2024

ISSN 1015-5589, Vol. XXXIII, No. 1

World Safety Journal

In This Edition

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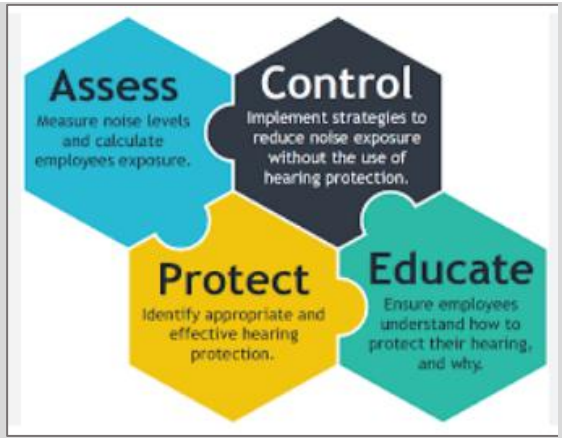

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Table of Contents

Employee Noise Exposure and Octave Band Analysis in a Manufacturing Setting
by Darren Gieseck, William Brazile, Margaret Gutilla, Daniel Autenrieth, and David Gilkey ..... Pages 1-24

Evaluating Ergonomic Risk for Nurses During Patient Transfers: A Pilot Study
by Madelyn Mariegard, and David Gilkey ..... Pages 25-34

Overcoming Hurdles: The Crucial Obstacles in Cultivating Corporate Safety Culture!
by Harbans Lal and E.M. Choueiri ..... Pages 35-47

LGBTQ+ Realities: A Comprehensive Exploration of Challenges, Opportunities, and International Perspectives in the MENA Region
by E.M. Choueiri ..... Pages 48-56

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World Safety Journal

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Employee Noise Exposure and Octave Band Analysis in a Manufacturing Setting

Darren Gieseck, MS[1], William Brazile, Ph.D., CIH, CSP[1], Margaret Gutilla, DrPH[2], Daniel Autenrieth, Ph.D., CIH, CSP[3], and David Gilkey, D.C., Ph.D., CPE, CSP[3,*]

[1] *Department of Environmental and Radiological Health Sciences, Colorado State University, 350 W Lake St. Suite 122A, Fort Collins, CO 80523*

[2] *Department of Health and Exercise Science, Colorado State University, Sage Hall Room 100A, Fort Collins, CO 80523*

3 Department of Safety, Health and Industrial Hygiene, Montana Technological University, 1300 West Park St, Butte, Montana 59701

KEYWORDS

Noise
Occupational Exposure
Industrial Setting
Can Manufacture

ABSTRACT

Worker exposure to hazardous levels of noise continues to be a concern in United States (US) industries. The National Institute for Occupational Safety and Health (NIOSH) has estimated that twenty-two million US workers are exposed to hazardous levels of noise each year, increasing the risk for noise-induced hearing loss (NIHL). One industry sector of concern for worker exposure to noise is metal can manufacturing because of the types and number of machines used in the production areas. To help further characterize the risk NIHL in the metal can manufacturing sector, a comprehensive noise evaluation was performed at a manufacturing site that produced aluminum metal cans. The purpose of this study was to (1) determine if workers in a metal can manufacturing facility were overexposed to hazardous levels of noise that could potentially result in NIHL; (2) measure and evaluate the machinery frequencies greater than 85 dBC to which employees were exposed; and (3) provide sound mitigation recommendations to the facility's safety team.

1. INTRODUCTION AND BACKGROUND

Occupational noise exposure has been well documented in the literature and is regulated in US industries to help reduce the incidence of NIHL. However, over exposure to hazardous levels of noise still occurs in many industries across the US. The NIOSH estimates that 22 million US workers are exposed to hazardous noise levels at work each year, defined as noise exposures exceeding 85 dBA (CDC, June 2023). Data collected from the 2014 National Health Interview Survey estimated that 25% of US workers have a history of hazardous noise exposure with 14% of workers being exposed the previous year (Kerns, et al., 2018). Specifically considering manufacturing workers, exposure was higher with 46% of manufacturing workers being exposed to hazardous levels of noise (CDC, June 2023).

