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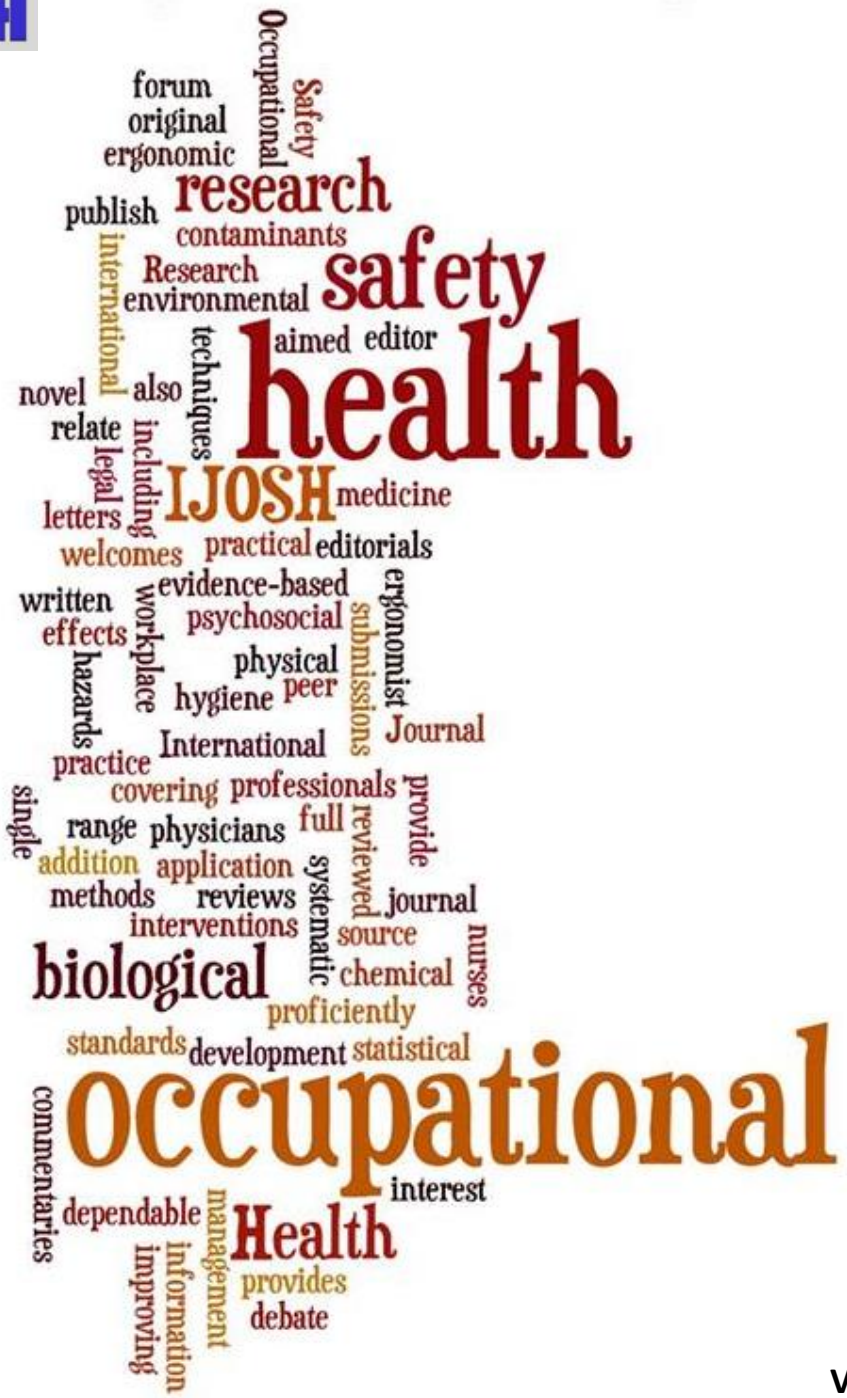

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Short Communication

Chromium toxicity among leather industry workers in Kolkata – a Pilot Study

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ABSTRACT

Introduction: Chromium (Cr) exposure is known to cause various health issues such as cancer, dermatitis, respiratory problems, etc. The recent exposure of Cr can be determined by analysis of Cr either in blood/urine/plasma, Cr (III) ions cannot permeate through cell membranes of red blood cells (RBC) because their ionic radii are bigger as compared to Cr (VI), and hence Cr in RBC is an indicator for exposure to Cr (VI) ions. The purpose of this study was to investigate chromium exposure, hygienic habits and the occurrence of dermatological problems with leather industry workers in Kolkata.

Methods: A total of 68 leather industry workers with minimum work exposure of five years and aged between 18-60 years were recruited for this study. The study protocol included a questionnaire and analysis of Cr in blood and urine samples by GF-AAS.

Results: All values were under the Biological Exposure Index (BEI) of 25µg /L at the end of the shift of a five-day work week recommended by the American Conference of Governmental Industrial Hygienists (AcGIH). 15.2% of subjects suffered from dermatological problems at least once in the last year during work in the leather industry.

Conclusion: It was found that workers in the leather industry were not using personal protective equipment (PPE), and the use of PPE must be promoted to them for occupational health and safety.

Keywords: Chromium, Tannery, Atomic Absorption Spectroscopy, Dermatitis, Occupational Health

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Introduction

Chromium (Cr) exists in oxidation states ranging from 0 to VI. Cr (III) is an essential micronutrient for humans.[1] Cr (VI) (chromate), is genotoxic and a group I carcinogen for humans with sufficient evidence for inhalation and lung cancer. Cr (VI) enters the cells through anion transporters, whereas Cr(III) enters through passive diffusion; as such, extracellular reduction of Cr (VI).[2] Cr (VI) toxicity effects may involve oxidative stress, inflammation, energy metabolism, protein synthesis endocytosis, ion binding, DNA binding and metabolism, cell morphogenesis, cell cycle regulation, autophagy, apoptosis, cell death, and carcinogenesis in human bronchial epithelial cells.[3] Chromium Sulphate is primarily used in the leather industry for tanning and processing. Finished leather is obtained by treating animal hides and skins with basic chromium sulfate, in

order to modify the macromolecular structure of collagen and make them suitable for use. It is also used in the synthesis of other chromium-based re-tanning agents and the production of chromic compounds.[4]

It is estimated that 90% of the leather produced worldwide is tanned with chromium sulfates, the consequence being that chromium exposure may occur from prolonged contact with various leather production processes and products.[5] Biological monitoring of any environmental toxicant is important to confirm the exposure either by estimating the toxicant as such or its metabolites in the body, to detect early signs of the onset of the disease, and also to prevent the further progress of the disease among occupationally exposed workers.[6] American Conference of Governmental Industrial Hygienists (ACGIH) recommendation for the Threshold Limit Value-Time Weighted Average (TLV-TWA) exposure limit value of 0.5 mg Cr/m^3 for chromium metal and Cr (III) compounds, 0.05 mg Cr/m^3 for Cr (VI) and 0.01 mg Cr/m^3 for insoluble Cr (VI) corresponds to a concentration accumulated over either an 8-h workday or a 40-h working week.[7-8] In India, the effect on environmental and human health of Cr contamination is reviewed and in a study blood Cr levels of children working in gem-polishing industries were studied.[9-11]

Maintenance of normal skin barrier function, in occupational settings, is important due to direct contact of various hazards with the skin that might induce skin disease or result in skin absorption of chemicals. Due to Cr (VI) in leather tanning and other processes in leather goods production, skin diseases including irritant and allergic contact dermatitis are common among leather industry workers.[12-14] The purpose of this study was to investigate chromium exposure, hygienic habits, and the occurrence of dermatological problems among leather industry workers.

Methods

The selected area of the study was Kolkata, the capital of the Indian state of West Bengal. Kolkata metropolitan area has a population of 1.41 million, according to the 2011 Indian census. West Bengal, particularly Kolkata and its suburbs has developed tremendously into a highly successful Leather & Leather Goods Export Hub from India within a short span of three decades.

A total of 68 leather industry workers with minimum work exposure of five years and aged between 18-60 years were recruited for this study. This Study is approved by the Human Ethics Committee of the Institute. The study protocol included a questionnaire and analysis of blood and urine samples by GF-AAS.

History of occupational exposure, demographic details, and history of skin problems during their different years of occupation was collected through an interview-administered questionnaire. Dermatitis was decided by the self-reported diagnosis of the occurrence of skin lesions by leather industry workers.[15]

All chemicals used in the study were of analytical grade or higher. Chromium standard for AAS, NaCl. Triton X-100 was obtained from Sigma Aldrich. Triton X-100 was used as a non-ionic surfactant.0.2% Nitric acid (v/v) was obtained after dilution with ultrapure water obtained by the Merck Synergy water purification system.

Perkin Elmer AA-800 (Waltham, MA, USA) graphite furnace atomic absorption spectroscopy (GF-AAS) was used for Cr analysis. A Zeeman correction was applied for checking the matrix effect. Analysis of Cr was performed at 357.9 nm using a hollow cathode Cr lamp (Perkin Elmer Lumina Lamp). The Lamp was operated at 3 mA and slit-width was kept at 0.05 cm. Graphite tubes (Perkin Elmer THGA Graphite Tubes, Part No.:B3 000641were used for experiments.

Blood samples of subjects were collected by venipuncture and taken in heparinized tubes. The collected samples were brought to the laboratory and kept in a deep fridge at –20 ˚C. Spot urine samples were collected from the exposed workers before starting the work in the morning (Pre-shift) and also at the end of the shift (Post-shift). The samples were collected in polythene bottles,

brought to the laboratory, and preserved in a deep fridge at –20 ˚C. To check errors due to sample contamination it was important to clean plastic wares thoroughly. This was achieved by keeping plastic materials in 20% nitric acid for a minimum of 12 h and rinsing three times thoroughly with ultrapure water before use for sample collection. The extract of the fourth was tested with AAS for the absence of Cr and this ensured three times rinsing of plastic wares removed chromium contamination. The blood of subjects was collected by drawing into metal-free Vacutainer tubes (10 mL capacity) supplied by BD Biosciences.

The Standard solution of Cr was 1000 mg/L. 1, 2, 5, 10, 15, and 20 mg/L working standards of Cr for the calibration curve were prepared by appropriate dilution with 2% v/v HNO_3 and 1.0% v/v Triton X-100 solution (Diluent-D).

Analysis of Cr in whole blood and urine samples was performed by the method reported by Devoy et.al with slight modifications to their reported method.[8] Blood sample (100 µL) was diluted by a factor of 1:5 by Diluent-D and the urine sample (100µL) by a factor of 1:2 by Diluent-D.

To analyze Cr in RBC, 1000µL of blood was left for 60 min at 25°C to allow separation of blood into two fractions viz. A and B: Fraction A, the supernatant (without RBC); and fraction B (with RBC). Fraction B was diluted with 3000 µL of saline solution (1%) and left to stand at room temperature for 20 min, and then centrifuged for 20 min at 3000 rpm. This procedure was repeated three times for sample clean-up with 3000 µL of 1% saline solution. RBC pellet was diluted to 1000 µL and further diluted by a factor of 1:5 by Diluent-D.

Data analysis of the study was performed with SPSS statistical software for windows. Mean ± S D was calculated in the report.

Results

The sample size, age range, and level of chromium exposure in leather industry workers are presented below (Table 1).

15.2% of subjects suffered from dermatological problems at least once in the last one year during work in the leather industry. The distribution of Cr levels in total blood, RBC and urine of dermatitis patients and healthy subjects are shown below (Figure 1).

Table1: Sample size, age range, and Level of chromium in leather industry workers.

Sample size	Age range	Level of chromium in whole blood (µg/L) Mean±SD Range	Level of chromium in RBC (µg/L) Mean±SD Range	Level of chromium in urine (µg/L)/Specific Gravity Mean±SD Range
68	18-60	8.37±6.39 1.04-24.83	3.91±2.81 1.01-17.26	7.15±5.72 1.07-25.00

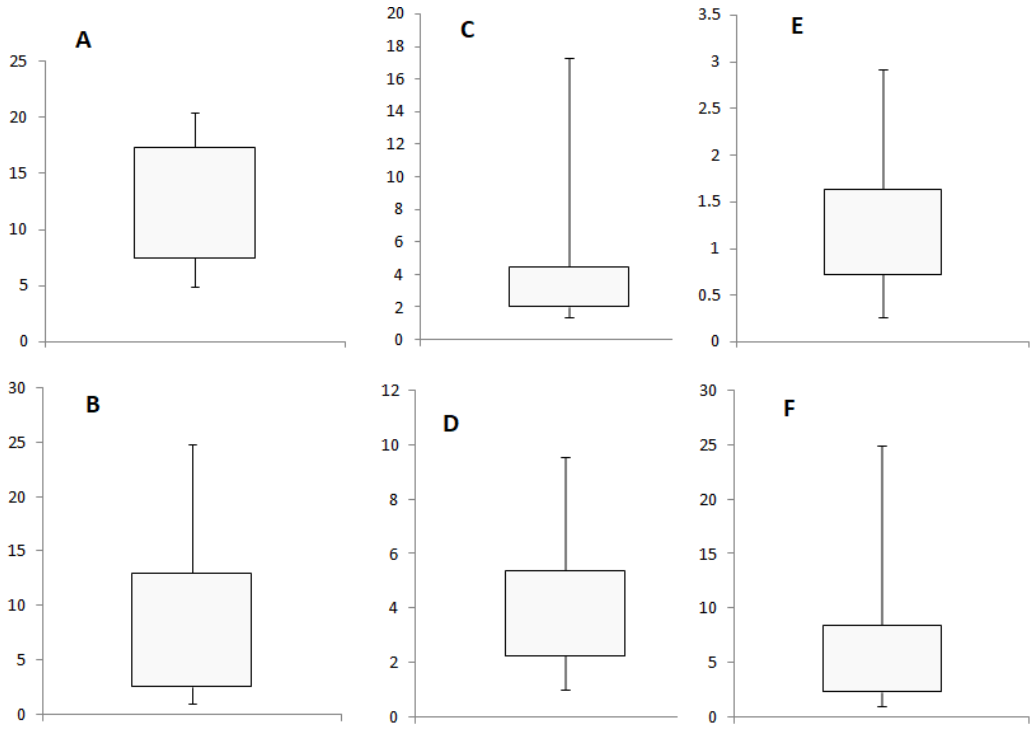

Figure 1: Distribution of Cr level in total blood of dermatitis patients (A) and healthy subjects (B); distribution of Cr level in RBC of dermatitis patients (C) and healthy subjects (D); distribution of Cr level in urine of dermatitis patients (E) and healthy subjects (F).

Discussion

Cr in urine is considered a trustworthy and sensitive indicator of Cr exposure. Analyzing Cr by AAS cannot give information on exposure by Cr (III) or Cr (VI), speciation is possible only by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). However, by analyzing Cr in RBC it is possible to indirectly measure the Cr (VI). Cr (III) ions cannot permeate through cell membranes of red blood cells (RBC) because their ionic radii are bigger as compared to Cr (VI), and hence Cr in RBC is an indicator for exposure to Cr (VI) ions.[8] In this study Cr (VI) exposure was assessed by GF-AAS. Differences in urinary dilution were corrected by measuring the specific gravity of urine, which is the ratio of the relative density of urine to water.[16]

This study gives information about Cr exposure in leather industry workers in Kolkata. All results showed BEI under the AcGIH limit of 25µg /L at the end of the shift of a five-day workweek. AcGIH does not recommend BEI values for Cr exposure in whole blood or RBC. In this study, Cr exposure was detected in whole blood, RBC and urine. RBC Cr is indicative of permeation of Cr (VI) ions through RBC and it will be available for detection till the cell lives (3 months or more).

Direct exposure to Cr and its complexes to the skin triggers dry skin, irritation and allergic reaction to the skin due to the cytotoxic properties of Cr; this may be diagnosed as irritant dermatitis. The immune system of the body may also respond in the form of inflammation due to Cr and this may be diagnosed as contact dermatitis. Contact dermatitis is triggered in two phases, in the first phase skin-Cr interaction happens and this step is known as the induction step whereas in the second phase immune system of the body responds in form of inflammation and this step is known as sensitization. For sensitization, a certain level of Cr exposure is required and this level is known as the threshold level.[17]

It was also found that leather industry workers were not using personal protective equipment during their work, which was against occupational safety and exposing their skin directly in contact with Cr and triggered dermatitis.

Conclusion

All results showed BEI under the AcGIH limit (25µg /L at the end of shift of a five-day work week), but AcGIH does not recommend BEI values for Cr exposure in whole blood or RBC.BEI for blood level Cr may be included by AcGIH, this will give information on exposure to Cr(VI). Workers were not using personal protective equipment during their work, which expose them to Cr and may lead to the dermatological problem. However, this was a pilot study and further study with a statistically appropriate sample size should be conducted for complete information. Meanwhile, workers should use personal protective equipment for occupational health and safety.

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Original Article

Chemical Safety Knowledge Assessment of Academic Researchers from Brazil During Covid-19 Pandemic

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ABSTRACT

Introduction: Laboratories are inextricably dangerous work environments, as fatal incidents are reported in both academic and non-academic environments worldwide, where poor safety culture has been recognized as the major accident contributor. Workers can be exposed to chemical, biological, physical, or radioactive hazards, in addition to musculoskeletal stresses. In Brazil, hundreds of thousands of workers are employed in laboratories, either in private or public institutions. Although laboratory safety can be governed by local, state, or federal regulations, learning how to identify common laboratory hazards is the first step to preventing accidents in the lab environment.

Methods: The study aimed to assess the degree level of safety culture in an academic population of research laboratories, located in the largest city in Brazil, and their compliance with occupational safety regulations during the COVID-19 outbreak. This study was carried out between October and November 2020. The results were obtained from the standardized questionnaire used to assess 98 researchers working in laboratories during the COVID-19 pandemic.

Results: The majority of respondents (95%) reported being exposed to more than two risks, simultaneously. About two-thirds (66%) of them were not fully aware of the laboratory's risk map. About half of the researchers (50%) were lacking in safety culture, and 57%and 43% were preoccupied with chemical and non-chemical hazards, respectively. Personal protective equipment (PPE) during laboratory work was used by most researchers, but 75% of researchers claim that security awareness learning should be a high priority for admission to laboratories. About 39% of researchers agreed that awareness of security must be improved in their laboratories

Conclusion: The survey proves the lack of information and attitudes about chemical safety, especially among less experienced researchers, even if they use personal protective equipment when necessary.

Keywords: Chemical Hazards, Chemical Safety, Laboratory Risk, Safety and Health

Introduction

In early 2020, the World Health Organization (WHO, 2020) announced the outbreak of COVID-19 as a pandemic. With the resumption of work in the laboratories, several concerns were raised by researchers related to chemical safety. The perceptions of chemical risk (chemical burns, exposure to chemical vapors, among others) were verified in research laboratories, public institutions, and the largest city in Brazil. Experimental laboratories and researchers are important parts of teaching at academic and research institutes.[1] The drug discovery to treat several pathological conditions as well as the development of vaccines demand an enormous amount of chemical reagents, equipment, and laborious procedures.[2,3,4] In Brazil, academic research is mainly developed by undergraduate and postgraduate students in public universities and research centers.[5] Besides serious accidents involving researchers and technicians in the conduct of their activities which have been reported elsewhere, literature is showing the perception of safety prevention.[6] Evidence showed that undergraduate and postgraduate students are the major individuals affected by chemical agents, as they do not often operate with solid experience based in chemical safety.[7] Ménard and co-workers reviewed fatal accidents registered worldwide between 2008-2018, and showed that for most cases, accidents in the laboratory are identical in the distinct teaching and research institutions.[8] Importantly, the same authors also highlighted the students' poor chemical safety knowledge, thus leaving a marked gap in safety precautions. According to Marin et al., the level of safety is related to the perceptions of risk shared by students, and accidents in university laboratories revealed significant gaps in safety.[9] The study showed that safety behavior may also emerge in informal groups and that improving safety conditions in college laboratories require a more careful analysis of the laboratory users' perceptions of safety that is needed to develop targeted safety interventions.

In addition, in a survey on the use of chemicals in academic research funded by the American Chemical Society, McEwen and co-workers focused on three areas: information, risk assessment, and lessons learned practices.[11] There were 195 Brazilian universities (105 public and 90 private) in 2017 with the main source of public universities in the state of São Paulo. The present work was carried out in an Institute of Health Sciences where approximately 171 laboratories perform experiments in several research fields (infectious diseases, immunology, physiology, cancer, neurosciences, cardiovascular and renal, bioengineering and biotechnology).[12]

This study was carried out anonymously, with one hundred researchers, to assess the degree of safety knowledge among researchers (undergraduate, postgraduate, laboratory technician, post-doctoral and principal investigator) about the risks involved in handling or exposure to product chemicals, the level of perception of actions and decisions on chemical safety and how safety protocols are being applied in the laboratories of the University of the State of São Paulo.

Methods

This study was conducted with the approval of the Human Research Ethics Committee (CEPSH 26427219.1.0000.5467). The study included 98 participants with female and male academic researchers, ranging from 19 to 70 years old, comprising undergraduate and postgraduate students (MSc., PhD), postdoctoral, technician, and principal investigators working remotely from home and locally in the different departments of a local Academic Research Institute during the COVID-19 pandemic in São Paulo-SP, Brazil. The study was conducted online, involving more than fifty laboratories and only 98 participants responded to the online survey. All 98 responses were included in further analysis. To understand how safety culture is considered in an academic environment, a total of 35 questions (Supplemental material) focused on aspects of laboratory safety behavior particularly on personal protective equipment (PPE), safety tools to help identify risks, hazards, and control measures, communication of hazards, practical

application of safety measures in the routine of the laboratory, laboratory waste, risk assessment and perception of risks. The questionnaire was conducted to ensure anonymity and was divided into 2 sections: 1) knowledge of safety and support tools in the identification of risks, hazards, and control measures, and 2) practical application of safety measures in the laboratory routine.

Respondents were recruited from October to November 2020 through emails containing a link to a questionnaire (35 questions), and a text explaining the objectives of the study and the respondents' rights in which the anonymity and confidentiality of data were highlighted. During the survey using the Google form platform, respondents were asked to answer some questions "yes" or "no". The total number of selected answers to the 35 questions was used to measure answers and plot graphs. At the end of the data collection, a data summary of the questionnaire was sent to the Director.

Data were presented as the mean of absolute values or percentages. The data processing and visualization tool for the presentation of results was Tableau Software LLC (Salesforce, Seattle, USA). This tool is suitable for data analysis and visualization applications, which allows users to publish interactive data on the web.

Results

The sociodemographic and occupational information of the participants are shown below (Table 1). The study group was composed of professors and graduate students and laboratory technicians. The profile of those surveyed described in table 1 represented the preponderance of risks of this population, in which a portion reported having no training in chemical safety.

Table 1. Socio-demographic profile of respondents (n=98)

Profile of informants interviewed		**n = 98**	**%**
Level of Research			
	Undergraduate	9	9.2
	Master's degree	15	15.3
	Doctoral degree	26	26.5
	Postdoctoral	5	5.1
	Technician	17	17.3
	Researcher professor	26	26.5
Lab experience in years			
	< 1 year	3	3.1
	1 to 3 years	12	12.2
	3 to 5 years	13	13.3
	> 5 years	70	71.4
Biosafety level (BSL)			
	BSL-1	68	69.4
	BSL-2	24	24.5
	BSL-3	2	2
	Unaware of the danger they were in	4	4.1
Laboratory safety training			
	Undergraduate	14	14.3
	Postgraduate	47	48
	Never	15	15.3
	Others	22	22.4

Researchers are subject to several risks simultaneously. For example, most respondents, above 80%, are subject to chemical, physical and ergonomic risks.

Multiple risk exposures in the laboratory

More than two-thirds (70%) of the interviewed population were exposed daily to more than two risk factors, with a predominance of chemical risk, followed by ergometric and biological risks (Figure 1A). More than three-fourths (75%) were subjected to risk level NB1. The research involved agents with the least degree of risk to laboratory personnel and the environment. In this case, the laboratory is not separated from the other premises of the building. Work was generally carried out on a bench (Figure 1B).

Perception degrees of potential risk exposures in the laboratory and safety equipment

According to figure 2, most respondents (70%) have access to information on chemical safety in their laboratories. On the other hand, more than half (60%) of undergraduate students were unaware of and did not access chemical safety information. Regarding the degree of perception and concern regarding exposure to risk in the laboratory, half of the interviewees showed to be aware and concerned about exposure to potential risks inherent to the work, especially chemical risks. More than two-thirds of the study population (70%) expressed concern about additional risks in the laboratory environment, such as physical, biological and ergometric risks.

Knowledge assessment of mandatory use of Personal Protective Equipment (PPE) in the workplace

According to Figure 3A, most respondents consider it important and necessary to use some PPE (gloves, masks, protective glasses and apron). When PPE is available, they use it frequently (figure 3B).

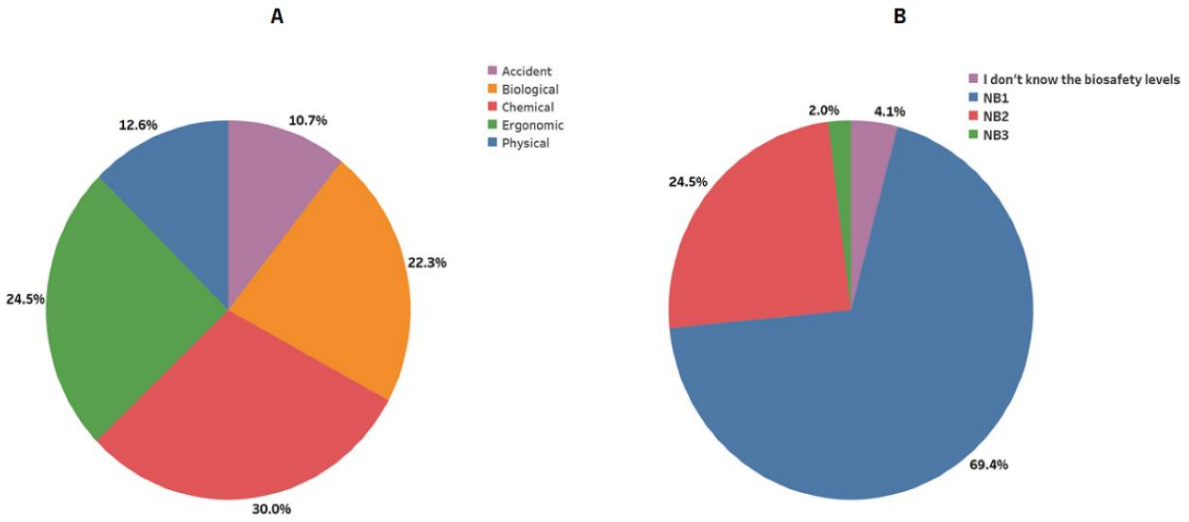

Figure 1. Risks in the laboratory. A) Categories of risks existing in the laboratory and B) Classification of the biosafety level of laboratories

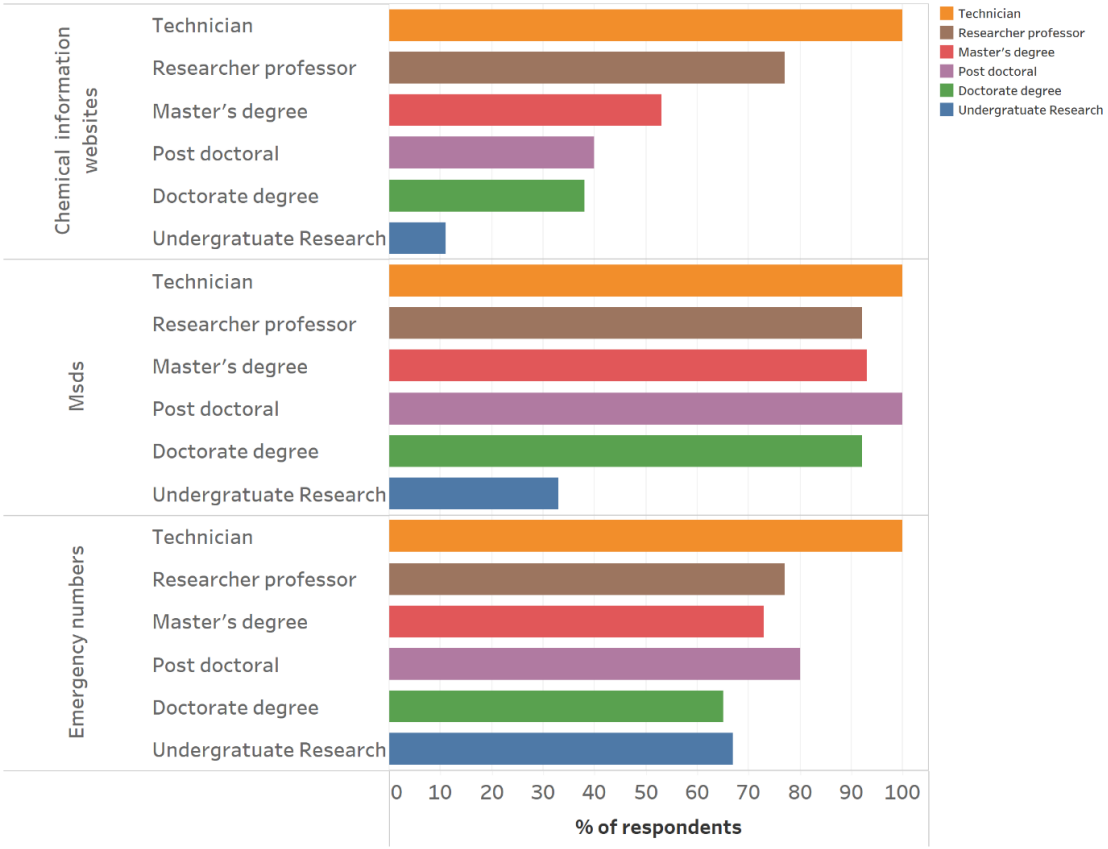

Figure 2. Lab safety education according to research level. Assessment of participants' knowledge about chemical information websites, Safety Data Sheets (SDS), labeling, GHS system and emergency numbers.

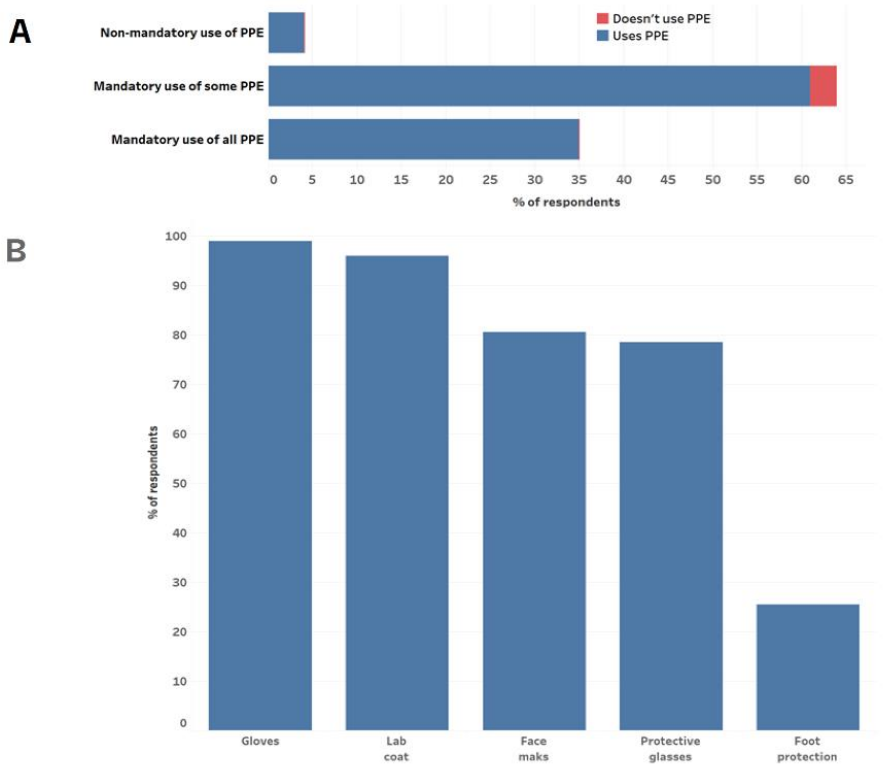

Figure 3. Use of personal protective equipment. A) Use of PPE according to mandatory use B) Frequency of use of different types of PPE.

Familiarity with chemical products handling, storage, and disposal

Most respondents (>70%) access the information and are familiar with the various systems for the disposal and storage of residual chemicals from the research developed (Figure 4). In practice, these residues accumulated in inappropriate places and were not inertized or recycled correctly. The researchers reported that there was a committee on chemical waste. However, it had difficulties in the treatment of chemical residues generated.

In response to the questionnaire, the researchers reported having little familiarity with the database and websites specialized in chemical safety and with the safety data sheets. About 42% of the researchers answered that they had no familiarity or experience in relation to the use of databases and safety information sheets on the use of chemical products, used in their research work. About 25% of the researchers reported knowing sites and databases on chemical safety, such as the American Chemical Society (ACS), PubChem, and CAMEO Chemicals.

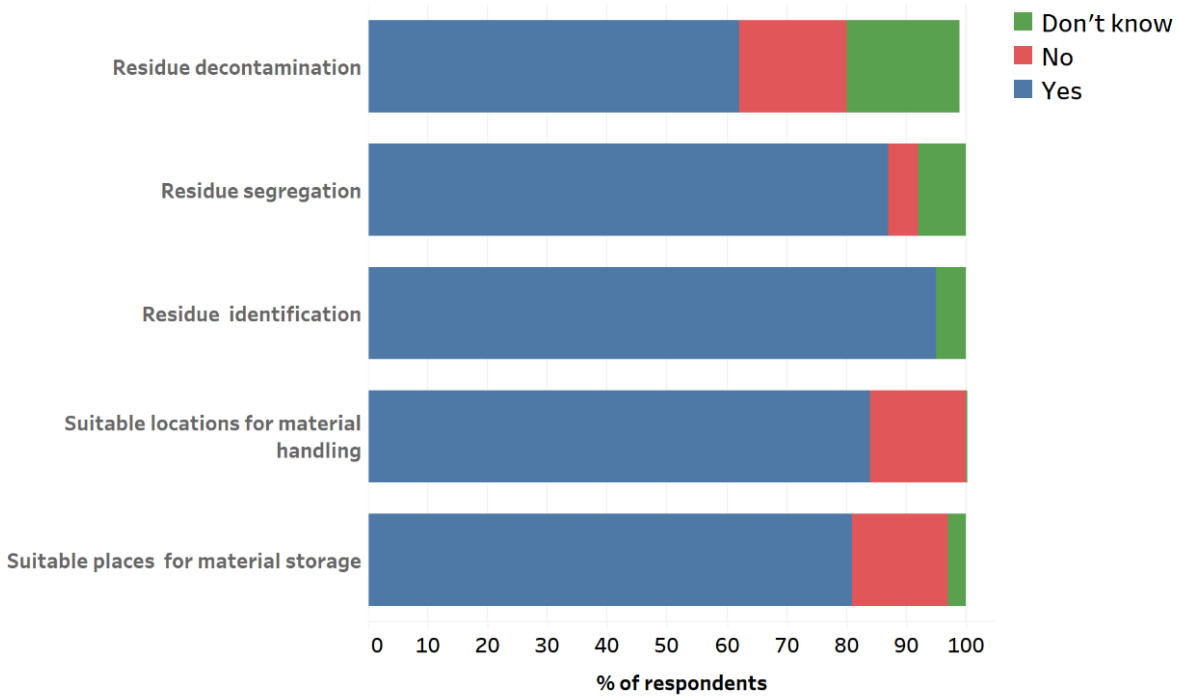

Figure 4. Familiarity with various aspects of material handling, storage and disposal.

Knowledge of the system of labeling and global harmonizes system (GHS) classification of chemical products routinely used in the research laboratory

More than half (58%) of the researchers knew and used the Classification and Labeling System (GHS), officially adopted in Brazil, while 16% of the interviewed people partially knew and 26% had no knowledge (Figure 5).

Regarding the knowledge of the labeling (pictograms) of chemical products used in the research laboratory by the interviewed researchers, figure 5B illustrated that more than half (56%) of the interviewees did not have this knowledge, while 41% knew partially and only 3% have this knowledge.

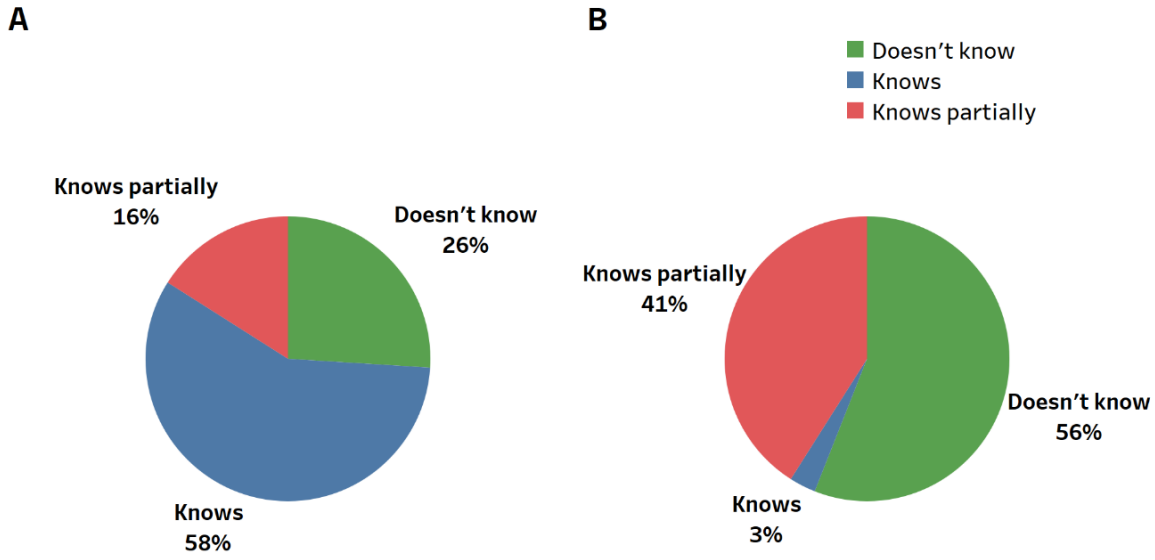

Figure 5. Chemical safety information. A) the percentage of respondents that check Global Harmonized System (GHS) classification when performing an experiment and B) knowledge of labeling system (pictograms) for chemical products

Perception regarding implementation of chemical safety training

More than 60% of the participants agreed that chemical safety training courses should be offered for all categories, and 28% partially agreed with this. Around 10% disagreed with the need for training on chemical safety. More than half of the population (56%) disagreed with the installation of frequent chemical safety meetings, while 31% thought partially in need of it. Only 8% fully agreed that training chemical safety meetings should be more frequent and up to date.

Assessment of the interviewee's safety profile in terms of isolated work and food consumption in the workplace:

The majority of respondents (87%) did not agree with the ingestion of food and beverages in the laboratory, while a small percentage (13%) agreed partially or didn't think there was a problem. Similarly, 27% of the same interviewees disagreed with solitary work in the laboratory, whilst 40% agreed partially or didn't see any problem with working by themselves.

Discussion

The respondents varied from undergraduates (with little or no laboratory experience) to senior researchers with more than five years of laboratory experience. Approximately 70% of respondents have five or more years of experience working in NBI security-level labs.

Researchers reported being exposed to different types of risks (chemical, physical and biological) in research laboratories (Figure 1). However, approximately one-third of researchers reported not knowing their laboratory's risk map, as well as not being concerned about chemical or non-chemical risks (Figure 2). Still, most researchers, about 60%, did not know about the content (or even the existence) of the laboratory safety manual (Figure 3). Approximately 50% of researchers were unaware of emergency contacts.

