders who are empowering, they are likely to have a positive experience in the workplace; which in turn influences their well-being. Through the behaviors of empowering leaders (e.g., enhancing work meaningfulness, providing autonomy, and ensuring participation in decision-making), employees can easily adapt to the work environment as a result of these experiences.[34,40] A positive psychological state is a necessity for the experience of well-being at work. An employee in a positive psychological state shows optimism and resilience, which in turn translate to well-being at work. This finding is supported by empirical literature. For example, a study conducted by Premchandran and Priyadarshi found that an increase in empowering leadership leads to an increase in subjective and psychological well-being among employees working in information technology firms in India.[32] Also, Kim and Beehr found a positive relationship between empowering leadership and employee well-being (other indicators such as life satisfaction and meaningful work were also influenced positively by empowering leadership).[33]The result is also in congruence with the affective event theory. The affective event theory was proposed by Weiss and

Cropanzano.[11] The theory offers further justification for the positive relationship between empowering leadership and workplace well-being. The theory is built on the premise that experiences in the workplace elicit positive or negative emotional reactions from employees which have consequences for workplace attitudes and behaviors. Based on this, empowering leadership elicits positive emotional reactions in the workplace, which in turn influence employee well-being at work.

The current study provides valuable insights into the predictor and criterion variables and provides sound implications for managerial practice for employees in manufacturing organizations. The study is not without limitations. These limitations are hinged on the cross-sectional nature of the study. With this in mind, it was difficult to draw any cause-effect relationship. Utilizing self-report measures for the collection of data can introduce bias or possibly confound the data. Future studies should incorporate the rating of other staff such as managers and coworkers to gather all-encompassing data that can represent all the key constructs in the study.

Conclusion

This study has successfully investigated and shown the empirical connection among the variables to provide answers to the hypotheses that were developed and tested. Consequent to the validation of the instrument adopted in this study, data were collected from 201 employees in manufacturing organizations in the Apapa area of Lagos State, Nigeria. Statistical analysis provided support for all the hypotheses, thereby helping in achieving the objectives of the study. More specifically, employee green behavior, core self-evaluations, and empowering leadership were significant predictors of workplace well-being in manufacturing organizations. First, the findings indicated that employee green behavior is necessary for well-being at work. Hence, it becomes necessary for practitioners to ensure that pro-environmental behaviors and practices are encouraged at the individual and organizational levels. The organization can promote this behavior through a supportive culture that encourages the practice of green behavior in the workplace. Second, it was found that core self-evaluations are important factors for employees' experience of well-being. Hence, a positive self-evaluation is necessary for well-being within the work environment. The organization can enhance this attribute by implementing training and programs targeted at personality development. Last, the findings revealed that empowering leadership promotes workplace well-being such that the higher the experience of empowerment from leaders (e.g., managers and supervisors), the higher the experience of well-being in the workplace. On this note, management staff can be trained on how to empower their colleagues and subordinates as this has positive implications for behaviors that enhance organizational productivity and individual well-being at work. In this regard, this study has been able to add new knowledge to the occupational health literature by unraveling the roles employee green behavior, core self-evaluations, and empowering leadership have on workplace well-being among employees in manufacturing organizations.

References

1. Zhang B, Yang L, Cheng X, Chen F. How does employee green behavior influence employee well-being? An empirical analysis. International Journal of Environmental Research and Public Health. 2021;18:166-9. Available from: https://doi.org/10.3390/ijerph18041669
2. Adegbite WM, Gbenga Bawalla O, Adedeji O. Measuring employees' well-being among Nigerian bankers: Exploring the socio-cultural indicators. Journal of Workplace Behavioral Health. 2020;35(4):279–304. Available from: https://doi.org/10.1080/15555240.2020.1834866
3. Caltabiano LM, Ricciardelli L. Applied topics in health psychology. Wiley Blackwell, Malden. 2012.
4. Nilsen C, Andel R, Fritzell J, Kareholt I. Work-related stress in midlife and all-cause mortality: can sense of coherence modify this association? European Journal of Public Health. 2016;26(6):1055-61. Available from: https://doi.org/10.1093/eurpub/ckw086
5. Jung HO, Han SW. Analysis of Differences in Variables Related to Health and Safety According to the Employment Type of Korean Workers. International Journal of Occupational Safety and Health. 2022; 12 (1):8-16. Available from: https://doi.org/10.3126/ijosh.v12i1.41030
6. Anwarsyah WI, Salendu A. Hubungan antara job demands dengan workplace well-being pada pekerja shift. Jurnal Psikologi Pitutur. 2012;1(1):32–44. Available from: https://jurnal.umk.ac.id/index.php/PSI/article/view/34/33
7. Hussain K, Abbas Z, Gulzar S, Jibril AB, Hussain A.

Examining the impact of abusive supervision on employees' psychological well-being and turnover intention: The mediating role of intrinsic motivation. Cogent Business and Management. 2020;7(1). Available from: https://doi.org/10.1080/23311975.2020.1818998

8. Ishola AA. Workplace safety management as correlates of wellbeing among factory workers in Oluyole industrial estate, Ibadan, Oyo State Nigeria. African Journal of Social Work. 2017;7(2):45-51. Available from: https://www.ajol.info/index.php/ajsw/article/view/165225
9. Ajala EM. The impact of workplace spirituality and employees' wellbeing at the industrial sector: the Nigerian experience. The African Symposium, 2013.
10. Judge TA, Locke EA, Durham CC. The dispositional causes of job satisfaction: A core evaluations approach. Research in Organizational Behavior. 1997;19:151-88.
11. Weiss HM, Cropanzano R. Affective event theory: A theoretical discussion of the structure, causes, and consequences of affect experience at work. In B. M. Staw and L. L. Cumming (Eds.), Research in organizational behavior: An annual series of analytical essays and critical reviews. Elsevier Science/JAI Press, 1996, pp. 1-74.
12. Dinner E, Oishi S, Ryan KL. Universals and cultural differences in the causes and structure of happiness: A multilevel review. In Mental Well-Being; Springer: Berlin/Heidelberg, 2013, pp. 153–76. Available from: https://psycnet.apa.org/doi/10.1007/978-94-007-5195-8_8
13. Zheng X, Zhu W, Zhao H, Zhang C. Employee well-being in organizations: Theoretical model, scale development, and cross-cultural validation. Journal of Organizational Behavior. 2015;36:621–44. Available from: https://doi.org/10.1002/job.1990
14. Boxall P, Guthrie JP, Paauwe J. Editorial introduction: Progressing our understanding of the mediating variables linking HRM, employee well-being and organizational performance. Human Resource Management Journal. 2016;26(2):103–11. Available from: https://doi.org/10.1111/1748-8583.12104
15. Ones D, Dilchert S. Environmental sustainability at work: A call to action. Industrial and Organizational Psychology. 2012;5(4):444-66. Available from: https://doi.org/10.1111/1467-8551.12597
16. Kim A, Kim Y, Han K, Jackson SE, Ployhart RE. Multilevel influences on voluntary workplace green behavior: Individual differences, leader behavior, and coworker advocacy. Journal of Management. 2017;43:1335–58. Available from: https://doi.org/10.1177/0149206314547386
17. Juan P, Nan H, Yu P. The influencing factors and theoretical explanations of employees' green behavior. Advances in Psychological Science. 2019;27(7):1297-1306. Available from: https://doi.org/10.3724/SP.J.1042.2019.01297
18. Einstein N, Ryan RM. When helping helps: Autonomous motivation for prosocial behavior and its influence on well-being for the helper and recipient. Journal of Personality and Social Psychology. 2010;98:222–44. Available from: https://doi.org/10.1037/a0016984
19. Rastogi R, Garg P. Organizational citizenship behavior: Towards psychological well-being of employees. International Journal of Arts and Social Sciences. 2011;4(22): 13-30.
20. Su L, Swanson SR. Perceived corporate social responsibility's impact on the well-being and supportive green behaviors of hotel employees: The mediating role of the employee corporate relationship. Tourism Management. 2019;72:437–50. Available from: https://doi.org/10.1016/j.tourman.2019.01.009
21. Joo BK, Jo SJ. The effects of perceived authentic leadership and core self-evaluations on organizational citizenship behavior: The role of psychological empowerment as a partial mediator. Leadership and Organization Development Journal. 2017;38(3):463–81. Available from: https://doi.org/10.1108/LODJ-11-2015-0254
22. Lopez YP, Dohrn S, Posig M. The effect of abusive leadership by coaches on Division I student-athletes' performance: The moderating role of core self-evaluations. Sport Management Review. 2020;23(1):130–41. Available from: https://doi.org/10.1016/j.smr.2019.07.001
23. Sudha KS, Shahnawaz MG. Core self-evaluation as a correlate of subjective well-being among special educators. Journal of the Indian Academy of Applied Psychology. 2013; 39(1):83–9.
24. Gibson A, Hicks R. Psychological capital and core self-evaluations in the workplace: Impacts on well-being. International Journal of Psychological Studies.

2018;10(2). Available from: https://doi.org/10.5539/ijps.v10n2p15

25. Sahu FM, Rath S. Self-efficacy and well-being in working and non-working women: The moderating role of involvement. Psychology and Developing Societies. 2003; 15(2):187–200. Available from: https://doi.org/10.1177/097133360301500205
26. Awan S, Sitwat A. Workplace spirituality, self-esteem, and psychological well-being among mental health professionals. Pakistan Journal of Psychological Research. 2014; 29(1):125–49.
27. Srivastava A, Bartol KM, Locke EA. Empowering leadership in management teams: Effects on knowledge sharing, efficacy, and performance. Academy of Management Journal. 2006;49(6):1239-51. Available from: https://doi.org/10.5465/amj.2006.23478718
28. Zhang X, Qian J, Wang B, Chen M. The role of reward omission in empowering leadership and employee outcomes: A moderated mediation model. Human Resources Management Journal. 2019;30(2):226-43. Available from: https://doi.org/10.1111/1748-8583.12260
29. Kim M, Beehr TA, Prewett MS. Employee responses to empowering Leadership: A meta-analysis. Journal of Leadership and Organizational Studies. 2018;25(3):257-76. Available from: https://doi.org/10.1177/1548051817750538
30. Conger JA, Kanungo RN. The empowerment process: Integrating theory and practice. Academy of Management Review. 1998;13(3):471-82. Available from: https://doi.org/10.5465/amr.1988.4306983
31. Premchandran R, Priyadarshi P. Employee well-being in the Indian IT/ITES sector: The role of empowering leadership and work-family enrichment. International Journal of Happiness and Development. 2018;4(4):340-59. Available from: https://doi.org/10.1504/IJHD.2018.096431
32. Kim M, Beehr TA. Organization-based self-esteem and meaningful work mediate effects of empowering leadership on employee behaviors and well-being. Journal of Leadership & Organizational Studies. 2018;25(4):385–98. Available from: https://doi.org/10.1177/1548051818762337
33. Judge TA, Erez A, Bono JE, Thoresen CJ. The core self-evaluations scale: Development of a measure. Personnel Psychology. 2003;56(2):303–31. Available from: https://doi.org/10.1111/j.1744-6570.2003.tb00152.x
34. Ahearne M, Mathieu J, Rapp A. To empower or not to empower your sales force? An empirical examination of the influence of leadership empowerment behavior on customer satisfaction and performance. Journal of Applied Psychology. 2005;90(5):945-55. Available from: https://doi.org/10.1037/0021-9010.90.5.945
35. Hewitt D, Cramer D. Understanding statistics in psychology with SPSS. Pearson Education, 2017.
36. Field A. Discovering statistics using IBM SPSS (5th ed.). SAGE Publications, 2018.
37. Rashid A, Zeb MA, Rashid A, Anwar S, Joaquim F, Halim Z. Conceptualization of smartphone usage and feature preferences among various demographics. Cluster Computing. 2020;23(3):1855–73.
38. Tehseen S, Ramayah T, Sajilan S. Testing and controlling for common method variance: A review of available methods. Journal of Management Sciences. 2017;4(2):142-68. Available from: https://doi.org/10.20547/jms.2014.1704202
39. Cohen J. Statistical power analysis for the behavioral sciences. Laurence Erlbaum Associates, 1988.
40. Edosomwan HS, Nwanzu CL. Psychological contract fulfillment and attitude towards organizational change: A mediation and moderation analysis of affective commitment and empowering leadership. Seisense Journal of Management. 2021; 4(4):62-76. Available from: https://doi.org/10.33215/sjom.v4i4.683

International Journal of Occupational Safety and Health

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

Original Article

Determining the COVID-19 Knowledge, Awareness and Anxiety Levels of Intern Dentists

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Date of submission: 22.05.2022
Date of acceptance: 29.09.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None

DOI:https://doi.org/10.3126/ijosh.v13i1.45270

ABSTRACT

Introduction: COVID-19 is a contagious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The nature of dentistry leads to close contact with patients and exposure to the saliva, blood and other bodily fluids during treatment processes and it is a field where high frequency devices that can make it easier for virus contamination are used. This study aims to determine the knowledge and approaches of COVID-19 infection control of intern dentists who have begun face-to-face education and their COVID-19 related fear and anxiety levels.

Methods: The study comprised 4th and 5th year students who began face-to-face education at the Ankara University Faculty of Dentistry 2020/2021 spring semester. A questionnaire was used as the data collection tool of this study. The data were collected using a knowledge questionnaire and a COVID-19 fear and anxiety scale.

Results: The average COVID-19 knowledge score of the students was 63.65±9.64, their coronavirus fear average score was 17.63±5.57, and their anxiety average score was found to be 2.37±3.32. A positive relationship was found between the anxiety scores and the COVID-19 fear scores. The results of this study show that the COVID-19 knowledge level and fear of dentistry students is moderate and that their COVID-19 anxiety level is low.

Conclusion: It was found that the knowledge and fear of coronavirus levels of intern dentistry students were moderate, and that their coronavirus anxiety level was low.

Keywords: Dentistry, employee safety, pandemic, students.