This study focused on the noise exposures at a metal can manufacturing facility that created aluminum metal cans in various shapes and sizes. The Standard Industrial Classification (SIC) code associated

* *Corresponding Author*: dgilkey@mtech.edu

https://doi.org/10.5281/zenodo.10911655

with this industry sector is 3411 and the North American Industry Classification System (NAICS) code is 332431. Equipment and background noise were evaluated using a sound level meter/octave band analyzer (SLM/OBA), and a 1/3 octave band analysis was conducted to measure and evaluate the frequencies associated with noise sources that were greater than 85 dBC. Additionally, individual noise exposures for employees were obtained using personal noise dosimeters with 1/1 octave band capabilities. Each of the personal samples included A- and Z-weighted assessments which provided insight for sound mitigation and hearing conservation recommendations.

The personal noise exposure data were evaluated against occupational noise exposure regulations and/or standards including the OSHA AL and PEL, the ACGIH TLV and the NIOSH REL to determine if workers were overexposed to noise. Of the samples collected, 100% of employees were overexposed to noise above the OSHA PEL and AL, the ACGIH TLV and NIOSH REL. To provide statistical support of these findings, a 95% confidence interval was calculated for each occupational exposure standard to provide a range of values that have a 95% chance of capturing the true average noise exposure of the total population. Further, upper and lower prediction limits were calculated to provide a range of values that have a 95% chance of capturing a future individual sample within the total population. Following the completion of the study, all associated recommendations were provided to the facility's corporate safety team to reduce the risk of noise-induced hearing loss (NIHL) with the appropriate interventions and control methods.

1.1 Human Sound Perception

When discussing auditory perceptions, human hearing is typically described as having the ability to interpret sound frequencies in the range of 20 Hz - 20,000 Hz (Kryter, 1985). Notably, frequencies around 4,000 Hz are amplified and are directly related to an increased risk of developing NIHL. Workers exposed to continuous noise greater than 85 dBA are at an increased risk of developing NIHL in industrial settings. To evaluate the potential for over exposure to noise and the associated frequencies, it is customary to describe the spectra of sound in accordance with the following spectrum frequency bands: one Hz wide, one-third wide, and one octave wide (Kryter, 1985).

1.2 Noise-Induced Hearing Loss

Conductive hearing loss and sensory hearing loss are considered the two types of damage that can affect an individual's ability to hear normally. Conductive hearing loss results from significant and rapid changes in local air pressure, physical penetrations of the ear drum, or trauma to the head. However, these hearing loss impacts are typically reversible through surgical intervention and are not a primary concern for chronic loss of hearing sensitivity. In contrast, sensory hearing loss results from noise exposure and is typically considered irreversible due to neural or inner ear damage. The loss of stereocilia and supporting cells; as well as the fusion of cilia, is a progressive process that results in the need for high acoustic energies and increased cochlea function to interpret the sound in the environment. Since damage to the cochlea cannot be measured directly to determine if an individual has developed these physiological changes, NIHL is assessed by measuring auditory sensitivity through absolute threshold testing (Berger et. al., 2003).

1.3 Physiological and Psychological Impacts of Noise

While the physiological impacts to the ear are often described when discussing noise and worker exposures, it is also important to recognize the significant impacts to other parts of the body and the psychological health of workers. Firstly, the social interaction between workers suffers due to the masking of verbal sounds in hearing impaired individuals. This results in stress from changes in interpersonal judgements and increased annoyance with the aversive work environment (Jones, 1981).

https://doi.org/10.5281/zenodo.10911655

Likewise, working in an environment with continuous noise at 80 dBA or greater is correlated with increased levels of stress (Fouladi et al., 2012). In addition to increased levels of stress, employees may experience chronic changes in sleep and cardiac functions. Employees that are exposed to sound greater than 75 dBA continuously for eight hours can experience changes in their nocturnal sleep architecture and heart rate (Gitajali and Anath, 2003). Moreover, employees exposed to noise greater than 90 dBA have been associated with an increased risk of hypertension and tachycardia across all sound frequencies (Said et al., 2022). Fourteen percent of US workers are likely able to attribute their work-related hypertension to noise exposure with 9% of workers also developing elevated levels of cholesterol (Kerns et al., 2018). However, these findings are typically associated with a stressful work environment and the type of work that the employee is performing is a significant factor when discussing noise exposures and cardiac impacts (Melamed et al., 1999).