Most researchers considered chemical safety training necessary (Figure 4). However, they did not consider the periodic meetings on chemical safety important, so only 8% report having frequent meetings to discuss the topic. Half of the researchers do not consult chemical safety information sites. The Safety Data Sheets (SDS), although available to researchers, were rarely consulted before carrying out experiments with chemicals. About half of the researchers reported knowing the preventive labeling of chemical products, such as danger phrases, pictograms and warning words, but only 26% knew the GHS system (Globally Harmonized System).[13,14]

Personal Protective Equipment (PPE) was used, when necessary, and collective protection

equipment was also used in most experiments (90% of researchers claim total or partial use of this equipment). Regarding undesirable practices in laboratories, most researchers reported consuming food and beverages within the laboratory environment. They even reported being alone in carrying out most of the experiments.

Peres and collaborators identified this problem in the construction of Good Laboratory Practice procedures in the academy.[16] Approximately 50% of researchers were unaware of emergency contacts. This lack of safety information was related to fewer years of research experience.

Most researchers considered chemical safety training to be necessary (Figure 4). However, they did not consider periodic meetings on chemical safety to be important so only 8% reported holding frequent meetings to discuss the topic.

Personal protective equipment (PPE) was used, when necessary, and collective protective equipment seemed to be used (90% of researchers stated the total or partial use of this equipment). Regarding undesirable practices in laboratories, most researchers reported consuming food and drinks within the research environment.

Ayi and co-workers conducted an online survey of Canadian academic laboratory workers on the lab safety culture. They showed a significant gap between how security is perceived and managed at universities.[10]

Perception of potential risks of the respondents

The interviewed population with knowledge about the safety manual showed that researchers with more experience were the ones who were more involved, as well as had more information about emergency contacts. Apart from the length of experience, a large percentage (above 75%) of the interviewed individuals with research time greater than three years did not know or had neither accessed the chemical safety manual, nor knowledge of emergency contacts in the case of events. The initial spread of COVID-19 brought a partial halt to some public academic institutions. The teaching staff was forced to take on new multiple tasks. The reopening was gradual and limited.[15]

Although laboratories faced stressful situations and many challenges daily, some lessons have been learned. The establishment of new leaders and individual actions, in the laboratories, in terms of safety.

Conclusion

The research showed a lack of information on chemical safety, especially among less experienced researchers, and personal protective equipment was used, when necessary.

All people who perform tasks in laboratory environments where chemical reagents are used must receive regular training (in the form of courses) to better understand the relevant aspects of chemical safety, which includes obtaining the correct information (directed to the reagents used in the activity performed), as well as taking a positive and preventive posture in the face of potential risks to which they are exposed. Finally, the results presented indicated that this scenario reflected the chemical safety conditions in the laboratories of most public universities in Brazil.

Recommendations:

Based on the results presented, this study recommends: each laboratory needs to adopt a code of conduct as per good chemical safety practices and it is necessary to overcome cultural barriers to implement safer laboratory practices in public universities.

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Original Article

COVID-19 related Symptoms and Vaccination Usage among Informal Waste Workers of Kathmandu, Nepal

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ABSTRACT

Introduction: About 56% of the total population of Nepal has been fully immunized against COVID-19. But still, migrant workers outside of Nepal are struggling to get COVID vaccines. This study was intended to study the COVID-19 symptoms among IWWs of Kathmandu and the usage of vaccines by them.

Methods: A Cross-sectional study was conducted among 107 IWWs of Kathmandu Valley from Balkhu, Sanepa, Kalimati and Teku areas. A convenience sampling method was used to find the respondents based on their willingness to participate in the study. A face-to-face interview was conducted using a structured questionnaire to collect data from IWWs.

Results: Following the COVID-19 symptoms, most of the waste workers had a fever (89.7%) followed by cough (86%) and respiratory problems (55.1%). Despite of majority of waste workers having COVID-related symptoms, only 19.6% of waste workers had done COVID tests. The majority of IWWs of Kathmandu were afraid to take the COVID vaccine. Around 77.6% of waste workers hadn't still taken the COVID vaccine with a majority (93.9 %) of them identified as Indian nationals.

Conclusion: Despite having COVID-related symptoms, IWWs haven't gone for COVID tests. Though interested, the IWWs need identity cards for vaccination which counts fewer waste workers being vaccinated.

Keywords: COVID-19, Informal waste worker, Kathmandu, Nepal, Solid waste, Vaccine

Introduction

Solid waste management has become a major challenge for different countries of the world. Around 2.01 billion tons of municipal solid waste is generated globally and is predicted to reach 3.40 billion tons by 2050.[1] The amount of solid waste generation in Asia is in an increasing trend which will reach one-third of global waste by 2050.[2] Nepal is one of the least developed countries located in South Asia which is also having greater challenges with solid waste management due to population growth.[3,4]

The rapid urbanization in Kathmandu valley has caused an increase in waste generation with the government facing a difficult situation for effective management of municipal solid waste.[5,6,7] A study conducted by the Central Bureau of Statistics has recorded 1653 tons of municipal solid waste generation in Nepal.[8] In 2013, the per capita waste generation of Nepal was 0.3 kg/day which is expected to reach 0.7 kg/day by 2025.[9,1]

This shows that Nepal is going to have a worst scenario of municipal solid waste in the coming years. Solid waste management is a public issue and can only be managed effectively by the active participation of every stakeholder.[10] A study conducted in 2014 recorded 8047 informal waste workers (IWWs) inside Kathmandu valley.[11] However, no study has been conducted recently to identify the exact number of informal workers in Kathmandu City. The informal waste workers are mobile and difficult to have their records due to the lack of governing and monitoring bodies in Nepal. Waste workers face significant occupational health risks due to the nature of their job. The waste workers are even vulnerable, coming in contact with COVID-19-infected people as they move from one place to other for waste collection.

A total of 446,721,132 Coronavirus cases have been recorded with 6,020,572 deaths globally affecting 224 countries and territories as of March 7, 2022.[12] Nepal has recorded 977,501 Coronavirus cases with 11,947 deaths as of March 7, 2022.[13] The first case of COVID-19 was reported on 13 January 2020 in Nepal in an individual who had returned to Nepal from Wuhan, China.[14] COVID-19 is caused by coronavirus-2 (SARS-CoV-2) leading to severe respiratory problems, hyperinflammatory responses, vascular damage, angiogenesis and widespread thrombosis.[15] The most common symptoms in the initial stage of COVID-19 is upper respiratory tract infection, accompanied by fever, muscle fatigue and pain.[15] COVID-19 has affected everyone whether living in high, middle, or low-income countries with severe health threats.[16] Around half of the respondents had experienced COVID-19-related symptoms during the pandemic with most of the facing fever, cough, aches and muscle pains.[17]

It was found that SARS-CoV-2 can survive on plastics and steel for 2-3 days, cardboard for <24 hours and copper for <4 hours.[18] The waste workers have little knowledge about occupational safety and health and adopt fewer safety practices at their workplace.[19,20] The IWWs deal with recyclables on daily basis increases the risk of contamination by the COVID-19 virus. The improper disposal of hazardous bio-medical waste (HBMW) causes a risk to public health and the surrounding environment.[21] The quality and quantity of municipal solid waste (MSW) were also greatly affected.[22] There are different types of vaccines available with different storage and distribution systems and possible adverse effects confusing the public.[23] Thus, this study was intended to study the COVID-19 symptoms among IWWs of Kathmandu and the usage of vaccines by them. A total of 56% of the total population of Nepal have been fully immunized against COVID.[24] But still migrant workers outside of Nepal are struggling to get COVID vaccines. This study has included two types of IWWs; one working at scrap centers and the other working as Itinerant Waste Buyers (IWBs). The waste segregator at scrap centers have fixed working hours whereas most of the IWBs work independently, purchases the items from houses/institutions, and sells them to scrap center. Whereas the IWBs are commonly called "Feriya" or "Kabadiwala" in Nepal belonging to poor and marginalized social groups.[25] Despite the daily engagement of IWWs with solid waste and the high risk of exposure to COVID-19, their vaccine usage has not been assessed properly yet. This needs to be addressed with utmost concern.

Methods

A Cross-sectional study was conducted among IWWs of Kathmandu Valley from Balkhu, Sanepa, Kalimati and Teku areas. Those areas were chosen purposively as the IWWs are more active and easily available in these areas of Kathmandu.[25] A pilot survey was conducted among 15 informal waste workers from four different scrap centers in December 2021. 93% of waste workers said that either they are afraid to take the COVID-19 vaccine or are not allowed/asked for it. Based on this, the alternatives for the questionnaire were derived. The sample respondents for this study included 107 waste workers excluding those involved in the pilot survey.

A convenience sampling method was used to find the respondents based on their willingness to participate in the study. As the IWWs are mobile, it's difficult to track their location. However, the IWWs come to the scrap center at least once a day

to sell the recyclables that they have collected. So the study was conducted among those IWBs and scrap center workers who were engaged with the scrap centers in the study sites and were willing to participate in this study. The face-to-face interview was conducted using a structured questionnaire to collect data from IWWs. As the respondents were illiterate, verbal consent was taken and noted in the survey form by the researcher. The data analysis was conducted in the statistical package for social sciences (SPSS) version 20. A descriptive statistics, frequency (n) and percentage (%) were used for report generation. A Pearson's chi-square test of association was used to determine the relationship between two categorical variables.

Results

Out of 107 respondents, 53.3% were males and 46.7% were females (Table 1). The respondents were from Nepal (69.2%) and India (30.8%). A question was asked regarding their educational status, where 57% of respondents shared that they haven't gone to schools or any educational institutions for formal education. However, it doesn't claim that they mightn't have been enrolled in any informal education, training, workshops, or seminars.

Table 1. Demographic details of respondents

Variables	Frequency (n= 107)	Percentage (%)
Gender		
Male	57	53.3
Female	50	46.7
Country of Birth		
Nepal	74	69.2
India	33	30.8
Age Group (years)		
18-28	32	29.9
29-39	36	33.6
40-50	28	26.2
51-61	9	8.4
62 and above	2	1.9
Education		
Yes	46	43
No	61	57
Education Level		
Primary	30	65.2
Lower Secondary	11	23.9
Secondary	5	10.9

COVID-19 related symptoms and vaccine usage

Multiple responses from waste workers on having COVID-related symptoms in the last year were recorded (Table 2). It was found that the majority of waste workers had a fever (89.7%) followed by cough (86%) and respiratory problems (55.1%).

Despite of majority of waste workers facing COVID-related symptoms, only 19.6% of waste workers had done a COVID test. It shows that 1.9% of waste workers got infected with COVID. The number of waste workers infected with COVID might be less due to the reason that a lesser number of people had gone for COVID test.

A majority (77.6%) of waste workers haven't still taken the COVID vaccine. From cross-tabulation (Table 3), it was found that 78.9% of male and 76% of female waste workers hadn't taken the COVID vaccination. Also, 93.9 % of Indian waste workers hadn't taken COVID vaccine.

A question was asked to find the reason for not having COVID vaccination to date, where 67.5% of waste workers said they are afraid of its consequences whereas, 30.1% said they are either not asked by anyone or not allowed for a vaccine. Apart from this, 50% of Nepalese who were authorized to have vaccination didn't take the vaccine as they were afraid. Also, the youths aged between 18-28 years were among the highest (80%)

number of respondents who were afraid of having COVID vaccine.

Table 2. COVID-related symptoms and vaccination

Variables	Frequency (n= 107)	Percentage (%)
COVID related symptoms		
Fever	96	89.7
Fatigue	48	44.9
Cough	92	86
Respiratory	59	55.1
Loss of smell	14	13.1
COVID test		
Yes	21	19.6
No	84	78.5
Missing	2	1.9
COVID detected		
Yes	2	1.9
No	105	98.1
Vaccination		
Yes	24	22.4
No	83	77.6
Reasons for no vaccination		
Afraid	56	67.5
Not asked	25	30.1
Missing	2	2.4

The p-value (0.7% = 0.007) for the nationality of the people and their vaccination was found to be less than 5% (α value), which means a significant association between nationality and vaccination. It shows that the vaccination of people is dependent on their nationality. Further, a test was conducted to find the strength of the association between the nationality of people and vaccination. The contingency coefficient value was found as 0.254 showing a weak association between the nationality of waste workers and vaccination. A similar case was with the nationality of waste workers and reasons behind not having the COVID vaccine which shows an association (p-value = 0.033) but was weak (Contingency Coefficient value = 0.245). However, the Pearson Chi-Square test didn't show any association between gender, age group and education of waste workers with COVID vaccination and reasons behind not having the vaccine.

Table 3. Association of different characteristics with COVID vaccination

Characteristics	Vaccinated (n= 107)		p-value	Reasons for no vaccination (n= 83)		p-value
	Yes n(%)	No n(%)		Afraid n(%)	Not asked n(%)	
Gender						
Male	12 (21.1)	45 (78.9)	0.715	29 (66)	15 (34)	0.735
Female	12 (24)	38 (76)		27 (73)	10 (27)	
Nationality						
Nepali	22 (29.7)	52 (70.3)	0.007	37 (72.5)	14 (27.5)	0.033
Indian	2 (6.1)	31 (93.9)		19 (63.3)	11 (36.7)	
Age Group						
18-28	6 (18.6)	26 (81.4)	0.117	20 (80)	5 (20)	0.457
29-39	8 (22.2)	28 (77.8)		13 (52)	12 (48)	
40-50	6 (21.4)	22 (78.6)		17 (74)	6 (26)	
51-61	4 (44.4)	5 (55.6)		5 (100)	0 (0)	

62 and above	0 (0)	2 (100)		2 (100)	0 (0)	
Education						
Yes	8 (17.4)	38 (82.6)	0.278	24 (64.9)	13 (35.1)	0.456
No	16 (26.2)	45 (73.8)		32 (72.7)	12 (27.3)	

Discussion

The study found the majority of the waste workers had symptoms of fever (89.7%), cough (86%) and respiratory problems (55.1%) during the COVID period which is higher than a similar study done among waste workers in Bangladesh which found only 22.2% respondents having fever.[17] In general, the most common symptoms in COVID-19 patients include fever (81.2%), cough (58.5%) and fatigue (38.5%).[26] But the difference could be due to the different time frames undertaken for the study. Also, the types of respondents and the nature of their work make one symptom more common than the other.

It was found that the majority of IWWs from India hadn't taken the COVID vaccine compared to IWWs from Nepal. A survey conducted in the United Kingdom found a high level of COVID-19 vaccine hesitancy among ethnic minority groups.[27] As a majority of IWBs belong to the "Madhesi" community, this could be the reason for vaccine hesitancy in Kathmandu as well. It is found that there is greater vaccination hesitancy among people with lower education, unemployed people, youths and ethnic groups.[28] However this study didn't find any association between gender, age group and education of IWWs with COVID vaccination.

A cross-sectional study conducted among 18,201 people in Bangladesh, India, Pakistan, and Nepal found that vaccine acceptance was statistically similar in both genders in Nepal.[29] This is similar to the findings of this study which shows no difference between genders who had taken COVID vaccination.

This study found that there was a significant association between nationality and vaccination in the IWWs of Kathmandu. Before 14th February 2022, people were required to show a Nepali identity certificate (citizenship/passport/voter identity) for COVID vaccination.[24] This might have been the main reason the Indian waste workers were deprived of having COVID vaccine. The people of low-income countries have low levels of education, income, and occupation which may directly affect the vaccine-accepting processes of their people.[30] A study conducted in lower-middle-income countries (India, Nepal, Nigeria and Pakistan) found the average vaccine acceptance rate to be 80.3% where concerns about side effects were the most common reason for hesitancy.[31] This study found that the most common reason for not having the COVID vaccine was that the IWWs were afraid to take a vaccine. The finding was similar to a cross-sectional study conducted in the Benadir region, Somalia which found that the majority (63.2%) of respondents refused to take the COVID-19 vaccine whereas 64.4% believe it wasn't safe.[32] The reasons for vaccine hesitancy in the United Kingdom were found to be concern about side effects and lack of trust.[27] A study found that mild effects were seen in people in Nepal after having the COVID-19 vaccine and it was acceptable in the sense that the body will need some time to adopt the vaccination dose and gather an immune system to induce protective antibodies.[33]

A study conducted in the United States found that 67% of people would accept a COVID-19 vaccine if it is recommended for them.[34] A study has found that around 65%, 66%, 72% and 74% of people from Bangladesh, India, Pakistan and Nepal, respectively are willing to be vaccinated against COVID-19.[29] As Nepal Government has allowed for COVID vaccine for all (no identity cards) from February 2022[24], IWWs should be notified and should be asked for vaccination.

Study Limitations

The study was limited to the core areas of Kathmandu Valley and only included the IWWs. As IWBs were the respondents who mainly belongs to the Terai region of Nepal and neighboring India, the number of people taking the COVID vaccine was less. The Nepal

Government has recently allowed all foreign nationals eligible for COVID vaccine, so the number might be high in the coming days.

Conclusion

The waste workers of Kathmandu seem to be reluctant to have COVID tests and don't want to take vaccines though they are having COVID-related symptoms. The majority of waste workers are afraid of taking a vaccine with Indian nationals not being allowed for vaccination. Though Nepal Government has recently relaxed the requirement of the national identity for the COVID vaccine and the IWWs are not unaware of it. Government should convince the people to implement the vaccine for all campaigns irrespective of boundaries and territories.

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Original Article

Descriptive Epidemiology of Occupational Injuries among urban construction workers - an observation from Eastern India

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ABSTRACT

Introduction: Bhubaneswar, Odisha, is seeing a boom in construction activities, with workers from remote areas coming for work. Poverty, illiteracy, coupled with employment and regular payments make them oblivious to unsafe working conditions. Long hours of heavy work in bad postures affect their musculoskeletal system leading to work-related musculoskeletal injuries. This study aimed to understand the epidemiology of the above injuries among the construction workers in Bhubaneswar

Methods: It was a work-site-based multistage cross-sectional study, where the sites engaging >=15 workers were selected randomly. A total of 520 workers (consented, >=21 years of age, and in this profession for at least 3 years) were recruited randomly. Data was collected by interviewing the study participants with the help of a pre-tested questionnaire focusing on sociodemographic profiles and relevant epidemiological variables related to occupational injury of urban construction workers. Data entry and analysis were done using SPSS version 20.

Results: Over 95% of the participants were heavy workers, 23.1% were laborers, 28.1% had < 10 years of experience, and 72.3% were satisfied with their job. A little more than 19% had work-related injuries in the last 3 months. Age, gender, alcohol abuse, better education, lesser work experience, skilled work and job dissatisfaction were found to be statistically significant when associated with the workplace injuries. Multivariate analysis revealed only age and lesser duration of working experience in the construction industry were associated with an increase in occupational injuries.

Conclusion: This study found that younger age, less work experience, male gender, use of alcohol, nature of work and lack of job satisfaction, and a few other factors were associated with work-related injuries. Often their occupational health and injuries get overlooked. Employers should be primarily responsible for their health, safety, and well-being.

Keywords: Construction Workers, Musculoskeletal Injuries, Occupational Accidents, Occupational Injuries, Work-related Injuries.

Introduction

Occupational healthcare delivery services are grossly neglected in many Asian countries including India.[1,2] The workforce and their occupational well-being are mostly under the ministry of labor, mines and industries, whereas healthcare is mostly under the ministry of health. India is one of the fastest growing economies in the world with about 500 million workforces and more than 90% of them are in informal economy sectors with almost no occupational health care delivery services for them.[1,2] It may be noted that the construction industry is one of the largest industries, ranking second only, next to agriculture. Being a labour-intensive sector, construction provides with opportunities for investment and employment (direct and indirect) to a sizeable chunk of the population, thereby being a vital part the economic activity, growth and development of our country.[1,2] Despite the contribution of construction industry and its workers towards the growth and development of our economy, health and safety of the workers remain overlooked, and the accurate statistics of occupational accidents and injuries are not even available.[2] Unfortunately, most construction workers belong to informal economy sectors, who are highly exploited socially, economically and medically, contrary to facilities of workers of formal economy sectors. Bhubaneswar, capital of Odisha, a state on the eastern coast of India, upon being listed as one of the cities under National Smart City Mission projects by the Government of India[3] has seen a boom in the development and construction activities in the city.

Workers from remote areas flock to the cities for work. Poverty and lack of education, coupled with regular employment and assured payments make the workers oblivious to unsafe working conditions. Long hours of laborious heavy work in bad postures over a prolonged period affects the musculoskeletal system of the workers. The afflictions are both short-term (in case of any injury) and long term (due to ergonomic reasons).[2] A systematic review revealed that work-related musculoskeletal disorders (WRMSD) and injuries were high in construction workers ranging from 25% of the studied population to as high as 96% of the studied population.[4] Occupational injuries often lead to musculoskeletal disorders (MSD), which in turn, diminish productivity, cause absence from work, impose costs on the public health system. Construction workers happen to be a class of people suffering from MSD often.[5] Musculoskeletal impairment was found to be a cause for frequent sickness absenteeism from work, in a study by Taimela et al.[6] Since limited data is available on WRMSD in construction workers in India, particularly in the eastern part of India, hence, this study was conducted to understand the epidemiology of work-related injuries among the construction workers in Bhubaneswar city, eastern India.

Methods

It was a construction site-based multistage cross-sectional study. North Zone of Bhubaneswar in Odisha was chosen; plots (standalone houses) that had active construction work going on, engaging a minimum of 15 workers were the chosen construction sites for this study. Construction workers (both males and females) who were of 21 and above years of age, with a minimum of 3 years of work experience in the construction industry and who gave consent to the study were included. The workers who were not physically involved in active construction activity, seriously ill workers, pregnant/lactating women and those who did not understand the local language were excluded.

Sample size was estimated to be 260 using a formula of $n = (Z)^2p\ (1-p)/\varepsilon^2$; where n= required sample size, p=estimated prevalence, ε = desired precision. An empirical study design of 2 was considered to adjust for the possibility of variance inflation due to higher inter-cluster (construction sites) and lower intra-cluster variation. Thus total sample size came to 260 x 2= 520.

Using the random method, the North Zone (comprising 21 wards) out of the three zones of Bhubaneswar was chosen in stage I. Five out of the twenty-one wards were chosen randomly for this study, in stage II. In stage III of the sampling, 10 random construction sites were chosen from each ward. In stage IV, construction site managers were

explained the project and its purpose and their permission was taken. The list of workers at the site was obtained and people meeting the inclusion and exclusion criteria were listed. By simple random technique, 10-11 workers were selected from each site and the process continued till 104 were selected from each ward. After that, another selected ward was visited and stage IV activity was repeated.

Data was entered in an MS Excel sheet. Frequency distribution, and univariate and multivariate analysis using SPSS Version 20 were done in this study. Ethical Clearance was obtained from the Research Committee and the Institutional Ethics Committee at Kalinga Institute of Medical Sciences, Bhubaneswar before the commencement of the study. For the purpose of this study, the workers were classified as heavy and moderate on the type of work and the hours they worked daily. Workers who were into masonry, rod-binding, centering, plumbing, marble work, carpentry and the manual labourers, who worked >=8 hours daily were classified as heavy workers. Painters, welders and electricians who were found to work 6 hours or less a day, were classified as moderate workers. Injuries that occurred at the workplace while performing assigned tasks have been defined as work-related injuries. Job satisfaction has been defined as the workers being content with their jobs and having no complaints despite the low income or hazardous surroundings - it was a subjective question that had 2 parts; first they were asked if they were satisfied with their job, and then they were asked why did they feel so. For this study, use of alcohol has been explained as use of alcohol at least once a week. Body Mass Index (BMI) is an easy, quick and inexpensive way of assessing one's nutritional status. BMI score of less than 18.5 is considered to be underweight. Personal Protective Equipment (PPE) are needed to be worn by workers to shield them from certain harsh elements and thereby prevent accidents at their workplace; these include rubber gloves, goggles, ear plugs, helmets, etc. All the workers who had some form of training (from some older family member or as an apprentice to an older colleague) and needed some sort of special skills to do their work have been categorised under skilled workers while workers who have never had such training were grouped under unskilled workers.

Results

A total of 520 workers fulfilling the study criteria were subjected for this study. The following table-1 shows the distribution of various demographic variables related to the study subjects. More than half of the studied workers were less than 40 years of age and more than two/thirds were males (73.8%), 73.5% were literates, 64.2% were Hindus, nearly 75% earned less than Rs.2252/- per capita per month, 64.6% were married and more than 70% lived in joint families (Table 1).

Table 1: Socio-demographic profile of the study participants (N=520)

Variable	N=520	Percentage (%)
Age Group (in years)		
21 - 29	168	32.3
30 - 39	102	19.6
40 - 49	92	17.7
50 - 59	114	21.9
60 - 69	44	8.5
Gender		
Female	136	26.2
Male	384	73.8
Education		
Illiterate	138	26.5
Primary School (Up to class 5)	160	30.8
Upper Primary (Class 6 & 7)	108	20.8
High School (Class 8 - Class 10)	106	20.4
Higher Secondary (Class 11& 12)	8	1.5

Religion		
Hindu	334	64.2
Muslim	180	34.6
Christian	6	1.2
Economic status (per capita per month – Rs.)*		
≥ 7770 Upper	10	1.9
3808 - 7769 Upper-middle	52	10.0
2253 - 3807 Middle	70	13.5
1166 - 2252 Lower-middle	288	55.4
<1166 Lower	100	19.2
Marital status		
Married	336	64.6
Unmarried	104	20.0
Divorced/ Widowed	80	15.4
Type of family		
Joint	384	73.8
Nuclear	104	20.0
Single Person	32	6.2

*using B.G. Prasad Scale[7]

Most of the workers (95%) were heavy workers in the studied sample. Over two-fifths were found to be unskilled workers who dabbled in cement work and worked as manual laborers. Nearly half of the workers were in the industry for less than 20 years (Table 2). Nearly one-fifth (19.2%) of the workers reported occupation-related injuries in the past 3 months. Over 70% were satisfied with their jobs - low wage, lack of job security, hard physical labour and not being able to see the family for long stretches of time were mainly cited as reasons for lack of job satisfaction.

Table 2: Frequency distribution of study participants according to their work environment details (N=520)

Variable	N=520	Percentage (%)
Work Type		
Heavy	496	95.4
Moderate	24	4.6
Nature of Work		
Masonry	54	10.4
Rod - Binding	50	9.6
Centering	44	8.5
Plumbing	50	9.6
Marble work	36	6.9
Carpenter	48	9.2
Cement work	94	18.1
Labourer	120	23.1
Welding	04	0.8
Painting	10	1.9
Electrical	10	1.9
Work years		
< 10 years	146	28.1
10 - 19 years	110	21.2
20 - 29 years	120	23.1
30 - 39 years	86	16.5
40 - 49 years	58	11.1

Work related injury in last 3 months		
Yes	100	19.2
No	420	80.8
Job Satisfaction		
Yes	188	72.3
No	72	27.7

Factors including age less than 40 years, male gender, use of alcohol, better education, skilled nature of work, lesser duration of work experience and lack of job satisfaction were found statistically significant (using the Chi-Square test) when the issue of work-related injury in the last 3 months was raised (Table 3). BMI, use of PPE, marital status, economic status, religion, presence of family and type of work were found to be not statistically significant (Chi-square test) with respect to workplace-related injuries in the last 3 months.

Table 3: Frequency and Significance of Factors contributing to Occupational Injuries

Variable	Grouping of Variable (Number)	Subjects with injury in the last 3 months (Out of 100)	Subjects with no injury in the last 3 months (Out of 420)	Odds ratio (95% CI of odds ratio)	p-value
Age	≤ 40 years (280)	78 (27.9%)	202 (72.1%)	**3.8 (2.3-6.3)**	0.00001*
	>40 years (240)	22 (9.2%)	218 (77.8%)		
Gender	Males (384)	90 (23.4%)	294 (76.6%)	**3.9 (1.9-7.7)**	0.000043*
	Females (136)	10 (7.4%)	126 (92.6%)		
B.M. I	< 18.5 (154)	36 (23.4%)	118 (76.6%)	1.4 (0.9-2.3)	0.12
	≥ 18.5 (366)	64 (17.5%)	302 (82.5%)		
Use of PPE	Used (114)	28 (24.6%)	86 (75.4%)	1.5 (0.9-2.5)	0.1
	Never (406)	72 (17.7%)	334 (82.3%)		
Current use of alcohol	Used (342)	76 (22.2%)	266 (77.8%)	**1.8 (1.1-3.0)**	0.016*
	Never (178)	24 (13.5%)	154 (86.5%)		
Currently Married	Yes (336)	60 (17.9%)	276 (82.1%)	0.8 (0.5-1.2)	0.28
	No (184)	40 (21.7%)	144 (78.3%)		
Family Present	Yes (488)	99 (20.3%)	389 (79.7%)	7.9 (1.1-58.5)	0.1
	No (32)	1 (3.1%)	31 (96.9%)		
Education	Upto class 5 (298)	38 (12.8%)	260 (87.2%)	**0.4 (0.2-0.6)**	.000014
	> class 5 (222)	62 (27.9%)	160 (72.1%)		
Economic status	Higher (62)	8 (12.9%)	54 (87.1%)	0.6 (0.3-1.3)	0.178
	Lower (458)	92 (20.1%)	366 (79.9%)		
Religion	Hindu (334)	72 (21.6%)	262 (78.4%)	1.55 (0.96-2.5)	0.7
	Non-Hindu (186)	28 (15.1%)	158 (84.9%)		
Work Type	Heavy (496)	96 (19.4%)	400 (80.6%)	1.2 (0.4-3.6)	0.744
	Moderate (24)	4 (16.7%)	20 (83.3%)		
Nature of Work	Unskilled (214)	30 (14%)	184 (86%)	**0.6 (0.3-0.9)**	0.012*
	Skilled (306)	70 (22.9%)	236 (77.1%)		
Duration of Work (Years)	<20 (256)	68 (26.6%)	188 (73.4%)	**2.6 (1.7-4.2)**	0.000029*
	>=20 (264)	32 (12.1%)	232 (87.9%)		
Job Satisfaction	Yes (376)	54 (14.4%)	322 (85.6%)	**0.4 (0.2-0.6)**	0.00001*
	No (144)	46 (31.9%)	98 (68.1%)		

* Statistically significant as per Chi-square test

A total of 520 workers were interviewed, out of which 280 were less than or equal to 40 years of age while 240 were over 40 years of age (Figure 1). The number of injured workers is taken into account; a person having more than one type or one episode of injury in the last 3 months is considered as one person reporting to having a work-related injury. It was found that 19.2% of the total workers had injuries while 27.9% of the less than up to 40 years age group had injuries and 9.2% of the above 40 years had injuries.

The frequency distribution of the nature of injuries (age-wise distribution of injuries in the past 3 months) is shown below (Figure 2). All 134 episodes of injuries, experienced by 100 workers are taken into account. Here it is seen that the major share of injuries falls under the musculoskeletal system (fractures, sprain/strain, dislocation and ligament tears), which has the potential to affect their ability to work and earn a livelihood. Also, it was the younger people who reported experiencing work-related injuries 104 cases out of 134 (77.6%) while their older counterparts reported to the rest 30 (22.4%) cases of injuries.

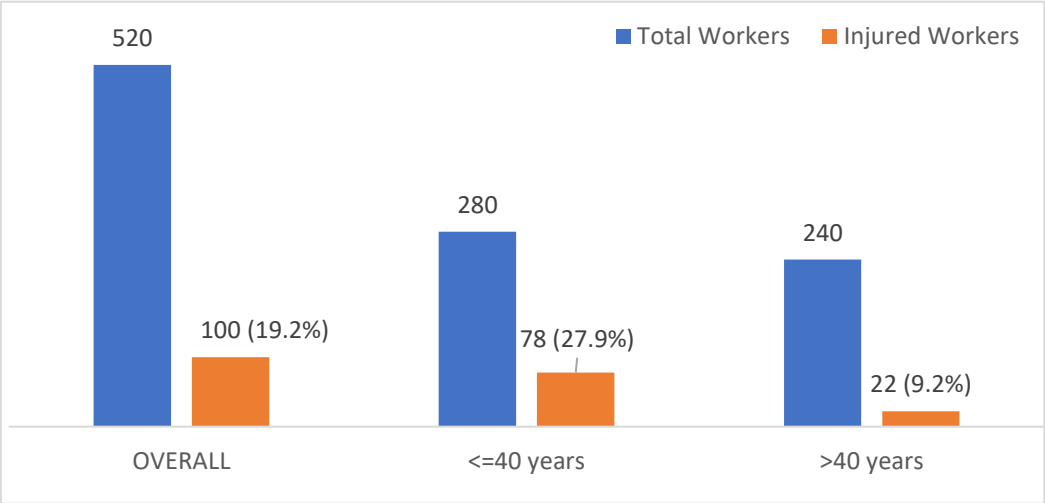

Figure 1: Distribution of study subjects with various age groups along with the prevalence of injuries

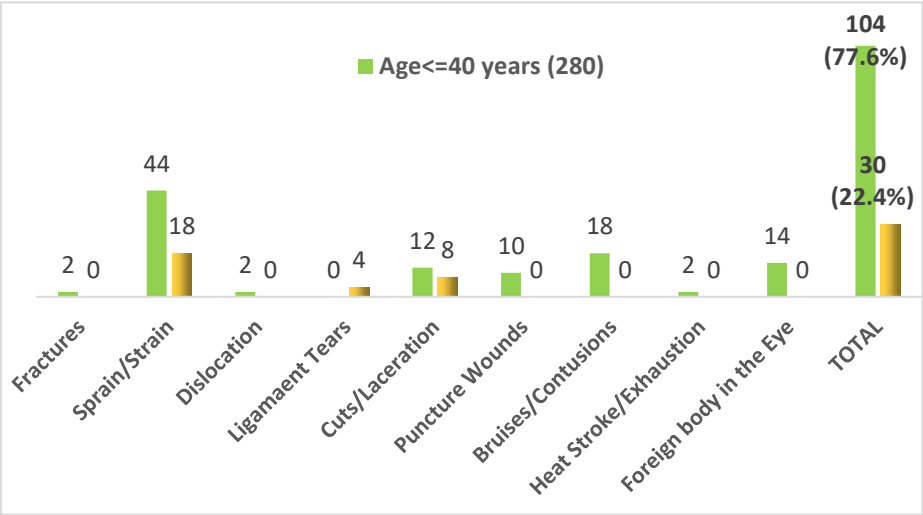

Figure 2: Association between nature of injury with age (multiple answers)

Discussion:

This study comprises 520 construction workers working at various construction sites in Bhubaneswar city, eastern India. It revealed that the overall prevalence of occupational injuries was 19.2% in the past 3 months. Breaking them into below 40 years and above 40 years age groups, revealed that the younger age group (<40 years) had a higher prevalence of occupational injuries compared to the workers above 40 years of age. This difference was statistically significant. This could be due to the fact of better adjusting healthy balance by the older workers while working, which helped them better avoid work-related injuries. Sex-wise, females had fewer injuries compared to their male counterparts (7.4% vs. 23.4%), which is statistically significant (table 3). This could be because females are usually associated with relatively milder work, whereas males are often associated with moderate to heavy work. These findings were supported by a Mangalore-based study, published in 2020.[8] The study reported that the prevalence of occupational injuries among their study participants was 36.28%. Lower age (<30 years) was one of the important causes and statistically significant factors associated with work-related injuries among construction workers. A Delhi-based study found that in 2017, only 37 females out of 44978 (0.82%) reported having construction site injuries as compared to 1043 out of 711,960 males (0.15%).[9] A Bangladesh-based study found that 57% of its study participants had occupational injuries in the past 12 months.[10] The same study too reported that lower age (<30 years) was associated with injury at the workplace. An Egyptian study among construction workers supported these findings.[11] The study found the overall prevalence of occupational injuries to be 46.2% and younger age was associated with more injuries. Hard physical labor with a high risk of occupational injuries is usually done by men according to ILO and WHO. As per ILO, the age of 46 years and above are considered to be old age since working on construction site require a lot of energy.[12] A study in Ethiopia found that being male elevated the odds of occupational injuries among construction workers.[13]

Better education and skilled work (table 3) were seen to be significantly associated with more reporting of workplace injuries in this study. This can be explained by the fact that better-educated ones were more aware and could report/recall their injuries better. Perception of these workers was more. On the other hand, the unskilled workers perhaps, were better adjusted to healthy ergonomic balance during their work - their muscle activities were possibly more coordinated as compared to that of the skilled workers. A Belgian study on farmers and a Korean study on construction workers too reported that better education led to a better perception of symptoms and resulted in more self-reporting.[14,15] But the Bangladesh-based study found that less education and lack of training increased the chances of injuries among the construction workers.[10]

Over half (65.8%) of the studied workers in this study, had reported consuming alcohol on the weekly basis. Also use of alcohol is statistically significant when associated with work-related injuries (table 3). Upon interviewing the study subjects further, it was learned that workers with self-reported injuries often consumed alcohol to subdue the physical pain. Rajeshkannan et al[16] found that 55.7% of the participants consumed alcohol, and a significant proportion of the study participants were users of multiple substances. It also reported that among the major industries, the highest rates of heavy alcohol use were found among construction workers. The Mangalore-based study too found that alcohol consumption was associated with more occupational injuries among construction workers. [8]

Even though 72.3% of the participants had reported being satisfied with their jobs in this study yet lack of job satisfaction is seen to be significantly associated (table 3) with injuries at the workplace. Other studies too have found that job dissatisfaction contributed to an increase in work-related injuries.[8,11,13] Less work experience in the construction industry also increased the instances of workplace injuries, this study found (table 3). Similar findings were reported by other studies.[8,11] This can be explained by the fact that a

lesser duration of employment is associated with less experience and a lack of awareness regarding workplace safety habits and hazards which results in increased chances of risk-taking behavior.[17,18] Younger workers did not usually comply with safe work procedures as per an Egypt-based report.[19] Nearly 75% of the study subjects earned less than Rs.2252/- per capita per month and thus had to be categorized under lower-middle and lower classes in the economic scales as per the B. G. Prasad Scale.[7] Bhubaneswar is classified under Area B and the skilled workers were to be paid Rs.389/- while the unskilled workers were to be paid Rs. 324/- as their daily minimum wage during the study period.[20] But our study found that they were getting paid way less than their right.

Following the above, multivariate analysis showed that only two factors - age less than equal to 40 years and lesser work experience (lesser duration of work) were statistically significant [2.9 (1.7 - 4.1) and 2.2 (1.5 - 3.9) respectively]. On the other hand, factors such as BMI, use of PPE, marital status, presence of family, socioeconomic status, religion, and work type were found to be not statistically significant in this study. With time, the women's workforce in the construction industry is on the rise.[21] These women need to be catered to not only for their occupational health but also obstetric care during their ante-natal and post-natal periods.

Limitations

Usual limitations associated with a cross-sectional study, self-reported behavior of the study subjects, non-availability of adequate representative female workers for the interview, interviewing participants in workplaces where privacy and suitable spaces were not available, apprehension of revealing unwanted information of the owner, loss of business hours and recall bias in some cases are some of the important limitations of this study.

Conclusion

This study looked into the issues of work-related injuries among the urban construction workers of Bhubaneswar, eastern India. This study revealed that young age (less than 40 years) and lesser work experience along with a few other factors are associated with higher occupational injuries. The study also observed that the health and safety issues of these underprivileged workers are often ignored. These need to be addressed by the local authority. A suitable intervention program targeting this group, need to be initiated based on their felt needs.

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Original Article

Determining low back pain factors and effects on daily activities in operating room personnel in Türkiye

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ABSTRACT

Introduction: Low back pain is a common problem among operating room personnel. The study was performed to determine low back pain (LBP) factors and effects on daily activities in operating room personnel.