Introduction

COVID-19 is a contagious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The World Health Organization (WHO) declared the new coronavirus (COVID-19) to be a global pandemic on the 11th of March 2020 (WHO, 2020). It has been reported that the COVID-19 outbreak has caused a public health emergency around the world, with large numbers of healthcare workers contracting the disease while working with infected people.[1] The nature of dentistry leads to close contact with patients and exposure to the saliva, blood and other bodily fluids during treatment processes and it is a field where high frequency devices that can make it easier for virus contamination are used.[2,3]

Therefore, dentistry is known to be one of the highest COVID-19 risk occupational groups.4 The Centers for Disease Control and Prevention, WHO and Ministry of Health have developed various guidelines to prevent the spread of COVID-19 in the practice of dentistry and to ensure a safe working environment. In this context, it is recommended that the transmission routes of

infection control are determined and the levels of knowledge and awareness of personnel working in this field are evaluated.[5]

Dentistry applications also include education as well as providing health services.[6] Education in dentistry faculties generally consists of the three stages of theoretical courses, preclinical and clinical applications.[7] In order to prevent the spread of the virus at the beginning of the pandemic period, measures were taken in many countries, including Turkey, such as postponing all treatments except for cases requiring urgent intervention and continuing dentistry education online.[8,9] It is stated that these measures have negatively affected the development of motor functions, independent decision making and work experience skills taught to students through clinical applications.[10] It is also said that the uncertainty in the education period during the pandemic has had various psychological effects on students.[11,12] The world returned to face-to-face education when the vaccine begun to be used in the struggle against the pandemic. Intern students of the Faculty of Medicine and Faculty of Dentistry were given priority for vaccinations on 14 January 2021 by the Ministry of Health. In line with the recommendations of the Council of Higher Education and the Ministry of Health in Turkey, 4th and 5th grade dentistry students who conduct clinical practices have been vaccinated and have returned to faculties.[10] During this time, information was posted about the pandemic on the website of the Ankara University Faculty of Dentistry. Additionally, seminars that were open to all students were carried out (http://www.dentistry.ankara.edu.tr). In the national and international literature, many studies have been carried out to determine the knowledge, attitudes and awareness of dentistry students or the levels of stress, fear, anxiety and worry of students during the pandemic.[13-16] However, no studies have been conducted after the transition to face-to-face education. In this study, it was aimed to determine the knowledge and attitudes of intern dentists who started face-to-face training towards the control of COVID-19 infections and to determine their fear and anxiety levels due to COVID-19.

Methods

The study comprised 4th and 5th year students who began face-to-face education at the Ankara University Faculty of Dentistry 2020/2021 spring semester. In this regard, the population of this study consisted of a total of 363 students, of whom 193 were 4th year and 170 were 5th year students. A sample size was not selected and the plan was to reach the whole of the population. The research group consisted of 213 students who volunteered. Therefore, 59% of the study population was reached. Ethical board approval from the Ankara University Faculty of Dentistry was obtained (Issue:36290600/38 No:09/02 Date:28.04.2021). Additional approval was obtained from the Ministry of Health for this study.

A questionnaire was used as the data collection tool of this study. The questionnaires were sent to the participants in May/June 2021 online via WhatsApp classroom groups and email. The questionnaires were prepared on google platforms. The questionnaire consisted of 3 sections. In the first section, there were 10 questions aimed at determining the descriptive characteristics of the participants (age, gender, class, who they lived with, the status of having COVID-19), their education about COVID-19, their perception of the disease, and their sources of information about COVID-19. In the second section, there were 22 questions aimed at evaluating their general knowledge regarding how COVID-19 spreads, its signs and symptoms, preventions and precautions. The questions were prepared by the researchers once the related literature and national/international guides were examined.[5,17-19] The third section of the questionnaire included the Fear of COVID-19 Scale comprised of 7 questions and the COVID-19 Anxiety Scale consisting of 5 questions. The Fear of COVID-19 Scale was developed by Ahorsu et al. to measure the fear levels of individuals during the COVID-19 pandemic.[20] The scale was adapted into Turkish by Haktanir et.al. It is a 5-point Likert scale ranging

from 1 (strongly disagree) to 5 (strongly agree).[21] The minimum score of the scale is 7 and the maximum is 35. The scale is one dimensional and is comprised of 7 items, there are no items that are reverse scored and increased score indicate increased fear of coronavirus. The COVID-19 Anxiety Scale was developed by Lee to measure the anxiety levels of individuals during the pandemic (α=.93).[22] The scale was adapted into Turkish by Evren et al.[23] The research group was asked to answer 5 questions as "Never", "Rarely, "less than one or two days", "A few days", "More than 7 days" and "Almost every day in the last 2 weeks" according to their practices in the previous two weeks. The minimum score for each question is 0 and the maximum is 4. The total score ranges from 0 to 20 and higher scores show that the individual has higher anxiety related to coronavirus. A total score of $\geqslant$ 7 on the scale indicates dysfunctional thinking associated with coronavirus. High scores on a particular item or high overall scale score ($\geqslant$ 7) indicate that the individual has problematic symptoms that may require further evaluation and/or treatment.

Confirmatory factor analysis (CFA) was conducted to evaluate the validity of the fear and anxiety scales used in the research for the research group. AMOS 24 statistical software was used for the CFA analysis. The Cronbach's alpha and composite reliability coefficients were used to evaluate consistency.[24]

The total knowledge score was determined by giving a 1 score for the "true" and a score of 0 (zero) score to the "false" and "I don't know" answers. The students' COVID-19 test success level was evaluated on a 0-100 scale. The Bloom's cut-off point was used to categorize the coronavirus knowledge scores. If the knowledge level was above 80% it was considered to be good score, a score between 50-79% it was taken as moderate and below 50% was taken as poor.

Within the scope of the research, descriptive findings are given as frequency, percentage, minimum, maximum, mean and standard deviation. Independent variables that were found to be statistically significant were analyzed with the multi variable regression analysis. The existence of a multicollinearity problem in the model was evaluated with VIF and tolerance values.[25-26] SPSS 26 statistical software was used to conduct the analysis.

As a result of the confirmatory factor analysis (CFA) conducted in order to evaluate the structural validity of the COVID-19 fear and anxiety scales on the study group, it is found that the values are above the good fit value limits (X^2/sd: 2.34; 0.32, GFI: 0.986; 0.997, NFI: 0.977; 0.995, SRMR: 0.071;0.038, AGFI: 0.972, 0.992).

The Cronbach's alfa coefficient was found to be 0.874, and the composite reliability coefficient was found as 0.878 in the reliability analysis of the fear scale based on which the structural validity was accepted. The Cronbach's alpha coefficient of the anxiety scale was 0.859, and the composite reliability coefficient was 0.866.

Results

The average age of the students in the study group was 22.56 (±1.41) and that 72.8% of them were female. 65.3% of the students were 4th year and 34.7% were 5th year students. When their COVID-19 characteristics were evaluated, 54.9% stated that they had attended lessons or meetings related to COVID-19. 19.2% of the patients had been infected with COVID-19. Additionally, while 49.8% of the students thought that the COVID-19 precautions taken in the workplace were sufficient, 12.2% stated that they were insufficient. The mean score of the students' COVID-19 knowledge level was calculated as 3.73 (±0.86), and the mean of the statement "COVID-19 is a serious disease" was calculated as 4.25 (±0.86).

The COVID-19 knowledge test mean score of the students was found to be 63.65 (±9.64). Lastly, it was found that the students obtained a mean score of 2.37 (±3.32) from the coronavirus anxiety scale and a mean score of 17.63 (±5.57) from the fear of coronavirus scale (Table 1). Accordingly, it can be said that the knowledge and fear of coronavirus levels of intern dentistry students were moderate, and that their coronavirus anxiety level was low.

Table 1. Sociodemographic characteristics and information about COVID-19

Sociodemographic characteristics and information about COVID-19		**n**	**%**
Gender			
Female		155	72.8
Male		58	27.2
Living conditions			
With Family		131	61.5
With Friends		57	26.8
Alone		25	11.7
Class			
4th year		139	65.3
5th year		74	34.7
Meetings or courses related to COVID-19			
Participated		117	54.9
Did not participate		96	45.1
Infected with COVID-19			
Yes		41	19.2
No		172	80.8
The COVID-19 precautions taken in the work environment			
Sufficient		106	49.8
Not Sufficient		26	12.2
Indecisive		81	38.0
Attitudes Towards COVID-19, Level of Knowledge, Level of Anxiety and Fear	**Min-Max**	**Avg.**	**(±Ss.)**
Give a value from 1 to 5 for your knowledge on Covid-19.	1-5	3.73	0.73
Give a value from 1 to 5 for the statement "COVID-19 is a serious disease".	1-5	4.25	0.86
Coronavirus Knowledge Level Score (0–100-point scale)	18.18-86.36	63.65	9.64
Coronavirus Anxiety Level	0,0-20.00	2.37	3.32
Coronavirus Fear Level	7.0-35.00	17.63	5.57

When the basic information resources that the research group followed during the pandemic are examined, it is found that the most common one was social media platforms (74.65%) followed by the Ministry of Health (71.36%) and then the World Health Organization (54.46%). This is followed by Television programs (46.95%), Turkish Medical Association (25.35%), Dentistry Association (20.19%), Other (15.96%), FDI (9.86%), European Center for Disease Prevention and Control (7.51%).

It was determined that the regression model applied for students' COVID-19 knowledge achievement levels was statistically significant (F:5,545, p=0.004) and 4.1% of the change in the students' knowledge level was explained by the independent variables. A statistically significant negative (β=-0.156, p=0.022) relationship was found between the ages and the COVID-19 knowledge success levels of the students within the scope of this research. A positive, statistically significant (β=0.141, p=0.039) relationship was found between the COVID-19 knowledge level and their own evaluations (Table 2).

It was determined that the regression model applied for students' COVID-19 knowledge achievement levels was statistically significant (F:5,545, p=0.004) and 4.1% of the change in the students' knowledge level was explained by the independent variables. A statistically significant negative (β=-0.156, p=0.022) relationship was

found between the ages and the COVID-19 knowledge success levels of the students within the scope of this research. A positive, statistically significant (β=0.141, p=0.039) relationship was found between the COVID-19 knowledge level and their own evaluations (Table 2).

The regression model applied for the variables affecting the coronavirus fear level was found to be statistically significant (F:16,238, p<0.001). According to the model, 22.3% of the change in students' coronavirus fear level is explained by the independent variables in the model (Table 3).

Table 2. Variables Affecting the COVID-19 Knowledge Level

Dependent Variable: COVID-19 Knowledge Test Level							
Independent Variables	**B**	**Standard Error**	**Standardize β**	**T**	**p**	**Tolerance**	**VIF**
Constant	17.746	2.503	-	7.090	**<0.001**	-	-
Age	-0.234	0.102	-0.156	-2.301	**0.022**	0.982	1.018
COVID-19 Knowledge Level Self Evaluation	0.410	0.197	0.141	2.081	**0.039**	0.982	1.018
F:5.545, p=0.004	Corrected R^2: 0.041						

Table 3. Variables Affecting the Coronavirus Fear Levels

Dependent Variable: Coronavirus Fear Level							
Independent Variables	**B**	**Standard Error**	**Standardize β**	**t**	**p**	**Tolerance**	**VIF**
Constant	6.625	1.720	-	3.851	**<0.001**	-	-
Female	1.425	0.784	0.114	1.817	0.071	0.930	1.075
Male (R)	-	-	-	-	-	-	-
"COVID-19 is a serious disease" statement evaluation	2.120	0.412	0.327	5.145	**<0.001**	0.907	1.103
The COVID-19 precautions in the work environment are sufficient (R)	-	-	-	-	**-**	-	-
I am indecisive about the COVID-19 precautions in the work environment	0.979	0.729	0.085	1.343	0.181	0.904	1.106
The COVID-19 precautions in the work environment are insufficient.	4.692	1.089	0.276	4.308	**<0.001**	0.891	1.122
F:16,238, p<0,001	**Corrected R^2:** 0,223						

(R): Reference Group

It was found that the regression model applied to determine the independent variables affecting the coronavirus anxiety level was statistically significant (F:5,804, p<0.001) and 10.2% of the change in the coronavirus anxiety level of the students was explained by the independent variables. A statistically significant positive (β=0.199, p=0.004) relationship was found between the statement *"COVID-19 is a serious disease"* and the students' coronavirus anxiety levels.

Additionally, the fact that the students within the scope of this study have had COVID-19 was observed to statistically significantly positively affect their coronavirus anxiety levels (β=0.174, p=0.009). It was determined that the coronavirus anxiety levels of students who found the measures to protect against COVID-19 at work insufficient were found to be statistically significantly and positively affected compared to those who found the measures sufficient (β=0.212, p=0.002) (Table 4).

A statistically significant moderate positive correlation was found between the students' fear of coronavirus and their anxiety about coronavirus. (r=0.620, p<0.001) (Table 5). When the relationship between the students' coronavirus knowledge scores and their anxiety and fear of coronavirus is examined, it is found that the regression model is not significantly meaningful (F:1.279, p=0.281) (Table 6)

Table 4. Variables Affecting the Coronavirus Anxiety Level

Dependent Variable: Coronavirus Anxiety Level							
Independent Variables	**B**	**Standard Error**	**Standardize β**	**t**	**p**	**Tolerance**	**VIF**
Constant	-1.800	1.123	-	-1.603	0.111	-	-
Female	0.229	0.502	0.031	0.456	0.649	0.929	1.076
Male (R)	-	-	-	-	-	-	-
"COVID-19 is a serious disease" statement evaluation	0.769	0.265	0.199	2.905	**0.004**	0.901	1.110
Did not have Covid-19 (R)	-	-	-	-	-	-	-
Had C-19ovid	1.462	0.551	0.174	2.654	**0.009**	0.986	1.014
The COVID-19 precautions in the work environment are sufficient (R)	-	-	-	-	**-**	-	-
I am indecisive about the COVID-19 precautions in the work environment	.484	0.468	0.071	1.035	0.302	0.902	1.109
The COVID-19 precautions in the work environment are insufficient.	2.150	0.698	0.212	3.079	**0.002**	0.890	1.123
F: 5.804, p<0.001	**Corrected R^2 :** 0.102						

(R): Reference Group

Table 5. Evaluation of the Relationship Between Anxiety and the Fear of Coronavirus

Measurements	**Coronavirus Anxiety**		
	n	**R**	**P**
Coronavirus Fear	213	0.620	**<0.001**

r: Spearman Correlation Coefficient

Table 6. Evaluation of the Relationship Between Coronavirus Knowledge Level and Anxiety and Fear

Dependent Variable: COVID-19 Knowledge Questionnaire Level							
Independent Variables	**B**	**Standard Error**	**Standardize β**	**T**	**P**	**Tolerance**	**VIF**
Constant	13.702	0.537	-	25.520	0.001	-	-
Coronavirus Anxiety	-0.089	0.056	-0.140	-1.592	0.113	0.611	1.638
Fear of Coronavirus	0.029	0.033	0.077	0.872	0.384	0.611	1.638
F:1.279, p=0.281	**Corrected R^2 :** 0.003						

Discussion

Firstly, in the fight against the pandemic, it is important to evaluate the knowledge and awareness of different populations towards the pandemic.[5,27,28] As the uncertainty reduces and the knowledge level increases, it is expected that the worry and anxiety will also reduce. Additionally, the uncertainty of a COVID-19 prognosis, lifestyle changes, quarantine limitations and education cuts result in fear, worry and anxiety, regardless of the increased knowledge level. The struggle to eliminate the effects of COVID-19 are continuing worldwide. Studies show that community health crises have many psychological effects on university students including worry, fear and anxiety.[29] In this context, this study aims to evaluate the knowledge and approaches as well as the fear and anxiety levels of intern dentists towards COVID-19 and to show the factors that affect them.