1.4 Manufacturing Worker Noise Exposure

Manufacturing processes can produce a variety of sounds that result in significant workplace noise. As a result, manufacturing production employees are at an increased risk for NIHL. For example, Subramaniam et al. (2018) found that employees working in a metal manufacturing area were exposed to average noise measurements of 103.27 dBA from machinery, well above what is considered a "safe" level of noise. As a result, the authors recommended hearing protection and minimizing time in this environment to reduce the risk of NIHL. The potential for high levels of noise in manufacturing settings is concerning to the industry sector in the current study because aluminum manufacturing workers are at an increased risk of developing NIHL when exposed to continuous noise as low as 85 dBA (Cantley et al., 2015). Rodriguez et al., (2012) found that employees working in the aluminum can manufacturing industry are at a greater risk of noise over exposure. More specifically, the authors found that employees working near the printer, lacquer spray, and necker machines used for aluminum can manufacturing were at an increased risk for hazardous noise exposure with potential decibel levels reaching 100 dBA or greater.

1.5 Noise Control Methods

Scientific minds have inquired into the nature and control of sound over millennia. Each of these individuals provided a building block for our understanding of sound as pressure changes and our knowledge for controlling these physical phenomena. Noise control can take place at the source of the noise, along the path of the noise, and/or by protecting the receiver (Bell, 1982). Further, noise is physically controlled by absorption, blocking, and/or cancelling of the noise along the previously described paths. This can be done by implementing shields, sound mitigating materials, and/or elimination of associated frequencies through engineering methods (Bell, 1982). An example of an early attempt at controlling noise comes from Wallace Clement. Around the year 1900, Wallace completed a series of research papers on sound reverberation in various rooms which are credited for being a starting point for architectural acoustics (Barron, 2003). Later research in the 1920's provided additional insight into the hazards associated with loudness and the human ear. As a result of this information, efforts to implement noise controls began in airplanes, automobiles, and buildings. Additionally, the scientific community was encouraged to increase research efforts in sound absorption by porous acoustic materials. These research efforts were again increased during World War II in an effort to improve communication among military personnel and research into noise control continued after the war had ended (Barron, 2003).

As of 2023, there has been a great amount of sound research which has provided a better understanding of how sound functions and the subsequent methods for best controlling noise. For example, impact noise in industry can be reduced by extending a punch press's cycle time and decreasing the peak

impact force (Bies et al., 2018). This is important because it demonstrates that when a process minimizes the "time rate" of change-of-force, there is an associated decrease in noise production. Additionally, it is now understood that minimizing the acoustic radiation efficiency (ARE) of a surface will decrease the vibration of the material and the associated noise. This can be applied to industry by replacing materials with high ARE, such as metal panels, with woven or perforated panels. Furthermore, it is known that the material type needed to absorb a given sound is dependent on the frequency of that sound. While a significant amount of research has been performed regarding various material types, the important aspect of choosing a material suitable for the environment is obtaining an acceptable sound absorption co-efficient based on the frequencies present in the area (Bies et al., 2018). Bies and colleagues (2018) suggested that implementation of engineering design changes at the beginning stages of development is the best way to minimize noise exposures. Technical improvements in noise mitigation through engineering methods have shown diminishments in noise by 20 dB. Despite achieving a 20 dB decrease in with the use of hearing protection, it has also been found that noise reduction levels drastically decrease by approximately 9 dB with improper instruction on the use of personal protective equipment (Verbeek et al., 2017).