Methods: The descriptive study was conducted in January 2018 in Ankara, Türkiye. The study sample consisted of 210 operating room personnel. Data from the study were collected using the Oswestry Low Back Pain Disability Questionnaire and Socio-Demographic Characteristics and Low Back Health Question Form.

Results: The majority of operating room personnel had LBP. The mean disability score of the Operating room personnel was 9.69±6.49. A total of 8.1% of operating room personnel had severe disabilities. The disability score of the operating room personnel was higher in women, nurses, and personnel who worked over 8 hours a day, those who had any level of stress, and those who lifted patients without assistance.

Conclusion: LBP remains an important problem in operating room staff and negatively affects daily activities. Considering the disability caused by LBP, to prevent LBP, developing comprehensive programs with hospital management including exercise, coping with stress, smoking cessation, and regulation of the working environment and conditions is suggested.

Keywords: Disability, Low back pain, Occupational health, Operating room

Introduction

Low back pain (LBP) is an important health problem that is common worldwide and is a major cause of disability.[1] LBP leads to a loss of working days, creating a serious economic burden on countries. [2,3] LBP is more common in some occupational groups that strain the lumbar region and require heavy lifting.[4,5] There are many occupational and individual risk factors for LBP. Chronic traumas such as physically heavy work, frequent bending, long-standing, lifting heavy loads, sudden unplanned movements, and repetitive movements cause LBP.[5-7]

It is emphasized that healthcare professionals have many risk factors that increase the risk of LBP. [8,11] Healthcare professionals often experience more LBP than other occupational groups, with the main factors being heavy lifting, sudden and unplanned movements, patient lifting, bending forward, standing in a fixed position, standing for extended periods, carrying patients, positioning patients, and stress.[4,12-16] Among healthcare

professionals, operating room (OR) personnel are exposed to almost all risks associated with LBP. Therefore, LBP is an important occupational problem in OR personnel. The main factors that increase the risk of LBP in this group are standing for a long-time during surgery, staying in a position that induces strain in the lumbar region, carrying patients, and lifting the surgery equipment.[17-21]

The prevalence of LBP, loss of workdays, healthcare costs, and reduced quality of life make it important to effectively implement measures for LBP.[2,3,8,22] LBP also influences an individual's ability to perform daily activities. Functional disability has been shown to increase as the severity of LBP increases.[23] More than half of the nurses were reported to have limited activities and 53.9% took sick leave due to LBP.[24] Approximately one-fourth of OR nurses were reported to have experienced moderate disability.[22] Although there have been interventional studies and programs to prevent LBP, it remains a serious occupational problem for healthcare professionals.[25-27] Considering this situation, more comprehensive studies in terms of factors affecting LBP will contribute to the multi-dimensional handling of the problem. Several studies have been conducted on LBP among healthcare professionals; however, extensive studies on LBP risk factors and disability in daily activities due to LBP are limited.[17,21]

Methods

This descriptive study was performed to determine LBP risk factors and disability levels in daily activities caused by LBP in OR personnel. The study was conducted between January 2 and 31, 2018, with doctors, nurses, anesthesia technicians surgical technicians, and healthcare aides working in the OR of the training and research hospital. The hospital has 1010 beds and 26 ORs. A convenience sampling method was used to select participants. The study included 250 OR personnel. A total of 210 (84%) OR personnel who volunteered and were not on sick leave were included. Forty OR personnel did not participate in the study due to sick leave, intense work tempo, or different working hours.

Characteristics of the Socio-Demographic and Low back Health Question Form and Oswestry Low Back Pain Disability Questionnaire were used as data collection tools.

Characteristics of the Socio-Demographic and Low back Health Question Form: This form consists of 30 questions developed by the researchers to determine the socio-demographic and low back health characteristics of healthcare professionals.[8,19-21,25,28]

Oswestry Low Back Pain Disability Questionnaire: It was developed by Fairbank et al. to evaluate functional disability in 1980.[29] The form was revised by Fritz et al. in 2001, converting it to a new version used today. This questionnaire is also referred to as the Oswestry Disability Index (ODI).[30] The Turkish validity and reliability of the ODI (2.0) was made by Yakut et al. in 2004. In this study, daily activities were measured in 10 different dimensions: severity of pain, personal care, lifting, walking, sitting, standing, sleeping, degree of pain change, social life, and travel.[31] While the minimum score obtained from the scale was 0, the maximum score was 50. An increased score indicates an increase in disability level. Cronbach's alpha for ODI was 0.89 in Yakut et al.'s study and 0.79 in this study.[31]

The percentage values obtained are interpreted as follows:

0%–20%: Minimal disability
21%–40%: Moderate disability
41%–60%: Severe disability
61%–80%: Completely disability
81%–100%: Bed bound/exaggerating symptoms

The Questionnaire was used without revision, as the questions were reported to be understandable by 10 OR personnel. One-to-one interviews with OR personnel were performed by the researcher, and their consent was obtained by explaining the aim of the study and what to expect from them. The forms were collected by visiting during the agreed hours and days. Forms were filled in an average of 15 minutes.

The Ethics committee approval required for the study was obtained from the Medical and Health Sciences Research Board (KA17 / 27) of Health Science University. The necessary official permits were obtained from the Medical Education Board

of the same university. Written informed consent was obtained from each operating room personnel. The study was conducted following the principles of the Declaration of Helsinki.

Data obtained from the study were transferred to the computer environment and analyzed with the IBM SPSS Statistics Version 17.0 (SPSS Inc., Chicago, Illinois, USA) package program. Descriptive data were expressed in mean ± standard deviation (SD), number and frequency. Shapiro Wilk's test was used due to the number of units upon an investigation of the normal distribution of variables. While analyzing the differences between the groups, the One sample test, and the One Way ANOVA test were used for variables that were normally distributed, and Mann-Whitney U and Kruskal-Wallis H tests were used when the variables were not normally distributed. A p-value of <0.05 was considered statistically significant.

Results

The mean age of the OR personnel was 38±8.02, and 41.9% were 31–40 years old. Furthermore, 75.7% were males, and 81.9% were married. Additionally, 53.8% of the OR personnel were doctors, 17.6% were nurses, 14.3% were anesthesia technicians, 3.3% were surgical technicians, and 11% were healthcare aides.

It was determined that 84.3% of OR personnel experienced LBP at least once in their lifetime, and the prevalence of LBP was 81.4% in a year. A total of 29.9% of patients were diagnosed with LBP (Table 1).

Table 1. Characteristics of the low back pain of the OR personnel

Characteristics	n (%)
Low back pain (n=210)	177(84.3)
Low back pain in the last year (n=177)	171 (81.4)
Diagnosis with low back pain(n=177)	124(70.1)
Sick leave for low back pain(n=177)	15(8.4)

Although not shown in the table, the majority of OR personnel performed risky movements for LBP. 77.2% of the OR personnel positioned patients, 69.9% carried patients between the stretcher and the operating table, 65.1% worked in a position that strained the low back, 54.4% rotated the upper part of the body, 53.9% performed unplanned sudden movement, 50.9% performed bending the low back forward without bending the knees, and 36.9% lifted heavy objects such as surgery sets higher than the low back. The most common activities where LBP was reported by the OR personnel included standing during operations for extended durations (40.6%), heavy lifting (33.8%), and working in the same position during surgery (23.6%).

The mean ODI score of the OR personnel was 9.69±6.49. While 51.9% of the OR personnel had minimal disability, 40% of them had moderate disability, 8.1% of them had severe disability. The mean ODI score was higher in OR personnel who have LBP (t=14.205, <0.001) (Table 2).

Table 2. ODI Score according to having low back pain in OR Personnel (N=210)

ODI Score%	n	%
Minimal	109	51.9
Moderate	84	40.0
Severe	40	8.1

Low back pain	n(%)	ODI Score%	ODI Score Mean (SD)	Test* p
Yes	177 (84.3)	22.16	11.05 (5.93)	14.205
No	33 (15.7)	3.61	1.78 (2.73)	<0.001
Total	210	19.25	9.60 (6.49)	

* Independent Sample T

The mean ODI scores were examined according to demographic characteristics and risk factors of OR personnel. Female scores were higher than male scores (t=3.791, <0.001), and nurses' scores were higher than doctors' scores (χ^2=14.264, p = 0.006) (Table 3).

OR personnel who work over 8 hours a day have a higher ODI score than OR personnel who work 8 hours or less (t=2.647, 0.009). The mean ODI score was higher in OR personnel who experienced stress at all levels in the work environment (χ^2=27.708, <0.001), and in those who did not receive help when lifting patients (t=-2.241, p <0.044) (Table 4).

Table 3. ODI scores according to the descriptive characteristics of OR Personnel (N=210)

Descriptive Characteristics		n(%)	ODI Score (%)	ODI Score Mean(SD)	Test, p-value
Gender	Female	51 (24.2)	25.16	12.50 (6.39)	**3.791**
	Male	159 (75.7)	17.36	8.66 (6.27)	**<0.001**
Age	<35 years	58 (27.6)	17.35	8.63 (5.57)	-1.328*
	≥35 years	152(72.4)	19.97	9.96 (6.79)	0.186
BMI	Normal (18.5-24.9)	88 (41.9)	19.36	9.65 (6.25)	3.251†
	Preobes (25-29.9)	101(48.1)	17.79	8.88 (6.35)	0.41
	Obes (≥30)	21 (10.0)	25.77	12.80 (7.56)	
Occupation	Doctor	113 (53.8)	16.87	8.42 (5.91)	**14.264‡**
	Nurse	37 (13.1)	26.31	13,10 (6.95)	**0.006**
	Anesthesia technician	30 (8.8)	17.67	8.83 (5.14)	
	Surgical technician	7 (9.1)	18.29	9.31 (5.04)	
	Healthcare aide	23 (10.8)	21.97	10.86 (8.47)	
Working years in occupation	≤5 year	26 (12.4)	15.24	7.57 (4.56)	1.911 †
	6-10 year	29 (13.8)	17.72	8.82 (5.95)	0.151
	> 10 year	155 (73.8)	20.21	10.08 (6.81)	
	Total	210		9.60 (6.49)	

*Independent Sample T , † One way Anova, ‡ Kruskal Wallis H

Table 4. ODI scores according to the risk factors of OR personnel (N=210)

Risk Factors		n (%)	ODI Score %	ODI Score Mean (SD)	p
Shift work	Yes	160 (76.2)	20.07	10.0(6.31)	1.652*
	No	50 (23.8)	16.64	8.28 (6.96)	0.100
Working over 8 hours	Yes	126 (60.0)	21.16	10.55 (6.33)	**2,647***
	No	84 (40.0)	16.39	8.16 (6.51)	**0.009**
Pregnancy (Female=46)	Yes	33 (71.7)	28.88	14.39 (5.03)	-1.872†
	No	13 (28.3)	23.41	11.61 (6.88)	0.061
Smoke Cigarette	Yes	85 (40.5)	20.16	10.08 (6.74)	.877*
	No	125 (59.5)	18.63	9.27 (6.33)	0.376

Sport	Yes	38 (18.1)	15.89	7.92 (6.15)	-1.769*
	No	172 (81.9)	19.99	9.97 (6.53)	0.078
Receiving support when lifting patients	Yes	143 (68.1)	17.92	8.92 (5.88)	**-2.241***
	Sometimes/No	67 (31.9.)	21.30	11.04 (7.49)	**0.044**
Stress in working	No stress	7 (3.3)	5.71	2.85(3.62)	**27.708‡**
	Mild stress	40 (19.0)	16.00	8.00 (6.11)	**<0.001**
	Moderate stress	92 (43.8)	17.15	8.55 (6.18)	
	Severe stress	71 (33.8)	25.15	12.52(6.19)	

* Independent Sample T, † Man Whitney U, ‡Kruskal Wallis H

Discussion

According to the results of the study, the majority of OR personnel had LBP. In studies with healthcare professionals in different countries, the prevalence of LBP ranged from approximately 45%–85%.[22, 32,33] The prevalence of LBP in healthcare workers in Türkiye is between 33% and 87.5%.[25,34-36] Nurses are the group most affected by LBP.[8,18,20] In our study, the prevalence of LBP was similar to that reported in the literature. OR personnel, especially nurses, are among the groups most affected by LBP due to the profession's characteristics and working environment and conditions. Excessive load on the lumbar region, lifting, bending, twisting, and intense physical activity are risks for LBP.[5]

Hospital personnel, especially OR personnel, report that factors that cause back pain include standing for extended durations, lifting heavy objects and patients, bending forward, being in a constant position for a long time, and experiencing psychological stress. These factors cause more LBP in healthcare professionals than in those working in other sectors. [8,14,36] In this study, OR personnel have many risk factors that can lead to low back pain. They reported being exposed to factors that strain the lumbar region, such as heavy lifting and standing for long hours, as well as standing for a long time in an inappropriate position. In addition, OR personnel have individual and professional risk factors such as stress, smoking cigarettes, obesity, not participating in sports, not paying attention to body mechanics, and standing for extended durations. The results indicated that most of these risks are preventable, and these factors can be controlled by individual and professional interventions and organizations.

Lack of assistance while removing patients is an important risk factor for LBP.[8] Louis Andersen et al. (2019) determined that patient transfer increased the risk of LBP by a factor of 3.58, which explains why LBP is higher in OR personnel.[16]

LBP causing different levels of disability for healthcare professionals has been previously reported. [22] In this study, while the mean ODI score in OR personnel was founded as 9.69±6.49, 51.9% of the OR personnel had minimal and 40% of them had a moderate disability. Moderate disability (24.9%-89.4%) related to back pain was found in the studies conducted with health care personnel.[37-39] According to this result, OR Personnel experience pain with sitting, lifting, and standing, but the daily activities were not affected. The mean ODI score of women was higher than that of men in this study ($p<0.05$). When the literature was reviewed, the frequency of LBP affecting daily activities was found to be higher in women than in men. [3, 40] LBP may cause more disability in women's daily activities than in men's due to factors such as a comparatively low physical endurance, giving birth, and continued workload at home.

While the mean scores of the nurses were higher than those of the other occupational groups, the mean scores of the nurses were significantly higher than those of the doctors and anesthesia technicians ($p<0.05$). The rate of nurses with LBP is higher than other healthcare professionals.[8,20,34] The higher LBP in nurses can be attributed to the fact that they consist mainly of women, have long working hours, and perform activities that strain lumbar regions, such as patient lifting.

Working for a long hour increases the risk of LBP. Similar to our study, other studies show that working more than 8 hours a day and working in

shifts were factors that increased LBP in nurses.[26, 36] Standing for an extended period increases the load on the lumbar region and may cause damage to the structures in this area over time.[8, 36] The fact that OR personnel have to stand for a long time due to the nature of their job may have led to this result.

The ODI scores of those who experienced stress at all levels in the work environment were higher than those of those who never experienced stress ($p<0.05$). In the literature, it is emphasized that physical and emotional stress factors affect LBP.[7,8, 36] This is an expected result given that ORs are extremely stressful environments for patients and employees.

Limitations of the study: This study was carried out in a single center. Therefore, the results cannot be generalized.

Conclusion

In conclusion, LBP was higher in OR personnel, and nurses had more disabilities in their daily activities than other personnel. Considering the results of the study, repetition of training programs for the correct use of body mechanics and lifting devices to raise awareness on low back health, to arrange the working environment following ergonomic principles, to provide lifting devices, and to facilitate staff access to them is recommended. Improving the number of personnel, arranging appropriate rest times for employees, and developing programs for coping with stress can be effective in preventing back pain. More comprehensive studies can be suggested about the relationship between stress, LBP, and disability.

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Original Article

Effect of Lifting Weight, Height and Asymmetry on Biomechanical Loading during Manual Lifting

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ABSTRACT

Introduction: In India, physical manual activities in asymmetrical postures overtax the human musculoskeletal system, which may exceed workers' physical limitations. Thus the purpose of this study was to examine the physical stresses experienced by the subject, based on subjective and biomechanical loading estimates while lifting weights to various heights, in an asymmetric direction and propose the safe limit for manual lifting.

Methods: A laboratory experiment was conducted utilizing twelve male subjects in the age group of 20 to 25 years who lifted 5 different weights between 10 to 20 kg from below the knee to various lifting heights (below the knee to ear level). The lifting task was performed in three asymmetric angles (45, 90, and 135-degree) using free-style lifting techniques. An ANOVA technique was used to analyze the influence of three parameters (Lifting weight, lifting height and asymmetric angle) on two responses; subjective estimates and biomechanical loading. The subjective estimate was obtained using workload assessment by body discomfort chart. The biomechanical loading (loading rate) was estimated from ground reaction force data, obtained from the force plate.

Results: Both the responses; subjective estimates and biomechanical loading followed a consistent pattern in predicting physical stress. The result revealed that lifting weights with higher destination heights and asymmetry angles increased the physiological workload and discomfort. Experiments have shown that the loading rate is reduced by 8 to 10% for each increase in the 45-degree angle of asymmetry.

Conclusion: In general, safe lifting of 15 kg weight up to ear level and 15 kg weight up to shoulder level are recommended for 45- and 90-degree asymmetry respectively to prevent any chronic injuries. A maximum of 12.5 kg lifting weight up to shoulder level is also proposed.

Keywords: Asymmetric posture, Loading rate, Manual material handling, Workload assessment.

Introduction

Construction workers are frequently exposed to forceful and repetitive exertions with awkward postures, which lead to work-related musculoskeletal disorders (WMSDs) such as strains, tendonitis, and back and wrist injuries.[1] Moreover, Back pain is the most prevalent and costly musculoskeletal disorder as a result of poor working conditions.[2] In the construction field, the worker experiences frequent bending and/or twisting of the body, lifting the load above and below the shoulder and knee level.[3] Considering the presence of heavy equipment, physically

demanding tools, and changing work environments, the job sites in the construction industry are more crucial to society, the economy and the business environments.[4]

Asymmetry occurs when an external load is handled in a non-sagittal plane. A lifter must usually twist his or her trunk off the sagittal plane while performing an asymmetric lifting task. Twisting the trunk in asymmetric lifting is hazardous in several investigations[5]. Large compression spinal force combined with axial shear torsional force impacted the intervertebral discs as well as trunk muscular activity during asymmetric lifting.[3,6] Second the maximal voluntary isometric strength was reduced during asymmetric lifting, also average upward acceleration and peak velocity or human lifting capability were lower in asymmetric lifting.[4,7,8,9] Third, poor posture stability and asymmetric muscular stresses on the spine can be caused by asymmetric lifting.[7]

In the building construction field, Indian workers often employ two hand lifting techniques while twisting their torsos, especially during loading and unloading in restricted workplaces or for irregular material handling. Restricted workplaces may cause low back pain. The study investigated that lifting at a low height, such as below the knee or even from the floor, results in twice the amount of spinal loading[10]. It is commonly agreed that the cause of lower back pain and injury is frequently related to the posture of lifting, the load, muscle fatigue, etc.[11,12]

In the literature, the loading conditions resulting from symmetric lifting are well documented, yet free-style asymmetric lifting above the subject's waist-level height has not been intensively studied.[13] It was also observed that previous studies of asymmetric lifting were limited to a 90-degree asymmetric angle, but none of the studies investigated lifting task parameters at a 135-degree asymmetric angle.[5,14] In line with this motivation, the purpose of the present experimental study is to evaluate the risk of asymmetrical lifting for two lifting task parameters; weight load and destination heights based on subjective and biomechanical loading estimates while lifting objects asymmetrically.

The lifting task was considered similar to the task used in the construction industry in India. The present ergonomic study may help workers to avoid hazards that cause injuries, illnesses, and fatalities in the construction field. The construction industry's safety and health performance might be considerably improved if appropriate and acceptable information about workplaces, manual jobs, and ongoing training and education is provided.

Methods

In the present study twelve healthy male university students (mean age 23.5 ± 1.78 years, weight 70.67 ± 2.57 kg, and height 1.76 ± 0.027 m), were participated in the study. The inclusion and exclusion criteria were designed to reflect a healthy and working population. None of the participants had experience in manual lifting tasks, and none had a history of neurological disorders, back pain, or any other musculoskeletal injury. The subject's mean height and weight were found to be approximately the same due to the closed age group. Before the experiment, each subject reviewed and signed an informed consent form approved by the University's Institutional Review Board. All of the subjects had been trained for the task before the actual experiment began. The remuneration was given to the subject for their participation. The lift's origin was in the sagittal plane, and asymmetrical lifting was investigated at 45°, 90°, and 135° departures from the sagittal plane to the right.

The lifting cycle began with the pan being lifted (dimension 30×30×25 cm) of a concrete-cement mixture, from the below knee height (origin) to a bench at the desired destination level. Subjects performed a lifting task with 5 different lifting weights, in which 10, 12.5, 15, 17.5 and 20 kg, the pan was lifted to 5 different vertical lifting heights; below the knee, knee, waist, shoulder and ear level of the subjects. The subjects were restricted to move their feet during the lifting cycle. For asymmetric lifting, the individual completed an initial symmetric lifting, then a desired asymmetric body turn to the right, and finally placed the container on the table. This manual lifting task was found to be consistent with the

building construction industry for performing the concreting operation.

Experimental Setup

The experimental study was performed in the Biomechanics Lab of the National Institute of Technology Rourkela; NIT Rourkela.[15] The study was carried out using laboratory simulated experiments in September 2019. The Kistler's multiaxial force platform (500×590×50 mm) measures GRFs and was used in this study (model AA9260). The analog output from the force platform passed through an internal amplifier and reached Kistler's data acquisition system (type 5691A1), where data was collected with a sampling frequency of 1000 Hz to generate a digital signal. The Nyquist theorem was used to determine the sampling frequency. For smoothing data, the Butterworth filter was used, which attenuated frequencies over the set cut-off frequency while allowing frequencies below the cut-off to pass through. Finally, the data was reflected in Bioware software.

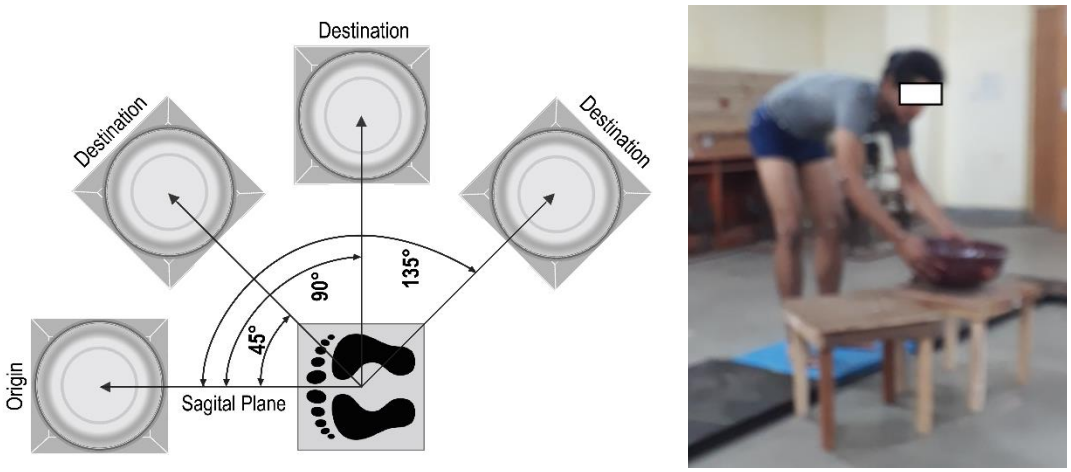

Figure 1. Schematic diagram and Laboratory set-up of the force plate

Biomechanical Evaluation

The manual lifting task was evaluated using data obtained from the force plate and subjective workload assessment chart. The vertical ground reaction force (GRF) (F_z) beneath feet produced during lifting was measured using force platforms. Fz always thrusts the body upward through the feet. The setup arrangement is shown in figure 1. The ratio of peak loading and time to peak loading during human activities is referred to as the loading rate (LR). Loading rate (LR) was calculated by determining the time required for the vertical force to rise by lifting the weight from the origin to the destination. The peak rate of vertical GRF (LR) indicates the possibility of chronic damage as a result of these activities.[16]

$$LR = \frac{F_{zmax} - F_{zmin}}{t_2 - t_1} \quad \text{(Equation 1)}$$

F_{zmax} and F_{zmin} are the peaks and the lower value of F_z of one lift and (t_2-t_1) is the time between these values. Finally, the magnitude of the loading rate obtained from GRF was compared to subjectively evaluated physical discomfort and overall workload.

The Subjective evaluation was performed by giving a questionnaire to each subject, figure 2.[17] The questionnaire includes a chart for measuring physical discomfort as well as a rating scale for the total workload. After executing the lifting task for each test condition, the subject was asked to rate the level of discomfort in each of the body parts, figure 2. The degree of discomfort is measured on a five-point scale that ranges from no sensation or soreness (zero) to extreme pain or soreness (4). Following the discomfort assessment, the subject was asked to rate the overall workload for the task. The overall workload scale is also a five-point scale, with '1' being very light and '5' being very hard. The physiological workload was thought to be a major risk factor for WMSD.[7]

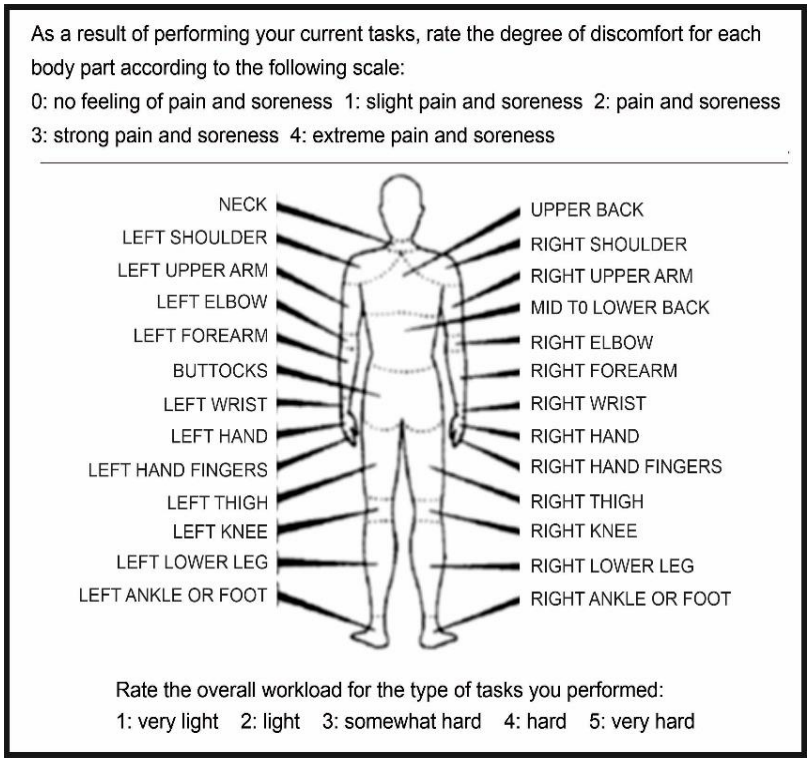

Figure 2. The body discomfort and overall workload questionnaire.[17]

Test Procedure

The weight was lifted using an open circular-shaped plastic pan with no handles. To make lifting easier, the weight of the concrete mixture (cement, sand, and grit) was placed in the pan. The pan is similar to that used in construction fieldwork. Before the lifting task, the subjects were given thorough instructions and requested to complete two to three trials while standing on a force plate.

Each participant was required to lift a load in 75 different combinations of lifting parameters (5 weights, 5 destinations and 3 asymmetrical angles) in an asymmetrical freestyle. A total of these 75 lifting tasks were randomly assigned to each subject during data collection to prevent *order* effects. After each lifting task, a sufficient rest period was given to allow the muscles to recuperate. The subjects were told to lift the weight with both hands while keeping their feet in the sagittal plane. During the lifting cycle, the subject was instructed to maintain a fixed, symmetrical foot position. The Fz was measured for each test condition for all the subjects against a time scale (in seconds).

Response Data Analysis

A repeated measures ANOVA was performed using the statistical package for social sciences (SPSS Inc., Chicago, USA, version 16) to evaluate the subject's response. The loading rate and overall workload were tested for the effect of lifting asymmetry, lifting weight, lifting heights and additional contrast tests (pairwise tests) for significant asymmetry effects. A p-value of 0.05 was considered significant. The repeated-measures design was well suited because each subject's assessments were collected repeatedly for all of the test situations. Wilcoxon signed-ranks test was also carried out on all the data to determine whether the independent variables had a significant effect on the dependent variables. For interpreting the ANOVA, two further statistical measures were used: partial eta squared and the observed power. Partial eta squared (η^2p) is a way to measure the effect size of different variables and to understand the major effects or interactions[18]. An observed power of 0.95 in the range of 0 to 1 indicates a 5% possibility of detecting a false positive result.

Results

Within-subject test of statistical analyses was performed to determine the general effects of lifting weight, lifting height and asymmetry angle on the loading rate and overall workload.

Table 1. Within-subjects effect of test parameters on Loading Rate and Overall Workload

Sources	Loading Rate					Overall Workload				
	df	F	Sig.(*p*)	η^2p	O.P	df	F	Sig.(*p*)	η^2p	O.P
W	4	10535.25	.00	.99	1.0	4	509.17	.00	.98	1.0
H	4	29785.34	.00	1.0	1.0	4	330.10	.00	.97	1.0
A	2	9523.67	.00	.99	1.0	2	165.32	.00	.94	1.0
W * H	16	2127.95	.00	.995	1.0	16	14.07	.00	.56	1.0
W * A	8	27.04	.00	.711	1.0	8	11.48	.00	.51	1.0
H * A	8	446.85	.00	.97	1.0	8	45.47	.00	.81	1.0
W * H * A	32	29.36	.00	.73	1.0	32	20.37	.00	.65	1.0

W- Lifting weight, H- Lifting Height, A-Asymmetry, df- degree of freedom, O.P-observed power

Table 1 interprets the main effects and interaction effects for the judgment of responses. The ANOVA result revealed that all the main and interaction effects are statistically significant. The results show that the highest contribution comes from the individual variables, followed by the contribution of the interaction variable, with a high value of observed power (O.P). The table clearly showed that each increase in lifting asymmetry significantly impacted the loading rate and overall workload (p<0.05). This effect was consistent for lifting weight and lifting height conditions.

The vertical reaction force was measured for all 12 subjects for all experimental conditions. One such sample plot of one subject lifting the weight of 17.5 Kg at shoulder height for one minute has been shown in Figure 3.

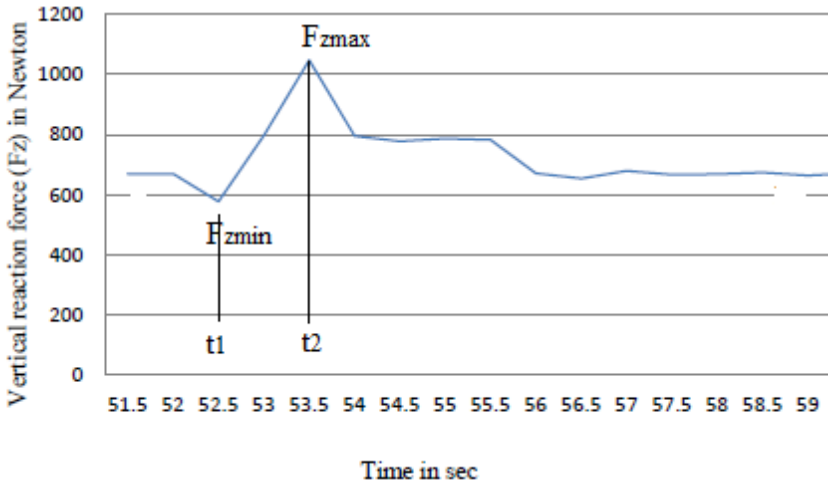

Figure 3. Vertical force-time graph of sample reading

The value of the mean loading rate and overall workload of all 12 subjects was plotted as shown in figures 4 & 5. The plot indicates that the loading rate was significantly increased with increasing lifting weight and also by increasing destination heights for all three asymmetry angles. There is no significant difference in loading rate predictions between the knee and waist height for all the asymmetric lifting weights (p>0.05). When the destination was raised above this lifting height to ear height, however, the loading rate increased dramatically (p<0.05). Moreover, when subjects lifted different weights to below knee height, no significant effect was detected (p>0.05). It has also been seen that the least loading rate was observed for lifting the smallest (10 kg) weight and that there was no significant difference in loading rate for all other asymmetric lifting heights (p>0.05). This was also confirmed by the least overall workload, figure 5. Plot 4 demonstrated that there is a substantial reduction in loading rate with an increase in lifting asymmetry irrespective of lifting weight and lifting height (p<0.05).

The mean overall workload for all 12 individuals was plotted in Fig. 5. It was interesting to find that the mean loading rate and the overall workload rating were well correlated to some extent. The overall workload yields an almost similar rating

between the knee and waist height for all of the asymmetric lifting weights ($p>0.05$). The rating of overall workload showed a significant rise while lifting asymmetrically more than about 12.5 kg weight ($p<0.05$). The result also clearly demonstrated that the overall workload increased with an increasing asymmetric angle for all lifting weights and heights ($p<0.05$).

The mean degree of discomfort for each body part was calculated for all 12 individuals. From the subjective rating of discomfort for 45-degree asymmetry, it was observed that lifting above 15 kg weight irrespective of lifting height, brings pain in the upper arms and back. The intensity of pain increased with increasing weight and lifting heights. In the case of 90-degree asymmetry, it was observed that lifting above 15 kg weight at shoulder height causes extreme pain (rating 4) in both arms and knees. An increase in lifting weights to 20 kg, raised this pain in the back and wrist. Further, lifting weights between 15 to 20 kg at ear height brings intense pain (rating 4) in the shoulder. In the case of 135-degree asymmetry, lifting 15 kg weight to shoulder height causes strong pain (rating 3) in the shoulders, upper arms and mid to lower back. Extreme pain (rating 4) was experienced in the upper arms when lifting the same weight at ear height. Moreover, a further increase in weight brings intense pain to ear height.

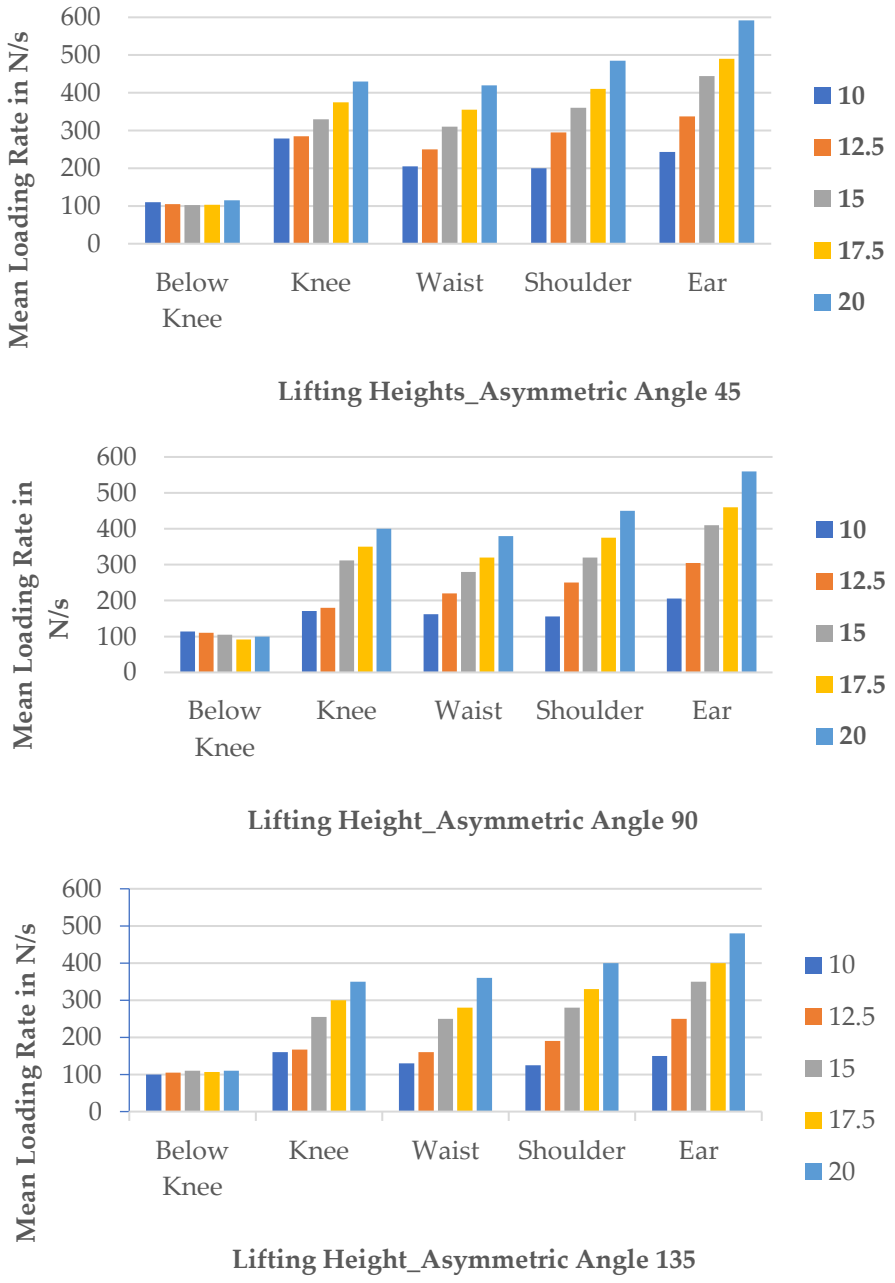

Figure 4. Mean loading rate plot with variation in weight (Kg) and asymmetric lifting height

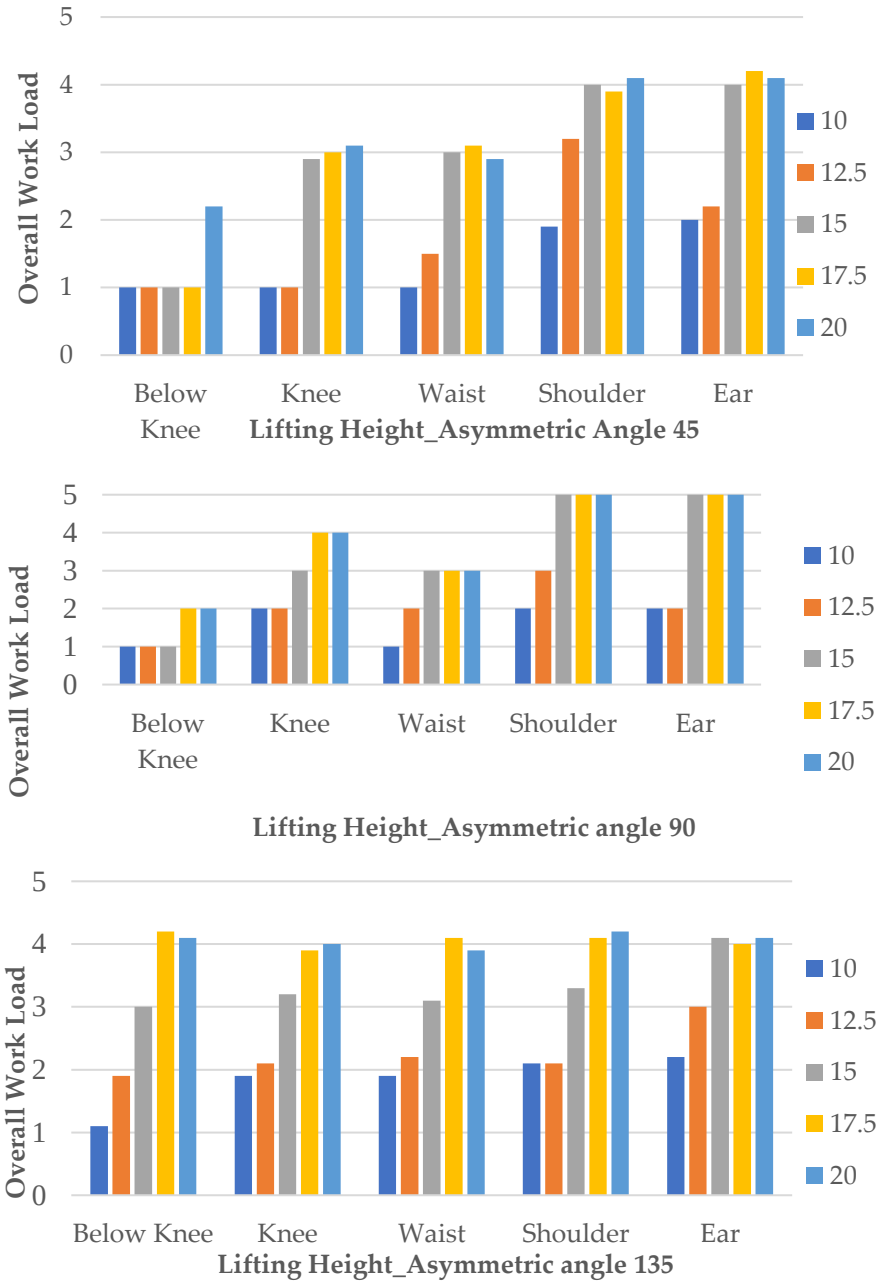

Figure 5. Mean workload plot with variation in weight (Kg) and asymmetric Lifting height.