The results of the study show that students obtained an average score from the knowledge level questionnaire. Additionally, it was found that the knowledge score increased as the age increased. Students who evaluated their own COVID-19 knowledge level as high obtained higher scores from the knowledge questions. Some studies conducted on dentistry students found that their COVID-19 knowledge level was moderate and others showed that it was high.[14,15,17,30,31] A study conducted on Faculty of Medicine students showed that the rate of correct answers to 10 knowledge questions was 78.3%.[32] In a study conducted on nursing students, it was determined that the levels of anxiety and fear of COVID-19 were high and 51.5% of the students experienced severe anxiety.[33] Studies conducted in different sample groups show that young people have a higher level of knowledge about COVID-19.[34]

The students included in the study stated that they followed social media, the Ministry of Health and the WHO official website as reliable sources of information about COVID-19. The literature also shows that the most common sources of knowledge are social media, WHO and government web sites.[27] The websites of the WHO and Ministry of Health are more commonly followed by medicine and dentistry students, whereas social media platforms have become a basic source of information for many people. This shows that social media can play a huge role in risk perception and the dissemination of reliable information during a pandemic.

Many people experience clinical fear and anxiety during a contagious disease pandemic. With the emergence and rapid spread of the COVID-19 disease, problems such as fear, worry, stress and anxiety are seen in health workers and dentists, especially since they carry a high risk in the society.[31,35] In this study, the students' scores on the coronavirus fear scale (17.63±5.57) were moderate, while the scores they received from the anxiety scale (2.37±3.32) were found to be low. A study conducted on dentistry students in Saudi Arabia showed that returning to face-to-face education during the COVID-19 period caused anxiety and stress in 85% of the participants.[9] A study conducted on 650 participants from 30 different countries showed that over two-thirds (78%) of general dentists stated that they had anxiety and

fear about the destructive effects of COVID-19.[36] Another study showed that 74.9% of students were psychologically affected by COVID-19.[13] It was also found that the female students who thought that the precautions taken were insufficient and that evaluated COVID-19 as a serious disease had higher scores from the fear and anxiety scales. This is supported by the literature.[35]The study conducted by Doshi et al. (2021) showed that females are 1.29 times more likely to fear COVID-19 in comparison to their male colleagues.[37] This can be explained by women being under higher pressure during the pandemic, their increased sense of responsibility or them worrying about their loved ones more. Additionally, our study shows that the fear and anxiety levels of students who thought the precautions taken against COVID-19 were sufficient were low. The data we obtained show that the views and risk situations of the participants related to the pandemic affect their level of anxiety. A study conducted by Yakar et.al (2020) showed that the anxiety levels of students who thought they had sufficient information about COVID-19 and that thought sufficient precautions were taken was higher.[32] In our study, the scores of those who had COVID-19 from the anxiety scale were higher than those who have not had the disease. This can be due to unpredictability, uncertainty, severity of the disease, lack of information and social isolation resulting from the epidemic.[38]

The literature shows that the anxiety and fear levels of people who have increased COVID-19 knowledge is lower.[39] However, in this study, a statistically significant relationship was not found between the knowledge level and the anxiety and fear levels. Similarly, to our study, some research shows that fear of COVID-19 is not related to the level of knowledge, whereas others have shown that the fear of the disease will increase as their COVID-19 knowledge level increases.[40]

The study has certain strong aspects. Firstly, it is the first study to research the effect of COVID-19 on the anxiety levels of intern dentists at university. The findings can be used to further investigate the causes of fear and anxiety, and to determine the strategies to be used in reducing fear and anxiety in students. Secondly, the fact that dentistry students who conduct clinical practices are included in the priority vaccination group makes it necessary to determine their knowledge, attitudes and awareness. The findings of this study fill all these gaps.

Regardless of the important findings of our study, it also has several limitations. The fact that the study was conducted at only one faculty and that the data were collected online via questionnaires reduces the generalizability of the results. However, it must be considered that a quick method is needed to determine the knowledge level of students, evaluate their fear and anxiety levels during this pandemic which is rapidly spreading.

Conclusion

It was found that the knowledge and fear of coronavirus levels of intern dentistry students were moderate, and that their coronavirus anxiety level was low. In addition, the fear and anxiety levels of females, those who have had COVID-19, those who find the measures taken in their working environment inadequate and those with a high-risk perception are higher. Therefore, psychological support and extra precautions can be provided for these groups. The holistic results obtained in this study can be informative for universities when evaluating stress, anxiety and fear levels and can guide the application of psychological health programs. In general, dentists must be aware that the COVID-19 pandemic is a critical period and follow the necessary standard precautions to ensure infection control strategies during this pandemic. It is recommended that the role of tele-dentistry be developed to improve the ability to combat epidemics and similar diseases.

References

1. Sohrabi C, Alsafi Z, O'Neill N, et al. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19). Int J Surg. 2020, 76:71–6. Available from: https://doi.org/10.1016/j.ijsu.2020.02.034
2. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine. J Dent Res. 2020, 99(5): 481-7. Available from: https://doi.org/10.1177/0022034520914246
3. Peng X, Xu X, Li Y, et al. Transmission routes of 2019-nCoV and controls in dental practice. International Journal of Oral Science 2020, 12(1): 9. Available from: https://doi.org/10.1038/s41368-020-0075-9
4. Gamio L. The workers who face the greatest coronavirus risk. The New York Times. Available from: https://www.nytimes.com/interactive/2020/03/15/business/economy/ coronavirus-worker-risk.html
5. Nasser Z, Fares Y, Daoud R, et al. Assessment of knowledge and practice of dentists towards Coronavirus Disease (COVID-19): a cross-sectional survey from Lebanon. BMC Oral Health 2020, 20(1): 281-90. Available from: https://doi.org/10.1186/s12903-020-01273-6
6. Kılıcarslan MA. Dentistry Practices During the Covid-19 Pandemic Process. Journal of Quality and Accreditation in Health 2020, 3(1): 36-42.
7. Recen D, Başer A and Yıldırım B. Distance Learning in Dentistry and Medical Education in the COVID-19 Era. In the proceedings of the International Dentistry&Health Congress, Turkey, Izmir, 28-29 November 2020, pp 312-16.
8. Gurgel BCDV, Borges SB, Borges REA, et al. COVID-19: Perspectives for the management of dental care and education. Journal of Applied Oral Science 2020, 28: 1-9. Available from: https://doi.org/10.1590/1678-7757-2020-0358
9. Kharma M. Y, Koussa B, Aldwaik A, et al. Assessment of anxiety and stress among dental students to return to training in dental college in COVID-19 era. European Journal of Dentistry 2020, 14(1): 86-90. Available from:https://doi.org/10.1055/s-0040-1717052
10. Onur OD, Isler S, Ak G, et al. New Normals in Dentistry Education during the Covid-19 Pandemic Period. Journal of Advanced Studies in Health Sciences 2021, 5(1): 32-40. Available from: https://doi.org/10.26650/JARHS2021-945208
11. Generali L, Iani C, Macaluso GM, et al. The perceived impact of the COVID‐19 pandemic on dental undergraduate students in the Italian region of Emilia‐Romagna. European Journal of Dental Education 2021; 25(3): 621-33. Available from: https://doi.org/10.1111/eje.12640
12. Santabarbara J, Idoiaga N, et al. Prevalence of Anxiety in Dental Students during the COVID-19 Outbreak: A Meta-Analysis. International Journal of Environmental Research and Public Health 2021, 18: 10978. Available from: https://doi.org/10.3390/ijerph182010978
13. Atas O, Yildirim TT. Evaluation of knowledge, attitudes, and clinical education of dental students about COVID-19 pandemic. Peer J. 2020, 8: e9575. Available from: https://doi.org/10.7717/peerj.9575
14. Umeizudike K. A, Isiekwe I. G, Fadeju A. D, et al. Nigerian undergraduate dental students' knowledge, perception, and attitude to COVID‐19 and infection control practices. Journal of Dental Education 2021, 85(2): 187-96. Available from: https://doi.org/10.1002/jdd.12423
15. Almulhim B, Alassaf A, Alghamdi S, et al. Dentistry amidst the COVID-19 pandemic: knowledge, attitude, and practices among the Saudi Arabian dental students. Frontiers in Medicine 2021, 8: 1-7. Available from: https://doi.org/10.3389/fmed.2021.654524
16. Aragao M. G. B, Gomes F. I. F, et al. Brazilian dental students and COVID‐19: A survey on knowledge and perceptions. European Journal of Dental Education 2021; 26: 93-105. Available from: https://doi.org/10.1111/eje.12676
17. Esmaeelinejad M, Mirmohammadkhani M, Naghipour A, et al. Knowledge and attitudes of Iranian dental students regarding infection control during the COVID-19 pandemic. Brazilian Oral Research 2020; 34: 1-11. Available from: https://doi.org/10.1590/1807-3107bor-2020.vol34.0121
18. Sarfaraz S, Shabbir J, Mudasser MA, et al. Knowledge

and attitude of dental practitioners related to disinfection during the COVID-19 pandemic. Healthcare 2020, 8(3): 232-41. Available from: https://doi.org/10.3390/healthcare8030232

19. Sarkarat F, Tootoonchian A, Hosseinpour M, et al. Knowledge of Iranian Dentists, Dental Specialists, and Dental Students Towards COVID-19: A Preliminary Survey of 778 Subjects. Shiraz E-Medical Journal 2020, 21(12):e106515. Available from: https://doi.org/10.5812/semj.106515.
20. Ahorsu DK, Lin C-Y, Imani V, et al. The fear of COVID-19 scale: development and initial validation. International Journal of Mental Health and Addiction 2020, 20: 1537-45. Available from: https://doi.org/10.1007/s11469-020-00270-8
21. Haktanir A, Seki T, Dilmaç B. Adaptation and evaluation of Turkish version of the fear of COVID-19 scale. Death Studies 2020, 46(3): 719-27. Available from: https://doi.org/10.1080/07481187.2020.1773026
22. Lee SA. Coronavirus Anxiety Scale: A brief mental health screener for COVID-19 related anxiety. Death Studies 2020, 44(7): 393-401. . Available from: https://doi.org/10.1080/07481187.2020.1748481
23. Evren C, Evren B, Dalbudak E, et al. Measuring anxiety related to COVID-19: A Turkish validation study of the Coronavirus Anxiety Scale. Death Studies 2020, 46(5): 1052-8. Available from: https://doi.org/10.1080/07481187.2020.1774969
24. Alpar R. Applied statistics and validity-reliability with examples from sports, health and education sciences. Ankara: Detay Publishing, 2010.
25. Härdle W, Simar L. Applied multivariate statistical analysis, Berlin: Springer, 2007. Avalable from: https://link.springer.com/book/10.1007/978-3-662-45171-7
26. Tabachnick BG, Fidell LS. Using multivariate statistics, Allyn & Bacon/Pearson Education, 2007
27. Elsharkawy NB, Abdelaziz EM. Levels of fear and uncertainty regarding the spread of coronavirus disease (COVID - 19) among university students. Perspectives in Psychiatric Care 2021, 57(3): 1356-64. Available from: https://doi.org/10.1111/ppc.12698
28. Geldsetzer P. Knowledge and perceptions of COVID-19 among the general public in the United States and the United Kingdom: a cross-sectional online survey. Annals of Internal Medicine 2020, 173(2): 157-60. Available from: https://doi.org/10.7326/M20-0912
29. Wong TW, Gao Y, Tam WWS. Anxiety among university students during the SARS epidemic in Hong Kong. Stress and Health: Journal of the International Society for the Investigation of Stress 2007, 23(1): 31-5. Available from: https://doi.org/10.1002/smi.1116
30. Devi P. N, Sudhakar U. Awareness on Precautions and Protocols Followed during COVID-19 among Dental Students. International Journal of Recent Advances in Multidisciplinary Topics 2021; 2(8): 48-52. Available from: https://journals.resaim.com/ijramt/article/view/1238
31. Kara T, Atas O. The Impact of COVID-19 Knowledge, Fear, Protection Level and Pandemic on Education of Senior Dentistry Students. Turkey Clinics. Journal of Dentistry Sciences 2021, 27(4): e9575. Available from: https://doi.org/10.5336/dentalsci.2020-80672
32. Yakar B, Kaygusuz T. O, Pirincci E, et al. Knowledge, attitude and anxiety of medical students about the current COVID-19 outbreak in Turkey. Family Practice and Palliative Care 2020, 5(2): 36-44. Available from: https://doi.org/10.22391/fppc.737469
33. Kuru AN, Ozturk CE. Anxiety and fear of COVID-19 among nursing students during the COVID-19 pandemic: A descriptive correlation study. Perspectives in Psychiatric Care 2020, 58(1): 141-8. Available from: https://doi.org/10.1111/ppc.12851
34. Abdel Wahed WY, Hefzy EM, Ahmed MI, et al. Assessment of knowledge, attitudes, and perception of health care workers regarding COVID-19, a cross-sectional study from Egypt. Journal of Community Health 2020, 45(6): 1242-51. Available from: https://doi.org/10.1007/s10900-020-00882-0
35. Tekin AU, Dincer NN, Yarkac FU, et al. Evaluation of fear and anxiety levels of dentistry residency students during the Covid-19 pandemic process. Necmettin Erbakan University Journal of Dentistry 2020, 2(3): 86-93. Available from: https://doi.org/10.51122/neudentj.2020.1
36. Ahmed MA, Jouhar R, Ahmed N, et al. Fear and

practice modifications among dentists to combat novel coronavirus disease (COVID-19) outbreak. International Journal of Environmental Research and Public Health 2020, 17(8): 2821-32. Available from: https://doi.org/10.3390/ijerph17082821

37. Doshi D, Karunakar P, Sukhabogi J. R, et al. Assessing Coronavirus Fear in Indian Population Using the Fear of COVID-19 Scale. International Journal of Mental Health and Addiction 2021, 19(6): 2383-91. Available from: https://doi.org/10.1007/s11469-020-00332-x

38. Zandifar A, Badrfam R. Iranian mental health during the COVID-19 epidemic. Asian Journal of Psychiatry 2020, 51: 101990. Available from: https://doi.org/10.1016/j.ajp.2020.101990

39. Saddik B, Hussein A, Sharif-Askari FS, et al. Increased Levels of Anxiety Among Medical and Non-Medical University Students During the COVID-19 Pandemic in the United Arab Emirates. Risk Management and Healthcare Policy 2020, 13: 2395-406. Available from: https://doi.org/10.2147/RMHP.S273333

40. Caycho-Rodríguez T, Tomás JM, Barboza-Palomino M, et al. Assessment of fear of COVID-19 in older adults: Validation of the fear of COVID-19 scale. International Journal of Mental Health and Addiction 2021, 20(2): 1231-45. Available from: https://doi.org/10.1007/s11469-020-00438-2

International Journal of Occupational Safety and Health

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

Original Article

Internet Gaming Disorder among Undergraduate Health Sciences Students in the Pokhara Valley: a Cross-Sectional Study

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Date of submission: 16.01.2022
Date of acceptance: 18.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:
https://doi.org/10.3126/ijosh.v13i1.42038

ABSTRACT

Introduction: Internet Gaming Disorder (IGD) is an emerging public health impact of technological advancement and globalization. This study was conducted to assess the prevalence and factors associated with IGD among undergraduate health sciences students.