OSHA requires that employees approach noise exposure in a preventative manner by implementing a hearing conservation program (HCP) when employees are exposed to noise in excess of 85 dBA as an eight-hour time weighted average (OSHA, 2008). The OSHA Occupational Noise Exposure standard requires employers to conduct annual audiometric testing, which meets American National Standards Institute (ANSI) SC-1969 specifications, on employees and provide the option of hearing protection at 85 dBA, but to enforce the use of hearing protection at 90 dBA (OSHA, 2008). Additionally, the OSHA Technical Manual (2022) requires an exchange rate of 5 dB, threshold of 80 dB and criterion level of 90 dB when sampling for employee noise exposures in assessing for compliance with the noise AL (CDC, June 2023).

Unfortunately, it has been found that Hearing Conservation Programs (HCP) alone do not effectively decrease the risk of hearing loss and noise should be controlled following the hierarchy of controls similar to any other hazard (Suter, 2012). The hierarchy of controls has five levels of actions aimed at reducing or eliminating noise hazards. The preferred order of action aimed at maximizing effective control begins with elimination of the noise source and is followed by substitution, engineering controls, administrative controls, and finally personal protective equipment (CDC, 2023). Since it has been shown that employees working in environments with noise levels at 85 dBA or lower have a smaller statistical chance of developing NIHL, it is suggested that the controls aim to reduce noise levels below this value through the hierarchy of controls and regular maintenance for better employee health outcomes (Verbeek et al., 2017).

Hearing protection is a form of personal protective equipment (PPE) and is considered a last line of defense for noise control. Earplugs and earmuffs are common examples of PPE used in occupational settings. Unfortunately, noise does persist in modern work environments and hearing protection is often used first as noise control in industries (Berger, 1993). The decibel reduction in noise afforded by hearing protection is described by the Noise Reduction Rating (NRR). The NRR is the standard used to determine effective noise reduction by assigning a standardized value to various forms of hearing protection (Berger, 1993). However, it has been found that 50% or greater derating should be applied to all forms of hearing protection using an NRR due to inherent inaccuracies in practical applications (Berger, 1993). This reduction in the rating is reinforced by OSHA requirements of a 50% reduction for all hearing protection using an NRR (OSHA, 2008). Additionally, it is recommended that employees be fitted with a combination of earplugs and earmuffs when exposed to noise greater than 95 dB (Berger, 1993). By combining these two forms of hearing protection, OSHA allows for 5 dB to be added to the NRR after the 50% adjustment, representing a significant increase in protection (Berger, 1993).

https://doi.org/10.5281/zenodo.10911655

However, it is also important to not overprotect workers to avoid disruption to communication. Overprotecting workers in industrial settings, as highlighted by Neitzel et al. (2019) in a study on metal manufacturing workers, can have unintended consequences. While worker safety is paramount, excessive overprotection can disrupt communication and compromise their ability to carry out tasks effectively. The study revealed that 86% of metal manufacturing workers were overprotected, underscores the importance of finding a balance between protecting employees from excessive noise exposure and ensuring they can still communicate and function optimally (Neitzel et al., 2019). Adhering to guidelines such as those set by the British Standards Institute to maintain attenuated exposure levels above 70 dBC is crucial in striking this balance, allowing workers to remain safe without hindering their productivity and effective communication on the job.

1.6 Industry Background

The Bureau of Labor Statistics (BLS) categorizes the industry sector in the current study under Fabricated Metal Production Manufacturing with the corresponding NAICS 332. Approximately 58,000 employees worked as cutting, punching, and machine press machine setters and operators (BLS, 2022). Additionally, 106,000 employees held the title of machinist and 67,000 were first line supervisors or managers (BLS, 2022). Ultimately, there were 3.6 total recordable cases per 100 full-time workers with 2 involving days away from work, job restriction, or transfer (BLS, 2022). Of the 14,500 hearing loss illness cases in the private industry sector during 2019, there were 1,400 cases attributed to fabricated metal product manufacturing (BLS, 2019).