Discussion

One of the prime beneficiaries of ergonomics is the construction industry, with its physically demanding work. Excessive physical demands beyond one's capabilities may lead to productivity, safety and health issues in construction. The study's major goal is to reduce worker fatigue as well as the danger of subsidence by employing the most optimal lifting parameters during lifting tasks. The present study will mimic occupational conditions adopted in the building construction field. The results can help further progress in the existing occupational lifting guidelines and raise awareness of musculoskeletal or chronic stresses in the workplace as a worldwide problem.

In the present study, lifting weight and lifting height had a major impact on the loading rate. Based on the result obtained, in general, the heavier weights did produce a higher loading rate than the lower ones throughout the process of lifting despite the lifting height. It has been observed that lifting weights with higher vertical lifting heights and asymmetry angles increased the physiological workload and discomfort. From the body discomfort and overall workload responses, the biggest complaints rated by subjects are mid to lower back followed by the upper arm and then shoulder, forearm and knee, among the other body parts. While lifting the weight from the origin, trunk flexion was rare, and lifting was primarily accomplished through knee flexion. This lifting becomes more stressful, at the

shoulder or ear height, due to the dynamic trunk motion. Lifting while bending creates a variety of back problems. It multiplies the weight of the object being lifted by the upper body's weight. Bending and/or extending your upper body increases the effective load on your back, causing lower-back stress and muscular fatigue. The most prevalent movements that produced back injuries were bending and twisting. When the subject lifted the weight in a restricted posture, without moving both feet, such confined workspaces increase low back pain in the subjects' bodies[19]. During asymmetric lifting, lateral bending action on the lumbar column and a rotation of each vertebra on its adjacent vertebra happen. This vertebral rotation has a high risk of injury.[20] Aside from the rotational consequences, imbalanced back muscle loading can provide highly concentrated stress, which can overstrain a specific muscle or muscles required to support the column.[20]

In the present study, various combinations of factors were explored to determine the least and the most exerting task conditions. For example, when the lifting weight was increased from 12.5 to 20 kg, for the same lifting height, the mean loading rate increased by about 32 to 40%. Similarly, when the lifting height was increased from knee to ear height for the same lifting weight, the loading rate increased by around 24 to 30 percent. This outcome applies to each asymmetric angle studied. The result revealed that there is no significant difference in loading rate for lifting the smallest (10 kg) weight irrespective of lifting heights. Thus lifting 10 kg weight from origin to ear height for an asymmetrical angle up to 135-degree is safe, as the spinal force generated was less than the recommended limit according to the NIOSH lifting criterion.[21] From the observed data, it is interesting to find that the mean loading rate and the overall workload rating are well correlated to some extent. Both are predicated on the idea of subjects exerting more effort when performing dynamic lifting tasks.

In the previous study by the author, the experiment was conducted for a symmetric posture with the same lifting weight and height conditions.[22] The result found a higher loading rate and less perceived discomfort as compared to the present asymmetric lifting study. In asymmetrical lifting tasks, the subject had to lift the pan and then turn the body through given degrees before placing the lifting weight on the table. Therefore, the cycle time for asymmetrical lifting was longer than for symmetrical lifting, leading to the occurrence of a lower loading rate. According to the findings of the present study, each increase in the 45-degree asymmetric angle reduces the loading rate by 8 to 10%. The results from the present study are consistent to some extent with the results of previous asymmetric studies.[23-25] This study revealed that asymmetric lifting led to a lower loading rate while the overall workload increased as compared to symmetric lifting. Regardless of whether the lift origins are on the left or right side, the revised NIOSH Lifting Equation reduces lifting weight limits by around 10% for every 30 degrees of asymmetry involved in the lift.[23] Several studies have shown reductions in maximum acceptable weights ranging from 8 to 22% when the load is asymmetrically applied to the trunk.[24,25]

The recommended weight limit is a weight limit below which virtually all healthy employees may accomplish for an extended period without increasing their risk of low back pain, according to the revised NIOSH lifting equation.[21] Although the loading rate and overall workload rating are two independent variables, the study found that they followed a similar pattern in predicting physical stress as a result of lifting tasks. Therefore, the safe limit for various task parameters has to be established to prevent/reduce injuries to workers engaged in lifting tasks. The safe limit has been proposed based on results obtained from loading rate and subjective rating, assuming alarming levels for perceived difficulty and workload as rating '2'. For example, if the weight is to be lifted from the origin to all given vertical destinations, then the weight should not exceed 15 kg at a 45-degree asymmetric angle. For a 90-degree asymmetric angle, this is restricted up to shoulder level. In the case of a 135-degree asymmetric angle, a maximum of 12.5 kg weight is permissible to lift safely up to shoulder level to prevent any chronic injuries.

Limitations of the Study

The majority of the construction workers in India are male, specifically lifting tasks in a constraint posture. Therefore, only male participants in a similar age range were chosen as the study's subjects. The study's limitations are that it did not take into account the participants' other existing health conditions, as well as their physical attributes like height, weight, and BMI. The authors believe that these factors contribute to the participants' different physical characteristics, such as height and weight. Analysis of these factors' effects on the physical capabilities of the subjects requires much more in-depth research. Another limitation of this study is that the participants were all male university students with no experience in manual lifting tasks. Investigating a broader spectrum of the population would result in a reliable generalization of our findings.

Conclusion

The workers were exposed to various risk hazards which affect health and safety issues in the building construction works. There has been a paucity of research on the physiological and subjective workloads of Indian male construction workers. This assessment of the physiological and subjective workload of MMH operations is essential for recommending remedial measures and assisting in the implementation of ergonomic guidelines for construction workers.

Even though both responses are distinct, the study found that they followed a consistent pattern in predicting physical stress as a result of lifting tasks. The physiological demands were shown to be increased while lifting loads with a greater vertical distance. Experiments have confirmed that the loading rate decreases linearly as the angle of asymmetry increases. Each increase in the 45-degree asymmetric angle reduces the loading rate by 8 to 10%. The subjects are most susceptible to pain in the lower back followed by the upper arm and then shoulder, forearm and knee. In general, safe lifting of 15 kg weight up to ear level and 15 kg weight up to shoulder level are recommended for 45- and 90-degree asymmetry respectively to prevent any chronic injuries. A maximum of 12.5 kg lifting weight up to shoulder level is also proposed.

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Original Article

Effects of emotional labor on musculoskeletal disorders among physical therapists in Seoul

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ABSTRACT

Introduction: Healthcare workers, including physical therapists, have some of the most important roles in the healthcare system, as observed during the coronavirus disease 2019 pandemic. Physical therapists encounter emotionally and physically vulnerable patients, experience emotional labor, and are exposed to conditions that can lead to job stress and musculoskeletal disorders. We aimed to examine the relationships between physical therapists' emotional labor, its effect on perceived job stress, and the risk of developing musculoskeletal disorders.

Methods: We conducted a 30-day survey among 230 physical therapists working in various settings from October 2 to November 1, 2019. Questionnaires, including questions on musculoskeletal symptoms, perceived job stress, and emotional labor, were administered to the participants.

Results: The emotional labor sub-factors "overload and conflict in customer service" (β=0.201, p>0.001), "emotional inconsistency and impairment" (β=0.199, p>0.001), and "organizational support and protection system" (β=0.298, p>0.001) affected the job stress sub-factors "physical environment" (β=0.105, p>0.020), "insufficient compensation" (β=0.072, p<0.05), and "relational conflict" (β=-0.083, p>0.024). These job stress sub-factors affected musculoskeletal disorders.

Conclusion: To prevent the long-term consequences of work-related strain, physical therapists should receive support for maintaining a healthy lifestyle and developing effective methods of communication with patients. Encouragement of activities for psychological rejuvenation and sharing emotional difficulties with colleagues is also desirable. Moreover, it is necessary to establish a direct line of grievance communication between physical therapists to hospitals.

Keywords: customer service conflict, customer service overload, emotional impairment, emotional inconsistency, job stress

Introduction

Emotions are a response to certain events or situations experienced in daily life and are an essential component of labor behavior.[1] Workers in the service and healthcare industries may experience "emotional labor" caused by interactions with customers and patients.[2] The number of people working in these service sectors in South Korea steadily increased from 7,245,658 in 2006 to 10,485,300 in 2015.[3] In fact, the third Work Environment Survey and the fourth National Health and Nutrition Survey revealed that approximately 38–42% of all wage earners in Korea are emotional laborers.[4]

Morris and Feldman defined "emotional labor" as the labor "exerted to express the emotions that an organization wants," and classified emotional labor based on the frequency of appropriate emotional expression, degree of care required for a good emotional expression, variety of emotions expressed, and emotional inconsistency.[5] Physical

therapists consider the patient's physical condition alongside their emotional state to provide the best treatment. Hence, physical therapists have to withhold their own emotions and cater to the patient's needs, which is a surface behavior. If the surface behavior persists, the therapist may change jobs after experiencing emotional inconsistency and job exhaustion.[6] Physical therapists can become fatigued because of the extensive patient management needs. Repeated occurrences of demanding emotional labor can lead to job exhaustion and affect interpersonal relationships, causing conflicts.[7]

Based on the existing literature, we hypothesized that emotional labor could lead to emotional inconsistency resulting in cognitive inconsistencies and job exhaustion.[8] This may cause various health problems, including cerebral hemorrhage, myocardial infarction, high blood pressure, musculoskeletal disorders, and depression.[9] Thus, job stress may affect the development of musculoskeletal disorders. Therefore, we aimed to examine the relationships between physical therapists' emotional labor, its effect on perceived job stress, and the risk of developing musculoskeletal disorders.

Methods

A total of 230 physical therapists anonymously participated in our study between October 2 and November 1, 2019. Of them, 209 physical therapists working in general hospitals (n=11), private hospitals (n=128), clinics (n=58), welfare centers (n=6), and rehabilitation centers (n=6) in Seoul were included, while 21 were excluded owing to insufficient answers. A proportionate stratified sampling method was used based on the working characteristics of the population. This study was conducted in accordance with the principles of the Helsinki Declaration. Informed consent was obtained from all study participants. The study participants agreed with the purpose and methods of the study and recognized the opportunities and risks of participating in the study.

The sample size was calculated using the following formula, where "N" is the number of physical therapists registered with the Korean Orthopedic Society (OWHI Korea, Osteopathic Health and Wellness Institute) under OCO (Osteopathic College of Ontario), "n" is the sample size, "e" is the margin of error or confidence interval, "Z" is the confidence level, and "P" is the observed percentage.

$$n = \frac{Z_{\frac{\alpha}{2}}^2 \cdot p(1-p)}{e^2}$$

N: 438, n: 205, e: 5%, Z: 95%, P: 0.5

As shown in Figure 1, the conceptual framework for the assessment of the relationship between excessive emotional labor and health suggested by Park was implemented in the study.[10] This is a parameter model that described the process of evaluating the results of emotional labor in three stages: contextual clues → emotional regulatory processes → long-term outcomes.

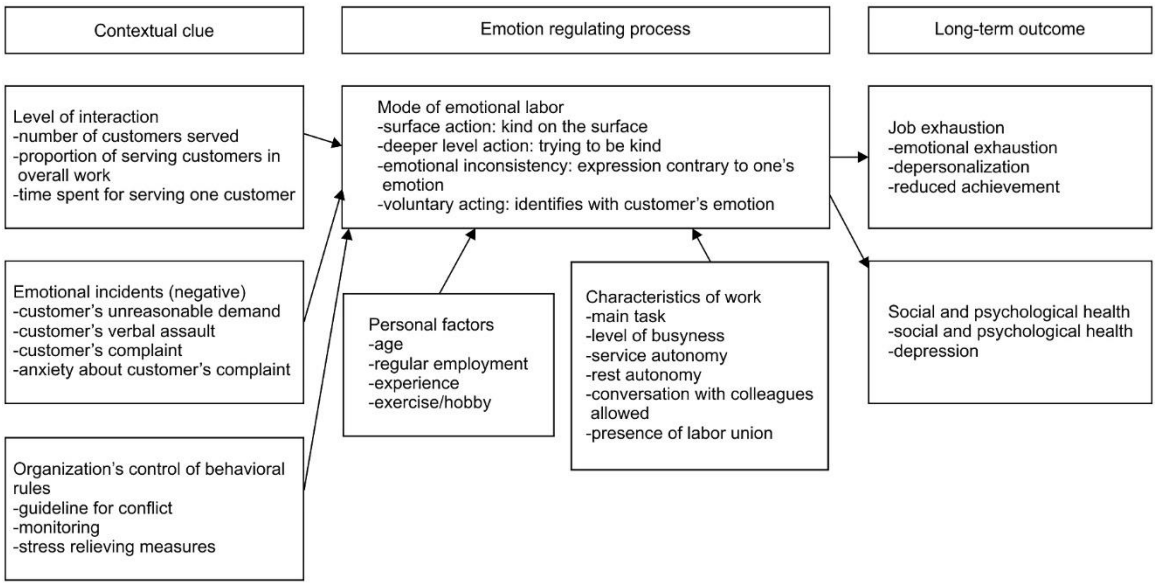

Figure 1. A conceptual framework for emotional labor and health

We used three sets of questionnaires to collect data regarding three variables from the study participants. For musculoskeletal symptoms, we adopted the "guideline for investigating factors for musculoskeletal strain work" from the Korea Occupational Safety and Health Agency (KOSHA) Guide (H-9-2018).[11] The guideline uses a criterion from the National Institute for Occupational Safety and Health in the USA. Questionnaires used for job stress and emotional labor were based on the KOSHA GUIDE-H-67-2012 and KOSHA GUIDE-H-163-2016.[12,13] The job stress survey consisted of a total of 43 questions and contained eight sub-factors of job stress (Appendix 4). The emotional labor survey consisted of a total of 24 questions and contained five sub-factors of emotional labor (Appendix 2).

All statistical analyses were performed using SPSS 25.0 (IBM Corp., Armonk, NY, USA). Frequency analyses were performed for musculoskeletal disorder status, general characteristics, and job characteristics. The effects of job-related psychological factors on the occurrence of musculoskeletal disorders among physical therapists were analyzed by correlation analysis. A linear multivariate regression analysis was used to determine the relationship between the symptoms of musculoskeletal disorders and each type of emotional labor and between the symptoms of musculoskeletal disorders and each type of job stress. The level of significance was set at $p<0.05$. The variables used in the multiple regression analysis were as follows: five sub-factors of emotional labor, eight sub-factors of job stress, and the presence or absence of musculoskeletal disorders. Using these variables, the sub-factors of job stress and emotional labor that could cause musculoskeletal disorders were identified sequentially.

Results

The general characteristics of physical therapists enrolled in the study are summarized below (Table 1). Approximately 73% (n=152) of the participants were women and 42.6% (n=89) were aged 20–30 years. The two most common departments in which the physical therapists worked were the orthopedic (45.45%, n=95) and neurology 21.1%, n=44) departments. A high proportion of participants had <5 years of experience (39.2%, n=82). Regarding the work environment, the average daily working, standing, and sitting times were 8.35±2.131, 4.45±1.365, and 4.35±1.293 h, respectively (Tables 1, 2). Approximately 22 patients were treated daily.

Table 1. General characteristics of the participants (personal characteristics)

Characteristic	Response item	Frequency (N)	Percentage (%)
Sex	Male	57	27.3
	Female	152	72.7
Age, years	20–29	89	42.6
	30–39	84	40.2
	40–49	30	14.4
	50–59	6	2.9
	>60	0	-
Department (physical therapy unit)	Orthopedic	95	45.5
	Neurological	44	21.1
	Pediatric	11	5.3
	Others*	59	28.2
Service experience, years	<5	82	39.2
	5–10	60	28.7
	11–20	51	24.4

	21–30	13	6.2
	>31	3	1.4

* Other departments include Welfare facilities, manual therapy rooms, and exercise clinics.

Table 2. General characteristics of the participants (working environment)

Survey question	Response item	Frequency (N)	Ratio (%)
Working time per day	Average time	8.35	0.9
Number of patients treated per day	Average time	22.16	20.2
Working Posture	Average standing time	4.45	2.7
	Average sitting time	4.35	1.9
Type of agency	General hospital	11	5.3
	Private hospital	128	61.2
	Clinic	58	27.8
	Welfare center/ rehabilitation center	12	5.7
Participation in education regarding musculoskeletal disease prevention	Yes	47	22.5
	No	162	77.5

N, number

Table 3. Results of the multiple regression analysis on the association between job stress and musculoskeletal disorder-related factors

Model	Unstandardized coefficients		Standardized coefficients	***t***	*p*-value	Coefficient of determination	**F**
	B	**Standard deviation**	**Beta**				
(Constant)	1.615	0.575		2.807	0.005	0.076	4.125**
Physical environment	0.105	0.045	0.136	2.332*	0.020		
Job demand	0.023	0.016	0.079	1.431	0.153		
Job autonomy	-0.030	0.048	-0.033	-0.616	0.538		
Relational conflict	-0.083	0.037	-0.120	-2.268*	0.024		
Job insecurity	-0.017	0.025	-0.035	-0.661	0.509		
Organizational system	-0.031	0.030	-0.071	-1.029	0.304		
Insufficient compensation	0.072	0.029	0.164	2.540*	0.011		
Corporate culture	0.007	0.039	0.011	0.188	0.851		

Multiple regression analysis **p<0.01

t, a statistical indicator of the difference in sample means;

F, a statistical indicator of the difference in several sample groups

The results of the multiple regression analysis on the association between job stress and musculoskeletal disorder-related factors are shown above (Table 3).

Table 4 presents the results of the correlation analysis between emotional labor and job stress factors. The analysis showed the highest positive correlation between the emotional labor sub-factor "organizational support and protection system" and the job stress sub-factor

"organizational system" (r=0.462, p<0.01). Other positive correlations were observed between the following: 1) emotional labor sub-factor "effort to control emotion and its diversity" and job stress sub-factors "physical environment" (r=0.309, p<0.01) and "job demand" (r=0.310 and p<0.01); 2) emotional labor sub-factor "overload and conflict in customer service" and job stress sub-factors "physical environment" (r=0.358, p<0.01) and "job demand" (r=0.326, p<0.01); 3) emotional labor sub-factor "emotional inconsistency and impairment" and job stress sub-factors "physical environment" (r=0.353, p<0.01) and "insufficient compensation" (r=0.383, p<0.01); 4) emotional labor sub-factor "surveillance and monitoring by organization" and job stress sub-factors "job demand" (r=0.307, p<0.01) and "corporate culture" (r=0.343, p<0.01); and 4) emotional labor sub-factor "organizational support and protection system" and job stress sub-factors "organizational system" (r=0.462, p<0.01) and "corporate culture" (r=0.436 and p<0.01).

Table 4. Results of correlation analysis between emotional labor and job stress factors

Correlation		Emotional labor					Job stress							
		V1	**V2**	**V3**	**V4**	**V5**	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**
Emotional labor	V1	1	0.491*	0.562**	0.312**	0.122	0.309**	0.310**	-0.140*	-0.072	0.104	0.278**	0.287**	0.149*
	V2		1	0.567**	0.382**	0.213**	0.358**	0.326**	-0.131	-0.040	0.098	0.289**	0.295**	0.274**
	V3			1	0.444**	0.191**	0.353**	0.307**	-0.160*	0.009	0.183**	0.313**	0.383**	0.266**
	V4				1	0.245**	0.155*	0.307**	-0.189**	0.153*	0.174*	0.303**	0.243**	0.343**
	V5					1	0.111	0.073	0.252**	0.435**	0.252**	0.462**	0.407**	0.436**
Job stress	V1						1	0.370**	-0.250**	0.059	0.235**	0.419**	0.406**	0.284**
	V2							1	-0.357**	0.015	0.137*	0.285**	0.160*	0.247**
	V3								1	0.017	-0.036	-0.123	0.104	-0.012
	V4									1	0.244*	0.359*	0.201*	.0294*
	V5										1	0.405*	0.272**	0.309*
	V6											1	0.598*	0.453*
	V7												1	0.401*
	V8													1

** p<0.01, * p<0.05

Emotional labor: V1, effort to control emotion and its diversity; V2, overload and conflict in customer service; V3, emotional inconsistency and impairment; V4, surveillance and monitoring by organization; V5, organizational support and protection system

Job stress: V1, physical environment; V2, job demand; V3, job autonomy; V4, relational conflict; V5, job insecurity; V6, organizational system; V7, insufficient compensation; V8, corporate culture

The results of multiple regression analysis on the association between job stress sub-factors and musculoskeletal disorders are presented below (Table 5).

Physical environment (β=105, p>0.020) and insufficient compensation (β=0.072, p>0.011) were significantly associated with musculoskeletal disorders.

Table 5. Reference values for job stress factor conversion scores by area stratified by sex

Area	Median value of Korean workers		The meaning of a score
	Male	Female	
Physical environment	44.5	44.5	A higher reference value indicates a worse physical environment
Job demand	50.1	54.2	A higher reference value indicates a higher job demand
Job autonomy	53.4	60.1	A higher reference value indicates a lower job autonomy
Relational conflict	33.4	33.4	A higher reference value indicates a higher conflict in relations
Job insecurity	50.1	50.1	A higher reference value indicates a higher relative instability of the job
Organizational system	52.4	52.4	A higher reference value indicates a less organized organization
Insufficient compensation	66.7	66.7	A higher reference value indicates a higher relative insufficiency of the compensation system
Corporate culture	41.7	41.7	A higher reference value indicates a more problematic corporate culture

※ The median value in Korean workers in each area may change depending on the results of future studies.

The emotional labor sub-factors "effort to emotional control and its diversity" (β = 0.074, p = 0.045), "overload and conflict in customer service" (β = 0.201, p <0.001), and "emotional inconsistency and impairment" (β = 0.087, p = 0.03) affected the job stress sub-factor "physical environment"; while the job stress sub-factor "physical environment" (β = 0.105, p = 0.020) affected the incidence of musculoskeletal disorders.

The emotional labor sub-factors "overload and conflict in customer service" (β = -0.144, p = 0.017), "surveillance and monitoring by organization" (β = 0.134, p = 0.012), and "organizational support and protection system" (β = 0.248, p <0.001) affected the job stress sub-factor "relational conflict", while the job stress sub-factor "relational conflict" (β = -0.083, p = 0.024) affected the incidence of musculoskeletal disorders.

The emotional labor sub-factors "emotional inconsistency and impairment" (β = 0.199, p <0.001) and "organizational support and protection system" (β = 0.298, p <0.001) affected the job stress sub-factor "insufficient compensation", and the job stress sub-factor "insufficient compensation" (β = 0.072, p <0.05)affected the incidence of musculoskeletal disorder (Figure 2).

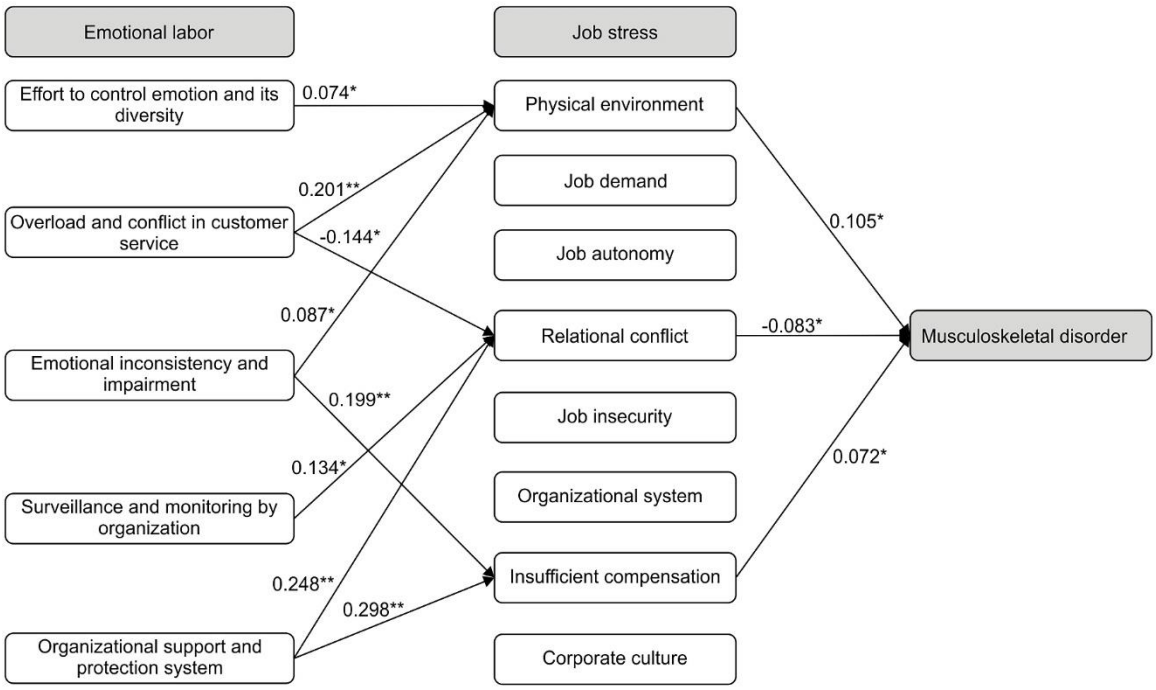

Figure 2. Model depicting the sequential influence of emotional labor and job stress on musculoskeletal disorders

Discussion

In this study, three main findings were presented regarding the effect of physical therapists' emotional labor on the incidence of musculoskeletal disorders. Especially, it was found that physical therapists' surface behavior, job exhaustion, and emotional management affected the physical burden, interpersonal relationships, and level of compensation, respectively, and eventually caused musculoskeletal disorders. As confirmed during the coronavirus disease 2019 pandemic, medical personnel are a key factor in healthcare systems. Owing to the growing aging population, the role of physical therapists is becoming increasingly important. To provide good quality medical services, the emotional and physical health of physical therapists must be managed.

To manage the emotional labor of physical therapists, it is necessary to develop and disseminate workers' self-protection manuals, including appropriate service standards and details of patient treatment procedures. Appropriate job cycles and service standards, adequate numbers of treated patients, comfortable spaces for relaxation, and adequate rest time are necessary for creating a suitable corporate culture. Future research should focus on document-based operational procedures, such as in-hospital treatment daily logs and customer complaint records, to identify relevant factors affecting the size and intensity of physical therapists' emotional labor. It is desirable to evaluate these factors using the Korean emotional labor evaluation tool used in this study (Appendix 2).[13]

Globally, musculoskeletal disorders are the second most common group of disorders, with low back pain being the most common.[14] This could be attributed to a decline in physical activity because of the development of mobile devices. Recent data suggest that one in two adults from the USA complains of musculoskeletal disorders, which is comparable to the frequency of cardiovascular and respiratory diseases.[15] Approximately, 57.5%, 58%, and 55.5% of physical therapists in the USA, the UK, and Australia, respectively, have musculoskeletal disorders.[16,17] Workload and excessive work-related activities are the most common causes of musculoskeletal disorders in this professional group (Appendix 3).[18]

Healthcare workers are more likely to experience job stress than non-health workers (Appendix 4). Stress triggered by emotional labor has a negative impact on organizational commitment and job satisfaction.[19] This adverse effect might result in poor quality of care, which may affect patient outcomes. Excessive workload increases the

frequency of medical disputes and increases competition among medical institutions, making clinicians, including physical therapists, more likely to experience high levels of emotional labor and job stress. [20]

Physical therapists need a lot of physical strength for activities such as lifting, moving, pushing, pulling, bending, and twisting movements while in contact with patients, putting excessive pressure on the musculoskeletal system (Appendix 1).[21] Stretching to relax the tensed body may be an appropriate form of intervention. Additionally, body relaxation through stretching has been reported to affect emotions.[22] Future studies should also examine the effects of interventions, such as self-developed stretching methods, that reduce musculoskeletal disorder symptoms related to emotional labor and job stress.[23]

This study has several strengths. To our knowledge, this is the first study to investigate the process, by which the emotional labor of Korean physical therapists causes job stress and musculoskeletal diseases. Therefore, our findings can be used to correct the misperception that telephone operators and service workers are the only emotional workers.

However, our study has an important limitation. Especially, the participants were all physical therapists who provided treatment based on osteopathy. As this study was inspired by and furthers the scope of the current published literature, it is expected that there will be follow-up studies targeting the examination of a wider range of occupational groups to expand our findings.

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Original Article

Evaluation of the knowledge of sun exposure and sun protective measures in healthcare workers

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ABSTRACT

Introduction: Solar ultraviolet (UV) radiation has a great impact on human life. The sun has always played an important role in Asian culture, so much so, that it is often prayed to as a God. Prolonged sun exposure can cause extensive and chronic harmful effects. Healthcare personnel is supposed to have good knowledge regarding sun protection as they play a key role in society disseminating knowledge to the general public. There are limited data regarding the knowledge of sun protection and sunscreen practice among health care workers.

Methods: This descriptive cross-sectional study was carried out from June to October 2020 on healthcare workers (medical staff) in Kathmandu Medical College Teaching Hospital. A questionnaire was distributed to the target study population without disturbing or hampering the healthcare worker's duty.

Results: Out of a total of 264 participants in the study, 84 (31.8%) were male and 180 (68.2%) were female. The knowledge of proper terminology for SPF (Sun Protection Factor) was noted in 196 (74.2%) and 57 (21.6%) agreed that the value of SPF was related to age. No significant difference was noted regarding knowledge about the time of sun exposure for Vitamin D synthesis. No significant differences were found in practices of sunscreen use for purposes of fairness, or prevention of tanning, wrinkle, mole, and skin cancer.

Conclusion: A higher level of education was associated with better knowledge and proper abiding practices regarding sunscreen use. As healthcare workers play a key role in distributing information in society, they should be targeted in education campaigns regarding sun exposure and sun protection measures; with these efforts focused more on nurses and medical officers.

Keywords: Health personnel, Knowledge, Sunscreen, Ultraviolet

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Introduction

Solar ultraviolet (UV) radiation has a great impact on human life. Sun has always been given importance in Asian culture to the extent that it is often considered of god, similar to the Greeks and Romans worshipping Apollo as the sun God and the god of light.[1] Even today, UV radiation via sunlight has important public health implications in the form of both beneficial and deleterious effects. Sun exposure causes extensive intrinsic as well as extrinsic changes in the skin and has many acute and chronic harmful effects.[2] Nowadays, there is an increasing awareness about the benefit

of sunlight for the synthesis of vitamin D.

Results of photo aging, such as pigmentation, sagging, wrinkling, and photo-carcinogenesis are caused by an alteration to DNA; which can be prevented with regular usage of sunscreen.[2] During summer, the ultraviolet (UV) energy received on the earth's surface is made up of 3.5% ultraviolet B (UVB) and 96.5%ultraviolet A (UVA) radiation.4UVA penetrates up to the dermis whereas UVB affects the epidermis of the skin.[3] Regular sunscreen usage can prevent photo-induced and photo-aggravated dermatoses. Food and Drug Administration have approved Sunscreen for use in the prevention of sunburn, photo-induced pigmentation, aging, and carcinoma of the skin.[4]

The mechanism by which sunscreens inhibit the transmission of UV radiation into the skin is by absorbing, reflecting, or scattering such radiation.[4] Sunscreens have been recommended as preventive and protective measures against sunlight, with the efficacy increasing with a higher sun protection factor.[4] Health care personnel supposedly have good knowledge regarding sun protection and they play a key role in society disseminating knowledge to the general public. There are limited data regarding the knowledge of sun protection and sunscreen practice in health care workers.

Our study aimed to determine the knowledge of healthcare workers regarding the solar spectrum, sunscreen, the relation of Vitamin D with sun exposure, the practice of using sunscreen and other sun protection methods.

Methods

This descriptive cross-sectional study was carried out from October 2020 to July 2021 on healthcare workers (medical staff) in Kathmandu Medical College Teaching Hospital after taking ethical approval from IRC. Non-medical hospital staff and health workers with less than one year of experience in healthcare practice were excluded from our study. All health workers working in the hospital who voluntarily agreed to participate were included.

Participants were informed about the purpose of the study and its methodology. The questionnaire was self-designed and pilot testing was done on 15 participants to calculate the approximate time to complete it and to determine the clarity of the questionnaire. Feedback was taken for further improvement and modification of the questionnaire. The researcher distributed the self-administered questionnaire to the target study population without disturbing or hampering the healthcare worker's duty. A researcher was available to clarify any issue and questionnaires were collected soon after responses were collected. The questionnaire consisted of three sections. The first section consisted of demographic variables including age, gender, education, and medical post. The second section consisted of knowledge regarding the sun, SPF, vitamin D, and sunscreen and the third section consisted of questions regarding the practice of sun protective measures. Data were entered and analyzed by SPSS version 20. Analytical statistics was applied using the chi-square test for testing the difference or association between two categorical variables, similarly, descriptive statistics were applied to calculate frequency and percentage.

Results

The participants in the survey aged between 24-67 years with a mean age of 34.74±7.839. Out of a total of 264 participants in the study, 84 (31.8%) were male and 180 (68.2%) were female. In our study, the healthcare workers participating were nursing staff 41(15.5%), Medical officers 81(30.7%), and consultant doctors, 142(53.8%). Among them, 89(33.7%) health workers had skin problems at some point in their lives. The number of participants who knew about the different spectra of ultraviolet radiation was 175 (66.3%). (Table 1).

Regarding the level of knowledge about sunscreen 212 (80.3%) agreed that sunscreen is expensive, (significant $p<0.005$). Out of 264 participants, only 196 (74.2%) knew the proper terminology for SPF (Sun Protection Factor) and only 59 (21.6%) agree that the value of SPF is related to age. Similarly, 120 (45.4%) participants knew about the difference between physical and chemical sunscreen and it was not significant. (Table 2).

Table 1: Socio-Demographics data of participants

Variables		N (%)
Gender	Male Female	84(31.8) 180(68.2)
Education qualification	Nursing Medical Officer Consultant	41(15.5) 81(30.7) 142(53.8)
Age range	20-29 30-39 40-49 50-59 > 60	81(30.7%) 120(45.5%) 52(19.7%) 5(1.9%) 6(2.3%)
Underlying skin condition	Yes No	89(33.7) 172(65.2)

Table 2: Health worker level of knowledge regarding Sunscreen

Variables		Nursing N (%)	Medical officer, N (%)	Consultant N (%)	p-value
Sunscreen is expensive	Agree Disagree Don't know	36 (13.6) 3 (1.1) 2 (0.7)	74 (28) 5 (1.8) 2 (0.7)	102 (38.6) 14 (5.3) 26 (9.8)	0.002
Meaning of SPF	Sun protection factor Sun prevention factor Sun protection formula Sun Prevention formula Don't know	27 (10.2) 4 (1.5) 5 (1.8) 2 (0.73) 3 (1.1)	58 (21.9) 2 (0.75) 13 (4.9) 2 (0.75) 6 (2.2)	111 (42) 10 (3.7) 4 (1.5) 2 (0.75) 15 (5.6)	0.023
Value of SPF is related to age	Agree Disagree Don't know	28 (10.6) 3 (1.1) 10 (3.7)	48 (18.1) 20 (7.5) 13 (4.9)	77 (29) 36 (13) 29 (10)	0.132
Difference between physical and chemical sunscreen	Yes No	17 (6.4) 24 (9)	35 (13.2) 46 (17.4)	68 (25.7) 74 (28)	0.681

Out of the total participants, 214 (81%) agreed that there is a relationship between sunlight and vitamin D synthesis

, and it was significant. No significant difference was noted regarding knowledge about the time of sunscreen exposure for vitamin D synthesis. Around 95 (45.5%) recommended that 20-30 minutes/week of sun exposure is required for vitamin D synthesis. Similarly, regarding vitamin D deficiency, 90(34%) agreed that regular use of sunscreen can cause vitamin D deficiency. (Table 3)

Regarding the knowledge about sunlight, only 172 (65.1%) were aware of different spectra of UV light. Similarly, 96 (36.3%) knew that skin condition gets aggravated by exposure to Ultra Violet radiation. Regarding outdoor activities among the three groups, Consultants, 52(19.6%) were more likely to spend lesser time outdoors and avoided sunlight exposure during peak hours. (Table 4)

Table 3: Health worker level of knowledge regarding vitamin D and Sunscreen

Variables		Nursing N (%)	Medical officer N(%)	Consultant N(%)	P-value
View on the relationship between sunlight and vitamin D	Agree Disagree Don't know	37 (14) 2 (0.75) 2 (0.75)	75 (28.4) 1 (0.3) 5 (1.8)	107 (40.5) 24 (9) 11 (4.1)	0.020
Is the area of sunlight exposure related to vitamin D synthesis	Yes No	28(10.6) 13 (4.9)	60 (22.7) 21 (7.5)	98 (37.1) 44 (16.6)	0.003
The exposure time required for vitamin D synthesis	20-30min/week 40-60min/week 60-90min/week	17 (6.4) 13 (4.5) 11 (4.1)	21 (7.9) 40 (15.1) 20 (7.5)	57 (21.5) 29 (10.9) 56 (21.2)	<0.001
View on sunscreen use and vitamin D deficiency	Agree Disagree Don't know	15 (5.6) 23 (8.7) 3 (1.1)	18 (6.8) 47 (17.8) 16 (6.06)	57 (21.5) 49 (18.5) 36 (13.6)	0.001

Table 4: Healthcare worker level of knowledge regarding sunlight

Variables		Nursing N(%)	Medical officer N(%)	Consultant N(%)	p-value
Know about the different spectra of UV light	Yes No	27 (10.2) 14 (5.3)	50 (18.9) 31 (11.7)	98 (37.1) 44 (16.6)	0.541
Do you think skin condition is aggravated by UV light	Yes No	13 (4.9) 28 (10.6)	33 (12.5) 48 (18.1)	50 (18.9) 92 (34.8)	0.567
Is sun exposure bad for the skin	Agree Disagree Don't know	26 (9.8) 15 (5.6) 0 (0)	64 (24.2) 13 (4.9) 4 (1.5)	98 (37.1) 33 (12.5) 11 (4.1)	0.048
Hours of outdoor activity you do in a week	<15hr/week 15-30hr/week >30hr/week	26 (9.8) 15 (5.6) 0 (0)	45 (17) 29 (10.9) 7 (2.6)	87 (32.9) 41 (15.5) 14 (5.3)	0.249
Avoid sunlight during peak hour	Always Sometimes Rarely Never	15 (5.6) 26 (9.8) 0 (0) 0 (0)	20 (7.5) 57 (21.5) 1 (0.37) 3 (1.1)	52 (19.6) 57 (21.5) 26 (9.8) 7 (2.6)	<0.001

According to the participants, 89 (33.7%) used coin size volume of sunscreen regularly and among them, 45 (17%) were consultant doctors. Regarding the sunscreen application time, 91(34.4%) used it in the morning, while 51(19.3%) used sunscreen whenever they go out in sun. Reapplication of sunscreen was done only by 73 (27.6%) participants. Most of the participants i.e. 124 (46.5%) used SPF of 30-50 and a majority of participants (62.1%), applied sunscreen only on the face followed by face and neck by 128(48-4%) and arm 32 (12.1%). (Table 5).