Methods: A web-based cross-sectional study was conducted during a period of November 2019 to July 2020. A total of 412 college students from Undergraduate Health Sciences colleges of Pokhara Metropolitan city in Gandaki province, Nepal were enrolled. Online google forms were sent to all the eligible students through email and other social media sites like face book with the help of coordinator and class representative. Collected data were analyzed using SPSS IBM v.22

Results: The finding of the study shows that the prevalence of Internet Gaming Disorder among Undergraduate Health Sciences students was 7.1%. Sex (p=0.027), loneliness level at home (p=0.019), number of close friends (p<0.001), types of game (p<0.001), time spent on play game (p<0.001) and, type of gamer (p<0.001) were the factors associated with Internet Gaming Disorder among the participants.

Conclusion: Sex of the participants, loneliness level at home, number of close friends, types of game, time spent on the game play, and type of gamer are the contributing factors for developing Internet Gaming Disorder. It is important to focus on these factors to address Internet Gaming Disorder and its psychological health effects.

Keywords: Developing countries, Internet addiction, Internet Gaming Disorder, Problematic gaming, Video games

Introduction

Internet Gaming Disorder (IGD) refers to the problematic use of online or offline video games. It is defined as persistent and recurrent use of the internet to engage in games, often with other players, leading to clinically significant impairment or distress as indicated by five (or more) of the nine criteria in a 12-month period.[1] World Health Organization (WHO) defined gaming disorder as "a pattern of gaming behavior (digital-gaming or video-gaming) characterized by impaired control over gaming, increasing priority given to gaming over other activities to the extent that gaming takes precedence over other interests and daily activities, and continuation or escalation of gaming despite the occurrence of negative consequences. Gaming disorder was incorporated as a mental health problem in the 11th revision of the International Classification of Disease (ICD-11) in 2018 and was recommended to the governments to formulate public health strategies and monitor IGD trends.[2]

The American Psychiatric Association (APA) included IGD in section III of the Diagnostic and

Statistical Manual of Mental Disorers-5th edition (DSM-5) on the condition that it guaranteed more clinical research and experience.[3] The essential feature of IGD is engaging in gaming for typically 8 to 10 hours or more per day, typically in internet-based group games.[4] Gaming is considered as safe activity but in certain population adverse consequences of involving in this behavior is noticed.[23] Engaging in gaming activities may promote negative behaviors such as smoking and aggression and could be harmful to physical and mental well-being.[24,25] Increase in internet use and video-gaming contributes to public concern on pathological or obsessive play of video games among children and adolescents worldwide.[22] Global Games Market (GGM) has shown that there were more than 2.5 billion gamers in the world in 2016, which is almost one-third of the total population globally.[5] A systematic review on IGD has shown the prevalence of IGD ranged from 0.7 percent to 27.5 percent.[6] In the context of Nepal, there has been very limited studies conducted on IGD to date. A cross-sectional study conducted during COVID-19 Pandemic Lockdown in 2020 showed that the prevalence of gaming disorder was 8.5% among 260 internet gaming users.[20] A study conducted among university students of Ilam on internet addiction showed that 42.84% of students played online games, as a major purpose of internet using.[7] Internet gaming disorder is a relatively new phenomenon, and all the studies on internet addiction that have been published in Nepal have pointed out that further research needs to be done in this area. A scoping review showed that 10-20% of children and adolescents have mental disorders and half of them started at age by 14 years [8]. However, internet gaming as a cause of these conditions has not been ruled out. Hence, this study aimed to assess the status of IGD and factors associated with it. Data obtained from this study generates evidence and would guide to the development of appropriate interventions and policies to prevention of problematic gaming and its psychological health effects.

Methods

A web-based cross-sectional study was conducted among students of Undergraduate Health Sciences Colleges of the Pokhara Metropolitan City, Gandaki province of Nepal. The study was conducted during November-July 2020. The study participants were undergraduate health sciences students. Sample size was calculated using the formula {$n= z^2p (1-p)/d^2$} where z= level of confidence according to the standard normal distribution (for a level of confidence of 95%, z= 1.96), p= prevalence of IGD= 50%= 0.5, q= 0.5, d= margin of error=0.05 and the sample size (n) was 424 after adding 10% non-response rate. The main instrument to collect data was online self-administered questionnaires using Google forms. The survey instrument was distributed to faculty members to assess its validity and reliability before pretesting among 42 (10% of sample) undergraduate students for relevance, clarity, and acceptability. Changes such as shuffling the question patterns were made before the final questionnaire survey was distributed to the research participants.

The study questionnaire consisted of the following two parts - Part A: General informative questionnaire to assess the socio-demographic profile, and Part B: The English version of the DSM-5 short (9-item) Dichotomous scale which compromises nine items, each reflecting one DSM-5 criteria for IGD. The psychometric properties of this instrument have been well-established.[1,26] For those who did not respond, the forms were sent at a gap of two days. The study included Undergraduate health sciences students of all semester and year studying in different medical colleges in Pokhara Metropolitan city. Interns and Post-graduate students were excluded from the study.

Ethical clearance was obtained from Institutional Review Committee (IRC) of Manmohan Memorial Institute of Health Sciences (MMIHS) Kathmandu, Nepal (Ref no: 77/27) prior to the start of study. The study was conducted during a period of November 2019 to July 2020. Questionnaire did not contain any identification detail such as email, name of the students and confidentiality was strictly maintained throughout the study. The participants had complete freedom to answer or decline the questionnaire.

The data were transferred from Google form into a spreadsheet and again transferred it to micro- soft excel 2016, analysis was done using the Statistical Package for Social Sciences software (SPSS IBM v. 22). Data were presented in the form of frequency and percentage. Chi-square test (at 5% level of significance and 95% CI) was done to show the association between dependent and independent variables. A p value of <0.05 was considered statistically significant for all the tests.

Results

There were total of 424 students out of which 412 students participated in the study. Table 1 denotes the demographic characteristics of the respondents. The mean age of the participants was 21.45 ± 2.11 years with the majority (80.6%) of females. Most (94.2%) of them were unmarried and were (99.5%) above the poverty line. Average income less than 1.90$ (dollars) per day is defined as below poverty line and equal or more than 1.90$ (dollars) per day is defined as above poverty line.[21]

Table 1. Some of the demographic Criteria for Participation

Variables	Frequency	Percentage
Age (in years)		
Mean ± SD	21.45 ± 2.11	
Sex		
Female	332	80.6
Male	80	19.4
Ethnicity		
Janajati	101	24.5
Brahmin	198	48.1
Chettri	88	21.4
Others	25	6.1
Marital status		
Unmarried	388	94.2
Married	24	5.8
Socio-economic status		
Below poverty	2	0.5
Above poverty	410	99.5

Table 2. IGD among the respondents was found to be (7.1%)

Variables	Frequency	Percentage
Prevalence of IGD		
No	273	92.9
Yes	21	7.1

Table 3 shows the analysis of factors significantly associated with IGD. Sex was significantly associated with IGD. The prevalence of IGD was higher in males than females. The study shows that males were 3 times more likely to have IGD than the female respondents (OR=2.906, 95% CI= 1.167-7.240). Loneliness level at home was seen to be significantly associated with the IGD of the respondents. The respondents who felt much lonely at home were 7 times more likely to have IGD than the respondents who did not feel lonely at home (OR= 6.583, 95% CI= 1.143-37.917). Likewise, the respondents who felt a little lonely at home were 3 times more likely to have IGD than the respondents who did not feel lonely at home (OR= 3.199, 95% CI= 1.179-8.679).

Number of close friends was also associated significantly with IGD. Respondents who had 1 to 2 close friends were 3 times more likely to have IGD than the respondents who had 7 or more close friends (OR= 3.205, 95% CI= 1.085-9.472). Likewise, respondents who had 3 to 6 close friends were less likely to have IGD than the respondents who had 7 or more close friends (OR= 0.393, 95% CI= 0.116-1.329).

Respondents who played action games were 13 times more likely to have IGD than the respondents who played strategic games (OR= 12.972, 95% CI= 3.600-46.746). Likewise, respondents who played adventure games were 5 times more likely to have IGD than the respondents who played strategic games (OR= 4.556, 95% CI= 0.883-23.495). Similarly, the respondents who played role-playing games were 4 times more likely to have IGD than the respondents who played strategic games (OR= 3.905, 95% CI= 0.381-40.054). Time spent on games was also found to be significantly associated with IGD. Respondents who played game for 8 and more than 8 hours were 7 times more likely to have IGD than the respondents who played games for 0 to 7 hours (OR= 6.951, 95% CI= 2.686-17.989). Respondents who were regular players were 8 times more likely to have IGD than the respondents who were irregular players (OR= 8.227, 95% CI= 3.037-22.284).

Table 3. Bivariate analysis of factors significantly associated with IGD

Factors	Prevalence of IGD		p-value	OR	95% CI (lower-upper limit)
	No	Yes			
Sex					
Female	217 (94.8%)	12 (5.2%)		**Ref**	
Male	56 (86.2%)	9 (13.8%)	0.022	**2.906**	1.167-7.240
Loneliness level at home					
None	158 (96.3%)	6 (3.7%)		**Ref**	
Little	107 (89.2%)	13 (10.8%)	0.022	**3.199**	1.179-8.679
Much	8 (80.0%)	2 (20.0%)	0.035	**6.583**	1.143-37.917
No. of close friends					
1 to 2	39 (79.6%)	10 (20.4%)	0.035	**3.205**	1.085-9.472
3 to 6	159 (97.0%)	5 (3.0%)	0.133	**0.393**	0.116-1.329
7 or more	75 (92.6%)	6 (7.4%)		**Ref**	
Types of game					
Role-playing	14 (93.3%)	1 (6.7%)	0.251	**3.905**	0.381-40.054
Action	59 (80.8%)	14 (19.2%)	0.000	**12.972**	3.600-46.746
Adventure	36 (92.3%)	3 (7.7%)	0.070	**4.556**	0.883-23.495
Strategy	164 (98.2%)	3 (1.8%)		**Ref**	
Time spend on game					
0 to 7 hrs.	212 (98.8%)	7 (3.2%)		**Ref**	
8 and more hrs.	61 (81.3%)	14 (18.7%)	0.000	**6.951**	2.686-17.989
Type of gamer					
Irregular	254 (95.1%)	13 (4.9%)		**Ref**	
Regular	19 (70.4%)	8 (29.6%)	0.000	**8.227**	3.037-22.284

Discussion

This study found that the prevalence of IGD among Undergraduate Health Sciences students was 7.1% whereas among 92.9% of the respondents there was no IGD. In the context of Nepal, a comprehensive literature review showed a study on gaming disorder in Nepal. A recent study done in 2020 showed that the prevalence of gaming disorder was 8.5%.[20] A study conducted in Kathmandu, Nepal among Health Sciences students in 2015 showed that 32.6% played online games on the internet.[9] Few studies on internet addiction among adolescent students in Nepal showed gaming as a major purpose of internet use.[7,9,10] Likewise, a study conducted in India showed that the prevalence of IGD was 3.50% which was similar to the study conducted in Thailand 5.4%.[11,12]

This study found sex as a strong predictor of IGD and prevalence was high among males than females among Undergraduate Health Science students. A study conducted in India showed that the prevalence of IGD was higher among male students than female students.[11] Majority of the

studies reported similar findings of high male prevalence like Lemmens et al (6.8%), Miller et al (3.1%).[13,14] From this study, it is evident that sex acts as an important risk factor for IGD. This may be because video games are marketed more towards males than females, there are not many games that attract girls, interactive online games and contents mainly rely on power, dominance, control and/or violence, which, may explain males' attraction on the internet use and games. Socio-demographic factors such as ethnicity, marital status, and family size were not associated with IGD in this study.