1.7 Occupational Noise Exposure Limits

OSHA mandates a noise PEL (or criterion level) of 90 dBA as an 8-hour time weighted average (TWA) using an exchange rate of 5 dB and a threshold of 90 dB. An exchange rate is the number of decibels increase that relates to a halving of the exposure time permitted and a threshold is the level of noise below which data are not accumulated (Larson, 2023). In addition, OSHA has an impulsive or impact noise limit at 140 dB peak sound pressure level (OSHA, 2008). To better protect employees from NIHL, OSHA published the Hearing Conservation Amendment (HCA) in 1981 to establish a general industry action level of 85 dBA as an 8-hour TWA with a criterion level of 90 dBA, an exchange rate of 5 dB, and a threshold of 85 dBA (OSHA, 2008). If an employee's exposure exceeds the AL of 85 dBA, the employer is required to enroll the employee in an HCP. The ACGIH recommends a TLV of 85 dBA as an eight-hour TWA, with an exchange rate of 3 dB, and a threshold of 80 dB (ACGIH, 2023). Recommendations for annual audiometric testing, training, and following NRR guidelines were provided by the ACGIH similar to OSHA.

The NIOSH noise REL is 85 dBA as an 8-hour TWA (NIOSH, 1998). Additionally, it is recommended to have an exchange rate of 3 dB, threshold of 80 dB and criterion level of 85 dB when sampling for employee noise exposures (NIOSH, 1998). These sampling criteria were recommended since the 40-year lifetime risk of NIHL is reduced from 25% at 90-dBA to 8% at 85 dBA (NIOSH, 1998). NIOSH writes that a noise exposure less than 85 dB can be accomplished by understanding noise exposure, eliminating or reducing noise, implementing engineering controls, using administrative controls, providing hearing protection, and finally (re)evaluation and documentation (NIOSH, 1998).

1.8 Study Purpose

The purpose of this study was to (1) determine if workers in a metal can manufacturing facility were overexposed to hazardous levels of noise that could potentially result in NIHL; (2) measure and evaluate the machinery frequencies greater than 85 dBC to which employees were exposed; and (3) provide sound mitigation recommendations to the facility's safety team. By measuring personal noise

https://doi.org/10.5281/zenodo.10911655

exposures, taking area noise measurements, and performing octave band evaluations, noise mitigation recommendations; including, but not limited to, noise reduction materials and hearing conservation protocols could be provided to the corporate safety team.

1.9 Hypothesis and Research Questions

The research team was guided by the following hypotheses:

H_0 1:	*The noise from the metal can manufacturing equipment is less than 85 dBA at one meter.*
H_a 1:	*The noise from the metal can manufacturing equipment is greater than or equal to 85 dBA at one meter.*

This hypothesis was tested by measuring noise emissions from machinery, equipment, and processes in the production areas at a distance of one meter.

H_0 2:	*Production employees are not exposed to a noise level that exceeds published occupational exposure limits.*
H_a 2:	*Production employees are exposed to noise exceeding published occupational exposure limits.*

This hypothesis was tested by taking personal noise dosimetry measurements and comparing the results to published occupational noise exposure limits.

1.10 Scope

The participants in this study included production employees in a metal can manufacturing facility located in Colorado, US. The facility had a total of 350 employees with approximately 84 employees, divided over four shifts, working in the production areas termed “Aluminum Bottle” and “Screw Lid Can”. Of these 84 production employees, 30 that were working the 6am-6pm shift were selected over the course of five days for personal noise sampling. Additionally, a 1/3 octave band analysis was performed on machinery in the areas of concern to determine the C-weighted noise frequencies associated with the production processes to be used in conjunction with acoustic studies previously obtained by the facility.

2. MATERIALS AND METHODS

2.1 Site Selection

The current study was performed at an aluminum manufacturing facility in Colorado. The site was chosen based on personal communication with a facility safety manager who had identified elevated noise levels. The specific areas in the facility identified for the study were chosen based on area noise measurements taken by the researcher during a normal-working hours walkthrough. Two production areas were noted as having the greatest concern for hazardous noise exposure, the Aluminum Bottle and Screw Lid Can areas where real-time A-weighted spot measurements indicated noise levels greater than 100 dBA.

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2.2 Facility Description

The primary purpose of the facility was aluminum can production of various sizes and shapes. While all specifics of the can-manufacturing process will not be discussed in this paper, general operations associated with the equipment of concern and the employees sampled will be described. Since the noise monitoring campaign included two production areas, the following descriptions will be categorized into the Aluminum Bottle and Screw Lid Can production areas.