No significant differences were found in the level of practice of sunscreen for precaution of fairness, or prevention of tanning, wrinkle, mole, and skin cancer. The most common reason for sunscreen application was to prevent sunburn 132(50%) and was significant. Apart from sunscreen other sun protection methods reported were the use of an umbrella 149 (56.4%), wearing sunglass 125(47.3%), and wearing full sleeves 106(40%) which were not significant. (Table 6).

Table 5: Practice of sunscreen by healthcare workers.

Variables		Nursing N (%)	Medical Officer N (%)	Consultant N (%)	p-value
The volume of sunscreen applied	Pea size	11 (4.1)	29 (10.9)	35 (13.2)	0.118
	Coin size	16 (6.06)	28 (10)	45 (17)	
	Double coin size	0 (0)	6 (2.2)	7 (2.6)	
Time of application	Morning	16 (6.06)	22 (8.3)	53 (20)	0.001
	Afternoon	3 (1.1)	7 (2.6)	11 (4.1)	
	Going out	7 (2.6)	30 (11.3)	14 (5.3)	
	Twice a day	1 (0.3)	5 (1.8)	10 (3.7)	
Reapplication	Yes	7 (2.6)	30 (11.3)	36 (13.6)	0.044
	No	34 (12.8)	51 (19.3)	106 (40)	
Use sunscreen indoor	Yes	13 (4.9)	28 (10.6)	50 (18.9)	0.235
	No	27 (10)	53 (20)	92 (34.8)	
SPF use	15-29	5 (1.8)	20 (7.5)	15 (5.6)	0.007
	30-50	22 (8.3)	37 (14)	65 (24)	
	>50	1 (0.3)	8 (3.03)	9 (3.4)	
Area of application	Face	25 (9.4)	57 (21.5)	82 (31)	0.172
	Neck	19 (7.1)	32 (12.1)	77 (29.1)	0.091
	Arm	5 (1.8)	2 (0.75)	25 (9.4)	0.004
	Other parts	0 (0)	2 (0.75)	0 (0)	

Table 6. The practice of sun protection measures by Healthcare workers.

Variables		Nursing N (%)	Medical officer N (%)	Consultant N (%)	p-value
Reason for use of sunscreen	Fairness	11 (4.1)	25 (9.4)	7 (10.2)	0.128
	Prevent tanning	18 (6.8)	33 (12.5)	44 (16.6)	0.178
	Prevent sunburn	17 (6.4)	50 (18.9)	65 (24.6)	0.036
	Prevent wrinkle	12 (4.5)	38 (14)	54 (20.4)	0.150
	Prevent early aging	10 (3.7)	28 (10.6)	49 (18.5)	0.447
	Prevent mole	5 (1.8)	22 (8.3)	37 (14)	0.144
	Prevent skin cancer	4 (1.5)	24 (9)	30 (11.3)	<0.01
Other sun protection measure used	Umbrella	15 (5.6)	48 (18.1)	86 (32)	0.233
	Hat	13 (4.9)	33 (12.5)	50 (18.9)	0.567
	Sunglasses	18 (6.8)	47 (17)	60 (22)	0.068
	Full sleeves	17 (6.4)	41 (15.5)	48 (18.1)	0.047

Discussion

Healthcare workers are considered to be well-educated and knowledgeable. Higher education level was known to be associated with increased use of sunscreen and other sun protection measures as they are aware of sun radiation damage to the skin.[5]

In our study, there were more female participants due to nursing female healthcare workers. Among the three groups in our study, the knowledge about UV radiation, sunscreen, physical and chemical sunscreen and SPF (Sun Protection Factor) was found more in consultant doctors and was statistically significant. The subgroup among the healthcare professions that had a lower knowledge also had a lower education level. A similar outcome was found in other studies.[6]

In our research, we assessed the relationship between vitamin D syntheses with sun exposure. It was found that 81.8% of healthcare workers agree that there is a relationship between vitamin D and sunlight, while 186 (70%) believe that sunlight exposure is related to vitamin D synthesis, which is similar to a study by Kaymalet al. [7] The study done by Neale et al. also supported the theoretical risk of sunscreens may affect vitamin D levels.[8] Young et al. concluded that high UVA-PF sunscreen enables significantly higher vitamin D

synthesis than a low UVA-PF sunscreen because the former, by default, transmits more UVB than the latter. Sunscreens (sun protection factor, SPF 15) applied at a sufficient thickness to inhibit sunburn during a week-long holiday with a very high UV index still allow a highly significant improvement of serum 25-hydroxyvitamin D3 concentration. An SPF 15 formulation with high UVA protection enables better vitamin D synthesis than a low UVA protection product. The former allows more UVB transmission.[9]

In this study, 87 (32.9%) participants avoided sunlight during peak hours, this may be due to indoor working hours. Similarly, Kaymak et al. found 'not going out at peak times' to be the most commonly adopted method with a figure of 45.3% and 53.0% in males and females.[10] The outcome of this study shows that consultants were more likely to be familiar with the sun's detrimental effects on skin and take protective measures, including sunscreen application.

A Greek study found the use of sunglasses (83.4%) as the most common sun protection measure in Mediterranean inhabitants, followed by protective clothing (57.8%),[11] in contrast to our study where other sun protection measures were less adopted. This can be due to a lack of knowledge, social and cultural norms, and economical barriers. Using an umbrella was the least adopted method of sun protection in Turkey,[11] similar to that of our study. In Saudi Arabia, 95% of respondents reported wearing long-sleeved cloth and a head cover, clearly influenced by customs and traditional dressing practices.[12]

Surprisingly, our study found that the knowledge about the relation of sun exposure with skin cancer is very low (21.9%), as opposed to many international studies, where the knowledge about sun exposure and its relation with skin cancer as well as adapted measures of sun protection was very high. For example, 85% in Australia, 92 % in Canada and the United States, and 92.5% in Malta where as 55.5% in India reportedly were more aware.[13,14] No significant difference was found among the three study groups (consultant, nursing, and medical officer) regarding the reason for using sunscreen. This is similar to the result of a study by Ergin et al.[15]

Conclusion

A higher level of education was associated with better knowledge and behavior toward sunscreen and the solar spectrum. As healthcare workers play a key role in distributing information in society, especially nurses, medical officers should be targeted in education campaigns regarding sun exposure and protection.

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Original Article

Prevalence of Occupational Injuries in selected Coir Industries in Sri Lanka: a cross-sectional study

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ABSTRACT

Introduction: The coir industry processes coconut fibers, and many are employed in this industry in Sri Lanka. This study aimed to find the prevalence of occupational injuries among coir workers.

Methods: This cross-sectional study was performed in 2021, in six medium-sized coir industries in Sri Lanka, each with 15-100 employees. The workers who were present at work on the two days the researchers visited the respective industries (128 of a total 214 workers) were interviewed on socio-demographics, work tasks they normally perform and occupational injuries they had experienced the last three months. Independent T-tests and Chi-square tests were used to analyze for differences between groups.

Results: The mean age of the 128 interviewed workers was 45 years and 53.9% were male. 34 (26.6%) of the workers had experienced at least one injury each during the past three months. Women reported significantly more injuries than men (38.9% vs 15.9%). The workers operating machines reported significantly more injuries than workers who performed other types of work (42.3% vs 22.0%). Slipping, tripping, and falling (64%) were the most common events of injuries seen among the injured workers, followed by cuts from sharp objects or machines (20%). The most common type of injury among the workers were cuts and bruises (50%).

Conclusion: At least one injury in the past three months had been experienced by 26.6 percent of the coir workers, mostly women and workers operating machines. Preventive measures are needed to minimize the risk of injuries.

Keywords: Coir industry, Occupational injuries, Sri Lanka

Introduction

The coir industry processes fibers from coconuts, also known as coir. India and Sri Lanka contribute about 90% of the total global coir fiber production of 350,000 metric tons per year.[1] In Sri Lanka, there are around 1040 coconut-based industries that employ almost 500,000 workers where 75% of them are females working part-time.[2] Most of the workers work for their family business or are self-employed. Coir-related exports account for 6% of total agricultural export and 0.35% of the GDP in Sri Lanka.[3] Thus, the coir industry plays an important role in sustaining the livelihood of many people in Sri Lanka although the working conditions are reported to be poor and productivity low.[1,2] However, very few studies have focused on working conditions and occupational injuries in this industry.

The coir fibers are extracted from the outer part, the husk of coconuts, and comprise brown and white fibers.[4] The brown coir is, for instance, used for upholstery padding (car seats), sacking, and horticulture. On the other hand, white coir is used to manufacture fine brushes, strings, ropes, and fishing nets, among other items.[5]

The coir industry in Sri Lanka includes two main types of workplaces: Factories and domestic work. The factory work in the coir industry is modernized, mechanized, and export-oriented. Particularly the brown-fiber production in the North-Western Province produces coir in factories. Domestic coir work is mainly performed by women in the Western and Southern regions of Sri Lanka and is a traditional, labor-intensive white-fiber industry.[3] The coir fiber extraction is processed through four main steps; Harvesting and husking, retting, defibering, and finishing.[6] Recently, mechanical techniques have been developed to speed up or eliminate the retting process. Small and medium-scale industries still extensively use the traditional drum system for fiber extractions where the workers put husks manually into the machines and pull them out after crushing the coir into fibers. The machines are considered very dangerous and unsafe for the workers.[7]

About 1,300 work-related accidents are reported in Sri Lanka annually, and about 80 are fatal accidents. In 2019, 18 non-fatal occupational injuries and one fatal occupational injury per 100 000 workers were reported from Sri Lanka. [8] However, these statistics probably do not reflect the accurate picture as reporting of occupational accidents is poor in Sri Lanka, and there is no information on how many injuries are reported from the coir industry.[9]However, we know that similar industry types, like sisal and jute, cause many and serious injuries among the workers, and it is likely that accidents and injuries constitute a problem also in the coir industry.[10, 11]

Therefore, the objective of this study is to obtain information about occupational injuries among coir workers. More knowledge from the industry could be useful in plans for the prevention of occupational injuries in the coir industry.

Methods

This cross-sectional study was performed over four weeks in February 2021. Six medium-sized industries, each with 15-100 employees, were randomly selected from a list of industries in the Western (Gampaha district) and North-Western provinces of Sri Lanka (Puttalam and Kurunegala districts). The study was planned by researchers in Norway and Sri Lanka. Due to the Covid-19 pandemic, the Norwegian researchers could not visit Sri Lanka, and the planning and education of assistants were performed online in close cooperation with the researcher in Sri Lanka. The researcher in Sri Lanka was responsible for contact and communication with the industries. In agreement with the owners of the industries, the workers were gathered for oral information about the project. The workers present at work on the days that the researchers visited the respective industries (128 of a total of 214 workers) were interviewed during working hours on occupational injuries they had experienced in the last three months. The interview of each worker was performed by two data assistants in a quiet part of the industry site with no employer present. The interviewer asked questions about the background of the worker (sex, age, education, years at work, and type of work) and any personal experienced injury in the past three months. They were also asked about which tasks they normally performed. The workers who had experienced an injury were asked to describe what happened (injury event like slipping, tripping, fall, cut by a sharp object, etc.) and the type of injury (cut, bruises, fracture, etc.). There were no suitable interview guides published on this topic for this setting. Thus, the project group developed relevant questions for the coir industry. This interview guide was developed in English but later translated into the local language by two native speakers. The procedure was to translate the interview back again to English by two other people. Afterward, the interview was adjusted to function optimally.

The study protocol received ethical clearance from both the Regional Committee for Medical and Health Research Ethics, Western Norway and the

Sri Lankan Committee, Faculty of Medicine, University of Kelaniya, Ragama, Sri Lanka. All participating workers signed informed consent after the purpose and the methods of the study were clearly explained to them.

Independent T-tests were used to compare the age, work year, years of school, years of work in the coir industry, and hours of working per day between the genders. The chi-square test was used to assess the difference in injuries last three months between groups. A significance cut-off point of $p \leq 0.05$ was used to determine significance. Data were analyzed by IBM SPSS Statistics for Windows (version 25), and tests were considered significant at $P < 0.05$.

Results

From the six selected coir industries, a total of 128 workers were interviewed, 53.9% were male, and 42.2% were female. Information about gender was missing from five people since the data assistants forgot to note the gender of four participants (Table). Information from these five participants was used in the descriptions and analyses where gender was not taken into account.

The mean age of the workers was 45 years, and on average they had worked for five years in this industry. The mean number of school years was seven years, ranging from zero to 12 years. The mean number of working hours per day was 8 hours, and it varied from 4 to 11 hours. There were no significant differences between males and females regarding age, work years, school years, and working hours (*T-test)*. About 65.6% had a permanent job in the factory, while the rest (31.3%) was temporary workers.

The most common work tasks reported were packing of coir (39.4%), operating machines (20.5%) and a combination of drying and packing of coir (17.2%) (Table 2). Among the male workers, 15.9% performed drying of coir, while no female workers were involved in this work task. Operating machines (34%) and packing of coir (34%) were the tasks most often reported by the females. They also worked in transportation (20.8%) and maintenance (11.2%), where no males were engaged. Most of the workers wore casual T-Shirts and pants and no proper work clothing. Protective gloves and shoes were not seen in five out of six factories.

Table 1: Socio-demographic characteristics of interviewed coir workers (n=128)

Variable	All	Male	Female	p-value*
		AM (SD) range	AM (SD) range	
Age (years)	45 (11) 17-73	46 (10) 28-73	44 (11) 17-63	0.29
Work years	5 (6) 0.25-30	4 (5) 0.25-30	5 (6) 0.25-30	0.50
School years	7 (3) 0-12	6 (2) 0-12	8 (3) 0-12	0.10
Working hours per day	8 (1) 4-11	8 (1) 4-10	8 (1) 4-11	0.17

Variable		No (%)
Gender	Male	69 (54)
	Female	54 (42)
	Missing	5 (4)
Permanent job	Yes	84 (66)
	No	40 (31)
	Missing	4 (3)

*AM: Arithmetic mean; SD: standard deviation; *Independent T-test*

Table 2: Type of work performed in the industry among 127* of 128 interviewed workers.

Type of work	Total /Percent N (%)	Male N (%)	Female N (%)
Drying of coir	11 (8.7)	11 (15.9)	0
Packing of coir	50 (39.4)	30 (43.5)	18 (34.0)
Operating machines	26 (20.5)	7 (10.1)	18 (34.0)
Transport	11 (8.7)	0	11 (20.8)
Maintenance	7 (5.5)	0	6 (11.2)
Drying and packing of coir	22 (17.2)	21 (30.5)	0
Total	127 (100)	69 (100)	53 (100)

** Missing data (Total n=1)*

Table 3: Injuries at work in the last three months in all industries

Factory	Total number of workers	Interviewed workers (% of total number)	Number (%) of persons with at least one injury in last 3 months among the interviewed
1st	15	15 (100)	8 (53.3)
2nd	100	46 (46.0)	13 (28.2)
3rd	31	31 (100)	4 (12.9)
4th	20	17 (85.0)	4 (23.5)
5th	28	15 (53.6)	5 (33.3)
6th	20	4 (20.0)	0 (0)
Total	214	128 (59.8)	34 (26.6)
Gender			
Male	88	69 (78.4)	11 (15.9)
Female	126	54 (42.9)	21 (38.9)
Work task			
Operating machines		26	11 (42.3)
Other work tasks		100	22 (22.0)

Totally 128 of the 214 workers (60%) in the six factories participated in the interview on injuries (Table 3). The participation rate in the factories varied between 20% and 100%. We have no information about why some of the workers did not want to participate in our study, but the need for high production in the industries might have influenced the participation rate. Among the 128 interviewed workers, 34 (26.6%) had experienced at least one injury each during the past 3 months, but the percentage varied from 0 to 53.3% between the factories.

A higher number of female than male workers reported having experienced at least one injury in the last 3 months (Table 3). The difference was significant, using a Chi-square test, p=0.004. The workers operating machines reported more injuries than workers who performed other types of work (Table 3). Using a Chi-square test, the difference was found to be significant (p=0.026).

Table 4 shows that the overall major injury event among the workers reporting at least one injury was slipped, tripped, and fall (64%), and this was the most frequent type of event among both males (71.4%) and females (56.3%). The next most frequent injury event in both genders was cut by a sharp object or machine, which accounted for 14.4% in males and 25% in females.

Furthermore, Table 4 shows that the most common type of injury among the workers reporting injuries were cuts and bruises (50%). The females were more likely to suffer from cuts and bruises (55%), often due to handling sharp tools like the combing machine. Other types of injuries comprised bruises (18.8%), cuts (15.6%), fractures (12.5%), cuts, bruises and fractures (3.1%).

Table 4: Type of injury events and injury

Type of Injury event*	**Total /Percent N (%)**	**Male N (%)**	**Female N (%)**
Slipped, tripped, and fall	16 (64.0)	5 (71.4)	9 (56.3)
Cut by a sharp object or machine	5 (20.0)	1 (14.3)	4 (25.0)
Pressure damage by machine	3 (12.0)	1 (14.3)	2 (12.4)
Trapped by the assembly line	1 (4.0)	0	1 (6.3)
Total	25 (100)	7 (100)	16 (100)
Type of Injury**			
Cut	5 (15.6)	2 (20.0)	3 (15.0)
Bruises	6 (18.8)	3 (30.0)	3 (15.0)
Fracture	4 (12.5)	1 (10.0)	2 (10.0)
Cut and bruises	16 (50.0)	4 (40.0)	11 (55.0)
Cut, bruises and fracture	1 (3.1)	0	1 (5.0)
Total	32 (100)	10 (100)	20 (100)

** Missing data for the Total type of injury event is 9 and gender is missing for 2, among 34 who had experienced at least one injury, because the data assistants did not note the information during the industry visit.*

** *Missing data for the Total number of types of injury is 2 and 4 were missing gender information combined with these injury figures, among 34 who had experienced at least one injury, because the data assistants did not note the information during the industry visit.*

Discussion

More than one-fourth (26.6%) of the coir workers in this study reported having been injured in the last three months. This indicates a high injury risk. To our knowledge, no previous studies on occupational health in the coir industry have specifically focused on occupational injuries among workers, and it is hard to find comparable studies. There are studies about different types of health issues among coir industry workers from India, but they consider other aspects of health than workplace injuries, like allergies, and neurological examinations.[13,14] Also, there is a study from the Solomon Islands about injuries among children who have experienced traumas from coconuts, but no similar study among adults.[15] However, studies are confirming that occupational injuries may have a high prevalence among workers performing strenuous physical work in low-income countries in work situations resembling the work in the coir industry.[16,17] For instance, an Ethiopian study in the textile industry shows an occupational injury one-year prevalence of 42.7 and a two-week prevalence of 6.7.[16] These figures are not directly comparable with our present study of a 3 months prevalence, but they show that occupational injuries are a large problem. A study from India shows that iron and steel industry workers have a one-year prevalence of 28%. [17]

A study among construction workers from Gondar in Ethiopia shows a three-month incidence of occupational injuries of 39%, which is higher than in our coir study.[18] The Gondar study included 566 construction workers from eight construction sites, and the workers were interviewed using a structured questionnaire. The methods were quite similar to the present coir study. The reason why the injury reporting was different might be explained by the different types of work. The construction industry might be more dangerous, with many falls from heights.

According to our study findings, the most common events causing injuries are slipping, tripping, and falling (50%). Many workers worked prolonged periods in hazardous conditions such as uneven floors or grounds and dusty floors, where they may easily slip, trip, and fall, resulting in injuries. Slipping, tripping, and falling are among some of the most common injuries reported in a wide variety of industry contexts.[16,19,20]

In the present study, cuts, and bruises were the most common injuries, accounting for 50% of the total. Fractures had a lower incidence (12.5%) than the other types of injuries in our study, but they must be considered more serious than most other types of injuries. However, this cannot be told with certainty, as the location of the injuries was not reported. On the other hand, serious fractures might not have been reported since these workers might not have returned to work within three months. A strength of this study is the topic itself, as injuries among coir workers are not much discussed in previous literature. This is probably because the coir workers in general represent a low societal class, where funding for research is hard to obtain. The methods of interviewing the workers were chosen as no statistics were available. Some of the workers were illiterate and self-reports by a written questionnaire were not possible. It is a limitation of our study that the interview guides used were not validated or standardized, as there were no such instruments available. This may raise questions of whether we registered the experienced injuries correctly. However, the questions were developed in cooperation with a physician who knew the industry and type of workers well, and by using an interview, we could make sure that the interviewers explained the questions to the workers. We decided to ask for 3 months of prevalence, due to the high risk of information bias in this group of workers. It might be difficult for the workers to remember their injuries for longer periods.

The external validity of this study is limited to coir workers in Sri Lanka in similar industry environments with similar demography and similar regulatory requirements. Only 6 industries were asked to participate, but they were randomly selected and are likely to be representative of the medium-sized industries in Sri Lanka. We do not know about any type of selection of the studied

industries, and they probably show how a coir industry in this country is organized and how the injuries are experienced.

With scarce resources and restrictions during the Covid 19 pandemic, data collection was done by data assistants while parts of the research team were in Norway. This may have led to the occurrence of missing data. The data collectors failed to fill out some of the information in the questionnaires. However, we did not see any specific pattern of which data were missing and do not think it influenced the results very much.

Another weakness of the study was the selection of workers with only one injury in the previous three months, while the plan was to record all injuries experienced by the workers. Also, there may have been some incidences of workers underreporting injuries as they might have been apprehensive of the consequences from the management. On the other hand, some workers may have over-reported injuries as they wanted to underline the need for prevention. We do not know if any of these options occurred in the present study, but we suggest further studies to observe the workplace over time to avoid self-reports and interview situations.

Our findings have created concern when considering occupational injuries among the workers in the coir industry of Sri Lanka. More studies are needed to map the working environment and find the reasons for the high number of injuries. However, operating hazardous machines seem to be a risky job in this industry, mainly affecting female workers. The high injury rate among the workers might put a heavy burden on the coir workers, their families as well as on the health systems of Sri Lanka. We suggest workplace improvements in the machine areas. The machines should be checked, and proper safeguards for the machines should be installed, if not present. A workplace safety and health program could be an important method in this industry to protect employees from the potential risks of injuries at work.

Conclusion

Among the 128 interviewed workers, 34 (26.6%) have experienced at least one injury each during the past 3 months, indicating a high injury risk. This raises concerns and highlights the need for preventive measures to minimize risks.

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Original Article

Role of the construction project team in health and safety management: a study of construction projects in the Wa Municipality of Ghana

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ABSTRACT

Introduction: The building industry is vulnerable to a variety of hazards, many of which pose a significant risk to workers' health and safety. This research aimed to examine the role of the construction project team in health and safety management in the Wa Municipality of Ghana.

Methods: This study used a descriptive survey with a quantitative approach as the research design. The study's population consisted of 52 construction project sites from the municipality. All 52 construction project sites in the area were chosen for the study. Descriptive and inferential statistics were used to summarize information from respondents.

Results: The study revealed that monitoring construction sites and ensuring the companies comply with state regulations on health and safety in the workplace obtained the highest ranking, ensuring workers comply with safety and health procedures and use personal protective equipment at construction project sites were ranked as the topmost roles of the construction project team, poor culture, and attitudes existed amongst construction workers, supervisors, and top management of companies toward health and safety.

Conclusion: It revealed a lack of health and safety management at all levels of the construction chain. First, there is poor culture and attitudes of construction workers, supervisors, and companies toward health and safety. Secondly, ineffective operation of safety regulation, inefficient institutional frameworks responsible for governing construction activities, and a lack of attention to safety management by main contractors/team. Despite the institutional provisions for construction safety in Ghana (the Labor Act, 2003 and the Factories, Offices, and Shops Act, 1970), there is no compliance with these Acts during construction.

Keywords: Construction workers, Health and safety, Hazard and risk, Occupational health, Project team, Safety management.

Introduction

Building workers play an important role in the construction of physical infrastructure, but they are sadly exposed to a variety of hazards when working on projects. According to studies, the building industry is responsible for 30 to 40% of all fatal workplace accidents worldwide.[1] For construction workers, safety is also a major concern. In the construction industry, construction workers, especially the construction project teams, have a variety of roles and responsibilities in health and safety management.[2]

First and foremost, some managers ensure that safety and health regulations are followed on the construction site. This role necessitates construction workers to adhere to health and safety regulations and ensure that site operatives complete tasks safely. Since it is management who

has to devise health and safety policies and devote adequate resources to sustain a robust construction safety effort, top management's dedication to worker health and safety is critical.[3] Even though construction workers play critical roles in the sector, many employees fail to follow safety and health policies to avoid accidents. As a result, maintaining a secure and stable work environment necessitates the concerted efforts of all team members. Employees must take a constructive, optimistic approach to prevent accidents. The Construction project team is required to be well-trained and competent in health and safety concerns related to the projects they supervise to achieve high health and safety results.

Due to the influx of multinational corporations into the region, the nation has seen some positive "Safety and Health practice infection" among some of the Ghanaian companies, given their corporate standards with clear requirements in occupational safety and health practices.[4] This is due to their demands that contractors and subcontractors, some of whom are Ghanaians, adhere to their health and safety regulations. For example, in the Upper West Region, many construction workers have not received occupational health and safety training to keep their skills and awareness of health and safety issues up to date on a consistent and structured basis to increase the quality of occupational health and safety services. Even though a portion of contract agreements was created to allow contractors to follow health and safety rules and regulations to minimize the problem, the issue still exists. The efficacy of construction workers in reducing construction-related accidents required further investigation, especially the workers' participation in safety training sessions and consultants' ability to enforce safety at work sites. Despite these concerns, there had been little research in the field under investigation. It indicates that little has been done to determine the current situation in Ghana's Upper West Region. Even the limited literature on the role of construction workers in reducing construction hazards and accidents in the study area is not explicitly related to actual injuries in the study area, indicating the need to fill the void.[5]

The study aimed to look at construction project team roles in health and safety management. The study's specific goal was to evaluate the role of the construction project team in the Upper West Region's health and safety management of construction projects.

Methods

The study was conducted in 2015 to examine the role of the construction project team in health and safety management in the Wa Municipality of Ghana.

The study adopted a quantitative approach, using a descriptive survey. Descriptive design was used because it allows researchers to determine the proportions of people in different classes and to account for the impact of participants that participate twice.[6]

While this design has some drawbacks, such as the difficulty in getting respondents to answer questions thoughtfully and honestly, it was chosen for the study because it deals with understanding and explaining the relationships between variables.[7]

The construction project team in the Region who are currently working was included in the target population. However, since the Association of Building and Civil Engineering Contractors of Ghana (ABCCG) did not have an updated list of construction firms immediately before the study, the researcher had to depend on the Municipals and Districts Assembly to obtain a list of registered construction firms. There were 52 construction companies registered with the Wa Municipal Assembly. As a result, the population consisted of all 52 construction project teams in the Region who were actively engaged by contractors and could provide information on the chosen subject.

All 52 respondents of chosen construction project team of construction firms (such as project/site managers, architects, engineers, foremen, craftsmen, laborers, and other personnel) in the study area were given a collection of questionnaires on the positions of project/site managers in health and safety management in the construction industry in the Region. The

researcher gave them an overview of the study's goals and assured them that any information they provided would be kept confidential and anonymous. The questionnaire was administered and collected over a week for all construction project teams. A total of 50 out of the 52 questionnaires distributed were successfully returned, giving a response rate of 96.2%.

The questions were organized using a five-point Likert scale format, Responses were ranked on the Likert scale from the lowest to the highest (1= strongly disagree, 2= disagree, 3= uncertain, 4= agree, and 5= strongly agree). The options reflect each respondent's level of agreement or priority with a particular question.

In terms of data processing, the data were coded and entered into the Statistical Package for the Social Sciences (SPSS version 21.0). To summarize information from respondents, descriptive statistics such as percentages, and frequencies were used. Inferential statistics like the relative importance index tool (RII) were also used to figure out how respondents felt about the analysis. The median, mode, standard deviation, and variance of each factor's responses are calculated.

Results

This section presents the background of the respondents. It is important to examine this to better understand the role of the team in ensuring safety at the worksite. Two major variables were examined – the gender of respondents and their educational background.

In all 46 males representing 92% and 4 females representing 8% making a total of 50 (100%) respondents were reached for the study.

In terms of educational status, the study sought to establish the highest educational level attained by respondents.

Only 10 percent of the respondents had a Senior Secondary School Certificate Examination/ West Africa Secondary school Certificate Examination (SSCE/WASSCE) qualification which is generic – not related to professional training. The remaining 90% had varied professional training and qualification. About 8 percent had National Vocational and Technical Institute (NVTI) qualifications. The percentage of those who indicated they have a Diploma qualification in the related field was 6 percent. Twenty percent (20%) indicated that they had attained Higher National Diploma (HND) qualification. On the other hand, 38 percent indicated that they had Bachelor's Degree qualification and 18 percent indicated that they had other qualifications (master's degree and Ph.D.). Their backgrounds, therefore, allowed them to at least reason from a broader perspective which will, in turn, reflect in their responses to the questions.

Table 1 describes the job titles of respondents in the survey. The respondents were made of various categories of job title holders in the construction industry such as project/site managers, architects, engineers, and quantity surveyors. The rests were foremen, laborers, craftsmen, or others.

. **Table 1.** Job Title of Respondents

Job title	Frequency	Percentage
Laborer	1	2.0
Craftsman	3	6.0
Foreman	7	14.0
Project/site manager	11	22.0
Architect	6	12.0
Others(Contractors, Engineers and Quantity Surveyors)	22	44.0
Total	50	100.0

Source: Field Data, August 2015.

Table 2 describes the years of working experience of the respondents in the study survey. Table. 3 below describes the roles of the construction project team in the construction industry in Ghana.

This analysis aimed to establish the relative importance of the various roles identified as roles of the construction project team. The score for each role is calculated by summing up the scores given to it by the respondents. The relative importance index (RII) was calculated using the following formula:

$$RII = \frac{\sum W}{A*N} \quad (0 \leq RII \leq 1) \qquad (1)$$

Where;

W – is the weight given to each role by the respondents and ranges from 1 to 4, (where "1" is "not at all important" and "4" is "very important");

A – is the highest weight (i.e., 4 in this case) and;

N – is the total number of respondents.

Table 2. Experience of respondents

Years	Frequency	Percentage
under 5 years	14	28
5 -10 years	20	40
11 - 15 years	7	14
16 - 20 years	4	8
21 - 30 years	3	6
above 30 years	2	4
Total	50	100

Source: Field Data, August 2015.

Table 3. Roles of the construction project team in health and safety management of construction projects.

SN	Roles	Mean	Std. Deviation	Rank
1	Monitor construction sites and ensure the company complies with state regulations on health and safety in the workplace.	4.38	.725	1st
2	Ensuring that workers comply with safety and health procedures and use safety equipment, clothing, and devices	4.32	.935	2nd
3	Ensure a health and safety plan is in place	4.26	.828	3rd
4	Taking necessary precautions to protect the safety and health of workers under their supervision	4.12	.982	4th
5	Ensure health and safety awareness at all levels within the organization	4.06	1.038	5th
6	Ensure adequate welfare facilities are on site	4.04	.925	6th
7	Cooperating with the workplace safety and health committee or representative	3.98	.622	7th
8	Advising workers of safety and health hazards in the work area	3.96	1.009	8th

Source: Field Data, August 2015.

The relative importance index for all the roles of the construction project team was calculated using equation (1) above. The indexes were ranked for project/site manager. Table 4. below provides responses from respondents in the study on the level of importance of roles played by the construction team in the construction industry in Ghana.

Table 4. Level of importance of the different roles played by the construction project team

S/N	Roles of the construction project team	RII	RANK
1	Ensuring that workers comply with safety and health procedures and use safety equipment, clothing, and devices	0.74	1st
2	Monitor construction sites and ensure the company complies with state regulations on health and safety in the workplace.	0.716	2nd
3	Ensure a health and safety plan is in place	0.704	3rd
4	Ensure adequate welfare facilities are on site	0.692	4th
5	Receives reports on workplace injuries, investigate the causes and may arrange for compensation for victims.	0.688	5th
6	Taking necessary precautions to protect the safety and health of workers under their supervision	0.684	6th
7	Organize the provision of protective clothing and equipment	0.68	7th
8	Ensuring the company has safety and health program in place	0.672	8th

Source: Field Data, August 2015.

Table 5 below provides responses of respondents in the survey on the challenges the construction project team faces in the management of health and safety on project sites in the region. It sorts the candid opinions of respondents on the extent to which they agree with each of the statements about challenges the construction project team faces in the management of health and safety on construction sites. Responses were ranked on the Likert scale from the lowest to the highest (1= strongly disagree, 2= disagree, 3= uncertain, 4= agree and 5= strongly agree) for the ten statements that were posed under the challenges of management of health and safety on project sites.

Table 5: Challenges in managing health and safety of project sites

Challenges	Mean	Std. Deviation	Rank
Poor culture and attitudes of construction workers, supervisors, and companies toward health and safety	4.02	1.059	1st
Inefficient institutional frameworks responsible for governing construction activities	4.00	1.030	2nd
Insufficient safety training	4.00	1.050	2nd
Poor safety and conscientiousness of workers	3.96	1.087	3rd
Reluctance to input resources for safety and health	3.94	.956	4th
Ineffective operation of safety regulation	3.90	1.111	5th
Provision of health insurance for employees on construction sites	3.90	4.414	5th
Inadequate government support for regulatory institutions for health and safety standards	3.86	1.107	6th
Lack of emphasis on safety by developers/clients; no external pressure on consultants and contracts to act on safety	3.84	1.167	7th
An Inadequate number of health and safety personnel on construction sites is likely to increase the prevalence rate of construction accidents in the municipality.	3.82	1.044	8th

Source: Field Data, August 2015.

Discussion

In this study, monitoring construction sites and ensuring the company complies with state regulations on health and safety in the workplace obtained the highest mean of 4.38, thus translating to a slightly above the 'agree' rating on the Likert scale. This indicates that the team endorsed the relevance of the practice. On ensuring that, workers comply with safety and health procedures and use safety equipment, clothing, and devices, the statement pulled a statistical mean of 4.32 and ranked 2nd among the responses. It shows that ensuring workers comply with safety and health procedures and use safety equipment, clothing, and devices are the construction project team's prerogatives. This result is in line with a study that says workplace injury and illness are prevented by good management practices, by people taking personal responsibility, and by competence.[8] It reiterates that regular inspection and consultation between management and employees will prevent many accidents from occurring. Further on, most respondents attested that the construction project team ensures a health and safety plan is in place. This assertion was ranked 3rd with a mean of 4.26 from the table. It can be seen from the table that respondents agreed that ensuring health and safety plans in most construction companies is the privilege of employees.

Similarly, taking necessary precautions to protect the safety and health of workers under their supervision is seen to be initiated by the construction project team. With a mean value of 4.12, most respondents have agreed taking necessary precautions to protect the safety and health of workers under their supervision is construction project team driven. This result is supported by a study that says the task of setting up health and assurance procedures for the company and subsequent assessing provisions in the workplace is best separated under a different executive functional head from the departmental and the construction project team responsible for operations under different regulations.[9]

Ensuring health and safety awareness at all levels within the organization was found to be an issue in most construction companies in the survey. In this study, with a mean of 4.06 (Table 3), it is evident that the construction project team has to ensure health and safety awareness at all levels within the organization. Therefore, the construction project team should ensure health and safety awareness at all levels within the organization is nothing less, than the construction project team's prerogative.

It is important to ensure adequate welfare facilities on site as it was 'agreed to' by respondents in the survey with a 6th rank and a mean value of 4.04 (Table 3). It was further observed in this study that with a mean of 3.98 and 7th rank, cooperating with the workplace safety and health committee or representative in most construction sites remains the prerogative of the construction project team to decide who should constitute workplace safety and health committee or representative. Harris et al indicate that every employer must ensure that plant and equipment are maintained in safe conditions, training and supervision in safe working practices are provided, but it is an equal responsibility of every employee to cooperate in making proper and full use of the facilities provided.[10] Advising workers about safety and health hazards in the work area has a significant mean of 3.96 each and 8th rank (Table 3).

Level of importance of the different roles played by the construction project team.

The section was to establish the level of importance to which the construction project team attached to their roles in the health and safety management of construction projects in Wa Municipality. The research undertaken established that ensuring that workers comply with safety and health procedures and use safety equipment, clothing, and devices in construction projects with a relative importance index of 0.74 and was ranked as the topmost role of the construction project team. This result is in line with other literature, which indicates that every employer must ensure that plant and equipment are maintained in safe conditions, training and supervision in safe working practices are provided, but it is an equal responsibility of every employee to cooperate in making proper and full

use of the facilities provided.[11] It has been observed in our study that the key roles that the construction project team played in construction projects were; to monitor construction sites and ensure the company complies with state regulations on health and safety in the workplace (RII = 0.716), ensure a health and safety plan is in place (RII = 0.704), ensure adequate welfare facilities are on site (RII =0.692), receives reports on workplace injuries, investigates the causes, and may arrange for compensation for victims (RII = 0.688), taking necessary precautions to protect the safety and health of workers under their supervision and ensure that employees maintain a clean, organized and orderly workplace (RII = 0.684) each, organize the provision of protective clothing and equipment (RII = 0.68), ensuring the company has safety and health program in place with RII(0.672), teach employees the fundamentals of safe work practices with RII(0.672).

Challenges in managing the health and safety of project sites

In our study, poor culture and attitudes of construction workers, supervisors, and companies toward health and safety obtained the highest mean of 4.02 thus translating to a slightly above the 'agree' rating on the Likert scale (table 5). This indicates that both management and construction workers endorse the elimination of the practice. This finding is also supported by another study.[12] Inefficient institutional frameworks responsible for governing construction activities and insufficient safety training pulled a statistical mean of 4.00 and 2nd rank from respondents' responses in this study. It signals that inefficient institutional frameworks responsible for governing construction activities and insufficient safety training are serious challenges to the construction project team. This result is in accordance with other studies, which indicate that institutional and legal frameworks governing occupational health and safety in developing countries tend to be weak and have little impact on practice.[13,14,15,16] Furthermore, most of the respondents attested to poor safety conscientiousness of workers. This assertion was ranked 3rd with a mean of 3.96. It can be seen from the table that respondents agreed the poor safety and conscientiousness of workers is a challenge to the construction project team.

Reluctance to input resources for safety and health is seen to be one of the top challenges of the construction project team in this study (table 5). With a mean value of 3.94, most respondents have agreed with reluctance to input resources for safety and health is management driven. Ineffective operation of safety regulations and provision of health insurance for employees in construction sites was found to be a challenge for the construction project team in most construction sites, with a mean of 3.90 in the survey, and a mean of approximately 3.86, it is evident that there was inadequate government support for regulatory institutions for health and safety standards. Therefore, giving opportunities for construction workers to make input in their various construction sites is a management prerogative. Similarly, it was noted that there was a lack of emphasis on safety by developers/clients; no external pressure on consultants and contracts to act on safety has a mean value of 3.84. It is further observed that with a mean of 3.82 and 8th rank, an inadequate number of health and safety personnel in construction sites is likely to increase the prevalence rate of construction accidents in the municipality. Although health and safety personnel views can be solicited, it remains the prerogative of the construction project team to decide who should constitute their health and safety committee.