Loneliness level at home was also significantly associated with IGD. A study conducted in Nepal showed that the respondents who felt much lonely at home were more addicted to the internet.[10] Previous studies have consistently confirmed the connection between loneliness and game addiction.[15,16] This may be because playing online games may temporarily provide an escape from the negative feelings associated with social deficiencies such as dysfunctional family, lack of friends, and may make them free from loneliness. Number of close friends was also significantly associated with IGD. This study did not find any association between tobacco, alcohol consumption, and IGD, this result was supported by a study done in Thailand.[12] The study shows no association between socioeconomic status, internet access, and IGD. Pawan Taechoyotin et al support the findings.[12]

Time spent on games was significantly associated with IGD. A study done in Thailand supports the findings. If the games are played in controlled duration, it has a positive effect on learning process, motivation, memory formation and gives rise to happiness in those who play game. However, excessive internet gaming activity may develop into IGD.[17] Types of gamers were also significantly associated with IGD. A similar study conducted in 2016 by Gaetan et al showed that compared to irregular gamers, regular gamers have IGD and express their emotions less, and have difficulty being emotionally reactive.[18] Types of games were also significantly associated with IGD. This study shows that respondent who play action games were more likely to have a prevalence of IGD, this might be because action games content rely on power, fights, control that will attract the gamers towards the action genre. A study conducted by Bonaire et al in 2019 supports this finding.[19] Video games act as a medium for projecting and experiencing one's emotional life by staging the emotional self and thus giving priority to gaming than other activities.[18]

Conclusion

The present study revealed 7.1% prevalence of IGD among Undergraduate Health sciences students of Pokhara Metropolitan city. We found respondent's sex, loneliness level at home, number of close friends, types of game played, time spent on a game per day, and type of gamer to be the contributing factors for developing IGD. Therefore, it is very important to focus on these factors to address IGD and its psychological health effects on undergraduate heath sciences students.

Acknowledgments

We'd like to express our gratitude to the participants in the study for their involvement and all the Undergraduate Health Sciences colleges of Pokhara Metropolitan City, for their support during study. We are grateful to all the faculties of the Department of Public Health, Manmohan Memorial Institute of Health Sciences, Kathmandu, Nepal.

References

1. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 5th Ed. Arlington,VA: American Psychiatric Association;2013. Available from: https://doi.org/10.1176/appi.books.9780890425596
2. WHO. Addictive behaviours: Gaming disorder [Internet]. 2020 [cited 2020 Nov 9]. Available from: https://www.who.int/news-room/questions-and-answers/item/addictive-behaviours-gaming-disorder
3. Jo YS, Bhang SY, Choi JS, Lee HK, Lee SY, Kweon YS. Clinical Characteristics of Diagnosis for Internet Gaming Disorder: Comparison of DSM-5 IGD and ICD-11 GD Diagnosis. Journal of clinical medicine.2019;8(7):945. Available from: https://doi.org/10.3390/jcm8070945

4. American Psychiatric Association. Update to DSM-5 Criteria, Text, and ICD-10 Codes [Internet]. [cited 2020 Aug 10]. Available from: https://www.psychiatry.org/psychiatrists/practice/dsm/updates-to-dsm-5

5. Newzoo. The Global Games Market 2016 | Per Region & Segment [Internet]. Newzoo. 2016 Apr 21 [cited 2020 Aug 10]. Available from: https://newzoo.com/insights/articles/global-games-market-reaches-99-6-billion-2016-mobile-generating-37/

6. Mihara S, Higuchi S. Cross-sectional and longitudinal epidemiological studies of Internet gaming disorder: A systematic review of the literature. Psychiatry Clin Neurosci. 2017 Jul;71(7):425–44. Available from: https://doi.org/10.1111/pcn.12532

7. Hashemian A, Direkvand-Moghadam A, Delpisheh A, Direkvand-Moghadam A. Prevalence of internet addiction among university students in Ilam: a cross-sectional study. International Journal of Epidemiologic Research [Internet]. 2014 Dec 1 [cited 2020 Sep 28];1(1):9–15. Available from: http://ijer.skums.ac.ir/article_8671.html

8. Chaulagain A, Kunwar A, Watts S, Guerrero APS, Skokauskas N. Child and adolescent mental health problems in Nepal: a scoping review. Int J Ment Health Syst. 2019;13:53. Available from: https://ijmhs.biomedcentral.com/articles/10.1186/s13033-019-0310-y

9. Marahatta S, Adhikari B, Aryal N, Regmi R.. Internet addiction and associated factors among health sciences students in Nepal. J Community Med Health Educ. 2015;5(4):6-10. Available from: https://doi.org/10.4172/2161-0711.1000362

10. Karmacharya I, Bhujel K, Yadav DK, Subedi K. Prevalence of Internet Addiction among Higher Secondary Level Students in Kathmandu District. Journal of Health and Allied Sciences [Internet]. 2018 [cited 2020 Aug 9];7(1):40-6. Available from: https://www.jhas.org.np/jhas/index.php/jhas/article/view/21

11. Undavalli VK, Rani GS, Kumar JR. Prevalence of internet gaming disorder in India: a technological hazard among adolescents. 2020. 2020;7(2):6. International Journal Of Community Medicine And Public Health. 2020 Feb;7(2):688-93. Available from: https://dx.doi.org/10.18203/2394-6040.ijcmph20200450

12. Taechoyotin P, Tongrod P, Thaweerungruangkul T, Towattananon N, Teekapakvisit P, Aksornpusitpong C, et al. Prevalence and associated factors of internet gaming disorder among secondary school students in rural community, Thailand: a cross-sectional study. BMC Res Notes [Internet]. 2020 [cited 2020 Sep 22];13(1):11. Available from: https://doi.org/10.1186/s13104-019-4862-3

13. Majumdar A. Japan plans "fasting camps" for Web-addicted children- Technology News, Firstpost [Internet]. 2013 Aug 27 [cited 2020 Aug 9]. Available from: https://www.firstpost.com/tech/news-analysis/japan-plans-fasting-camps-for-web-addicted-children-3635073.html

14. Lemmens JS, Valkenburg PM, Peter J. Development and Validation of a Game Addiction Scale for Adolescents. Media Psychology [Internet]. 2009 Feb 26 [cited 2020 Aug 11];12(1):77-95. Available from: https://doi.org/10.1080/15213260802669458

15. Spilkova J, Chomynova P, Csemy L. Predictors of excessive use of social media and excessive online gaming in Czech teenagers. J Behav Addict. 2017 Dec 1;6(4):611-9. Available from: https://doi.org/10.1556/2006.6.2017.064

16. VAN Rooij AJ, Kuss DJ, Griffiths MD, Shorter GW, Schoenmakers MT, D VDM. The (co-)occurrence of problematic video gaming, substance use, and psychosocial problems in adolescents. J Behav Addict. 2014;3(3):157-65. Available from: https://doi.org/10.1556/jba.3.2014.013

17. Blum K, Thanos PK, Oscar-Berman M, Febo M, Baron D, Badgaiyan RD, et al. Dopamine in the Brain: Hypothesizing Surfeit or Deficit Links to Reward and Addiction. J Reward Defic Syndr [Internet]. 2015 [cited 2021 Mar 22];1(3):95–104. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4936401/

18. Gaetan S, Bréjard V, Bonnet A. Video Games in Adolescence and Emotional Functioning: Emotion Regulation, Emotion Intensity, Emotion Expression, and Alexithymia. Computers in Human Behavior. 2016 Aug 1;61:344-9. Available from: https://doi.org/10.1016/j.chb.2016.03.027

19. Bonnaire C, Baptista D. Internet gaming disorder in male and female young adults: The role of alexithymia, depression, anxiety and gaming type. Psychiatry Res. 2019;272:521-30. Available from: https://doi.org/10.1016/j.psychres.2018.12.158 -

20. Shrestha MV, Shrestha N, Sharma SC, Joshi SK. Gaming Disorder among Medical College Students during COVID-19 Pandemic Lockdown. Kathmandu University medical journal (KUMJ). 2020;18(70):48-52. Available from: https://doi.org/10.3126/kumj.v18i2.32956

21. Ferreira F, Jolliffe DM, Prydz EB. The international poverty line has just been raised to $1.90 a day, but global poverty is basically unchanged. How is that even possible? [Internet]. Let's Talk Development, World Bank Blogs. 2015 Oct 4 [Cited 2022 Mar 3]. Available from: https://blogs.worldbank.org/developmenttalk/international-poverty-line-has-just-been-raised-190-day-global-poverty-basically-unchanged-how-even

22. Choo H, Gentile DA, Sim T, Li D, Khoo A, Liau AK. Pathological video-gaming among Singaporean youth. Annals of the Academy of Medicine, Singapore. 2010;39(11):822-9. Available from: http://hdl.handle.net/10497/16240

23. Saunders JB, Hao W, Long J, King DL, Mann K, Fauth-Bühler M, et al. Gaming disorder: Its delineation as an important condition for diagnosis, management, and prevention. J Behav Addict. 2017;6(3):271-9. Available from: https://doi.org/10.1556/2006.6.2017.039

24. Dejan S, Ana D, Pal Singh BY, et al. Assessing the symptoms of Internet Gaming Disorder among college/university students: An international validation study of a self-report. Psihologija. 2020;53:43-63. Available from: https://doi.org/10.2298/PSI190421015S

25. Anderson CA, Shibuya A, Ihori N, Swing EL, Bushman BJ, Sakamoto A, et al. Violent video game effects on aggression, empathy, and prosocial behavior in eastern and western countries: a meta-analytic review. Psychological bulletin. 2010;136(2):151-73. Available from: https://doi.org/10.1037/a0018251

26. Petry NM, Rehbein F, Gentile DA, Lemmens JS, Rumpf HJ, Mößle T, et al. An international consensus for assessing internet gaming disorder using the new DSM-5 approach. Addiction (Abingdon, England). 2014;109(9):1399-406. Available from: https://doi.org/10.1111/add.12457

International Journal of Occupational Safety and Health

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

Review Article

Solid waste workers in India and the COVID-19 pandemic: A review of intersecting challenges

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ABSTRACT

Introduction: Municipal garbage/refuse, sludge, industrial and commercial waste, etc. is termed Solid Waste (SW) and those who handle such waste are SW workers. But the COVID-19 pandemic has hit them hard. SW workers play a vital role in waste management to safeguard and promote public health. But they are often unappreciated and the various health risks and vulnerabilities associated with waste handling are overlooked. This study aimed to review the working conditions and morbidities of SW workers highlighting the longstanding challenges before and after the onset of COVID-19 in India.

Methods: Databases such as PubMed and Google Scholar were used for the inclusion of articles. Drawing from the literature on the working conditions and morbidities of SW workers in India alongside grey literature and news reports by electronic media during the pandemic, this paper highlights the longstanding challenges of SW workers.

Results: The health morbidities and structural challenges due to caste, and class that were reported as being faced by SW workers across the studies have worsened at the onset of COVID-19. There is a multiplying effect of their vulnerability due to the disadvantages of caste and class. Due to power dynamics, they were forced to work without proper wages and appropriate healthcare resources. Many incidents across the country reported stigma and discrimination; poor access and utilization of Personal Protective Equipment (PPE) among SW workers resulted in infections and deaths due to the pandemic. Lack of proper data on COVID-19 infected SW workers; lack of proper certification had halted their insurance claims.

Conclusion: This paper noted the multiplying effect of long-standing vulnerabilities that were exposed during the pandemic. Proper maintenance of health records and a sustainable employee grievance redressal mechanism are essential. The need of the hour is to focus on strategies to improve their working conditions along with policies to protect their dignity and empower them.

Keywords: Discrimination, Health, India, Morbidities, Occupation, Personal Protective Equipment, Solid Waste Workers.

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Date of submission: 18.02.2022
Date of acceptance: 15.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v13i1.43113

Introduction

In the country's capital, Delhi, more than half of the Coronavirus Disease (COVID-19) deaths among the staff of the municipal corporation were the *safai karamcharis* i.e. the Solid Waste (SW) workers.[1] Municipal garbage/refuse, sludge, industrial and commercial waste, etc. is termed as SW and those who handle such waste are SW workers. These workers play a vital role in waste management to safeguard and promote public health. But they are often unappreciated, underpaid and overlooked. They suffer from various health risks and vulnerabilities due to physical, chemical and psychosocial hazards associated with waste handling.[2]

There is an ever-present risk of infection, infestation, and death for the SW workers. It is no surprise that the pandemic has hit them hard.

The World Health Organization (WHO) declared COVID-19 as a pandemic on March 11th, 2020. During this pandemic, various types of waste including healthcare waste are being generated. Microbiologic wastes and injuries from sharps have more risk of transmission of infectious diseases.[3] Household waste management also remains critical during the COVID-19 crisis as healthcare waste could be easily mixed with domestic waste. A COVID-infected person probably generates around 3.4kg of hazardous waste per day.[4] People in quarantine or isolation have limited awareness about proper waste disposal from households/areas and such infected waste was being disposed of in a common bin along with the domestic waste.[4] It has been more than a year since the outbreak of COVID, yet still household waste segregation practices in the cities have not changed.[5,6] The possibility of the spread of infection from these sources, and the work environment during the pandemic might put the SW workers at high risk of contracting COVID infection given the inadequate Personal Protective Equipment (PPE) they have.

The workers handling waste are employed in their jobs either by municipalities or connected with any associations/co-operatives or self-employed. Based on how they are employed and the activities associated with waste handling, the workers fall into various categories. They could be door-to-door solid waste collectors, on-route/truck waste pickers, street sweepers, silt removal/drainage cleaners, and street/dump/landfill waste pickers.[7] These workers also include those handling general waste from hospitals. Most of the SW workers are engaged in waste handling based on caste, particularly the lowest in the hierarchy of caste system in India or the generational transmission in their family.[8] The individuals involved in these jobs are considered "dirty" and hence "untouchables" in India.[9] This is apparent from the most commonly used term *"kachrawalla"* (garbage people) to refer to SW workers instead of *"safaiwalla"* (cleaning staff).[10]

In developing countries, because of limited resources, the process of waste handling in urban localities mostly remains manual[11] putting the SW workers at risk of injuries as the job of waste handling itself involves physical hazards while lifting waste loads, using trolleys, contact with sharps, etc. Also, there is a risk of biological hazards due to bacteria, viruses, or fungi and injuries or zoonotic diseases due to animal/insect bites. Due to this, SW workers are likely to suffer from various medical conditions including dermatological, respiratory, gastrointestinal problems, and many other morbidities. None of the workers in the study had awareness regarding diseases caused due to handling waste.[12] Due to direct contact with waste, they are at risk of health hazards. There may be cuts and infections from sharps. Hazardous smoke from burning waste if inhaled is an issue affecting their health.[13] On the other hand, Bio-Medical Waste (BMW) and municipal waste should not be mixed,[14] that needs attention because of the nature of the risk it poses to people who handle it or comes in contact with it putting them at risk of Hepatitis B, C, and other infections. In 2009, India had a Hepatitis outbreak in Modassa, Gujarat due to unsatisfactory BMW management.[15] Without proper protective wear, without appropriate preventive care, SW workers continue to risk their lives working through different kinds of waste ending up in multiple morbidities.