2.3 Aluminum Bottle Process Description

The Aluminum Bottle area end product is aluminum cans with a label, but without a top. The production process is initiated by placing aluminum coils on an uncoiler with lubrication. The aluminum is then fed into the Minster (DAC-150-24125) Cupper Press which creates cups that are dispersed into a series of eight 5500 Canmakers (741.S). The cans are trimmed, and base coats are applied as indicated. After being moved through the production room on conveyors, the cans are decorated by the "Decorator" and given an internal coating at a series of eight Stolle Machines (1S206802). Finally, the cans are transported to the twelve Bottle Neckers (A30-030) before flanging, final inspections, and palletization.

During the initial area noise evaluation, it was noted that all steps of the Aluminum Bottle process produced intermittent real-time noise measurements greater than 100 dBA. Since there was indication that the entire process contributed hazardous noise levels in this work area, employees working in the Aluminum Bottle area were solicited for participation in the study. In addition, noise measurements of the specific production machinery involved in the Aluminum Bottle process were taken.

2.4 Screw Lid Can Process Description

The Screw Lid Can area end product is a finished cap for the top of their respective cans. As with the Aluminum Bottle process, the Screw Lid Can process is initiated by placing aluminum coils on an uncoiler with lubrication. The aluminum is then fed into two Minster (P2H-160-29708) shell presses followed by curling and compound sealing. After being moved through the production room on a series of conveyors, the cap enters a liner oven for heated application of an interior shell. Lastly, the cap tabs are finalized, and the caps are palletized for later use.

During the initial area noise evaluation, it was noted that the areas near the two Minster presses had real-time noise measurements greater than 100 dBA. The remainder of the process was evaluated for area noise but found to have relatively lower noise levels. Therefore, workers performing tasks near the Minster presses were the focus of the Screw Lid Can area and they were solicited for participation in the study.

2.5 Production Machinery

While additional machinery such as conveyors were present in the production areas, not all of these machines were measured for noise emission. A list of the major machinery that was evaluated during the study for noise emission is provided in Table 1.

https://doi.org/10.5281/zenodo.10911655

Table 1. Machinery Evaluated for Noise Emissions

Machinery	Serial Number
Minster Shell Press	P2H-160-29708
Minster/Sequa Cupper Press	DAC-150-
5500 Canmaker	741.S
Decorator	Unknown
Bottle Necker	A30-030
Stolle Machines	1S206802

A TSI QUEST (Shoreview, MN, USA) sound level meter was used to take average C- weighted sound pressure level (SPL) measurements of the production machinery at a distance of one meter. A 1/3 octave band analysis was included in the data collection and was used for noise frequency categorization and noise damping recommendations. All noise samples were uploaded to the G4 LD Utility software (ver. 4.9.1) and later Microsoft Excel (ver. 16.77.1) for statistical analysis and table/graph creation.

2.6 Employee Recruitment

During the time this study took place, 84 employees worked in the Aluminum Bottle and Screw Lid Can production areas. The Aluminum Bottle area had 13 employees working per shift over four shifts (52 workers) and the Screw Lid Can area had 8 employees working per shift over four shifts (32 workers). Employees working the 6am-6pm shift were solicited for the study over the course of five samplings days. Each day, 4 volunteer subjects were selected from the Aluminum Bottle area and 2 volunteer subjects were selected from the Screw Lid Can area for a total of 20 Aluminum Bottle and 10 Screw Lid Can employees. Of the 30 samples collected, 5 were repeat volunteer subjects and all subjects were over 18 years of age. All aspects of the study were performed in accordance with a human subjects' study protocol approved by the researchers' Institutional Review Board (IRB).

2.7 Personal Noise Dosimetry

Study subjects were fitted with SPARTAN 730 personal noise dosimeters (Depew, NY, USA) near the beginning of their work shifts, and the dosimeters were collected near the end of their work shifts (approximately 11 hours). All personal noise samples were uploaded to the G4 LD Utility software (ver. 4.9.1) and later Excel (ver. 16.77.1) for statistical analysis. The specifications related to the personal noise dosimeters used are summarized in Table 2. The measurement settings used for the dosimeters are presented in Table 3.