Conclusion

The paper sought to examine the current state of health and safety management on construction sites in Wa Municipality. It revealed a lack of health and safety management at all levels of the construction chain. First, there is poor culture and attitudes of construction workers, supervisors, and companies toward health and safety. Secondly, ineffective operation of safety regulation, inefficient institutional frameworks responsible for governing construction activities, and a lack of attention to safety management by main contractors/team. Despite the institutional

provisions for construction safety in Ghana (the Labour Act, 2003 and the Factories, Offices, and Shops Act, 1970), there is no compliance with these Acts during construction. This is partly due to non-enforcement, leading to poor attitude of workers, and limited knowledge of the institutional provisions on safety at construction sites. Finally, this result compares with other studies both in Ghana and some western countries seems to indicate that the role of the construction project team in health and safety management in the construction industry can best be explained by management policies and practices.

Recommendations

Based on the findings of the study, it is recommended that the construction project team monitors construction sites to ensure that companies comply with the institutional arrangement on health and safety in construction sites. Again, the construction team should create awareness of the institutional arrangements required to keep construction workers, supervisors, and companies in general informed of their obligations toward the health and safety of construction sites. Finally, the construction project team should provide adequate training in the correct use of machinery and equipment, safety gadgets for the employees on the job, and adequate first aid and first aiders on construction sites.

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Original Article

Scientific Support of Occupational Risk Management Decisions in Industrial Sectors in Case of Uncertainty

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ABSTRACT

Introduction: The lack of generally accepted techniques (methods, algorithms) that can be used to quantify the risk of injury in the workplace today necessitates appropriate theoretical and experimental studies. Since labor protection management is carried out by planning and implementing preventive measures, a scientific justification for the priority of these measures is required.

Methods: In this study, theoretical methods were used, namely: analysis of modern methods for occupational risk assessing and labor protection managing; synthesis to improve the decision-making algorithm that ensures effective management of labor protection at enterprises; expert evaluation of the weighting coefficients of potential hazards and questioning of employees; mathematical modeling and the modified Elmery method were applied for practical testing of theoretical results.

Results: An occupational risk management algorithm has been developed to substantiate management decisions on planning measures to reduce risk, the implementation of which ensures the effectiveness of measures aimed at reducing risk. If the decision-making situation is characterized by conditions of uncertainty (it is impossible to obtain mathematical models of acceptable accuracy), the assessment of the predictive values of occupational risk is carried out exclusively by an expert. Practical testing of the algorithm shows that the deviation of the values of expert estimates from the results of measurements by an automated control system and portable equipment ranges from 2 to 6%. Therefore, for a quick calculation of risks, it is advisable to use the expert method, as the most economical and fairly accurate.

Conclusion: It has been established that in conditions of uncertainty (lack of necessary data or available data are incomplete or unreliable), experts involved in solving the problem of risk management use their knowledge and experience in solving similar problems. As a promising direction for further research, it should be noted the development of a methodology for a comprehensive assessment of the effectiveness of operational management decisions for planning and implementing measures to reduce risks.

Keywords: Algorithm, Environmental health, Expert method, Mathematical model, Occupational risk

Introduction

These days are accompanied by significant changes in the socio-economic organization of public life, which contribute to the formation of the market and market relations, rapid industrial progress[1,2] and the emergence of new risks in the workplace.[3] The transition to the active implementation of a risk-based approach is defined by the Concept of reforming the labor protection management system (OSMS) in Ukraine. The construction of such systems, the phased introduction of which will ensure that occupational risk is taken into account when planning preventive measures, provides for a set of theoretical and experimental studies aimed at scientific substantiation of the identification of hazards existing in production and the assessment of occupational risks.

The contemporary principles and methods of risk assessment to a large extent form the basis of improving labor protection management. They have contributed to the achievement of certain successes related to both theoretical research and the practical application of management models and methods.[4-8] However, as practice shows, the choice and rational application of the occupational risk assessment method requires the development of an additional methodology (algorithm) for its practical implementation, as well as a description of data processing methods in the process of planning activities for specific production conditions.

Traditionally, when developing measures to reduce the level of occupational morbidity and industrial injuries, the results of an analysis of the causes, types of events, and other factors that led to accidents are used. But such an approach, as has been repeatedly noted in scientific papers and publications does not meet modern requirements.[8,9] At the same time, the approach to planning events based on the assessment of occupational risks confirms its effectiveness for enterprises of various industries, primarily the most important for the economy of Ukraine (mining and quarrying, production of machinery and equipment, metallurgical production, processing industry)[10], also for certain professions, in particular, drivers of vehicles.[11,12] Risk assessment methods are described in sufficient detail in the international standard IEC 31010:200 "31010:2009 Risk management - Risk assessment techniques" [13] and other standards. Quite a lot of scientific research has been devoted to the study of various aspects and features of these methods, however, these studies do not aim to investigate and solve the problem of operational management of professional risks in the absence of adequate data, and acceptable accuracy.

Therefore, improving worker safety by eliminating accidents involves risk assessment. For an unacceptable and high level of risk, it is urgent to introduce measures to eliminate or minimize the likelihood of a hazard realizing, prioritizing the severity of the consequences. For an average level of risk, a decision is made on the advisability of introducing measures to minimize or eliminate the risk, taking into account the ratio of costs and benefits. An acceptable risk does not require the application of measures to reduce it, but there is a need for constant monitoring to be able to manage the risk.

Establishments should have procedures for identifying existing hazards and assessing occupational risk, which is used in planning and implementing the necessary preventive measures. Methods and methods for identifying and assessing risks must be selected by the characteristics of the workplace, while all types of work and all hazard factors must be taken into account.

The lack of generally accepted techniques (methods, algorithms) that can be used to quantify the risk of injury in the workplace today necessitates the appropriate theoretical and experimental studies. The use of international experience at individual enterprises can significantly improve the state of industrial safety, but there are very few such examples. At the state level, in the absence of generalized databases on working conditions and workplace hazards, the most effective way to assess risks is to study the causes and circumstances of accidents, based on which the justification of preventive measures and the formation of recommendations to reduce risks

is carried out.

Workers are affected by production factors of various physical nature, which can be grouped as physical factors (noise, vibration, illumination, dustiness, etc.), factors leading to injuries (worker fall, falling objects, electric shock, etc.), ergonomic factors (order in the workplace, movement routes, escape routes, working posture, etc.). Simultaneous accounting of the whole variety of these factors is in most cases impossible, but even if such accounting is carried out, the question arises: which of the factors poses a danger to the health of workers and what degree of danger does it have? The answer to this question is not obvious, since in real production conditions all the necessary information about possible hazards, methods of processing, and algorithms of actions for making effective decisions are often missing. Since labor protection management is carried out by planning and implementing preventive measures, that is, there must be strict adherence to the hierarchy of prevention and control measures, and a scientific justification for the priority of these measures is required. Unfortunately, one often has to choose, for example, between collective or individual protection measures, and the decision is not always the right one. Some examples from life experience are well described in the work. Also, the existence of a similar problem in various countries of the world is confirmed by initial studies. [14,15,16] Such a justification can be obtained by clearly performing certain actions, that is, an algorithm. Therefore, the purpose of this theoretical study is to improve the decision-making algorithm for effective labor protection management in enterprises. At the same time, it is expected that if the decision-making algorithm is supplemented with certain stages using a modified risk assessment method, then the priority of measures in the management of labor protection will be obvious. Also, the study is expected to receive practical confirmation of theoretical results through their implementation in real production conditions.

Methods

The following methods were used in this study:

1) analysis of modern assessment methods for assessing occupational risks and managing labor protection in the industry in various countries of the world was carried out based on open sources of information, in particular, a search was made in scientific databases PubMed, ScienceDirect, Mendeley, ResearchGate, Google Scholar for relevant keywords. There were no restrictions on the rating of scientific publications. Emphasis was placed on publications in the last 5 years on risk management under conditions of uncertainty, preference was given to publications with the highest citation. However, earlier works, which have useful information for the present study, were also taken into account and were identified in the list of references when studying recent sources. The comparative method and the method of logical thinking were applied to compare existing occupational hazards, the response of workers to various types of hazards, and proposed approaches to risk management in different countries and various industrial enterprises. To analyze the state of labor protection in actually operating industrial enterprises of various industries, consultations were held with fellow practitioners from the expert and technical center of the State Labour Service and the National Research Institute of Industrial Safety and Labour Protection. The consultants were specialists with a fairly large experience (15...20 years) in the analysis of industrial risks and the state of labor protection at enterprises of various types of economic activity. As a basis for such an analysis, first of all, the data of mandatory reporting submitted by enterprises were used. As additional information and analytical documents were used, the results of questionnaires and surveys of certain categories of employees (such documents are usually not subject to publication, but can be used in agreement with the management of the enterprise for analytical research by scientific organizations);

2) synthesis to improve the decision-making algorithm that ensures effective management of labor protection at enterprises;

3) expert evaluation of the weighting coefficients of potential hazards and questioning of employees to accumulate the necessary information about working conditions to practical

testing of the theoretical research results. Noise levels were measured using a mobile application by experts at selected time points. The measurement results were analyzed, if necessary, refined, and recorded on electronic media for further processing. 3 experts were invited:

- Expert 1: deputy director of the enterprise for industrial safety; responsibilities: approval of action plans for labor protection, monitoring the implementation of measures; work experience of about 20 years in the mining industry; occupied the positions of a mining engineer, foreman, site manager;
- Expert 2: a representative of the trade union organization of the enterprise; responsibilities: organizing and conducting training and testing knowledge on labor protection of employees of the enterprise, as well as laboratory studies of working conditions at workplaces; work experience of more than 10 years;
- Expert 3: engineer for labor protection and safety of the enterprise; a young specialist engaged in scientific research on the influence of production factors on the body of workers; work experience - about 2 years; in agreement with the management of the enterprise, collects statistical data on actual noise levels at the workplaces of the enterprise for generalization and further research;

4) mathematical modeling and the modified Elmery method were applied for practical testing of theoretical results.

The well-known Elmery method is based on the observations and results of the actual values of industrial factors (input data) at workplaces, covering all the most important components of labor protection, such as noise, vibration, air temperature at the workplace, etc. Based on the results of the observations, a special questionnaire should be filled out for each workplace, in which one of two estimates can be made for each of the factors: “meets requirements” or “does not meets requirements”. Next, the Elmery index should be defined as the ratio of the number of factors estimated "meets requirements" to the total number of factors.

Advantages of the method: simplicity, visibility, speed, the applicability of the method at enterprises and organizations of any activity field, special skills, and competence are not required. Disadvantage: all factors affecting occupational safety are taken as equivalent (for example, the increased noise level is equivalent to the presence of hazardous chemicals in the workplace). Such an approach to a certain extent simplifies the risk assessment but does not allow for assessing the real state of safety, as well as reasonable planning of preventive and protective measures, taking into account their priority.

In the present study, a modified Elmery method was applied, adapted to the conditions of industrial production of any industry by improving the method of calculating the safety index based on weighting factors.[17] The weight coefficient of each factor is determined as follows. If the actual value of the factor does not exceed the normative one, the weight coefficient will be equal to some minimum value (depending on the accepted evaluation scale). If the actual value of the factor exceeds the standard value, the weighting factor is assigned a value that reflects the potential hazard or danger to the health of workers.

For example, it might look like this: if the actual value of the factor does not exceed the standard value, the weighting factor is equal to 1; if the actual value of the factor exceeds the standard value by 15%, then the level of the weighting factor is equal to 1.15.

For factors, the level of which cannot be determined by measurements, it is proposed to determine their weight coefficients by expert means. Accounting for the specifics of a particular enterprise can be achieved through a flexible mechanism of the questionnaire system, which allows you to include only those factors that are present in the workplace in the studied factors.

Results

It has been established that traditionally planning of labor protection measures is based on an assessment of the production factors levels, and in case of detection of an excess of the actual value over the normative one, the corresponding measure is included in the action plan (figure 1).

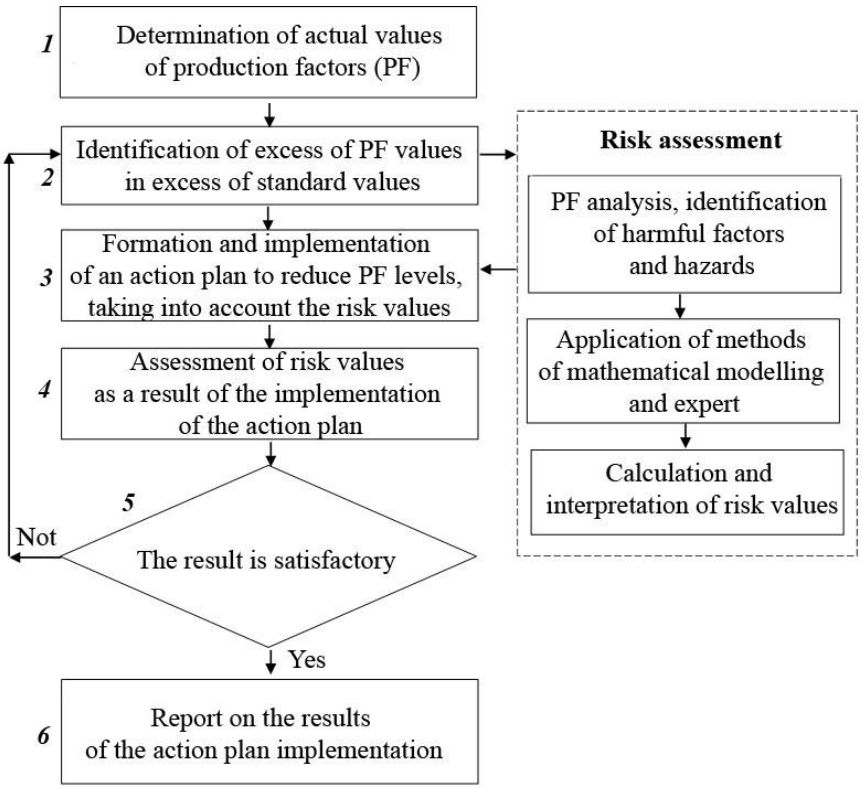

Figure 1. Algorithm for occupational risk managing

That is, the execution of blocks 1...6 of the algorithm is ensured (figure 1). Disadvantages of this approach: a deliberate lack of funds for the implementation of all activities, therefore, a situation is possible when a less significant event is planned and implemented to the detriment of a more significant one.

The improvement of the algorithm (figure 1) compared to the traditional ones is the addition of the "Risk assessment" block. The implementation of the "Risk Assessment" block allows not only to "filter" the activities that do not affect (slightly affect) the risk but also to rank many activities according to the criterion of decreasing their significance in terms of minimizing risks in the workplace.

In practice, the list of activities turns out to be quite large, and its full implementation is impossible due to limited resources (financial, material, human). The task facing the manager (decision maker) is to justify the ranking of measures in descending order of their "importance" in terms of improving the state of labor protection. As a criterion of "importance", it is proposed to use the occupational risk criterion calculated using the modernized Elmery method. The main reason for the modernization of the Elmery method is the need for a differentiated account of each production factor according to the degree of its influence on occupational risk, unlike the classical Elmery method.

An extractive industry enterprise was studied to demonstrate the practical implementation of improved labor protection management. The initial data for planning measures for labor protection are the actual values of production factors at the workplace and the standard values of these factors levels. Data on actual values were determined by direct measurements or questionnaires. The accepted levels of occupational risk gradation and recommended actions (measures) are shown in Table 1.

Thus, a gradation of weight coefficients for each factor is accepted, that is, the range 0...24 corresponds to the state of the factor that meets the requirements of regulatory documents, the state of 75...100 corresponds to the state of a dangerous factor, which can lead to an accident with serious consequences, accidents, etc.

As an example, were considered the results of assessing one of the production factors (noise level) at the workplaces of an extractive industry enterprise (figure 2).

Table 1. Occupational risk gradation levels

Risk assessment		Recommended actions
Limit values (in points)	Name	
75…100	unacceptable	Elimination/risk reduction measures are mandatory and must be initiated urgently Work must be stopped immediately. Start work no sooner than the risk has been eliminated or the degree of risk has been reduced to an acceptable level.
50…74	high	Risk elimination/mitigation measures are mandatory and must be initiated urgently The decision to stop work is made taking into account the ratio of the severity of the consequences of the costs of introducing measures to reduce the risk.
25…49	average	Risk mitigation measures are mandatory but not urgent Compliance with the applicable control measures and the use of regulated safety equipment is mandatory.
0…24	acceptable	Development and implementation of activities is not required The need to ensure constant monitoring of the state of the production environment in order to be able to manage risk

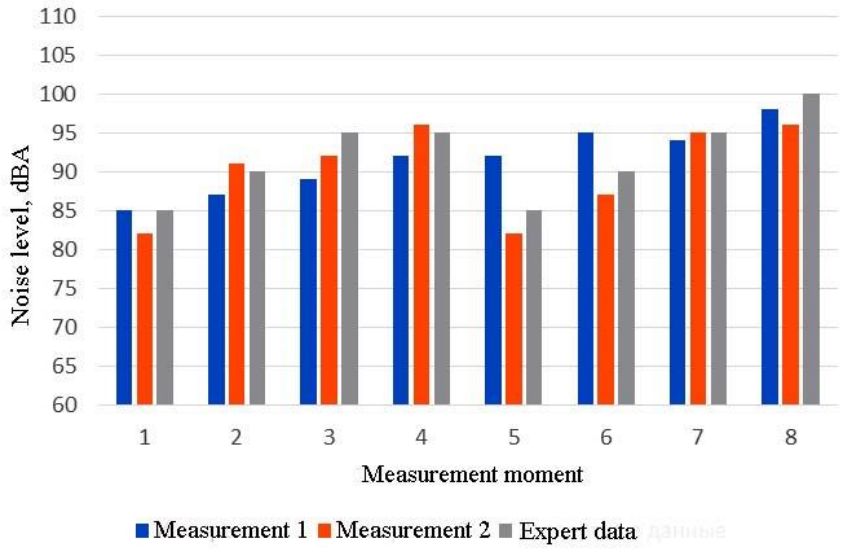

Figure 2. Measurement results and expert assessments of the noise level in the process of production equipment robots

For the study, a workplace was chosen, which is characterized by an increased noise level (exceeding 75 dBA characterizes harmful working conditions). The results were obtained in three ways:

1)"Measurement 1" - measurements were taken using an automated system for monitoring working conditions (allows you to measure several parameters simultaneously with a given discreteness, high accuracy and high costs);
2)"Measurement 2" - measurements were carried out using portable equipment at pre-selected time points in manual or semi-automatic mode (average accuracy, average costs);
3)"Expert data" - measurements were taken by an expert at pre-selected time points using a mobile application installed on a smartphone (average accuracy, minimal costs).

It has been established that the deviation of the values of expert estimates from the measurement results ("Measurement 1") does not exceed 6%. But at the same time, measurement using portable equipment ("Measurements 2") gives an error of only 2%, therefore, to obtain data on the actual values of production factors necessary for the rapid calculation of risks, it is advisable to use this

particular option, as the most economical and sufficiently accurate.

Three measurement options (carried out as an experiment) show that it is not necessary to use the most expensive and difficult-to-apply option "Measurement 1".

The average excess of the noise level above the norm is 9.2% (11.5 dBA) (figure 2), which means that the average noise level is 91.5 dBA.

Obtaining the value of the weight coefficient characterizing the noise was carried out as follows. If the noise level is less than Norm (80 dBA), then the factor can be assigned a value in the range 0…25. The maximum possible noise level (for this equipment) is 110 dBA. Then the existing range of 80...110 is divided into 4 classes, similar to that shown in Table. 2: 75…100 (unacceptable); 50…74 (high); 25…49 (medium); 0…24 (acceptable). That is, the noise range 80…87.50 corresponds to the range of weight coefficient values 0…24, the noise range 87.51…95.0 corresponds to the range of weight coefficient values 25…49, etc. Therefore, for a noise level of 91.5 dBA, the value of the weighting factor will be 37.

Similarly, in practice, the values of all other production factors present in the workplace are determined. Further, the calculation of the Elmery index and the occupational risk level is determined by formulas (1) and (2)

$$I_E = \frac{\sum_{i=1}^{n_1} v_i}{\sum_{i=1}^{n_1} v_i + \sum_{j=1}^{n_2} r_j} \cdot 100 \qquad (1)$$

where I_E is the Elmeri index; v_i is the weight coefficient of the factor that determines its impact on occupational risk (for factors whose level meets the requirements of regulatory documents); r_j is the weight coefficient of the factor that determines its impact on occupational risk (for factors whose level does not meet the requirements of regulatory documents, factors that predetermine the risk); n_1, n_2 are respectively, the number of production factors, the level of which meets and does not meet the requirements of regulatory documents.

Then the occupational risk is determined by the formula:

$$R = 100 - I_E \qquad (2)$$

Based on the "Measurement 1" data (as the most accurate), a mathematical model was obtained that establishes the dependence of the noise level (Y) on the time since the start of work (T):

$$Y = -19121.5638 + 855.7325 \cdot T - 14.3567 \cdot T^2 + 0.1070 \cdot T^3 - 0.0003 \cdot T^4. \qquad (3)$$

What is the necessity and benefit of the obtained mathematical model? With a constant technological process, it is enough to carry out only 8 measurements at arbitrary points and, by substituting the values into the model, get the results. If the obtained result coincides (within the margin of error) with the actual noise value (obtained by measuring earlier), then the process is proceeding normally. If there are deviations toward an increase in the noise level, this is a signal to the work manager that it is necessary to take some measures to control the operation of the equipment.

Discussion

The principal feature of the proposed algorithm is the use of predictive risk assessments for planning activities, as the result of the implementation of measures aimed at changing the main indicators of labor protection. Traditional approaches use risk assessments obtained solely as a result of processing retrospective data [18,19], which leads to the use of obviously outdated results and, as a result, to inefficient planning of activities.

Another distinctive feature of the algorithm can be considered the involvement of qualified experts using the available data and information materials (figure 1, Risk assessment block). In conditions of uncertainty, when all necessary (or adequate) data are not available, experts use their knowledge and experience in solving similar problems [20]. In addition, in some cases, qualified experts can assess the levels of production factors [21], which traditionally requires the use of measuring equipment.

The resulting mathematical model in a practical aspect makes it possible to reduce the number of measurements of the industrial noise level to the required minimum (in the current case, once an hour during an eight-hour work shift). At the same time, work can be continued in this case if all labor protection requirements are met: the use of personal protective equipment, strict adherence to work and rest regimes, as well as monitoring of the level of production factors, in particular noise.

The measured value is substituted into formula (3), and the calculation is carried out, after which the calculated value is compared with the existing one. The application of the obtained mathematical model (3), which establishes the dependence of the level of industrial noise from the time the equipment began to operate, can be used in practice to assess the noise level that creates similar (or similar in technical characteristics) equipment. In this case, it should be taken into account that if there are changes in the technological process, the replacement of raw materials, etc., then the resulting model should be refined. To do this, it is necessary to re-measure noise levels at certain time intervals and build a new model based on the data obtained. Practical experience shows that the general appearance of the new model will not differ significantly from the existing one if the changes in the technological process were insignificant. But, if the technology or other factors of production have undergone significant changes, then, obviously, the type of model will also differ significantly from the type of model obtained earlier.

The construction of mathematical models and the calculation of predictive estimates of occupational risk (as a result of the implementation of planned activities, stage 5 of the algorithm) is based on the assumption that the level of occupational risk at each time t is characterized by the value defined in the task of managing this indicator. This indicator depends on the values of the plural number of factors of the state of labor protection at the previous point in time (t-1) and the expected results of the implementation of the adopted managerial decision:

$$R_i = F(X_t, Q_i) \quad (4)$$

where R_i is a mathematical model that establishes a relationship between the risk value and a set of production factors (the values of which correspond to the time t); Q_i is management decision (action plan) $Q_i = \{q_1^i, q_2^i, q_3^i, \ldots\}$.

The formation of various options for action plans is carried out based on the processing of available statistical data, with the use of expert and analytical support. First of all, from the pre-formed set of activities Qi, those activities are excluded, the implementation of which at the time of the decision (t) is impossible due to the lack of any resources (human, financial), insufficient level of performance discipline, lack of time, etc. Further, the set of measures must be sorted so that each action (for example, q_1^i) allows reducing the risk by an amount not less than the next action (q_2^i). Recommended for selection will be an action plan that will allow for the reduction of the occupational risk value calculated by the formula (3) to the maximum extent.

To conduct experimental studies, taking into account expert assessments, three action plans (Q_1, Q_2, Q_3) were formed that implement different strategies for managing labor protection in an extractive industry enterprise. Further, with the use of mathematical models, the calculated values of risk reduction for each activity were obtained, the results are presented in figure 3.

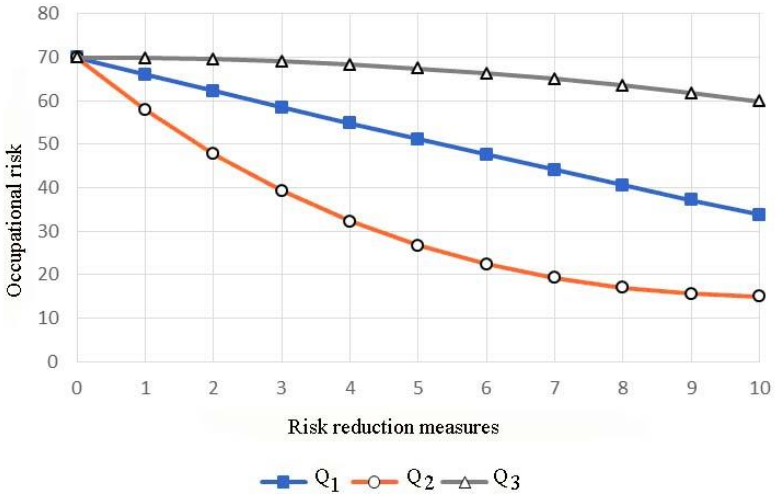

Figure 3. Graphical interpretation of the dependences of the level of occupational risk on the results of the implementation of labor protection measures

As is obvious from figure 3 in the considered case, the best is the action plan Q_2, which will be accepted taking into account the calculations of the expected decline in professional levels (block "Risk assessment" of the algorithm, figure 1). Plans Q_1 and Q_3 were taken without regard to risks.

In addition, the obtained dependences can be expressed by power polynomials. In particular, the mathematical model that establishes the dependence of the level of occupational risk (R) on the results of the implementation of labor protection measures (Q_2) has the form of a polynomial of the 3rd degree:

$$R(X, Q_2) = 70 - 12.9819 \cdot Q_2 + 0.9815 \cdot Q_2^2 - 0.0234 \cdot Q_2^3 \quad (5)$$

The use of the obtained dependencies of occupational risk on the results of the implementation of labor protection measures can be useful at the planning stage of measures since by substituting specific values of the corresponding numbers of measures into the formula, you can get the expected risk assessment.

If the decision-making situation is characterized by conditions of uncertainty (it is impossible to obtain mathematical models of acceptable accuracy), the assessment of the predictive values of occupational risk is carried out exclusively by an expert. [22,23]

Thus, the occupational risk indicator used at the final stage of planning activities determines the degree of achievement of the result of solving the task.

Ways to solve problems

As can be seen from the presented algorithm, the transition to new technology for the development, adoption, and evaluation of management decisions involves the implementation of the functions of scientific support for management activities through the integrated use of modern information technologies, mathematical modeling, forecasting and expert methods. At the same time, it should be noted that decision-making under traditional and new management technologies remains the prerogative of the manager responsible for solving the task.

The implementation of a management decision to reduce risks has many qualities. The economic aspect is that the development and implementation of any management decision require resources. The organizational aspect is that for effective work on the adoption and implementation of decisions, it is necessary to appoint one or more executors, endowed with rights, duties and responsibilities, as well as to allocate the necessary (financial, material, human) resources. The social aspect implies the existence of an effective mechanism for managing performers based on motivation. The legal aspect consists of strict compliance with the requirements of the current regulatory legal and legislative acts, as well as other documents that must be taken into account in the process of implementing the decision.

Conclusion

An occupational risk management algorithm is proposed for use in the field of labor protection, which provides for the implementation of the stages of development, adoption and evaluation of the effectiveness of management decisions on planning and implementing measures. The algorithm is based on the use of databases on the state of labor protection, as well as methods of statistical data processing, mathematical modeling and forecasting, and expert assessments. For an adequate assessment of occupational risks, it is necessary to have objective data from different periods: the onset of traumatic events in the past, the current state of threats to the life and health of people, and the future state of threats. At the same time, in conditions of uncertainty (lack of necessary data or available data are incomplete or unreliable), experts involved in solving the problem of risk management use their knowledge and experience in solving similar problems.

The resulting mathematical model in a practical aspect makes it possible to reduce the number of measurements of the industrial noise level to the required minimum (in the current case, once an hour during an eight-hour work shift). At the same time, work can be continued in this case if all labor protection requirements are met. The application of the obtained mathematical model (3), which establishes the dependence of the level

of industrial noise from the time the equipment began to operate, can be used in practice to assess the noise level that creates similar (or similar in technical characteristics) equipment. Practical experience shows that the general appearance of the new model will not differ significantly from the existing one if the changes in the technological process were insignificant. But, if the technology or other factors of production have undergone significant changes, then, obviously, the type of model will also differ significantly from the type of model obtained earlier.

As a promising direction for further research, it should be noted the development of a methodology for a comprehensive assessment of the effectiveness of operational management decisions for planning and implementing measures to reduce risks, [24] especially if experts have to work under stressful conditions for long periods, which will contribute to their fatigue. [25]

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Original Article

Work-Related Musculoskeletal Disorders and Mental Health among Nursing Personnel in the Context of COVID-19 Pandemic in West Bengal, India

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ABSTRACT

Introduction: COVID-19 outbreak created enormous turmoil all over the world. The health sectors were overburdened with critically ill COVID-19 patients. The load on the health sector burdened and fatigued the health care workers especially the nursing personnel as they were in direct contact with the symptomatic patients predominantly. In each wave, the patients' number surged and overwhelmed the health sectors. In this study, the prevalence of work-related musculoskeletal disorders (WMSDs) discomfort and mental exhaustion among the nursing personnel were assessed.

Methods: The duration of the study was from the end of September 2021 to March 2022. The factors that sourced the discomfort symptoms amidst and the interludes of the later waves of COVID-19 and their interrelations were also assessed here. The Modified Nordic Questionnaire and the COVID Stress Scales (CSS) were used in this study.

Results: 73.9% of subjects (N=88) reported the presence of WMSDs symptoms in at least one body region in the last one-year time period with the most prevalent discomfort in the lower back region (42%), followed by discomforts in the ankles, neck, and knee. The mean value of the total score of CSS was 33.74(±19.90) with high mean values in compulsive checking, danger, and contamination subscales. This study showed significant positive correlations between the presence of WMSD symptoms with BMI (r_s=0.266, p= 0.012) and CSS total scores (r_s=0.216, p=0.043).

Conclusion: Large percentages of reports on musculoskeletal discomforts with reports on mental enervation related to COVID-19 indicated weariness of the nursing personnel. The physical exhaustion due to overloading work and the interplay between mental stress and WMSDs revealed pivotal issues of concern.

Keywords: COVID-19, COVID stress scales, Nordic questionnaire, Nursing personnel, Work-related musculoskeletal disorders (WMSDs)

Introduction

The outbreak of COVID-19 or severe acute respiratory syndrome novel coronavirus (SARS-CoV-2) has horrified the world with innumerable shocking and untimely deaths, and a much larger number of ailing people. It was primarily reported in the Hubei Province of China and within a very short time, it grasped the whole country and then

almost every country in the world. As this virus can be transmitted very quickly in several ways like direct transmission, contact transmission, aerosol transmission, etc., healthcare workers became the most susceptible ones to the infection. Despite the outbreak of COVID-19 from December 2019 to January 2020, in a few continents and countries such as India, a considerable number of COVID-19- positive scenarios started appearing in March 2020.[1] The second wave of COVID-19 started in the middle of March 2021, and 144,829 cases were detected in India on April 9th. The largely affected states were Maharashtra, Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, and West Bengal.[2] The case surge that started in mid-March 2021 and spiked quickly in April, there were more than 300,000 new infections found after 10 consecutive days of recording and on May 1, India reported just over 400,000 new COVID-19 cases in a single day.[3] The 2nd wave showed some striking differences from the 1st wave. Though the scarcity of PPE, medicines, and beds declined, more younger people were affected and there were high positivity rates. Various new symptoms surfaced with an increased number of patients facing breathlessness and there was an increased need for mechanical ventilators and oxygen requirements for the patients.[4] On 24th November 2021, the omicron variant of COVID-19 was reported to the World Health Organization (WHO) by South Africa. Along with various other countries, the Omicron variant was found in India also and caused a rapid rise in COVID cases in Mumbai, Delhi, and also in other states.[5] According to the health bulletin issued by the Government of West Bengal, there were 16,93,744 total COVID cases in West Bengal up to 6th January 2022 with active cases of 41,101 on that day. 2,228 patients and 154 patients were admitted to hospitals and safe homes respectively. Up to 21st February 2022, there were 20,13,553 total cases and 4,443 active cases.[6]

Since 2020 with the increasing numbers of COVID-19 patients everywhere and with an increased load on hospitals and health sectors, health workers faced massive challenges. As the health workers too became infected, the shortage of staff in health sectors imposed far greater hurdles on them. During the outbreaks, nursing staff needed to work in emergency units, intensive care units (ICUs), and COVID units for a long time wearing personal protective equipment (PPE). Increased workload and exhaustive work conditions made the situation more tiring. In a study performed by Nie et al (2020), among 263 nurses, 199 reported changes in duties due to the virus outbreak, 135 reported overtime work, and 66 were found to be with psychosocial distress. The stress symptoms related to COVID-19, concern for the family, being employed in an emergency department, treated differently as they were working in the health sector, were found to be associated with distress.[7] In a study performed by Said and El-Shafei (2021), nurses were found to be with high-stress levels. Workload, personal fear, demands, stigma, tackling and adjusting to deaths of patients, and contact with infections were found to be as probable stressors.[8] In another study performed in Bangladesh, 61.9% of nurses showed some degree of psychological distress during the outbreak. 50.5% and 51.8% of subjects among them reported depression and anxiety respectively.[9] In India, 12.1% and 14.7% of subjects among 354 nurses showed severe anxiety and depression respectively in a study performed by Sharma et al. (2021).[10] In a study performed by Jose et al, (2020) 86% of nurses feared the transmission of infections to family members even if they maintain the safety measures needed. Emergency department nurses showed moderate to high levels of burnout.[11]

The occurrence of musculoskeletal disorders (MSDs) was found to be very high in health sectors, especially in nursing sectors. Work-related musculoskeletal disorders (WMSDs) is a collective term that encompasses damaging conditions of muscles, nerves, joints, bones, ligaments, tendons, and adjacent blood vessels and leads to various kinds of discomforts and strain injuries in the lower back, knee, shoulder, hands, joints and deters body movements. Nursing personnel is exposed to various factors in their work area which can lead to WMSDs. Older persons and persons with disability or critically ill patients depend on the nursing staff for their daily

activities and these patient-handling tasks were found to be highly associated with WMSD symptoms among the workers. Factors like manual handling of patients and instruments, changing clothes and assisting in their daily activities, patients' degree of dependency, and co-operations were found to be related to the onset and aggravation of WMSD symptoms among nursing personnel. WMSDs among workers can affect the quality of life, daily chores, and service life. Absenteeism due to discomfort indirectly increases the cost of health services and also decreases overall productivity.[12] As health sectors are the occupational sectors with an overloading burden, the outbreak of COVID-19 has made the situation more critical. Sharp increases in patients number along with more critically ill patients, created havoc in health sectors which resulted in fast arrangements to increase bed numbers, staff requirements, the need for more critical care instruments, medicines, PPE kits, and scarcity of workspaces in different wards. As there was an increased number of COVID patients in covid wards, a large amount of the nursing population of the health sector was ascertained to the COVID patients admitted. This caused increased task demand among the nursing personnel allotted to the other non-COVID wards of that health sector. Work hours increased not only for hours but sometimes for days. As nurses were the frontline warriors since the first scenarios of the outbreak, they became more prone to infections. Not only did the mental exhaustion, but they also faced the increased workload in deteriorated work conditions. As the nursing task is notably risk-prone and can lead to WMSDs, the alteration in occupation due to the COVID-19 outbreak caused far greater consequences. Since the 1st wave of COVID-19, the number of patients, the type of population infected, the symptoms, and the arrangements in the health sectors were changed. The ease of accessibility of the medicines and equipment and the availability of the vaccines made the situation a little bit easier. But as we are forced to live with the COVID virus and already endured three waves of this, it will never be insignificant to prepare for alarming situations in the future. The situations in this pandemic and the changes in demand and work procedures in health sectors affected the physical and mental health of the health workers. In each wave, the patients' number surged and that overloaded the health sectors for several months durations. The nursing personnel was forced to task in these altered situations repeatedly. The effects on their mental state, the consequences of the unendurable workload, and the interplay between them along with their manifestation on the nurses' overall health have not been assessed properly yet. This needs to be addressed with utmost concern.

This present study, it is aimed to analyze the COVID-19-related stresses among nursing personnel and the prevalence of musculoskeletal discomfort among them.

The objectives of this study are,

- To find the prevalence of WMSDs among the nursing personnel employed in overburdened health sectors amidst, and the interludes of the later waves of COVID-19.
- To assess the COVID-19-related stress among the nursing personnel.
- To analyze the components that sourced the WMSDs among them since the COVID-19 outbreak.

Methods

The study was performed in 5 different hospitals and nursing homes in West Bengal. The study period was from 25th September 2021 to 23rd March 2022. Taking the confidence level of 95% with a 10% margin of error and 50% population proportion, using Cochran's formula[13], the calculated sample size was 96.

$$n = \frac{z^2 pq}{e^2}$$

Where, z is the confidence level, e is the margin of error/level of precision, p is the population parameter and q is (1-p).

To meet the above sample number 120 nursing personnel were selected randomly and approached for the study. As 13 nursing personnel were engaged in major patient and ward-related activities and 6 nursing personnel were not available due to the culmination of duty hours, 101 nursing personnel participated in the study Finally, 88 subjects were selected maintaining the

inclusion criteria of this study. The inclusion criteria of this study were female registered nurses employed in different wards of the hospitals and nursing homes of West Bengal during the COVID-19 pandemic. The exclusion criteria of this study were nurses with histories of major accidents and injuries in the past, chronic musculoskeletal diseases, clinically diagnosed psychological disorders, histories of recent major surgery, pregnancy, and availing sick leaves of 7 days or more within the previous one month from the day of the study. The ethical clearance for this study was obtained by the Institutional Human Ethical Committee, Department of Physiology, University of Calcutta.

At first, the hospital and nursing home authorities were approached with request letters mentioning the details of the study and after preliminary approval from the authority, the details of the study and study procedures were described to the nursing superintendents and/or subsequent officials. After the introduction with the nursing staff present there, the particulars of the study were described and willing subjects were taken for the study. Participants were given the consent forms mentioning the essentials of the study and then they were asked to come to the interview room one by one to avoid the hindrances of biased answering. They were asked not to discourse the questionnaires and details of the procedures with others.