While Indian cities race to stand among *Swachh Bharat Abhiyan* (Clean India Programme) clean city rankings, the predicament of SW workers who strive to achieve this cleanliness is still questionable. As the population expands in urban settings, they have to cope with the increasing waste generation, particularly the healthcare waste mixed with domestic waste which is very risky, especially during a pandemic. Working conditions during public health emergencies are even more pathetic for SW workers. Health risks and impacts due to the pandemic varies across caste, class and gender and their vulnerability multiplies as these aspects intersect.[16] This affects their quality of life

leading to job losses and increased economic burden. All the challenges that the SW worker group has been facing are long-standing for decades.

Therefore, drawing from literature on their working conditions and morbidities alongside grey literature and news reports during the pandemic, this paper aims to highlight the longstanding challenges of SW workers in India. On the whole, the paper showcases their plight before and after the onset of COVID.

Methods

This is a review of literature reporting on occupation-related issues and health morbidities of SW workers in India. Various groups such as sweepers, garbage collectors, workers at dumpsites, sewer workers, etc. were considered SW workers and included in the review. Though not formally engaged, even ragpickers deal with solid waste contributing to waste management, hence were also included. Workers handling electronic waste or working in hospital settings were excluded.

Studies on social challenges, occupational morbidities, practices and healthcare among SW workers engaged under municipalities and those on ragpickers published from 2001 to 2021 were included. Articles were searched in the PubMed database using search terms like waste worker, garbage collector, sewage worker, *safai karamchari*, sanitation worker, conservancy staff, waste loader, waste handler, sweeper, hazard, morbidities, health problem, risk, workplace, personal protective equipment, protective gear, and safety wear. A hand search of articles and cross-references in Google scholar were also screened for inclusion. Titles and abstracts of the identified articles were screened; articles that were eligible to be included were cross-checked for duplicates. Studies with no full-text access or only abstracts available, reports, commentaries, dissertations, and editorials/letters to the editor were excluded. The second tier of grey literature included was the news reports by the electronic media from January 2020 to July 2021, hand searched in Google about SW workers experiencing challenges during the COVID-19 pandemic in India.

Results

The findings are focused on different sections. The first section presents the occupational challenges and health morbidities associated with waste handling through secondary data findings of original research studies among SW workers and ragpickers in India. The second section presents their hardships during COVID-19 in India collected through several e-newspaper reports.

Challenges before the COVID-19 pandemic

Structural differences related to the job of waste handling:

SW workers are usually engaged as permanent or contractual. In a study among sanitary workers in Kerala, 64.6% of them were regular corporation workers[17] while studies in Odisha and Karnataka found predominantly contract workers.[18,19] Wage difference between regular and contractual workers has also been reported. Some of the contractual workers get no or minimal hike in salaries even after several years into the job. Those employed on a contractual basis continue this job because of the lack of availability of other jobs. Only regular workers reported receiving medical benefits or allowance.[20] The working conditions are very vital for any occupation, but the job of waste handling by nature itself involves unhygienic conditions. A few studies reported a lack of basic amenities like drinking water, adequate seating at the reporting places, washing facilities (soap and water), or toilets near collection points, workplaces, or work stations in dumping yards.[8,21,22] While some workplaces have the facilities but are not in a condition to utilize them or were grossly inadequate. The workers had no proper lunch break and eat only after their work is complete.[8]

Adding to these workplace issues along with a diverse group of morbidities and problems with PPE, social challenges turn this group into one of the most vulnerable. Many studies noted how SW workers were downtrodden. The SW workers face stigma/discrimination from society due to their occupation, their families were treated as untouchables, have no proper social life and verbal

abuses were very common.[18,23] Discrimination in marriages and school was also reported.[11] Social exclusion, threatening by high caste people, or being accused of thefts was reported but the ragpickers were habituated with all the abuse considering it as a part of their work itself.[24] Lack of visibility in society makes them fall prey to these structural differences. Such a scenario worsens at times of onset of any health emergency.

A pool of Health Morbidities among SW workers: SW workers experience a diverse group of health morbidities most of which are specific to their occupation or have more risk of acquiring particular morbidity than a general population.[25] The most commonly reported occupational health problems are skin problems, cuts, bruises and wounds.[8,26,27] Among SW workers, Jayakrishnan et al., 2013 and T. Patil & Raje, 2020 reported a high prevalence of injury with sharps (73.2% and 70%).[21,11] Among ragpickers, a few studies reported a very high prevalence (75%-93%) of injury with sharps.[28-30] High prevalence of skin infections among SW workers was seen in a study[12] compared to a few other studies.[20,31] Nayak. et al., 2013 documented various types of dermatological problems reported due to waste handling.[32] Attack by animals during work was also reported among municipal SW workers[21,31] and rag pickers.[28,33]

A study among the municipal SW workers in Chennai had 3.3 times the odds of having respiratory morbidity than the control group[25] and it was 4.24 times among sweepers in Nagpur than a control group of Class IV workers in the office buildings.[34] The risk increased significantly with increased duration of service.[12,34] Studies of lung function tests among SW workers reported a significant reduction in lung capacity as the years of work experience increased. They were also significantly reduced than a control group compared across most of the studies.[35,36] This reduction was also significant among those who did not use masks and who used masks regularly while sweeping.[37]

SW workers especially the sewer workers would be exposed to drains that have a niche for leptospira so are at risk of leptospirosis which is both an occupational disease and a zoonosis. In a study on seroprevalence of leptospirosis, sewage workers were second-highest among five high-risk occupational groups assessed.[38] SW workers are exposed to many pollutants present in the waste they handle and would even contain toxic heavy metals. Biochemical tests among SW workers engaged formally had altered elemental profiles in the blood such are iron, bromine, and copper-zinc ratio; compared to that of the general population.[39] Hematological tests had shown increased white blood cells suggesting inflammation and allergic reactions among SW workers.[25] Biochemical tests among ragpickers had shown that their occupation adversely affects immunity,[40] even causing cytological and genotoxic damage[41] which leads to cancer. Significant airway inflammation was found among women ragpickers making them more vulnerable to chronic diseases compared to a control group of women.[42] Sputum cytological changes such as metaplasia and dysplasia of airway epithelial cells were observed in a study which is a sign of greater risk of cancer.[43]

Apart from health issues that were common to the job of waste handling, certain other chronic morbidities reported were diabetes and cardiovascular problems.[17,26,44] SW workers were found to have 1.8 fold higher risk for hypertension.[25] A study in Ahmedabad reported a comparatively high proportion of hypertension[35] among SW workers group involved in street sweeping than a control group of administrative staff (public health supervisor, sanitary inspector, and sub-sanitary inspector). Other morbidities such as tuberculosis[25], eye problems[12,31], dental problems[11], gastrointestinal problems[11] and frequent hit and run accidents[22,29] were also reported. Most of the SW workers were not having nutritious food in a study in Tamil Nadu but the method of assessment isn't clear.[45] This could be supported by a study finding of street sweepers who are significantly underweight compared to the control group at Ahmedabad Municipal Corporation.[35] Anemia was also an issue of concern reported commonly among SW workers and rag pickers across studies.[35,17,46,47]

On the other hand, mental health problems such as mild depression were reported among half of the workers in a few studies.[28,48] A study in Mumbai reported poor mental health among SW workers compared to a control group of class-IV employees working as back office helpers or fogging/spraying workers.[49] This was due to various reasons such as fear of loss of job, low wages, daily struggle for survival, lack of hope for a better life and uncertainty about their future.[50] In a study in Pune, quality of life assessed among SW workers was found to be affected negatively, particularly in their physical, social, and environmental domains[36] than the control group. The social domain among sewage workers in Puducherry was found to be very low in a study.[44]

Healthcare access:

In case of any morbidity, mostly the SW workers continue with their work without any appropriate treatment. With a fear of loss of pay, the SW workers don't get their wounds treated adequately, exposing them to further complications. Inadequate knowledge about healthcare and where to access the services is also a critical factor. They usually resort to alcohol consumption and self-medication to get relief from their symptoms[19] or rely on home remedies for minor health problems.[18] Desludging workers would apply mud immediately when injured as a temporary first aid[27] but this has a risk of acquiring tetanus. A comparative study in Ahmedabad showed that the administrative group had better health-seeking behavior attributing to controlled hypertension than the SW workers group.[35] About 68.7% of SW workers who were formally engaged were utilizing government hospitals for health problems[17] as they could not afford treatment in private hospitals. But it was reported that government hospitals lacked proper health facilities (particularly pharmacy and diagnostic tests), and healthcare is often delayed due to overcrowding and poor attention from doctors.[8,22]

There was no health education given or regular health checkups at the workplace. Though the Municipal Corporation of Greater Mumbai has earlier organized medical check-ups, most of the SW workers have not attended them.[8] A study among conservancy workers in Chennai has highlighted the need for prophylactic immunizations, especially Hepatitis-B vaccination (HBV) as an 8% prevalence of hepatitis B carriers was found among SW workers.[25] Majority of SW workers have not got any vaccination such as HBV or tetanus toxoid[31] and only three had received HBV vaccine in a study.[21] While 30.6% of them had taken tetanus injections and were working under a municipal corporation in Maharashtra.[11] In contrast, only 35.16% of SW workers under Aurangabad Municipal Corporation were not immunized against hepatitis B and 19.24% did not receive TT in the recent past or were not fully immunized against Tetanus.[26]

While ragpickers were ignorant of their health. The services being inexpensive, they too prefer government hospitals but only in case of serious illness.[46,48] Some of them rely on self-treatment if the health facility is distant to them. A few would opt not to procure the prescribed medication as they felt it was unaffordable.[48] Despite dog bites reported among 23 workers, only two of them had completed post-exposure prophylaxis for rabies from a nearby municipal dispensary in a study among women ragpickers in Mumbai. This study also found that women ragpickers were married at a young age, had a low preference for temporary contraceptive methods, and experienced multiple pregnancies.[46] Antenatal care is important for the health of women and the unborn child, but the majority of ragpickers had no proper antenatal care.[33,46] Mohapatra, 2012 reported in a study that 40.5% had delivery/abortion by doctors while 59.46% approached *dhais*.[47] This finding was similar to a study by Uplap and Bhate, 2014 with 43.5% having home delivery and 47.6% with hospital delivery in the last pregnancy.[46] But in a recent study, home deliveries were high (80%) among women ragpickers.[33] There were studies promoting health in this group which were found to be effective in improving knowledge on anemia prevention and reproductive health,[46] and knowledge on the occupational hazard and hygiene.[51]

The use of PPE among SW workers was never a

convention:

Lack of safety measures and lack of awareness regarding health were the prime causes of health morbidities and occupational hazards. Most of the studies among SW workers in India reported inadequate use/supply of PPE at the workplace such as the use of gloves, gumboots/protective footwear, masks, and reflector aprons.

The findings across studies ranged from complete no use to a considerable rate of use of PPE by the municipal SW workers. In one of the municipalities in New Delhi, Patel & Datta, 2018 reported comparatively good rates of using one or the other PPE; 86%, 80.5%, 53.7% and 19.5% were using aprons with reflectors, shoes, masks and gloves respectively while working.[52] Another recent study in Puducherry reported that 44.8%, 19%, and 10% were using footwear, gloves, and facemask respectively and none were using goggles or suits.[44] It could be observed from these studies that the use of gloves is comparatively less than other forms of PPE being used. A few studies reported that none of the SW workers engaged under municipalities were using PPE while working.[19,32,34] The reasons included an irregular supply of PPE and lack of motivation to use. Even though half of them were provided with PPE[17], only 20%[37] or less than 20% were using PPE citing the reasons for not using such as non-availability, not being aware of such devices, found it difficult to work with devices on.[26]

Some municipal corporations don't provide PPE regularly, even if they provide it would be of poor quality or a poor fit for the workers. The size/design of PPE was inflexible for the nature of their work which was even leading to accidental injuries while working with these devices. Due to these difficulties, most of them were not using PPE.[8,23,27] While 12.3% of the SW workers working under municipalities were using unconventional PPE such as handkerchiefs and dupattas[35] and most of them used towels to cover their faces.[27] Gautam et al., 2021 conducted a study among SW workers working in sewers that highlighted various constraints in using the currently available PPE which also explored workers' preferences about PPE and its design. This study revealed preference for PPE in the following order- gloves, mouth mask, gas monitor and gumboots, goggles, helmets, and jackets. These SW workers preferred waterproof, splash-proof, grippy, arm-length gloves that are easy to clean and aid in protecting from sharps. A tight-fitting, waterproof, and easy-to-communicate mask was the first choice, which can protect from harmful gases.[27]

Similar to municipal SW workers, the use of unconventional PPE was found among ragpickers where 60% of them used plastic bags or a hook as a precautionary measure while searching through the waste.[28] In one of the recent studies, 23% of them reported using masks/gloves.[41] Notably, a high proportion (70.3%) of ragpickers working at a dump yard in Chennai reported using one or the other PPE, such as gloves, footwear, headgear, and masks.[48] Most of the studies reported that none of the ragpickers used PPE.[29,33] The ragpickers did not care about the risk of injury and even the availability of PPE was also a problem.