Table 2. SPARTAN Model 730 Specifications

Specifications	Code	Dosimeters/Serial Number	
ANSI	S1.25-1991	10044	11263
IEC	61252:2017	11256	11103
FCC ID	2AA9B04	11241	
IC ID	12208A-04	11110	

https://doi.org/10.5281/zenodo.10911655

Table 3. Personal Noise Dosimeter Settings

Virtual Dosimeter	1	2	3	4
Mode	DOSE	DOSE	DOSE	DOSE
Title	OSHA-PEL	OSHA-HC	ACGIH	NIOSH
Frequency Weighting	A	A	A	A
Time Weighting	Slow	Slow	Slow	Slow
Peak Weighting	C	C	C	C
Exchange Rate	5 dB	5 dB	3 dB	3 dB
Threshold	90.0 dB	80.0 dB	80.0 dB	80.0 dB
Criterion Level	90.0 dB	90.0 dB	85.0 dB	85.0 dB
Shift Time	12 hours	12 hours	12 hours	12 hours

2.8 Statistical Analysis

All data collected in the current study were compiled into a Microsoft Excel (ver. 16.77.1) sheet for storage and analyzed using traditional descriptive statistical methods. The data were then used for subsequent graph creation. The analysis of the data included a 95% confidence interval with upper and lower prediction limits associated with both eight- and 12-hour TWAs, describing the range of noise exposures that have a 95% chance of containing the true population average and potential individual exposures, respectively.

2.9 Equations for Calculations

The TWA (8) was calculated by compressing the sampling time to estimate the 8-hour exposure using Equation 1 and the projected TWA (12) was calculated to estimate the 12-hour exposure by expanding the sampling time using Equation 2. Table 4 provides the exchange rates used in the calculations and the associated q value (Davis, 2023). Standard Error was then calculated using Equation 3, so it could be used to calculate the Margin of Error with Equation 6. Lastly, for each occupational exposure standard, a 95% confidence interval was calculated using equation 7 along with upper and lower predictions using equation 8 (Nist, 2023). All equations used for calculations are summarized in table 5.

Table 4. Exchange Rate Constants

Exchange rate	q value
3	10
5	16.61

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Table 5. Equations for Calculations

TWA (8) = L_{avg} + q * Log_{10} (shift sample time/8)	(Equation 1)
Projected TWA (12) = L_{avg} + q * Log_{10} (12/8)	(Equation 2)
Standard Error (SE) = $\frac{Standard\ Deviation}{\sqrt{Sample\ Size}}$	(Equation 3)
Aluminum Bottle Critical Value for T-Distribution = +/- 2.093	(Equation 4)
Screw Lid Can Critical Value for T-Distribution = +/- 2.262	(Equation 5)
Margin of Error (MOE) = Critical value * ($\frac{SE}{\sqrt{Sample\ Size}}$)	(Equation 6)
95% Confidence interval = Mean +/- MOE	(Equation 7)
Upper and Lower Prediction limits =	(Equation 8)

TWA (8) = 8-hour time-weighted average noise exposure
Projected TWA 12 = Projected 12-hour time-weighted average
L_{avg} = Average sound pressure level
q = A constant of 10 when an exchange rate of 3 is used and a constant of 16.61 when an exchange rate of 5 is used.

3. RESULTS

3.1 Equipment Noise

The Aluminum Bottle production area had a total of five machine types that were evaluated using the SLM/OBA: the Minster Cupper Press, 5500 Canmaker, Decorator, Bottle Necker, and Stolle Machine. In total, The Aluminum Bottle area had one Minster Cupper Press, eight Stolle Machines, eight 5500 Canmakers, twelve Bottle Neckers, and one Decorator. However, only one of each machine type was selected for sampling and the remainder of the machines continued running during sample collection. The average sound pressure levels ranged from 97.1 – 99.6 dBC with the frequencies greater than 85 dBC ranging from 63 Hz – 6,300 Hz. These dBC results are presented in Table 6.