At first, the body height and body weight of the subject was measured using an anthropometer (Martin's Anthropometer) and a weighing machine ("Crown" weighing Machine, Mfg. by Raymon Surgical Co.) and noted down along with the age of the subject. The questions "Have you tested positive for COVID-19?" and "Have your relatives/close ones tested positive for COVID-19?" were asked to the subjects and the answers were noted down. The Modified Nordic Questionnaire[14,15] and the COVID Stress Scales (CSS)[16] were used in this study. In the Modified Nordic Questionnaire, various body parts like the neck, shoulder, elbow, hand, upper and lower back, thigh, knee, and feet were cited. There were questions about the presence of pain or uneasiness in the said areas within the last 12 months and also within the last 7 days. Subjects were asked to point out appropriate body parts with discomforts. In the CSS there were 36 items encompassing factors of 5 dimensions of stress and anxiety related to COVID-19. Fear related to danger and contamination, fear related to economic consequences, xenophobia, compulsive checking and seeking reassurances, and symptoms of traumatic stress were the 5 dimensions incorporated in this scale. All the items were rated 0 to 4 where 0 indicated the lowest response and 4 indicated the highest. Body mass index (BMI) was calculated from the data of body height and body weight.[17]

SPSS 23 version was used to analyze the data. Descriptive statistics were used to estimate the percentages of discomfort reports in different body areas of the subjects, along with the age, body height, weight, BMI, and CSS responses. Spearman correlation was used to evaluate the relationship between WMSD symptoms with BMI and total CSS response values.

Results

In this present study, the mean age of the subjects (N=88) was 33 years. The mean height and weight were 1.53 m and 59 kg respectively. The mean value of BMI was 25.12 kg/m^2 (Table 1).

Table 1. Demographics of the subjects

Variable	Minimum	Maximum	Mean (SD)
Age (Years)	20.00	59.00	32.8295 (±10.46)
Height (m)	1.30	1.68	1.5325 (±0.09)
Weight (kg)	31.00	85.00	59.0068 (±10.90)
BMI (kg/m^2)	16.22	44.77	25.1212 (±4.30)

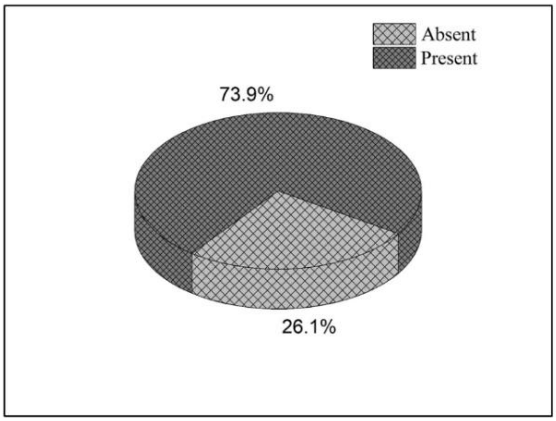
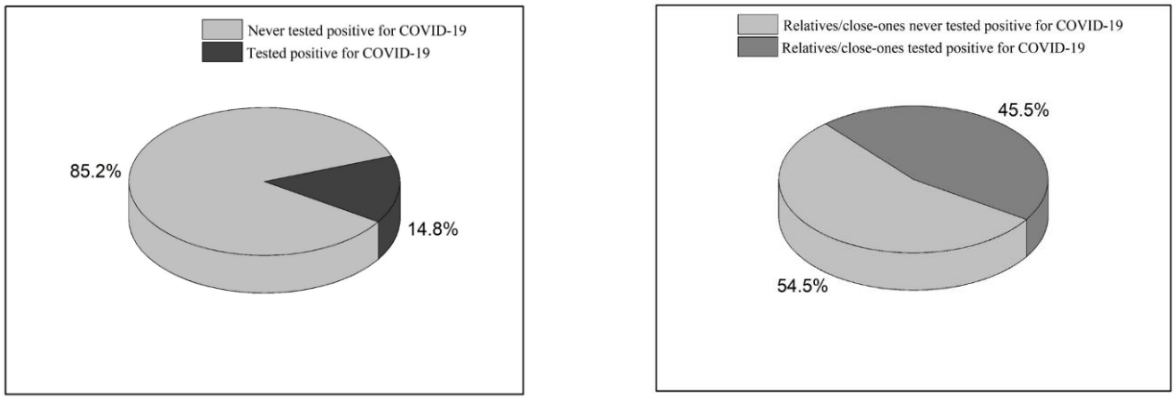


Figure 1. Percentages of the prevalence of WMSDs among the subjects

Here, 73.9% (n=65) of subjects reported the presence of WMSD symptoms in at least one body region in the last one-year time period (Figure 1). The most prevalent discomfort was pain in the lower back region. 42% of subjects reported discomfort in that area over the last year with 30.7% and 18.2% reports of hindrance in daily work and symptoms in the last 7 days respectively. Discomfort in the ankles was the next prevalent one with 26.1% of reports. Discomfort in the neck and knee constituted 22.7% and 20.5% of complaints respectively. 9.1% and 8% reported pain in the shoulder and hip regions correspondingly. Prevalence of musculoskeletal discomfort and BMI showed a significant positive correlation ($r_s = 0.266$; $p = 0.012$).

In this study with the question "Have you tested positive for COVID-19?", 14.8% of subjects answered "Yes" and with the question, "Have your relatives/close ones tested positive for COVID-19?", 45.5% answered "Yes" (Figure 2).



(a) (b)

Figure 2. Percentage of the prevalence of COVID-19 positivity among:
(a) the subjects, and (b) the subjects' relatives/close-ones

Among all the subjects, the minimum score obtained from all 6 subscales in CSS encompassing 5 dimensions was 0. The maximum scores were 20, 18, 19, 21, 20, and 13 for Danger, Contamination, Socio-economic consequences, Xenophobia, Compulsive checking, and Traumatic stress subscales respectively. The mean (±standard deviation) values of the same were 6.91 (±4.89), 5.78 (±5.31), 4.55 (±5.41), 3.44 (±5.44), 10.85 (±5.57), and 2.20 (±3.12) respectively.

The five dimensions of COVID-related stress of CSS were represented in six subscales. The first factor associated with danger and contamination-related stress were denoted as two separate subscale responses. Mean (SD) response values of the subjects with WMSDs (n=65) and without WMSDs (n=23) on the different subscales of CSS are reported below (Table 2). The mean response values in each CSS subscale were higher among the subjects with WMSDs rather than subjects without WMSDs except for the danger subscale where the dispersal of the responses was slightly higher among the subjects without WMSDs.

The mean (SD) values in the Compulsive checking

subscale were highest concerning the other subscales among both the subjects with and without WMSDs. The distribution of subjects' responses on the Compulsive checking subscale is depicted below (Figure 3).

Table 2. Mean (SD) response values of the 6 subscales of CSS among the subjects with and without WMSDs

CSS Subscales	Mean (SD)	
	Subjects with WMSDs (n=65)	Subjects without WMSDs (n=23)
Danger subscale	6.91 (±4.89)	6.91 (±5.02)
Contamination subscale	6.46 (± 5.51)	3.87 (±4.20)
Socio-economic consequences subscale	4.82 (±5.33)	3.78 (±5.70)
Xenophobia subscale	3.66 (±5.44)	2.83 (±5.50)
Compulsive checking subscale	11.17 (±5.24)	9.96 (±6.46)
Traumatic Stress subscale	2.68 (±3.35)	0.87 (±1.77)

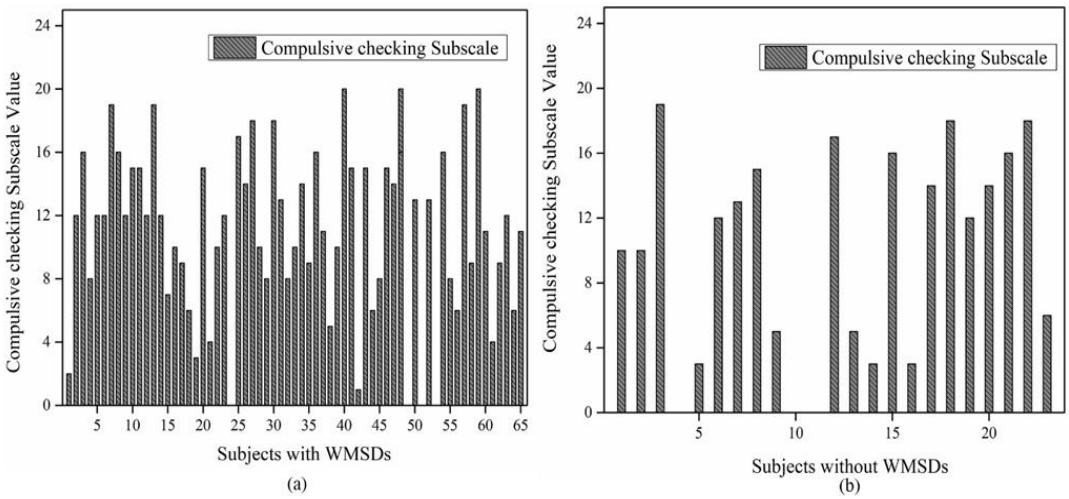


Figure 3: Distribution of the responses of the subjects (a) with WMSDs and (b) without WMSDs on the Compulsive checking subscale of CSS

In this study, the mean value of the total score of CSS was 33.74 (±19.90) with a minimum value of 0 to a maximum value of 86. The distribution of total scores of the subjects with and without WMSDs on the CSS responses is depicted below (Figure 4). The prevalence of WMSDs showed a significant positive correlation with CSS total scores ($r_s = 0.216$; $p = 0.043$).

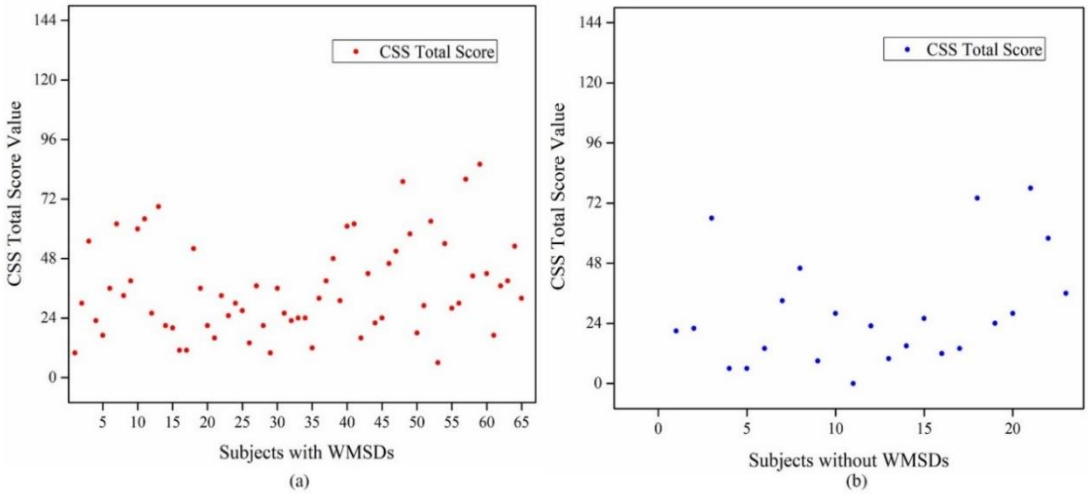


Figure 4. Distribution of the total scores of CSS among the subjects: (a) with WMSDs and (b) without WMSDs

Discussion

In this present study, the mean age of the subjects (N=88) was 33 years and they belonged to the young group of workers with a suitable amount of experience in this field. The mean height and weight were 1.53 m and 59 kg respectively. The mean value of BMI was 25.12 kg/m^2. A large number of subjects (73.9%) reported discomfort in at least one body region in the last 12 months. The most prevalent discomfort was a pain in the lower back region with a percentage of 42%. There were discomforts in the ankles, neck, and knees with percentages of 26.1%, 22.7%, and 20.5% respectively. This study corresponded with the work performed by Amin et al (2020), where 73.1% of the nurses reported WMSDs for the last 12 months. The most reported discomforts were in the neck, feet, upper back, and shoulder regions with percentages of 48.9%, 47.2%, 40.7%, and 36.9% respectively.[18] Another study executed by Yang et al (2020) showed supporting evidence where 96.8% of ICU nurses complained 12 months of the prevalence of WMSDs. The highest rates of described WMSDs were in the low back area with a percentage of 80.5%, followed by the neck region and shoulder with percentages of 79% and 70.4% respectively.[19]

In this study prevalence of musculoskeletal discomfort and BMI showed a significant positive correlation with an r_s-value of 0.266 in p= 0.012. In previous studies, BMI was associated with the onset and aggravation of WMSD symptoms among workers.[20] This study supported the findings that being overweight and obese were linked with an amplified risk of the lower limb and lower back pain and injuries.[21]

In this study with the question "Have you tested positive for COVID-19?", the answer of 14.8% of subjects was affirmative, and with the question, "Have your relatives/close ones tested positive for COVID-19?", there were 45.5% positive answers.

As the health workers were the frontline warriors in this pandemic, they were the ones with the highest risk of exposure. Infections among them further burdened the remaining workforce to meet the work demand. Being in the risk-prone zone also troubled the healthcare workers who were already struggling with chronic co-morbidities. The infection rate was at least 11-fold higher in healthcare workers than in the general population. Though the nursing personnel and other health workers maintained wearing masks and PPE regularly which safeguarded them but with the high workload and long duty hours the stringency was relaxed. Shortage of PPEs led to reusing PPEs, constrained workspaces led to a lack of social distancing while resting or eating, high workloads led to inadequate handwashing, human errors in touching the outer surface of the mask, etc.[22] All these factors led to more risk to the workers and increased infections. In a study performed by David et al (2021) in Brazil, the nursing personnel was found to be at the highest risk of infections and deaths.[23] A large number of subjects also reported incidents of COVID cases among their relatives or close ones. This could source fear and anxiety-related stress among the nursing personnel.

In this study, the mean value of the total score of CSS was 33.74(±19.90). The mean values for Danger, Contamination, Socio-economic consequences, Xenophobia, Compulsive checking, and Traumatic stress subscales were 6.91(±4.89), 5.78(±5.31), 4.55(±5.41), 3.44(±5.44), 10.85(±5.57), and 2.20(±3.12) respectively. This study showed high mean values in compulsive checking, danger, and contamination subscales. Subjects reported checking COVID -19 related news, blogs, and videos related to symptoms, scientific advancements, medicines, suggestions by researchers, new rules and regulations imposed, on mobile phones, and other relevant sources available. Asking the doctors for advice and checking the bodies for probable symptoms were also common. Concerns about infections, anxieties about safety measures not being enough to safeguard from the virus, worries about family members getting infected, and worries about touching and cough/sneeze-related contamination in public places, and in public transport were found to be important factors for concerns. In line with these results, Portuguese nurses showed a high level of stress with anxiety and depression

compared to the general population. The presence and/or absence of adequate protective equipment showed a relation to the level of stress, anxiety, and depression.[24] Another study performed in Saudi Arabia showed similar concerns. The core of the nursing profession was built on caring for the sick, and the nursing personnel put their very best to ensure that, but the load of COVID-19 on the health sectors, patients' increased needs, insufficient protective equipment, risk of infections, altered guidelines, physical and mental exhaustion challenged the professional quality of life of the workers.[25] The health workers showed alarming rates of insomnia symptoms along with anxiety and depression during the early phase of the pandemic.[26] As with the passing months, the level of stress and anxiety related to COVID-19 declined concerning the starting months of the pandemic. Though the number of patients spiked with each wave, the habituation to the situation, the learnings from the scenarios of the subsequent waves, acclimatization to the protocols, a better understanding of the safety rules, better management of the wards, beds, protective equipment and findings and availability of vaccines contributed to weakened fear and anxiety related to COVID. Though the health care workers were struggling with the fear of infections, the anxious situations, uncomfortable circumstances, and painful feelings wearing PPEs, their devotion to their duties and altruistic feeling toward the patients helped them to carry on the responsibilities they are assigned, and also helped them to fight through the high-stress level while working.[27] But after all of that, the present levels of stress and anxiety among them are still a matter of concern as it is directly affecting the physical and mental health of the workers.

As the nurses were already overburdened with a high workload previously from the pandemic, more upsurge in work hours in each wave heightened the stress level among nurses. Studies not related to COVID-19 had already connected long working hours to mental fatigue and other disorders like changed sleeping patterns and musculoskeletal discomforts. Increased number of working hours during the pandemic was found to be directly related to nurses' stress levels.[28]

This study showed a significant positive correlation between the presence of WMSD symptoms and CSS total scores with r_s=0.216 and p=0.043, which indicated an increased rate of WMSDs with heightened COVID-related stress. It can be predicted from the outcomes that nursing personnel assigned with more duty hours in the emergency or COVID wards with a large number of critically ill patients, the heightened mental stress among them, and both the intensified physical demand and psychological distresses, catalyzed by functioning continuously in various wards with COVID-19 patients, collectively encumbered their physical health possibly leading to WMSDs symptoms among them.

It was informed previously in studies that stressors like job demand, responsibility at the workplace, and having control in the workplace were linked with MSDs symptoms.[29,30] High demands with less control, low support in workplaces, and effort-reward disparity were also reported to be related to discomfort in various body areas.[31] Discomfort and pain also can make workers less tolerant of the emotional demand of the workplace and on the other side, excessive physical and mental demands can again lead to WMSDs manifestation and intensification.[32] The significant correlation between CSS total scores and discomfort reports showed analogous tendencies. Excessive mental load, stress, and anxiety can lead to physical manifestation, and tolerating discomforts while attaining the exhaustive demand can also lead to more mental fatigue. Increased demand due to the pandemic had also backed the discomforts.

This pandemic pointed out the need for changes in the healthcare sector all over the world. It can be stated from the learnings and struggles so far amidst the pandemic, that the virus is still present and continuously challenging the community, and preparations must be done to fight now and in the future. In both resource-limited and resource-rich settings, adequate and attainable changes should be done to avoid infections and ensure the overall well-being of the health workers. Changes in ICU designs, safer positioning of beds and intensive care equipment, staff recruitment and preparing expandable trained staff pool, ensuring the safety

and physical and mental well-being of the staff, confirming effective supply and proper utilization of PPEs needs to be done in the health sectors.[33,34]

Conclusion

The outbreak of COVID-19 took a toll on society. The overburdened health sectors, severely ill patients, and deaths all over the world startled and frightened everyone. Despite the fear of the situation, the frontline workers are continuously serving the community with courage and responsibility. The healthcare workers were the ones who dealt with the overcrowded conditions of hospitals and nursing homes. Since 2020, in each wave, the situation changed and the nursing personnel needed to modify themselves physically and mentally according to the demands. Most of the time the nurses were the ones who were in direct contact with the patients. They had dealt with the exhaustive feelings of wearing PPEs for long often in adverse climatic conditions, excessive workload, a sharp increase in the patient-to-nurse ratio, increased duty hours along with the fear of getting infected and chances of transmitting the virus to the family members. These not only increased their mental stress and anxiety but also deteriorated their physical condition. Nurses' complaints of musculoskeletal discomforts along with high psychological distress surfaced a firm connection between the stress related to COVID-19 and the musculoskeletal discomforts. Alteration to the arrangements in the emergency, ICUs, and COVID units, increased number of staff, staff recruitment, staff turnover, proper rest breaks, training to the staff for proper use of protective equipment and safety protocols, arranging ample number of PPEs, addressing the physical discomfort and mental health of the workers needs to be done to ensure the safety of the workers and smooth operations in health systems.

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Review Article

Evidence-Based Treatment Strategies For "Text Neck Syndrome ": A Review

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ABSTRACT

Introduction: Text neck syndrome is an overuse condition or repetitive stress injury in which the cervical spine is flexed forward or down for extensive stretch while gazing at a smartphone or other electronic device. Individuals with this syndrome usually present with neck pain, restricted cervical range of motion, reduced muscle strength and endurance, and altered cervical joint position error along with postural alterations like forward head posture and rounded shoulders as well.

Methods: We performed a systematic review of the Text Neck Syndrome and discussed the evidence-based studies. For the review, an electronic search for relevant articles using PUBMED, MEDLINE, Pedro, Research Gate, Google Scholar, and CINHAL databases up to March 2022 was done wherein MeSH search terms and free words were used. In addition to the electronic search, articles were searched manually for relevant studies. Articles were selected based on the author's expertise, self-knowledge and reflective practice.

Results: The current study included 17 articles that fulfilled the inclusion criteria suggesting that Text Neck Syndrome is an upcoming concern and requires attention. The above-reviewed studies provided evidence that physiotherapy as a mode of treatment is effective in treating Text Neck Syndrome.

Conclusion: This review spoke about the text neck syndrome and its rising consequences and also about the treatment approaches available in treating and minimizing the symptoms of this syndrome. Further research is required over what more preventive strategies can be adopted in the case of the Text neck syndrome.

Keywords: Cervical Joint Position Error, Cervical Range of Motion, Physical Therapy, Postural Correction, Text Neck Syndrome.

Introduction

By now, we know the result of smartphones and their impact on numerous businesses, health, social life, and education. Students are taking online lessons from institutions and studying on their phones; in addition, the use of smartphones for amusement has surged during the lockdown.[1] When looking down at their mobile devices' screens, users commonly adopt a prolonged forward head posture.[2,3] Dr. Dean L. Fishman, a chiropractor in the United States, created the term "text neck." Text neck is a term used to describe a repetitive stress injury or overuse condition in which a person has his or her head hanging or flexed forward and is stooped down for lengthy periods looking at his or her mobile phone or other electronic devices.[3,4,5]The prevalence of Text Neck Syndrome is 32% in India.[6] The prevalence of Academic staff in one of the Malaysian Universities with frequent smartphone use was 41%,[7] prevalence among the medical students of Jeddah and Saudi Arabia was seen was 68.1%.[8] According to a recent research, 79 % of those aged 18 to 44 keep their phones with them virtually all of the time, with only 2 hours of their waking day spent without them.[9,10]

In the neutral position, an adult's head weighs 10-12 pounds. With the flexion of the head, the load increases towards the neck, and the weight is calculated to be 27, 40, 49, and 60 pounds at 15°, 30°, 45°, and 60°, respectively. People who use a smartphone frequently have a downward gaze to focus on lowered things and keep their heads in a forward position for lengthy periods, which can cause neck strain.[9]

In addition, maintaining a forward head posture reduces cervical lordosis in the lower cervical vertebrae and provides a posterior curve in the upper thoracic vertebrae, which helps to maintain balance. Forward Head Posture is the term for this .[6,9] Neck pain and soreness are the most typical symptoms of Text Neck Syndrome. Furthermore, shoulder pain and stiffness, as well as upper back pain ranging from persistent, nagging pain to sudden and severe upper back muscular spasms, may result in painful shoulder muscle spasms.[9,10]

As a result, people with Text Neck Syndrome have less strength and endurance in their neck muscles, as well as postural alterations. Text neck, if ignored and untreated, can result in serious long-term consequences, such as flattening of the spinal curvature, early onset of arthritis, spinal misalignment, spinal degeneration, disc compression, disc herniation, nerve or muscle damage, inflammation of cervical ligaments, nerve irritation, and an increase in spine curvature.[5,10,11]

When it comes to the treatment of Text Neck Syndrome, to date only symptomatic treatment has been given. Physiotherapy interventions can be done to treat text neck syndrome, some of which include ultrasound, manual traction, manual exercise, cervical muscle stretching, cervical joint manipulation, and McKenzie. But all of these only provide subsequent relief in symptoms of Text Neck Syndrome. There is an increasing need for a structured treatment protocol in such individuals to avoid long-term complications which are mostly seen at an early age.

Methods

Search Strategy: We performed a narrative review on Text Neck Syndrome and the possible treatment strategies and discussed the evidence-based studies. For the review, an electronic search for relevant articles using PUBMED, MEDLINE, Pedro, Research Gate, Google Scholar and CINHAL databases up to March 2022 was done wherein MeSH search terms and free words like "Text Neck Syndrome", "Desktop workers " "Medical Management" "Physical Therapy", "Physiotherapy Treatment", "Forward Head Posture", "Cervical Proprioceptive Training ", "Strengthening Exercises", "Resistance Training" were used. Boolean operators like "AND", "OR" and "AND NOT " were used. In addition to the electronic search, articles were searched manually for relevant studies. Articles were selected based on the authors' expertise, self-knowledge and reflective practice.

Study Selection: A systematic review was undertaken. We included studies published in English up to March 2022, which focused only on

physiotherapy as one of the choices of treatment in individuals with Text Neck Syndrome. The studies included adults between 18-44 years of age who were diagnosed with Text Neck Syndrome.

Data Extraction: All steps in the selection and extraction processes were assessed. The titles and abstracts of the references were screened. . Full texts of relevant publications were reviewed and were included if they met the inclusion criteria. One researcher collected the database and included the relevant ones based on the inclusion criteria.

The inclusion criteria for the study were databases in the form of randomized clinical trials, randomized control trials, comparative studies and cross-sectional studies. Also, the studies included individuals who were falling in between the age group of 18-44 years and diagnosed with Text Neck Syndrome. The studies used for this review ranged from symptoms, medical treatment and physiotherapy treatment strategies of Text Neck Syndrome. Then these databases were studied by researcher 2 and were analyzed and discussed. Then both researchers read and reviewed the final data to avoid any bias.

Results

The current study included 17 articles that fulfilled the inclusion criteria focusing on the treatment approaches that are available in individuals with Text Neck Syndrome.

A systematic review regarding the conservative management of Mechanical Neck Disorders(MND) was carried out in the year 2007 by Anita R. Gross et al; which included 88 randomized controlled trials which were undertaken and studied by two authors. The results of this study revealed that there was strong evidence supporting that multi-modal approaches including stretching/ strengthening exercise and mobilization/manipulation for subacute/chronic MND reduced pain and helped to, improve function. Moderate evidence was seen in exercises where stretching and strengthening exercises had an intermediate to long-term effect on managing MND. Also, intravenous glucocorticoids for pain reduction and reduced sick leave in cases of acute WAD (Whiplash Associated Disorders), and epidural injections for pain reduction and improved function in cases of chronic neck disorder with radiculopathy were seen to be beneficial.[12]

Jill Shah et al. spoke about the effects of Pilates along with the Conventional Exercise Program and Conventional Exercise Program Alone in Subjects with Text Neck Syndrome. The participants in this study ranged in age from 18 to 22 years old and used their smartphones for at least 4 hours per day. The participants were placed into two groups: Group A received a conventional exercise program, whereas Group B received a Pilates exercise program in addition to a conventional exercise program for five sessions per week for six weeks. The findings of this study revealed that after a six-week treatment program, both groups, Group A, which received only conventional exercises, and Group B, which received Pilates along with conventional exercises, improved their neck flexor muscle strength and endurance, as well as pain and disability. However, in comparison to Group A, Group B showed a statistically significant improvement (p value< 0.05).[6]

Divya Jain et al; carried out a study in the year 2021, named "Effectiveness of Progressive Resisted Exercise along with Conventional Exercise and Conventional

Exercise Program alone in Subjects with Text Neck Syndrome". There were 80 participants in this study, who were randomly assigned to one of two groups: Group 1 or Group 2. For four weeks, group one received a normal exercise program, whereas group two received Progressive Resisted Training in addition to a conventional exercise program. The severity of the discomfort, the strength of the neck muscles, and functional activity will all be assessed. Post-treatment results suggested that a combination of progressive resisted exercise training and a traditional exercise program was effective in treating Text Neck Syndrome.[13]

A study done by Ozan Soyer et al; in 2020 spoke about the effect of Postural Correction and Exercise on Neck Pains in Cell Phone Users where

49 participants were included who had neck pain and had been spotted using a mobile phone for at least two hours per day for at least five years and were between the ages of 15 and 40. Patients in group 1 were given a planned exercise program that included neck muscular stretching and posture exercises, and they were told to do 10 repetitions of each exercise for two sets every day for a month. In addition to exercises, participants were given tips on how to improve their posture and set limits on how much time they may spend on their phones. For a month, Group 2 patients did not get any treatment. The neck pain score in group 1 was found to be considerably lower ($p<0.001$). According to the findings, reducing the amount of time spent on a mobile phone, exercising regularly, and correcting the head forward position by raising awareness can help avoid the development of text neck syndrome.[14]

Harshadeep Kothare et al; performed a study called "Immediate effects of kinesio taping on upper trapezius muscle on subjects having text neck". A total of 50 people aged 20 to 22 took part in the study. Students who had used a smartphone for at least 2 hours per day for more than 6 months and complained of neck pain during and after use, as well as an NDI score of 30 percent to 48 percent, indicating significant disability, were included in the study. For three days, Kinesio Taping was administered to the bilateral Upper Trapezius muscle. Before removing the tape, the NPRS and NDI were taken on the third day. With a p-value of ($p<0.0001$), there was a significant difference between before and post-NPRS and NDI scores. As a result, it was established that applying KT to the bilateral Upper Trapezius muscle for three days was useful in Text Neck students.[15]

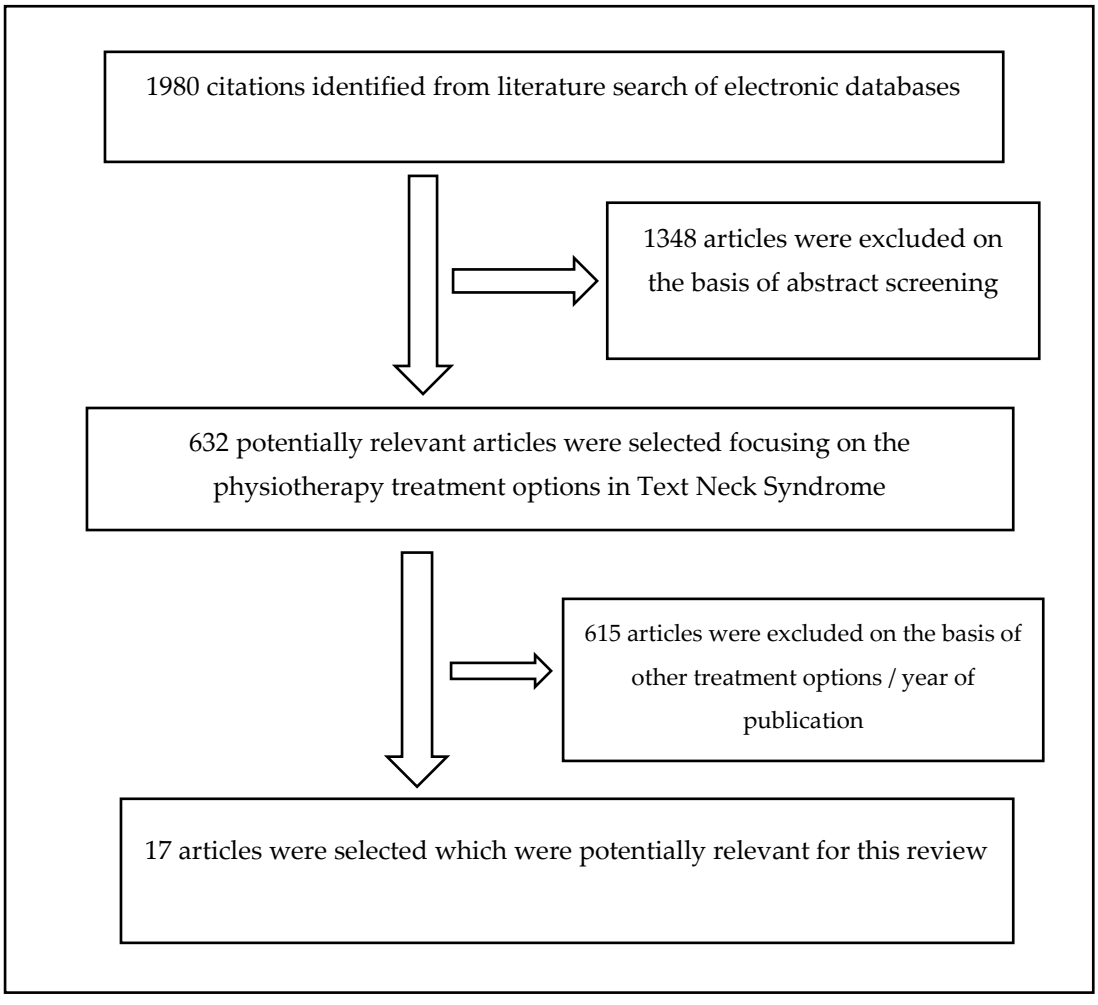

Figure 1: Flowchart depicting the selection of database for the review.

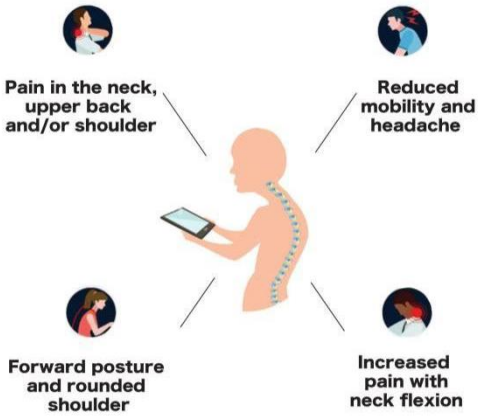

Figure 2: Pictorial representation of symptoms seen in Text Neck Syndrome.

Table 1: Studies summarizing Text Neck Syndrome and Evidence-based physical therapy in Text Neck Syndrome.

STUDY TITLE	NAME OF THE AUTHOR, YEAR OF THE STUDY	RESULTS	REMARKS
Assessment of Co-Morbid Factors Associated with Text-Neck Syndrome among Mobile Phone Users[9]	M. Vijayakumar, Sanika Mujumdar, Aishwarya Dehadrai , 2018	Forward head posture, Grip strength, Active cervical joint ROM and Neck muscles' strength were assessed. The results revealed evidence of neck pain, upper back pain, forward head posture, reduced grip strength and reduced range of motion and muscle strength.	Text Neck-induced co-morbidities are chronic and progressive in nature.
Effectiveness of Pilates along with Conventional Exercise Program and Conventional Exercise Program Alone in Subjects with Text Neck Syndrome[1]	Jill Shah, Krupa Soni, 2019	**Group A:** Conventional Exercise Program **Group B:** Pilates exercise along with the conventional exercise program Sessions were given 5 times per week for 6 weeks.	The study concluded that Pilates along with the conventional exercise program was more effective in treating patients with Text Neck Syndrome.
Effectiveness of Progressive Resisted Exercise along with Conventional Exercise and Conventional	Divya Jain, Swapna Jawade and Neha Chitale, 2021	**Group A:** Cryotherapy, active range of motion exercises, isometric exercises and chin tuck. all these were given for 4 weeks. **Group B:** Progressive Resisted Exercises using Elastic therabands, free weights, and	The Progressive Resisted Exercise Group showed better results in treating the Text Neck Syndrome than the conventional group

Exercise Program alone in Subjects with Text Neck Syndrome[13]		exercise machines were given for a duration of 4 weeks.	
The McKenzie Exercise Methods For Prevent Text Neck Syndrome Due to Gadget Overused[16]	Desti Kurniawati, 2021	-	The use of McKenzie in providing effective exercise to improve the cervical range of motion
Immediate effects of kinesio taping on upper trapezius muscle on subjects having text neck[15]	Harshadeep Kothare, Chanakya Patil and Revati Muley, 2019	Kinesio Tape was applied over the bilateral Upper Trapezius muscle for three days.	Application of KT for three days over bilateral Upper Trapezius muscle was found to be beneficial in Text Neck students.
Effects of work-from-home use of laptop or mobile phone causing Text neck syndrome during the quarantine period COVID-19[17]	Baba Mastnath University, Asthal Bohar, 2021	This study supports that 46% suffering from discomfort, mild to moderate neck pain, and stiffness related to working from home who use laptops on daily basis.	The prevalence of neck pain in laptop users was mild to moderate in these individuals.
Effect of an office ergonomic randomized controlled trial among workers with neck and upper extremity pain[18]	Jonathan Dropkin, Hyun Kim , 2014	A 7-month office ergonomic intervention study evaluated the effects of 2 engineering controls And training on neck/UE pain and mechanical exposures. A 3 month follow-up was also taken.	The intervention reduced non-neutral postures in the non-dominant upper extremity and also increased hand activity in the distal aspect of the same extremity.
The Effect of Postural Correction and Exercise on Neck Pains in Cell Phone Users [11]	Ozan Soyer, Zeynep Ülkü Akarırmak, 2020	Group 1: Structured exercise program including neck stretches, neck range of motion exercises and postural advice was given of 10 repetitions × 2 sets daily for a month. Group 2 : No treatment was given	Group 1 showed significant improvement in posture and helped in the treatment of Text Neck Syndrome as compared to Group 2.
A Study to Assess the Prevalence of Text Neck	Amninder Kaur , Simran Makker, 2021	Data was gathered using Neck Disability Index and Pittsburgh Sleep Quality Index to assess the quality of sleep.	Text Neck Syndrome is associated with neck disability and quality of sleep.

Syndrome and Quality of Sleep among Smartphone Users in Selected Colleges of District Ludhiana, Punjab[19]		The results revealed that nearly half of the smartphone users had mild neck disability and subjects had good sleep quality whereas poor sleep quality.	
Cervical Proprioception in a Young Population Who Spend Long Periods on Mobile Devices: A 2-Group Comparative Observational Study[20]	Andrew Portelli, and Susan A. Reid, 2018	Assessment of the recruits was done based on VAS and head repositioning accuracy (HRA) test. Results revealed a significant correlation between time spent on electronic devices and cervical pain intensity and between cervical pain intensity and HRA during flexion.	There was a greater proprioceptive error noted during cervical flexion in the Text Neck Participants.
Prevalence and awareness of text neck syndrome & addiction to smartphones in the doctor of physical therapy students of Peshawar[21]	Shamaal Khattak , Mashal Gul , Hoor Ali Kakar , Ghazanfar Ullah, Mujeeb Ur Rahman, 2020	Participants were given a questionnaire regarding neck pain and the knowledge about Text Neck Syndrome and a Smartphone Addiction Scale to measure self-reported addiction to smart phone use.	Around one-fourth of the students were suffering from text neck pain with overuse of smartphone and low level of awareness regarding it.
Text neck: An adverse postural Phenomenon[22]	Ira Fiebert, Fran Kistner, Christine Gissendanner, and Christopher DaSilva, 2020	Results showed that prolonged use of hand-held devices leads to adverse anatomical and biomechanical changes in the cervical and the thoracic spine along with postural changes and, muscular imbalances.	Proper postural advice while using hand-held devices is mandatory for such individuals.
The impact of home office setup due to COVID-19 pandemic on IT professionals' physical health: a systematic review[23]	Oana-Ruxandra STÎNCEL, Andreea NIȚĂ, Mihaela ORAVIȚA, 2021	The research was conducted based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) methodology.	The study confirmed that in the case of IT professionals, there is a strong association between working from home, poor ergonomic workstations and high prevalence of musculoskeletal complaints, and, especially, an increased occurrence of neck pain.
Musculoskeletal Disorders among Video Display Terminal Users:	Rivu Basu , Aparajita Dasgupta , Gautam Ghosal, 2014	The study included 206 individuals from the Software Company of Sector V, Kolkata, the IT hub of West Bengal.	Results revealed that 90.78% of the population showed some form of musculoskeletal symptoms

A Cross-Sectional Study in a Software Company[14]			which were highest in fingers, elbows, wrist, shoulder, upper and lower back.
Correlation between the Guyon Canal Syndrome and the Forward HeadPosture in Prolonged Smartphone Users[6]	Shinde SB, Vaidya AA, Bhore PR, 2022	80 respondents from a college and the data that was collected included demographic details, smartphone usage characteristics, the severity of pain, the presence of FHP, and mechano-sensitivity of the ulnar nerve.	Results revealed a positive correlation between forwarding head posture and Guyon canal syndrome in prolonged smartphone users.
Conservative Management of Mechanical Neck Disorders: A Systematic Review[12]	Anita r. Gross, Charlie Goldsmith, Jan Hoving, Ted Haines, Paul Peloso, Peter Aker, Pasqualina Santaguida, Cynthia Myers, 2006	88 unique Randomized Clinical Trials were studied to study the effect of various treatment strategies for the management of Mechanical Neck Disorders (MND)	Exercise with mobilization/manipulation, exercise alone, intramuscular lidocaine, intravenous glucocorticoid, low-level laser therapy, and intravenous glucocorticoid for acute whiplash-related illnesses all showed intermediate or long-term advantages in the treatment of chronic MND.
Medicinal and Injection therapies for mechanical neck disorders[24]	Peloso P, Gross A, Haines T, Trinh K, Goldsmith CH, Aker P, Cervical Overview Group, 2004	32 randomized controlled trials were included that examined the effects of oral NSAIDs, psychotropic agents, injections of steroids, and anesthetic agents	Results revealed that treatments for acute whiplash and chronic MND included intravenous methylprednisolone injection and lidocaine intramuscular injection.