Frontline warriors during the COVID-19 pandemic no-where in the front

The chaos has been continuing as the first and second waves of COVID-19 hit the country. Several lockdowns were imposed to date but health and emergency services were continued. SW workers too continued their work during the chaos. It is this group of workers who were most affected during the pandemic. A study by Urban Management Centre and Water Aid India has reported that with added responsibilities such as disinfection to prevent transmission of the virus, some of the SW workers had to work for additional 2-6 hours per day than their usual work hours without any compensation for the extra workload.[53] Long shifts of up to 30 hours were reported among some of the hospital waste workers. Public transport services were suspended to combat the spread of the virus. The SW workers had to commute either by walking for long distances or using their mode of transport bearing the additional fuel expenses.[53] The SW workers continued to work for their livelihoods with the fear of not only getting contracted the COVID infection but with an added

fear of spreading it to their families. Some of them reported losing jobs if they got infected or if any of their family members were infected or passed away due to COVID.[54]

The COVID-19 pandemic was found to be yet another intersectional aspect pushing SW workers to extremely strenuous livelihoods. Though there were instances during the pandemic applauding the SW workers across the country for being the frontline warriors fighting for cleanliness and sanitation of the cities, the ground reality of their lives remained the same. The literature findings in earlier sections showed decreased lung capacity among SW workers along with other co-morbidities which are potential risk factors for contracting COVID further worsening their health morbidities. The occupational issues of SW workers do not just constitute health morbidities but pull up wider social and economic problems resulting in horizontal inequities that are exacerbated during the current pandemic. The injustices for SW workers such as getting ostracized have been continued by social division with cultural stigmas of impurity and dirt[55] associated with low caste people. Discrimination due to their class, caste and stigmatized occupation roles has been rampant during the pandemic[56] in terms of provision of hygienic food, PPE, wages and quarantine holidays. Their plight is not new to the current COVID-19 situation; they have been striving for better livelihoods and working conditions for ages. Only a few social activists such as Harnam Singh have been fighting against such unfair treatment of SW workers during the pandemic as well as before its onset. The hardships among SW workers during COVID-19 in India are presented in Table 1 through second-tier grey literature i.e. the news reports on SW workers during the pandemic

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Table 1. Incidents reported among SW workers during COVID-19 in India.

Date	Source	Incident
8th April 2020	The Telegraph online	Death of a sweeper who was forced to spray chemicals in an area in Uttar Pradesh without any PPE like mask or gloves.[57]
15th April 2020	Nava Telangana	Waste handlers in Medak, Telangana were working without a mask and bare hands while cleaning drains, sweeping and garbage collection.[58]
19th April 2020	India.com	In Uttar Pradesh, a SW worker succumbed to death, who was forced to drink disinfectant for mistakenly spraying it on the foot of a man.[59]
28th April 2020	Sabrang India	Sanitation workers of Brihan Mumbai Municipal Corporation were given Hazmat (hazardous materials) suits. They were asked to wash and reuse them.[60]
7th May 2020	The Wire	Without PPE, a sanitation worker in Rajasthan has packed a COVID-19 patient's body unaware of the details of the patient.[61]
10th May 2020	News Meter	During the COVID-19 lockdown, sanitation workers at hospitals in Hyderabad were made to travel packed in buses and also reported harassment by police on their way to pick-up points.[62]
3rd July 2020	The News Minute	The death of six sanitation workers in Chennai due to COVID-19 was not recorded by the corporation which made the family ineligible for compensation.[63]
15th July 2020	Deccan Chronicle	Sanitation workers reported a huge wage difference between contract and permanent workers in Hyderabad. Permanent workers had only 15 days of work while contract workers did their job the entire month.[64]
3rd August 2020	The Federal	Garbage collection vehicles were used to distribute food for SW workers while food supply to other officials has good transportation in Chennai Corporation.[56]

23rd August 2020	News Meter	Nine sanitation workers in Gajwel, Telangana, who were infected with COVID-19 reported caste discrimination by officials. They traveled to the hospital in a tractor used for carrying municipal waste as the authorities didn't care.[65]
8th April 2021	The New Indian Express	SW workers in Greater Hyderabad Municipal Corporation (GHMC) were working for 14 hours/day without PPE even during the second wave of the Covid-19 pandemic. They often come across domestic waste mixed with medical waste.[4]
29th April 2021	The Indian Express	SW workers in Bengaluru have been working without PPE even during the second wave of the Covid-19 pandemic. Their plight was the same for one year of the onset of the pandemic. They handle the waste of those in home isolation but were not provided with PPE.[66]
20th May 2021	The Wire	Around 1,500 permanent SW workers of the Greater Chennai Corporation tested positive in 2020. SW workers reported that they were at least receiving use-and-throw masks and gloves daily in 2020. But the distribution of safety gear has reduced in the second wave of the pandemic. A worker had developed allergies after being bitten by a scorpion while collecting waste.[67]
23rd May 2021	Deccan Chronicle	Salaries were deducted for over 200 SW workers in Hyderabad despite the government order to pay full salaries to frontline workers in case of contracting Covid-19.[68]
1st July 2021	Citizen Matters	COVID has affected the earnings of informal waste collectors. Healthcare access was difficult and one of their fellow workers lost his wife during labor due to delivery complications.[69]

Not even half of the SW workers surveyed during the pandemic received safety provisions like masks, gloves, soaps, sanitizers and towels.[70] A study during the pandemic found a discrepancy in the provision of PPE to permanent and contractual or SW workers engaged by municipalities and by private agencies. In a study 40% of SW workers reported a lack of access to handwashing facilities at the workplace while some of them also reported a lack of changing and washing facilities.[53] These were reported even before the pandemic as evident from the literature. Even though the National policy on Safety, Health and Environment at work place recommends safe, just and humane working conditions,[71] improvements in their work environment and practices are far in sight. A major setback in India is that there is no organized segregation of SW at the household level or at the community bin.[72] Similarly, 78.5% of SW workers in a study in Kerala reported that they get unsegregated waste from the houses.[21] This was the same even during the pandemic.[4] Waste segregation at its generation level has been blind spotted without taking into concern about who is going to handle it. Basic standard of living and health care access is critical during infectious disease outbreaks. Waste management is even more critical in times of the pandemic and there is a compelling need for addressing the multitude of issues plaguing the SW workers.

Access to healthcare services in general situations and even at times of an emergency remains a mirage to SW workers. The Indian government announced health insurance coverage for sanitation workers during the pandemic in 2020[73] but in a study by Nigam D.D & Dubey S, 2020, 87.5% of sanitation workers reported no assurance from the government about health insurance, free treatment, or job security during COVID-19.[70] Though there is provision for such schemes/insurances, the SW workers or their dependents were yet to avail them.[63,67] The terms and conditions under these insurances, lack of proper data on COVID-19 infected SW workers, and lack of proper certification had halted their claims.[54] Vaccination for COVID-19 was made available for SW workers from January 2021 in India. Some of the SW workers were hesitant to get their jabs due to fear of falling sick and losing wages as the supervisor usually look for

opportunities to deduct their wages.[74] Even when services are available, the extent to which people gain access depends on: financial, organizational, social or cultural barriers that limit utilization.[75] There is a need for facilitating a process whereby SW workers can command appropriate health care resources that are long-standing to improve their health along with stronger actions to safeguard their dignity. COVID-19 is an appropriate opportunity to demand that health services are available including an adequate supply of PPEs.

Target-11.6 of the Sustainable Development Goals (SDGs) focuses on improved urban solid waste management and this will positively impact the other SDGs. SW workers thereby prevent the spread of diseases and contribute to SDG3 i.e. Good health and well-being. This in turn directly helps in making cities safe and sustainable (SDG11), also increasing the availability of clean water because of improved sanitation(SDG6), protecting land and water bodies thereby indirectly contributing to SDGs 14 and 15. To achieve these goals, enhancing the livelihoods and workplace conditions of SW workers have to cross hand in hand. Health is not limited to the physical dimension; it even includes mental and social well-being. Good health is important for cultivating sustained urban livelihoods, developing a healthy workforce, creating resilient and diverse cities, facilitating mobility, encouraging social engagement, and protecting vulnerable population groups. So strong urban policies should be framed considering all the existing challenges.[76] Therefore, it is important to recognize the vulnerabilities of SW workers and associated factors for good policy practice.

Conclusion

The paper highlights the fact that the challenges of SW workers, including the crucial considerations of caste and class, have been long-standing and worsened at the onset of COVID-19 in India. Inadequate use of PPE is not an abrupt scenario; many studies have been reporting the same. Whether it is an availability or affordability or design issue, there are no measures or adequate policies in place for addressing their concerns and nothing has been improved over years. The diverse group of health morbidities, a serious public health concern, could have been brought down to a considerable rate if there has been an appropriate use of PPE. COVID-19 has multiplied these health vulnerabilities. It is equally important to combat the increased rate of morbidities among this group contributing to the global disease burden. Even social stigma, their economic status, access to healthcare and the cost factor involved are the key issues. All the measures to address their problems are partial and temporary which vanish or become less interesting to the authorities as time goes by. Periodic health screening, appropriate use of PPE, maintaining records and employee grievance redressal mechanism is essential. Exploratory research in different settings helps in understanding workplace challenges besides health morbidities. Interventions targeting one particular population group like SW workers will contribute to sustainable health for all given their key role in keeping cities clean and safe. Without SW workers we can neither achieve sustainable goals nor mitigate the risk of COVID-19.

Acknowledgments

The author is grateful to Dr. Ashima Sood (Co-Director, Centre for Urbanism and Cultural Economics and Associate professor at Anant National University, Ahmedabad, India) and Dr.Anitha C.T (Associate Professor, School of Medical Sciences, University of Hyderabad-Institution of Eminence, Telangana, India) for reviewing the draft, providing valuable suggestions and for their constant support and encouragement to work on this review paper.

References

1. Rajput A. Delhi: Half of Covid dead under municipal corporations are safai karamcharis. The Indian Express. Available from: https://indianexpress.com/article/cities/delhi/delhi-half-of-covid-dead-under-municipal-corporations-are-safai-karamcharis-7333365/ 2021 May 28.
2. Baral YR. Waste Workers and Occupational Health Risks. International Journal of Occupational Safety and Health. 2018;8(2):1-3. Available from: https://doi.org/10.3126/ijosh.v8i2.23328
3. Centers for Disease Control and Prevention. Infection Control. Guidelines for Environmental Infection Control in Health-Care Facilities. 2003.Available from: https://www.cdc.gov/infectioncontrol/guidelines/environmental/background/medical-waste.html.
4. Tiwari M. Sanitation staff forced to work sans safety gear in Hyderabad. The New Indian Express. Available from: https://www.newindianexpress.com/cities/hyderabad/2021/apr/08/sanitation-staff-forced-to-work-sans-safety-gear-inhyderabad-2287304.html (accessed on 2021 Apr 8)
5. Moulika.KV. Hyderabad: Lack of knowledge on Covid waste disposal causes concern. The Times of India. Available from: https://timesofindia.indiatimes.com/city/hyderabad/lack-of-knowledge-on-covid-waste-disposal-causes-concern/articleshow/82187431.cms 2021 Apr 22.
6. Sharma V. Delhi: Apathy of residents pushing wastepickers to Covid's door. The Times of India. Available from: https://timesofindia.indiatimes.com/city/delhi/apathy-of-residents-pushing-wastepickers-to-covids-door/articleshow/82248098.cms (2021 Apr 26)
7. WIEGO. Basic Categories of Waste Pickers. Women in Informal Employment: Globalizing and Organizing. Available from: https://www.wiego.org/basic-categories-waste-pickers (Accessed on 2021 May 9)
8. Salve P, Bansod DW, Kadlak H. Safai Karamcharis in a Vicious Cycle: A Study in the Perspective of Caste. Economic & Political Weekly. 2017;LII(13):6.
9. Kadam DH, Gawde NC. Understanding Pathways to Health with Legacy of Caste among Sanitation Workers: An Eco-Social Approach. Int J Preven Curat Comm Med. 2017;3(1&2):84-96.
10. PRIA. Lived Realities of Women Sanitation Workers in India: Insights from a Participatory Research Conducted in Three Cities of India. 2019 Jun. Available from: https://www.pria.org/knowledge_resource/1560777260_Occasional%20Paper%204%20(2019)%20(Lived%20Realities%20of%20Women%20Sanitation%20Workers%20i....pdf
11. Patil T, Raje SS. Occupational and social hazards among domestic solid waste collectors: a cross sectional study. International Journal Of Community Medicine And Public Health. 2020;7(2):625. Available from: https://doi.org/10.18203/2394-6040.ijcmph20200439
12. Giri PA, Kasbe AM, Aras RY. A Study on Morbidity Profile of Sewage Workers in Mumbai City. Public Health. 2010;2(12):450-63.
13. Ali M, Di Bella V. Topic Guide: Solid waste management. 2016. Available from: Available from: https://doi.org/10.12774/eod_tg.april2016.alimetal
14. Toolkit for Solid Waste Management, Jawaharlal Nehru National Urban Renewal Mission, Ministry of Urban Development, Government of India. 2012 Nov.
15. Sogi GM, Sudan J. Biomedical Waste – Health beyond Healthcare. Contemporary Clinical Dentistry. 2019;10(2):183-4. Available from: https://doi.org/10.4103/ccd.ccd_495_19
16. Dutta M, Agarwal D, Sivakami M. The "invisible" among the marginalised: Do gender and intersectionality matter in the Covid-19 response? Indian Journal of Medical Ethics. 2020 Aug 01-07. Available from: https://doi.org/10.20529/IJME.2020.086
17. Chellamma P, Sudhiraj S, Vijayakumar A. Morbidity Profile Of Sanitary Workers In Thrissur Corporation, Kerala. Journal of Evolution of Medical and Dental Sciences. 2015;4(89):15468-9. Available from: https://doi.org/10.14260/jemds/2015/2211

18. Lenka AK. Health, Identity and Livelihood Status of Sanitation Workers in Bhubaneswar City, Odisha. International Journal of Research and Analytical Reviews. 2020;7(4):867-79.

19. Rangamani S, Obalesha KB, Gaitonde R. Health issues of sanitation workers in a town in Karnataka: Findings from a lay health-monitoring study. Natl Med J India. 2015;28(2):70-3.

20. Thakur P, Ganguly R, Dhulia A. Occupational Health Hazard Exposure among municipal solid waste workers in Himachal Pradesh, India. Waste Management. 2018;78:483-9. Available from: https://doi.org/10.1016/j.wasman.2018.06.020

21. Jayakrishnan T, Jeeja M, Bhaskar R. Occupational health problems of municipal solid waste management workers in India. International Journal of Environmental Health Engineering. 2013 Nov 29;2(1):42. Available from: https://doi.org/10.4103/2277-9183.122430

22. Ramitha KL, Ankitha T, Alankrutha RV, Anitha C T. A Cross-Sectional Study on Occupational Health and Safety of Municipal Solid Waste Workers in Telangana, India. Indian Journal of Occupational and Environmental Medicine. 2021;25(3):169-77. Available from: https://doi.org/10.4103/ijoem.ijoem_21_21

23. Ingole A. Scavenging for the State Manual Scavenging in Civic Municipalities. Economic & Political Weekly. 2016;51(23). https://www.epw.in/journal/2016/23/reports-states/scavenging-state.html

24. Wittmer J. "We live and we do this work": Women waste pickers' experiences of wellbeing in Ahmedabad, India. World Development. 2021;140:105253. Available from: https://doi.org/10.1016/j.worlddev.2020.105253

25. Kandasamy SP, Akolkar AB, Manoharan A, Paranji S. Municipal solid waste management at Chennai in southern India – an occupational health perspective. International Journal of Health Promotion and Education. 2013;51(1):50-61. Available from: https://doi.org/10.1080/14635240.2012.750068

26. Mahajan SM, Pawar KH, Jadhav VS, Magare AR. Health Status of Sanitary Workers of Municipal Corporation of Aurangabad City. Indian Journal of Preventive Medicine. 2017;5(2):90-6. DOI: https://doi.org/10.21088/ijpm.2321.5917.5217.7

27. Gautam M, Wankhade K, Sarangan G, Sudhakar S. Framework for addressing occupational safety of de-sludging operators: A study in two Indian cities. Journal of Environmental Management. 2021;289:112243. Available from: https://doi.org/10.1016/j.jenvman. 2021.112243

28. Mote BN, Kadam SB, Kalaskar SK, Thakare BS, Adhav AS, Muthuvel T. Occupational and Environmental Health Hazards (Physical & Mental) Among Rag-Pickers in Mumbai Slums: A Cross-Sectional Study. Science Journal of Public Health. 2016;4(1):1-10. Available from: https://doi.org/10.11648/j.sjph.20160401.11

29. Chokhandre P, Singh S, Kashyap GC. Prevalence, predictors and economic burden of morbidities among waste-pickers of Mumbai, India: a cross-sectional study. Journal of Occupational Medicine and Toxicology. 2017;12(1). Available from: https://doi.org/10.1186/s12995-017-0176-3

30. Dubey V, Dubey S, Shukla S. Chemical Studies on the Solid Waste Collection by Rag Pickers at Sidhi Municipality, M.P. India. IOSR Journal of Applied Chemistry. 2015;8(10):34-41. Available from: https://doi.org/10.9790/5736-081013441

31. Pushparani JP, A. C, J. K. A cross-sectional study to assess the health profile of street sweepers and sanitary workers in a zone of Greater Chennai Corporation, Tamil Nadu, India. International Journal Of Community Medicine And Public Health. 2018;5(10):4357. Available from: https://doi.org/10.18203/2394-6040.ijcmph20183974

32. Nayak. S, Shenoi S, Kaur G, Bisen N, Purkayastha A, Chalissery J. Dermatologic evaluation of street sanitation workers. Indian Journal of Dermatology. 2013;58(3):246. Available from: https://doi.org/10.4103/0019-5154.110888

33. Dongre PB, Kamble RK. Rag Pickers Occupational Health Assessment in Chandrapur City, Central India. International Journal of Basic and Applied Physiology. 2019;8(1):87-92.

34. Yogesh SD, Zodpey SP. Respiratory morbidity among street sweepers working at Hanumannagar Zone of

Nagpur Municipal Corporation, Maharashtra. Indian J Public Health. 2008;52(3):147-9. PMID: 19189837.

35. Parikh S, Shah A, Davda B, Bala D. Study of noncommunicable diseases among the street sweepers of Muster Station, Ahmedabad municipal corporation. Indian Journal of Community Medicine. 2019;44(3):225. Available from: https://doi.org/10.4103/ijcm.IJCM_322_18

36. Kulkarni M, Pingale D. Effects of occupational exposures on the lung functions and quality of life of garbage collectors in the urban area. Indian Journal of Occupational and Environmental Medicine. 2019;23(3):102. Available from: https://doi.org/10.4103/ijoem.IJOEM_128_19

37. Sangolli B, Rashmi BM, Jagadish S, Sreeharsha, Chaitra B. A cross-sectional study of pulmonary function tests among the municipal street sweepers of Chitradurga District, Karnataka. IP Indian Journal of Immunology and Respiratory Medicine. 2018;3(3):108-13. Available from: https://doi.org/10.18231/2581-4222.2018.0029

38. Sharma S, Vijayachari P, Sugunan AP, Natarajaseenivasan K, Sehgal SC. Seroprevalence Of Leptospirosis Among High-Risk Population Of Andaman Islands, India. The American Journal of Tropical Medicine and Hygiene. 2006;74(2):278-83. Available from: https://doi.org/10.4269/ajtmh.2006.74.278

39. Basu R, Ram SS, Biswas A, et al. Investigation on the trace elemental profile of sewage workers in Kolkata, an Indian megacity. J Public Health Res. 2015;4(2). Available from: https://doi.org/10.4081/jphr.2015.473

40. Mondal NK, Siddique S, Banerjee M, Roychoudhury S, Mukherjee S, Slaughter MS, et al. Alteration in Leukocyte Subsets and Expressions of FcγR and Complement Receptors among Female Ragpickers in Eastern India. Saf Health Work. 2017 Jun;8(2):198-205. Available from: https://doi.org/10.1016/j.shaw.2016.10.004

41. Fulwani D, Banda D, Shah H, Chandel D. Women rag pickers at a dump in Ahmedabad: Genotoxicity and oxidative stress. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 2020;858-60:503254. Available from: https://doi.org/10.1016/j.mrgentox.2020.503254

42. Ray MR , Choudhury SR , Mukherjee S, Siddique S, Banerjee M, Akolkar AB, et al. Airway Inflammation and Upregulation of β 2 Mac - 1 Integrin Expression on Circulating Leukocytes of Female Ragpickers in India. Journal of Occupational Health. 2009;51(3):232-8. Available from: https://doi.org/10.1539/joh.L8116

43. Selvi PK, Akolkar AB, Saranya P. Occupational health hazards of the working group associated with municipal solid waste management at Kolkata in Eastern India. International Journal of Environment and Health. 2012;6(2):141-54. Available from: https://doi.org/10.1504/IJENVH.2012.049320

44. Madhumithra D, Saya GK, Olickal JJ, Kanungo S, Chinnakali P. Quality of life and its determinants among sewage workers: A cross-sectional study in Puducherry, South India. Niger Postgrad Med J. 2021 Jan-Mar;28(1):57-61. Available from: https://doi.org/10.4103/npmj.npmj_351_20

45. Kalaiyarasan.M, Kumar M. DS. A Study On Socio-economic Conditions Among Scavengers With Special Reference To Ganeshapuram, Thiruvearampur Block, Truchirappalli District. Indian Journal of Applied Research. 2014;4(12):101-4.

46. Uplap P, Bhate K. Health profile of women ragpicker members of a nongovernmental organization in Mumbai, India. Indian Journal of Occupational and Environmental Medicine. 2014;18(3):140. Available from: https://doi.org/10.4103/0019-5278.146912

47. Mohapatra KK. Women Workers in Informal Sector in India: Understanding the Occupational Vulnerability. International Journal of Humanities and Social Science. 2012;2(21):11.

48. Ananthakrishnan S, Patil RR. Health status and health seeking behaviour of rag pickers in the municipal dump yard in Chennai. Public Health Research Series. 2013;2:43-7.

49. Salve P, Chokhandre P, Bansod D. Assessing musculoskeletal disorders among municipal waste loaders of Mumbai, India. Int J Occup Med Environ Health. 2017 Oct 6;30(6):875-86. Available from: https://doi.org/10.13075/ijomeh.1896.01049

50. Chokhandre P, Kashyap GC. Assessment of Psychological Well-being of Waste-pickers of Mumbai, India. Asian Journal of Epidemiology. 2017;10(3):138-

43. Available from: https://doi.org/10.3923/aje.2017.138.143

51. Agarwalla R, Pathak R, Singh M, Islam F, Parashar M. Effectiveness of awareness package on occupational health hazards among ragpickers of New Delhi, India. Indian Journal of Occupational and Environmental Medicine. 2017;21(2):89. Available from: https://doi.org/10.4103/ijoem.IJOEM_52_17

52. Patel VS, Datta U. Assessment of Knowledge and Preventive Practices about Occupational Health Hazard among Safai Karmchari of Municipality in Delhi. Epidemiology International. 2018;03(04):1-9. Available from: https://doi.org/10.24321/2455.7048.201816

53. Urban Management Centre and WaterAid India. Health, Safety and Social Security Challenges of Sanitation Workers during the COVID-19 Pandemic in India.; 2020.

54. Saikia A. Coronavirus crisis: These frontline workers died of Covid-19. Their families are now struggling to get insurance money. https://scroll.in/article/968700/these-frontline-workers-died-of-covid-19-their-families-are-now-struggling-to-get-insurance-money (2020 Jul 29)

55. Dias SM, Ogando AC. Rethinking gender and waste: exploratory findings from participatory action research in Brazil. Work Organisation, Labour & Globalisation. 2015;9(2):51-63. Available from: https://doi.org/10.13169/workorgalaboglob.9.2.0051

56. Kumar NV. Chennai corporation delivers food to sanitation workers in garbage van. The Federal. https://thefederal.com/states/south/tamil-nadu/chennai-corporation-delivers-food-to-sanitation-workers-in-garbage-van/ (Published August 3, 2020. Accessed 2020 Sep 16)

57. The Telegraph online. Sweeper faints, dies after fogging in Uttar Pradesh. Available from: https://www.telegraphindia.com/india/sweeper-faints-dies-after-fogging-in-uttar-pradesh/cid/1763307. 2020 Aug 4.

58. Parisudhya kaarmikulaku rakshana edhi? [Where is the protection for sanitation workers?]. NavaTelangana. http://m.navatelangana.com/article/medak/979048 (2020 Apr 15. Accessed 2020 Sep 17)

59. Manral K. Coronavirus: Sanitation Worker Forced to Drink Disinfectant in UP's Rampur, Dies. Available from: https://www.india.com/news/india/coronavirus-sanitation-worker-forced-to-drink-disinfectant-in-ups-rampur-dies-4004512/ (2020 Apr 19)

60. Covid-19: JNU sanitation workers denied pay, protective gear. Available from: https://sabrangindia.in/article/covid-19-jnu-sanitation-workers-denied-pay-protective-gear (2020 Apr 28. Accessed 2020 May 8)

61. Jain S. Rajasthan: Sanitation Worker Made to Pack COVID-19 Patient's Body Without PPE. Available from: https://m.thewire.in/article/rights/rajasthan-sanitation-worker-covid-19-patient-body-ppe (2020 May 7. Accessed 2020 May 8.)

62. Puzhakkal D. Hyderabad Sanitation workers forced to travel in packed RTC buses violating social distancing norms. Available from: https://www.google.com/amp/s/newsmeter.in/hyderabad-sanitation-workers-forced-to-travel-in-packed-rtc-buses-violating-social-distancing-norms/ (2020 May 10. Accessed 2020 Sep 15)

63. Bharathi SP. COVID-19: Deaths of 6 Chennai sanitation workers unrecorded, no solatium for families. Available from: https://www.thenewsminute.com/article/covid-19-deaths-6-chennai-sanitation-workers-unrecorded-no-solatium-families-127892 (2020 Jul 3)

64. No end to woes of Gandhi: Now ward boys join nurses on strike. Deccan Chronicle. Available from: https://www.google.com/amp/s/www.deccanchronicle.com/amp/nation/in-other-news/150720/no-end-to-woes-of-gandhi-now-ward-boys-join-nurses-on-strike.html (2020 Jul 15. Accessed 2020 Sep 15)

65. Bhosale A. Sanitation workers in Gajwel protest after 9 COVID-positive workers taken to hospital in tractor. Available from: https://m.dailyhunt.in/news/india/english/news+meter+english-epaper-newsmeng/sanitation+workers+in+gajwel+protest+after+9+covid+positive+workers+taken+to+hospital+in+tractor-newsid-n208819012 (2020 Aug 23.)

66. Arakal RA. Bengaluru sanitation workers allege lack of safety gear amid Covid, demand masks, gloves. The Indian Express. Available from: https://indianexpress.com/article/cities/bangalore/bengaluru-sanitation-workers-allege-lack-of-safety-gear-amid-covid-demand-masks-gloves-7292569/ (2021 Apr 29)

67. Jayarajan S. A Year Into Pandemic, Chennai's Sanitation Workers Still Don't Have the Right Gear. The Wire. https://thewire.in/labour/a-year-into-pandemic-chennais-sanitation-workers-still-dont-have-the-right-gear (2021 May 20)

68. Deccan Chronicle. GHMC denies wages for Covid-hit sanitary staff. https://www.deccanchronicle.com/nation/current-affairs/230521/ghmc-denies-wages-for-covid-hit-sanitary-staff.html (2021 May 23)

69. Chandran P. How the pandemic locked waste workers out of livelihoods. https://bengaluru.citizenmatters.in/pandemic-waste-workers-livelihoods-63472 (Published July 1, 2021)

70. Nigam D.D, Dubey S. Condition of Sanitation Workers in India: A Survey during COVID-19 and Lockdown.; 2020.

71. Safety, Health and Environment at Work Place. Government of Inda- Ministry of Labour and Employment. https://labour.gov.in/policies/safety-health-and-environment-work-place (2015 Nov 30. Accessed 2020 Sep 16)

72. Agarwal R, Chaudhary M, Singh J. Waste Management Initiatives In India For Human Well Being. European Scientific Journal. 2015: 105-27.

73. Economic Times. Govt to provide Rs 50 lakh insurance per health care worker for 3 months due to Coronavirus. Available from: https://economictimes.indiatimes.com/wealth/personal-finance-news/govt-to-provide-rs-50-lakh-health-insurance-per-health-care-worker-for-3-months-due-to-coronavirus/articleshow/74827328.cms?from=mdr (2020 Jul 21)

74. The Wire. Glorified as 'COVID Warriors', Sanitation Workers Suffer Worst of All in the Pandemic. Available from: https://thewire.in/labour/glorified-as-covid-warriors-sanitation-workers-suffer-worst-of-all-in-the-pandemic (2021 Jul 6)

75. Gulliford M, Figueroa-Munoz J, Morgan M, et al. What does "access to health care" mean? Journal of Health Services Research & Policy. 2002;7(3):186-8. Available from: Available from: https://doi.org/10.1258/135581902760082517

76. World Health Organization. Urban health. Available from: https://www.who.int/health-topics/urban-health