Discussion

This systematic review highlights the current evidence on the Text Neck Syndrome and the treatment strategies that are taken to treat this syndrome. Speaking treatment options range from conservative management, medical management, and physiotherapy treatment which does help in improving range of motion, reducing pain, and increasing muscle strength, functional capability and quality of life in such individuals.

Studies by M. Vijayakumar et al; stated that there were 100% samples with neck pain and Forward head posture while 94.91% samples with upper back pain, 89.83% with headache and poor grip strength and 59.32% with shoulder pain. This study showed that the severity of neck pain among Text-neck syndrome patients was more followed by upper back, headache and then shoulder pain. This study also focused on the assessment of the grip strength in such individuals which revealed below-average to poor grip strength after prolonged hours of texting. Ewa Gustafsson et al also commented on the differences seen in texting velocity between men and women, with women texting with higher velocity.[25] This would further result in wrist and thumb pain associated with below-average to poor grip strength. Thus, Text Neck Syndrome is susceptible to causing a loss in grip strength eventually leading to a loss of ability to perform functional activities. Prolonged shearing of the vertebrae from the forward head posture sooner

or later irritates the small facet cervical joints as well as soft tissues and ligaments which causes neck and upper back pain leading to trigger points in the trapezius, sternocleidomastoid and rhomboids muscles, along with limited cervical joint range of motion. Also, due to hypomobility of cervical joints, chronic neck pain and ultimately spinal degeneration will occur at an early age.[26] Similarly, the forward head posture resulted in adaptive shortening of the occipital muscles causing the cervical spine to change alignment resulting in increased stress on the facet joints and posterior discs and other posterior elements. This position may in turn lead to weakness of deep cervical flexors.[9]

Text Neck Syndrome has been termed as an adverse postural phenomenon by Ira Fiebert et al [22], specifically because of the changes that are seen after prolonged use of hand-held mobile devices(HHMD) which results in adverse anatomical and bio-mechanical changes in the cervical and thoracic spine, muscular imbalances, and postural compensations, all of which contribute to muscular overuse and fatigue resulting in pain. It's mentioned the cervical posture and thoracic posture while texting. About cervical posture, those using an HHMD at an average of 2 hours/day for 10 years are at high risk for developing decreased cervical lordosis, thereby greatly increasing their risk for future neck pathologies. Studies have also found that the neck flexion angle tends to increase more significantly while using an HHMD in a sitting versus a standing position. On average, the neck flexion angle while sitting is 10- 14% greater than when standing.[22,27] The placement of the device also appears to play a factor in changes in head and neck flexion angles. Using devices placed on a person's lap, for example, leads to increased head and neck flexion angles.[22,28] Even though bilateral texting task shows increased cervical flexion rather than single-hand texting; still texting with only one hand was associated with more asymmetrical cervical spine postures, including an increase in cervical rotation and side bending.[22,29]

Also, differences seen in posture when it comes to HHMD are not only limited to the cervical spine but also affect the kinematics of the thoracic spine. The Cranio-vertebral Angle (CVA) is a measurement of the degree of forward head posture and lesser CVA values are indicative of an increased degree and severity of forward head posture. The upper thoracic angle is a measurement of the degree of thoracic kyphosis. Lau et al. found that subjects with neck pain displayed a smaller CVA and a larger upper thoracic angle, demonstrating a higher degree of forward head posture and thoracic kyphosis compared to the asymptomatic subjects.[22,30] Likewise, the change in the thoracic angle predicted neck pain more accurately than changes in CVA. As the upper thoracic angle increased the degree of thoracic kyphosis also increased, and there was a simultaneous increase in perceived neck pain which was seen. These findings indicate that the anatomical and postural changes associated with HHMD use are not limited to just the cervical spine, but musculoskeletal changes taking place in the thoracic spine may contribute to pain and the development of other symptoms commonly seen with text neck.[22,31]

Discussing the treatment protocols or regimes followed when it comes to Text Neck Syndrome they are very limited. As it is an upcoming syndrome, usually only symptomatic treatment has been given importance. A study was conducted on individuals with Text Neck Syndrome which compared the effect of Pilates along with conventional exercise program and conventional exercise program alone which showed evidence that greater improvement was in reducing pain, neck disability, increasing cervical muscle strength and endurance in individuals who received the combination of Pilates along with conventional exercise program rather than the conventional exercise program group. They stated that Exercise is the most effective way to treat patients with neck pain and in case of neck pain, the majority of treatment protocols focus on the deep neck flexors, as they play a major role in stabilizing the proper alignment of the cervical spine. Similarly, Pilates and spinal extension exercises helped in re-educating the stabilizing (postural) muscles of the spine and shoulder girdle, and have beneficial

effects to manage back pain and restore function. It also helps by encouraging activation of the deep neck flexor muscles with a neutral position of the cervical spine which in turn helps to build strength and endurance of the cervical muscles and thus reducing pain and disability.[6,32]

Evidence state that Upper Trapezius is usually the most affected and fatigued

muscle due to prolonged smartphone use under electromyogram. Smartphone use for more than 30 minutes showed that pain increased with increased muscle fatigability.[15,33] Kinesio Taping(KT) is effective in treating the upper trapezius in individuals with Text Neck Syndrome. The pressure and stretching effect of kinesio tape on the skin is believed to stimulate cutaneous mechano-receptors, which in turn conveys information about joint position and movement, and therefore may enhance proprioception.[15,34] It also helps in alleviating the workload on the trapezius muscle and allows the subject to maintain the shoulder and neck in their neutral position. Likewise, it is known that blood and lymph circulation may be enhanced at sites where kinesio tape was applied, thus muscular and myofascial function at those sites was affected which helped in reducing the tension over the muscles and helped in improving functional ability.[15]

Studies done previously showed that postural correction with the help of a specifically structured exercise program has shown a positive effect in individuals with neck pain in prolonged cell phone users. The focus was on three of the frequently involved muscles, trapezius, sternocleidomastoid and levator scapulae (LS). The exercise program included a structured regime consisting of neck muscle stretching and posture exercises. Also, they were informed to perform exercises for 10 repetitions and 2 sets every day. Neck exercises included a variety of movements namely, neck rotations, neck extension, LS stretch, lateral neck stretch in standing and lying positions, standing chest stretch, shoulder roll, corner chest stretch and trapezius muscle stretch in lying position. In addition to exercises, they received written advice for posture correction and limitations during cell phone usage. The written postural advice consisted of instructions like taking a break after every 20 minutes of phone usage, maintaining the neck angle while using the phone and avoiding high repetitive typing and scrolling the screen for a long time. One month of the above-mentioned exercise program combined with postural correction depicted a significant reduction in neck pain and cervical lordosis and increased the cervical range of motion along with neck muscle strength.[23]

Also, certain studies have given evidence that intravenous glucocorticoids and epidural injections have helped reduce pain intensity and function in individuals who experience neck pain or mechanical neck disorders. Similarly, oral psychotropic agents like Cyclobenzaprine, Diazepam and Tetrazepam have been found to reduce pain and increase range of motion. Oral anti-inflammatories and oral analgesics were found to be ineffective in reducing neck pain intensity.[12,24] Also we know that neck pain is the most common symptom of Text Neck Syndrome and hence this above-mentioned evidence of medical management will show the same effect on these individuals in terms of pain, range of motion and function.

From the above-discussed studies, we can see that there are a major amount of limitations when it comes to treating this syndrome as a whole. The limitations found in the above-reviewed studies were unstructured treatment protocols, the duration of the therapy session to be given and the total regime of the entire treatment protocol. Future studies should consider meta-analysis on the Text Neck Syndrome and randomized control study designs with appropriate control groups focusing on all aspects of the treatment protocol, such as type, and dosage in terms of volume, intensity, and duration of the same.

Conclusion

The above-reviewed literature regarding Text Neck Syndrome and its effects and available treatment options revealed that it is definitely an upcoming concern for white-collar workers. When it comes to occupational stresses, the above-reviewed studies concluded that visual stress,

pain in the neck and upper back region, altered neurodynamics and tightness in neck muscles due to strain have been reported as the main concern. Also, prior screening of these workers is mandatory to see those who are at risk of developing the syndrome and who have already started to experience the symptoms. The symptom can result from due improper workstations, poor ergonomics, inadequate breaks and prolonged improper postures. For the treatment of this syndrome needs to be a combination of various treatment approaches which will focus on every aspect of the syndrome. Integrated postural training in such cases can be a beneficial approach in such individuals which will combine pain management and focus on increasing the cervical range of motion, strengthening, stretching, and postural correction. Physical therapy methods that include a patient-centered approach, home exercises and postural correction are the prime aspects of managing this syndrome at an early age to avoid the later consequences.

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Review Article

The impact of leadership on the psychosocial safety climate of organizations: A scoping review

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ABSTRACT

Growing evidence suggests that work-related psychological injuries are a concern worldwide. While previous efforts to address psychological injuries mainly focused on the individual level of analysis, the psychosocial safety climate (PSC) theory emphasizes the analysis and prevention of psychological injuries at the organizational level. While there is abundant evidence of the impact of leadership on other climate constructs, scant attention has been paid to the impact of leadership on PSC.

This study is a scoping review of the extant literature to determine the state of the discipline in relation to the impact of leadership on the psychosocial safety climate of organizations.

Three databases were searched, supplemented by a pearling exercise and Google Scholar searches, which yielded 14 studies that met the selection criteria. Our study shows that while much work has been done about the behavior of managers and organizational infrastructure to yield high levels of PSC, there is a dearth of studies on the impact of specific leadership styles on the PSC of organizations. We recommend further studies of leadership, especially the impact of post-heroic leadership styles, on the psychosocial safety climate of workplaces.

Keywords: psychosocial safety climate, leadership, management, psychological hazards, scoping review, workplace psychological injuries

Introduction

Globally there is growing evidence that psychological injuries are significant contributors to the burden of disease.[1] This injury type is also becoming more prevalent in the workplace and is predicted to be one of the major trends in occupational injuries.[2] This increasing trend has led to clarion calls from scholars to address this insidious phenomenon in the workplace.[3] While many jurisdictions now address physical and psychological safety in the workplace, the evidence suggests that safety authorities are yet to have the same success with psychological injuries as they have had with physical injuries.[4]

The prevalence of psychological injuries in the workplace also appears to be a universal problem, and finding solutions to this problem is therefore of interest to all.[5] One of the challenges that

practitioners and scholars however experience is that the true extent of psychological injuries in workplaces is not always known. While workplace safety regulators record psychological injuries, these statistics do not provide an accurate account of the epidemiology of psychological injuries as they are retrospective and only capture psychological hazards where official claims have been made. Access to workplaces is also often restricted, frustrating research into this phenomenon.[6] Owing to these shortcomings, studying psychological injuries at the individual level is likely not to provide a true representation of the problem.

In this review, we study psychological injuries through the psychosocial safety climate (PSC) theory. PSC is a climate construct that refers to an organization's priority for protecting workers' psychological health. This priority is reflected through enacted policies, procedures, and practices so that when workers view these collectively, they form an opinion of the organization's psychosocial safety climate.[7] This theory further posits that work conditions and worker health and engagement can be predicted when the psychosocial safety climate of an organization is known.[6,7] The level of PSC in an organization is said to indicate the extent to which management prioritizes psychological hazards in the workplace, so in an organization with a high PSC, management prioritizes psychological health more than in an organization with a low PSC.[6] The predictive nature of this construct allows it to serve as a lead indicator for psychological hazards as it predicts the likelihood of psychological injuries occurring in the workplace.[8] While many other climate constructs exist, psychosocial safety climate was tested and found to be distinctly different from other climate constructs, including safety climate, team psychological climate, and perceived organizational support and team climate.[9,10] The literature thus shows that psychosocial safety climate, as a newly introduced construct, is a valid construct for predicting psychological injuries.

As senior managers are the purveyors of policies, procedures and practices that determine the PSC of organizations, we posit that leadership directly impacts PSC. While there have been reviews on the impact of leadership on psychological safety (the individual-level construct), no such reviews have been done to scope the literature on the impact of leadership on psychosocial safety climate (the organization-level construct).

It is our view that a scoping review of the impact of leadership on the organization-level construct (PSC) is warranted as such a review will contribute to the field as it will set out what is known and identify the gaps in the literature. The purpose of this review is therefore to scope the extant literature to determine the antecedents of leadership for the promotion of a positive psychosocial safety climate in workplaces and in so doing advance the understanding of the field.

Methods

This scoping review follows the model proposed by Arksey and O'Malley (2005), with the exclusion of the optional 'consultation with stakeholders' step.[11] Searches were conducted in Scopus, Web of Science, Emerald Insight, and Google Scholar. This was followed by a pearling exercise to identify possible sources in the reference lists of the selected articles. Search terms used included psychosocial safety climate, PSC, leader*, manage*, with the Boolean operator AND and OR with truncation. A schematical representation of the search strategy is provided in Appendix A. The initial search yielded 107 results. After removing duplicate articles, titles and abstracts were reviewed, and 14 papers met the selection criteria.

Selection Criteria

A scoping review does not require the reviewer to consider the quality of selected papers and therefore allows for a much wider search to describe the breadth of the field.[11] Papers written in English and published after 2010, the year in which PSC was introduced into the literature, were included. As this literature review solely focuses on leadership's impact on the organizational-level construct, only studies that addressed PSC were included.

Results

The initial search yielded 107 results. After

removing duplicate articles, titles and abstracts were reviewed, and 14 papers met the selection criteria (see Table 1). We conducted a thematic analysis on the 14 papers in the data set and through the process of manual coding, identified four themes covered in the literature.[12] Our first theme is management support. Papers under this theme primarily focus on the behavior that leaders should display to bring about a positive psychosocial safety climate. Our second theme focuses on the hard and soft systems that should be in place for the promotion of PSC. We refer to this theme as infrastructure for PSC. Our third theme was the impact of PSC on managerial quality, and the final theme was that of leadership. While it may appear as if this theme is similar to our first theme, we believe leadership transcends management, and papers on this theme elucidate leadership styles that impact PSC.

Of the studies conducted, most occurred in the North Americas.[13-17] Three studies were conducted in Australia, with a further three in Europe.[18-23] While the aforementioned studies were conducted in high-income countries, two studies were conducted in an upper-middle-income country (Malaysia) and a lower-middle-income country (Vietnam).[25,26] The final paper by Dormann et al. (2019) can be described as an opinion piece.[27] Research conducted using quantitative methods dominates the dataset, with eight papers employing cross-sectional or longitudinal studies. Five papers presented research findings based on qualitative data or mixed-methods studies.[14,15,17,19,22]

Management Support

Management support has been studied the most in relation to PSC, with 57% (8/14) of the studies in the dataset reflecting this theme. PSC is determined by policies and procedures, and can therefore be described as what organizations say they do for the prevention of psychological stress.[24] PSC support is related to work engagement, through the mediating effect of management support. In other words, the PSC said to be applicable in a workplace brings about work engagement, but only if management offers demonstrated support for employees' psychological health.[26] While Yulita and colleagues' (2017) study was conducted in a cohort of Malaysian teachers, similar findings were made in an Australian study among ambulance staff across two states where it was found that PSC contributes to better mental health outcomes in workers.[19] In this study the behavior of managers, referred to as manager PSC, accounted for a higher variance in the mental health of workers (13%, for both well-being and common mental health disorders). This finding is in support of the finding of Yulita et al. (2017) of enacted PSC on the psychological health of workers. Interestingly Petrie et al. (2018) also studied observed management support and found that this construct did not have the same effect as manager PSC on mental health.[19] Observed manager support only resulted in a 10% variance in well-being and a 7% variance in symptoms of common mental disorders. These findings confirm the importance of manager support as a modifiable factor influencing employee mental health.

The difference between what organizations say they do (enacted PSC) and what is observed, observed management support, as noted by Petrie et al. (2018) can be problematic and was highlighted by Zinsser and Zinsser (2016).[14] They found that although management support for psychological hazards was demonstrated, workers' perceptions of management support differed from management support captured in the PSC-12, the validated scale for the measurement of PSC.[28] In this study, workers equated management support with the visibility of managers (p. 60).[14] This seems to support the finding of Petrie et al. (2018) that observed management support has a lesser effect on workers' mental health than manager PSC.[19] The work of Nguyen et al. (2017), however, seems to refute this.[25] These authors studied workers' perceptions of management support, known as Perceived Organizational Support (POS), and how it impacts the PSC of an organization. In this study, the impact of PSC and POS is studied on perceptions of bullying, employee well-being, and engagement. Nguyen et al. (2017) hypothesized that the overarching beliefs of support for mental

health in the workplace will influence perceptions of bullying, employee well-being and engagement.[25] This study appears to be the first study among a heterogeneous group of public sector workers and does not focus on one segment of the workforce only, as was the case with Zinsser and Zinsser (2016), Petrie et al. (2018), and Yulita et al. (2017).[14,19,26] The study of Nguyen et al. (2017) is, therefore, more generalizable.[25] Whether the results of this study would be applicable in a Western context remains to be seen, as it was conducted in Vietnam, where relationships in the workplace might be characterized by a high power distance culture and where acceptance of the hierarchy is more prevalent than in Western settings.[25] Geisler et al. (2019) went further and studied the impact of PSC on the retention of workers in a cohort of social workers.[22] While previous studies focused on the link between PSC and engagement, Geisler et al (2019) demonstrated that support from superiors and the social community at work was positively related to social workers' organizational commitment, compared with work engagement and job satisfaction. In other words, high levels of PSC improved the retention rate of the social workers in this study.[22]

While much of the emphasis of PSC is on workers, St-Hilaire and Gilbert (2019) also studied the effect of PSC, but in this study, the focus was on the mental health of managers.[15] They argue that managers' mental health problems frustrated their ability to implement preventative interventions for subordinates' mental health. Since managers are the conduits of PSC, that is, they are part of the mechanism to facilitate the organization's espoused PSC, this is a very interesting finding as it suggests that an organization's PSC should be such that it prevents psychological hazards among managers first, before it can prevent psychological hazards among workers. St-Hilaire and Gilbert's (2019) study makes a valuable contribution as they argue for a more systemic and collective view of workplace mental health, one in which managers' mental health is included. By doing so, the mental health of all, workers and managers, will be improved.[15]

While the focus of the aforementioned studies was on the mental health of workers, Mansour and Tremblay's (2018) work saw a shift in the impact of PSC on constructs external to the workplace, namely, work-family conflict and family–work conflict.[16] These authors measured two dimensions of work–family conflict, namely a time-based measure and a strain-based measure. To clarify: a time conflict occurs when the time spent on one role makes it difficult to fulfill the requirements of another role, while a strain-based conflict exists when the strain of functioning in one role makes it difficult to operate in another role. Mansour and Tremblay (2018) examined the specific contributions of PSC through family-supportive supervisor behavior (FSSB) to reduce both work-family conflict (WFC) and family–work conflict (FWC).[16] In this regard they examined whether the relationship between family-supportive supervisor behavior (FSSB) and work-family conflict (WFC) is weaker in organizations where the level of PSC is high, as opposed to those where the level of PSC is low. The findings of this study indicated that PSC is negatively and directly associated with work-–family conflict time (WFC time), family–work conflict time (FWC time), work-family conflict strain (WFC strain), and family-work conflict strain (FWC strain). In other words, in an organization with low levels of PSC, the time spent on work activities makes it difficult for workers to fulfill their family commitments. Also, in organizations with low PSC, the strain that workers endure makes it difficult to function effectively in their respective family roles.

The theme of management support was further explored by McLinton et al. (2018) in what these authors called high-risk and low-risk PSC environments.[20] They found that in teams with low-risk PSC, managers ensure workers feel valued and supported. In doing so, these managers are good role models for safety. In teams with high-risk PSC, workers view managers as not making their staff feel valued, providing support when requested, or exhibiting good role modeling (pp. 241-242).[20] Further elements that this study identified are the 'conflicting pressures'

that workers experience in high-risk PSC environments. As this research was conducted in a healthcare setting, this factor appears to be very industry-specific and therefore goes beyond the four factors identified in the PSC-12.[28] McLinton et al. (2018) found that in low-risk PSC teams, workloads are spread to not cause psychological harm.[20] In these teams, managers also create policies and procedures that are realistically achievable. In high-risk PSC teams, on the other hand, workers are forced to choose between workloads and working unsafely.

Infrastructure to Support PSC

When the literature is studied, the importance of organizational and environmental factors, and how they relate to psychosocial factors in the workplace, becomes evident. This theme focuses on the systems that should be in place to ensure positive PSC. In the dataset, Einarsen et al. (2019), for instance, studied the impact of human resources practices, perceived financial resources and organizational size on what they call 'ethical infrastructure against workplace bullying' (p. 673).[21] The construct of 'ethical infrastructure' in relation to workplace bullying appears very closely related to the psychosocial safety climate. For instance, they described ethical infrastructure against workplace bullying as referring to formal and informal systems in organizations that prevent organization members from committing acts of bullying. While formal ethical structures for the prevention of bullying consist of policy documents and compliance programs, informal systems are the subtle messages about the organization's values and behavior in relation to bullying. In this study, Einarsen et al. (2019) found that high-quality human resources practices, as operationalized by policies, procedures, and training, affected an ethical infrastructure against workplace bullying. That is, owing to the high-quality human resources practices, workers perceived the organization as having the infrastructure to protect them against bullying. Interestingly, the study also found that financial resources and organization size did not predict an ethical infrastructure against workplace bullying.[21]

Martin et al. (2018) also addressed the theme of infrastructure for positive PSC. In their qualitative study with managers who manage staff with mental health issues, they noted some aspects that demonstrate the lack of a good infrastructure for high PSC.[18] Managers noted that they often 'felt out of their depth', that they had limited knowledge and understanding of mental health issues, and that these challenges were exacerbated by a lack of organizational support and insufficient guidance about the appropriate actions to take (p. 452).[18] One of the tenets of high PSC is that psychological health is given the same attention as production goals.[7] The study by Martin et al. (2018) noted that 37.5% of participants found it challenging to balance the needs of employees with mental health issues with the commercial needs of the organization (p. 454).[18] This paper is the first to indicate that while managers are required to 'act appropriately' once psychological hazards are brought to their attention, the reality is that managers may need support in doing this.[18]

While the previous studies mentioned some elements of an infrastructure needed for high levels of PSC, the study of Teo et al.(2020) went beyond just one element of infrastructure for PSC and studied the impact of high-performance work systems (HPWS) on bullying in the workplace.[17] HPWS are integrated systems of HR practices that include selective staffing, self-managed teams, decentralized decision-making, extensive training, flexible job assignments, open communication, and performance-contingent compensation. The integration of these HR systems leads to knowledge resources that ultimately lead to increased financial performance.[29] Of particular interest is that the study of Teo et al. (2020) was the first to examine PSC as a moderator, finding PSC moderated the impact of HPWS on workplace bullying. [17] These authors found that the positive impact of HPWS practices was moderated by high levels of PSC. In other words, in a workplace characterized by high-performance work practices, the presence of a safe psychosocial work climate reduced exposure to workplace bullying and increased effective commitment.[17]

PSC's Impact on Management Quality

Whereas previous studies have focused on describing the impact of leadership behavior on employees' psychological health, Biron et al. (2018) aimed to identify the effect of PSC on managerial quality, with the psychosocial mechanisms in the managers' work environment explaining this association.[13] While at first glance St-Hilaire and Gilbert's (2019) study on the impact of PSC on the mental health of managers may seem to fall into this category, their study primarily focuses on managers as a subset of workers and does not address the quality of managers' practice.[15] Biron et al. (2018) is therefore the only study in the dataset that explores the relationship between PSC and the quality of managerial practice. Biron et al's (2018) work is all the more noteworthy for the following reason. Previous authors have already shown that espoused PSC and enacted PSC are important for employee psychological health and work engagement. [14,19,26] Biron et al. (2018), however, had a different direction from the previously mentioned studies. Their research found that PSC is temporally before managerial quality. They found that the relationship between PSC at T1 and managerial quality at T2 were stronger than the relationship between managerial quality at T1 and PSC at T2.[13] PSC thus has a strong influence on the quality of management in an organization. While their finding is interesting, they comment that management quality is also called leadership quality (p. 229).[13] The reader is therefore left to conclude that this finding is also applicable to leadership. We dispute this view and believe that management and leadership are two dissimilar constructs and findings applicable to management cannot simply be transferred to leadership without giving due consideration to the difference between the two constructs.[30]

Leadership

Dollard and Jain (2019) were the first to address the link between a specific leadership style and PSC.[23] In their work, these authors elucidated the relationship between ethical leadership and PSC and concluded that ethical leadership is required for effective occupational safety and health management, particularly as it relates to PSC. An interesting feature of Dollard and Jain's (2019) study is that they did not use any of the ethical leadership questionnaires to measure ethical leadership.[31] Instead, they used data from the Corruption Perception Index for 31 European countries and contrasted this with leadership for PSC, work conditions, and worker health and well-being. Dollard and Jain (2019) found that corruption had a 17% effect on PSC. In other words, countries with high levels of corruption have a lower level of PSC. An interesting observation in this study is Dollard and Jain's (2019) inference that ethical leadership is the leadership model that should prevent corrupt public values from impacting worker health.[23] This is not an unreasonable conclusion, as the basis of ethical leadership is the ethical behavior that leaders are required to have, including characteristics like honesty, trustworthiness, fair and principled decision-making, and care for people and the broader society.[32, 33] Similarly, it could also be argued that authentic leadership could be the leadership model that would prevent corrupt social values from entering the workplace, as this leadership style also draws on, and promotes an ethical climate.[34] Dollard and Jain's (2019) study only infers that ethical leadership could have a positive association with PSC, as the study did not measure the dyadic relationship between leaders and followers. [23]

In the selected studies, Dormann et al. (2019) also comments on leadership and its impact on PSC.[27] Of importance is Dormann et al's. (2019) assertion that scholars still do not know what leadership style is likely to build PSC (p. 442).[27] In the development of climate theories such as safety climate, researchers analyzed different leadership styles to determine the leadership style most likely to promote a certain organizational climate. It is therefore very interesting to note that Dormann et al. (2019) proposes a different development path for determining the relationship between leadership and PSC.[27] They argue that it would be possible to identify a construct empirically, which they call Leadership for Psychological Safety (LPS), and that this would provide a better

explanation for the emergence of PSC. While we do not challenge that LPS is possible to be identified, we are of the view that discarding the testing of contemporary leadership styles in relation to PSC is premature and should be investigated by researchers.

Table 1: Articles forming part of this review

	Authors	Publication	Focus of Study	Study Design	Variables Studied	Findings
1	Biron et al [13]	*International Journal of Workplace Health Management*	Impact of PSC on managerial quality.	Intervention study, followed by longitudinal study (*N*=192)	Managerial quality is affected by managers' own psychosocial work factors and is in turn affected by the organizational PSC.	Job control was found to be a significant mediator of the relationship between PSC and managerial quality. PSC is positively related to managerial quality. Job control partially mediated the effect of PSC on managerial quality.
2	Zinsser and Zinsser [14]	*Research in Human Development*	Explores the extent to which PSC exists in a preschool context.	Focus-group interviews.	Explores the extent to which PSC applies to preschool contexts.	Examples of management practices and policies and procedures that reflect a degree of valuing of teacher well-being and psychological safety are presented. The study also highlighted that participants' understanding of management support differed from that contained in the PSC-12.
3	St-Hilaire and Gilbert [15]	*Organizational Dynamics*	The mental health of managers with an emphasis on what leaders should know to manage the mental health of managers.	Interviews.	Emphasizes what leaders should know to help with the mental health of managers.	Mental health support for managers who are required to implement leadership policies is lacking. Argues for a more systemic and collective view of workplace mental health, one in which managers' mental health is included. By doing so, the mental health of all, workers and managers, will be improved.
4	Mansour and Tremblay [16]	*Personnel Review*	Tests the direct and indirect effects of manager PSC on work-family conflict.	Cross-sectional. (*N*=562)	Direct and indirect effects of PSC on WFC/FWC-time and WFC/FWC-strain via family-supportive supervisor behavior (FSSB).	When senior managers value employees' psychosocial safety, consider it a priority, act quickly to correct problems affecting employees' psychological well-being and put in place a good system of communication at all levels, a favorable effect on the work environment is created. Therefore, managers and supervisors should show more support to workers' family issues and encourage workers to talk about their difficulties at work or/and at home. This support can make workers more resourceful and therefore more capable of successfully balancing work and family.
5	Teo et al [17]	*International Journal of Hospitality Management*	Adoption of high-performance work systems (HPWS) to eliminate workplace bullying.	Longitudinal (*N*=467 and *N*=203)	The role of HPWS is examined in enhancing the commitment of employees.	High-performance work systems play a key role, together with psychosocial safety climate (PSC) and perceived organizational support (POS), in preventing employee exposure to workplace bullying in the hospitality sector.
6	Martin et al [18]	*International Journal of Workplace Health Management*	Challenges faced by managers who are required to manage employees with mental health issues.	Semi-structured interviews.	Engagement of employees. For PSC to be high, policies should include support for managers.	Understanding managers' experience is critical to the successful implementation of human resources policies regarding employee health and well-being. Implementation of human resources policies for mental health should consider support for managers as part of the implementation strategy.
7	Petrie et al [19]	*PLoS ONE*	Manager support in determining the mental health of ambulance personnel.	Cross-sectional (*N*=1622)	Items to determine manager behavior were developed by the authors.	MB accounted for a 10% variance in well-being and a 7% variance in symptoms of common mental health disorders, while manager psychosocial safety climate accounted for a larger proportion (13%) of both employee mental health outcomes. Findings confirm the importance of manager support as a potentially modifiable factor influencing employee mental health.

	Authors	Publication	Focus of Study	Study Design	Variables Studied	Findings
8	McLinton et al [20]	*Safety Science*	How PSC theory manifests in healthcare, by studying the factors that shape PSC in healthcare.	Mixed methods (*N*=27)	Leadership style and manager support.	Findings suggest that PSC theory might at a broad level apply to a wide range of industries, such as through key themes like 'Communication' and 'Group Expectations'. Concerning leadership, improving the frontline-to-management disconnect is highlighted as a source for PSC improvement.
9	Einarsen et al [21]	*Personnel Review*	Organization size, financial resources and high-quality human resources management practices on workplace bullying.	Cross-sectional, (*N*=429)	How the mentioned variables predict the existence of a well-developed ethical infrastructure against workplace bullying.	High-quality human resources management created an ethical infrastructure for the prevention of bullying. Organizational size and financial resources did not predict an ethical infrastructure for the prevention of bullying.
10	Geisler et al [22]	*Human Services Organizations: Management, & Governance*	Impact of PSC, job demands, job resources and assessment for quality of work related to work engagement.	Cross-sectional. (*N*=831)	How (PSC), job demands, job resources and assessments for quality of work related to social workers' work engagement, job satisfaction, and organizational commitment.	To improve the understanding of factors contributing to the retention of social workers by investigating the relationship between specific work environmental factors and positive work attitudes. Quality of work was strongly related to job demand, job resources and assessment for quality of work. PSC was found to be related to social workers' job satisfaction.
11	Dollard and Jain [23]	*Psychosocial Safety Climate: A New Work Stress Theory* (edited book)	Compared the corruption perception index of 31 European countries against PSC and employee wellness.	Interviews	Corruption and PSC.	Corruption of public values undermines leadership for psychosocial safety climate and suggests that ethical leadership is required to improve PSC.
12	Nguyen et al [25]	*Public Management Review*	Existence of PSC in the public sector.	Cross-sectional *N*=274	To study PSC and its impact on the public sector.	The impact of PSC and perceived organizational support (POS) is studied on perceptions of bullying, employee engagement and well-being. Overarching beliefs of support for mental health in the workplace influence perceptions of bullying, employee well-being and engagement.
13	Yulita et al [26]	*Safety Science*	Explores organizational level PSC (also known as espoused PSC) and enacted PSC (operationalized as management support) and their relationship with worker psychological health and motivation.	Diary questionnaires	The climate created by PSC brings about an environment where managers provide support. Management support also mediates engagement.	Organizational PSC was positively related to daily enacted managerial support. For work engagement, espoused PSC was related to work engagement through enacted managerial support. For emotional exhaustion, enacted managerial support moderated the negative relationship between espoused PSC and daily emotional exhaustion. The beneficial effects of espoused PSC were evident when high levels aligned with high levels of enacted managerial support. PSC acts as a safety signal. When high-espoused PSC is coupled with repeated, unequivocal and stable managerial support, employees feel safe in protecting themselves from emotional exhaustion in their environment
14	Dormann et al [27]	*Psychosocial Safety Climate: A New Work Stress Theory* (edited book)	PSC Review	Summary of chapters in an edited book	Provides a summary of all chapters in the edited book and an opinion on the direction of the study of leadership in relation to PSC.	Suggests a new leadership construct, Leadership for Psychological Safety (LPS) that would better facilitate PSC in organizations.

Discussion

This scoping review set out to determine what is already known in terms of management and leadership concerning PSC. While some authors treat management and leadership as interchangeable constructs, we are of the view that these are separate constructs.[30] It was interesting to note that the search yielded more articles related to the impact of management practices on PSC than articles related to the impact of leadership on PSC, demonstrating that this is an under-researched topic.

Concerning management, the review has identified the support that managers should provide to workers as critical for the establishment of PSC. The PSC that is stated by an organization is related to engagement, but only if managers offer demonstrated support to workers. Similarly, management support was found to account for a higher variance in the mental health of workers. We would argue that management support can be demonstrated under various leadership styles. Transformational leadership, for instance, identifies organizational needs and employee safety needs. This leadership style stimulates and satisfies the higher needs of workers to achieve organizational goals.[35] This leadership style was found to contribute to the establishment of a safety culture. Since PSC originated from the safety culture study field, we are of the view that it would be prudent to explore the impact of this leadership style on this construct.[7]

One study found that managers' mental health thwarts their ability to implement mental health interventions. Support for managers' mental health is therefore of utmost importance as managers are often responsible for the implementation of PSC interventions. A smaller proportion of the selected studies, 21% (3/14), related to the theme of infrastructure to support PSC. In this regard, high-quality human resource practices were found to engender an ethical infrastructure for the prevention of bullying. The size and financial resources of an organization were not found to contribute to the PSC of an organization. The lack of infrastructure was also highlighted concerning managers' providing support to staff with mental health issues. In this regard, infrastructural issues hindering managers from providing support to staff include the lack of information to deal with mental health issues adequately and the lack of organizational support. One paper has gone beyond single elements of infrastructure and has studied the impact of high-performance work systems (HPWS) on bullying. Within an environment of HPWS, PSC was found to reduce the impact of bullying. While this result is promising, especially given the fact that many organizations strive to implement some form of HPWS, this study was limited to the hospitality industry in the USA.[17] As psychological injuries in the workplace appears to be a universal problem, the literature will therefore benefit from more empirical studies to further test the association of HPWS with psychological hazards, like bullying and burnout. [5]

An interesting observation in the selected studies was the fact that researchers have also studied the impact of PSC on managerial quality and found that PSC improved managerial quality. In our view, the authors of this study, however, erroneously concluded that this is also true for leadership.[13] Earlier in this review we noted the difference between management and leadership, and would therefore argue that further research is needed to determine the impact of PSC on leadership. Of the studies that solely focused on leadership's impact on PSC, the dataset only contains one empirical study and one opinion piece that relate to leadership and PSC. Dollard and Jain (2019), in a study of 31 European countries, found that corruption had a significant effect on PSC. [23] This they established by studying the link between the corruption levels in European countries and the PSC at an organizational level in these countries. Their study found that PSC played a significant role in preventing the corruption of public values from infiltrating organizations.[23] Dollard and Jain (2019) thus concluded that ethical leadership is likely to be the leadership model that will prevent corruption from infiltrating organizations. This study did not specifically test ethical leadership at the organizational level and one could argue that

other leadership styles, like authentic leadership, also have an ethical foundation and could therefore contribute to higher levels of PSC. The empirical testing of different leadership models, therefore, seems to be a natural progression in the testing of a psychosocial safety climate.

Lastly, Dormann et al. (2019) acknowledge the lacunae in relation to studies that investigate the impact of leadership on PSC. These authors, however, go further and claim that notions of transformational leadership may not contribute to PSC, and suggest that a different leadership style, leadership for psychological safety (LPS), could be identified empirically and that this leadership style is likely to contribute to PSC.[27] While we do not disagree with this assertion, we believe that, as with the development of safety climate, various contemporary leadership styles should be explored concerning PSC to advance the field.

Limitations

The limited number of papers included in the data set was surprising, especially when compared with leadership studies conducted on psychological safety, at the individual level of analysis. By limiting the date range to publications from 2010 it is possible that sources that are aligned with the idea of PSC, but do not use that particular term, might have been missed. Searching all databases is not possible, and we acknowledge that by limiting our search it is likely that some literature may have been omitted. To mitigate this, a pearling exercise was conducted and we could not identify other sources. While the results were surprising, as only 14 papers satisfied the selection criteria, it is noted that all papers in the dataset were peer-reviewed. It could therefore be argued that papers in the dataset are of high quality, as they exclude grey literature not subjected to reviewer scrutiny.[36]

We also acknowledge the debate among scholars about conceptualizing organizational climate as an individual-level construct (psychological safety), or a group-level construct (which includes PSC). For organizational-level constructs to be measured, respondents' scores need to be aggregated to form the group-level construct. With the aggregation of respondents' scores, there is an opportunity for variability that exists within groups not to be reflected in the overall score attributed to the organizational climate construct.[37] Recent developments in the literature however provide support for studying organizational climate at the group level. [38]

Conclusion

The literature has shown that PSC holds promise for the promotion of psychological health in organizations. As PSC is promoted by the leadership of organizations, the impact of leadership on this construct is therefore an area of research that requires further study. This review has shown that there are few research papers on leadership, with most of the work conducted in management support and some on the infrastructure required to promote PSC. Concerning leadership, however, there appears to be a dearth of information on the dyadic relationship between followers and leaders in relation to PSC. Before the final review of this paper, one article on the impact of leadership and PSC was published: 'How Psychosocial Safety Climate (PSC) Gets Stronger Over Time: A First Look At Leadership And Climate Strength'. As the title suggests, this study is the first to give insights into how one of the contemporary leadership styles (transformational leadership) impacts PSC. In this work, the authors introduce a new construct, PSC leadership, into the literature, and through a longitudinal study conclude that transformational leadership has a smaller impact on PSC.[39]

Questions relating to other contemporary leadership styles and their impact on PSC remain unanswered. Our view is therefore that further investigation of the different leadership theories, in relation to PSC, will benefit the development of the field. This review can potentially serve as an impetus for further studies to test the dyadic relationship between leaders and followers to explain how leadership impacts the psychosocial safety climate in organizations.

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Appendix A: Schematical representation of the search