Table 6. Noise Emission of Select Machinery

Machine	Sound Pressure Level at 1	Frequency range > 85 dBC (Hz)
Minster Cupper Press	99.6	63-2,500
5500 Canmaker	99.6	500-6,300
Decorator	99.3	500-4,000
Bottle Necker	97.8	160; 250-315; 2,000-4,000
Stolle Machine	97.1	500; 1,000-2,500

https://doi.org/10.5281/zenodo.10911655

Figures 1 to 5 summarize the octave band data obtained for each machine type in the Aluminum Bottle area.

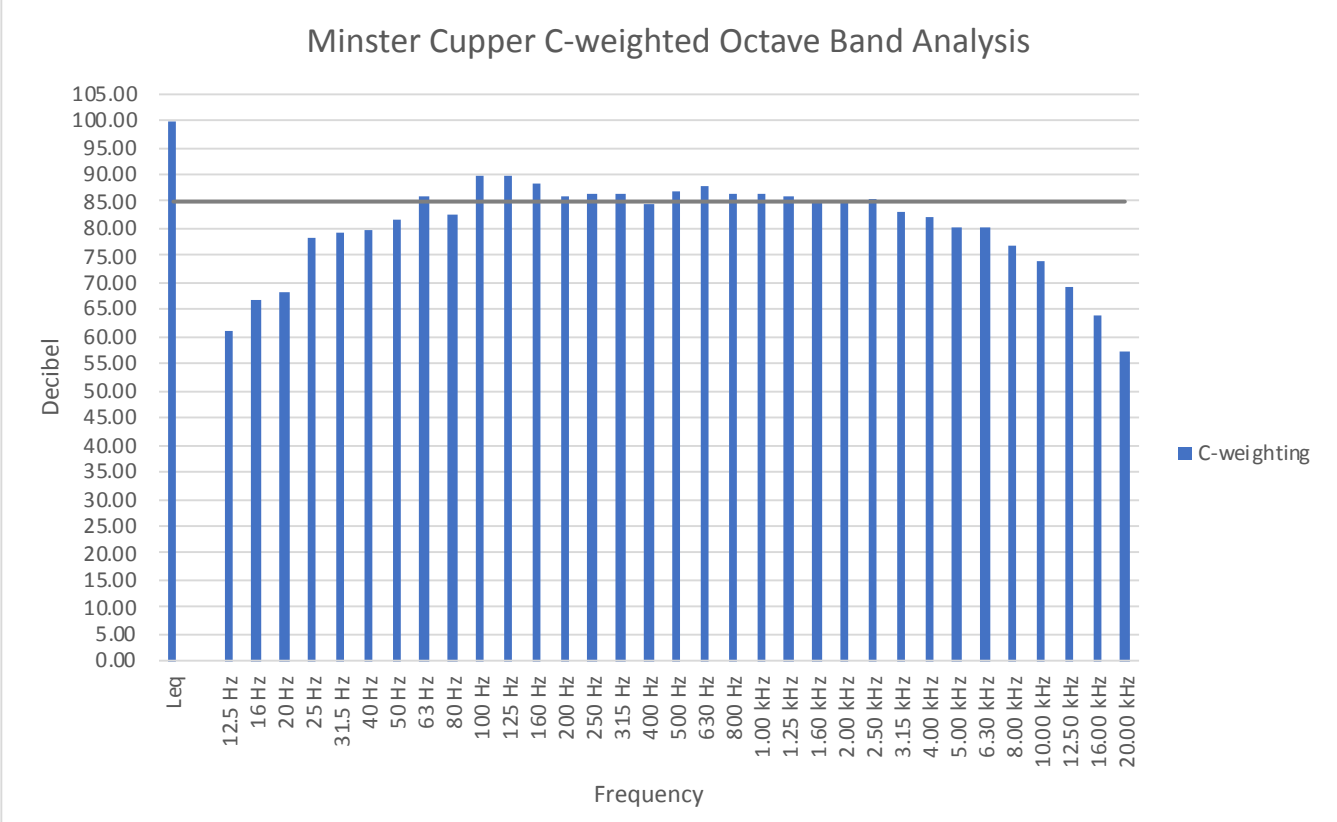

Figure 1. C-weighted Octave Band Results for the Minster Cupper Press

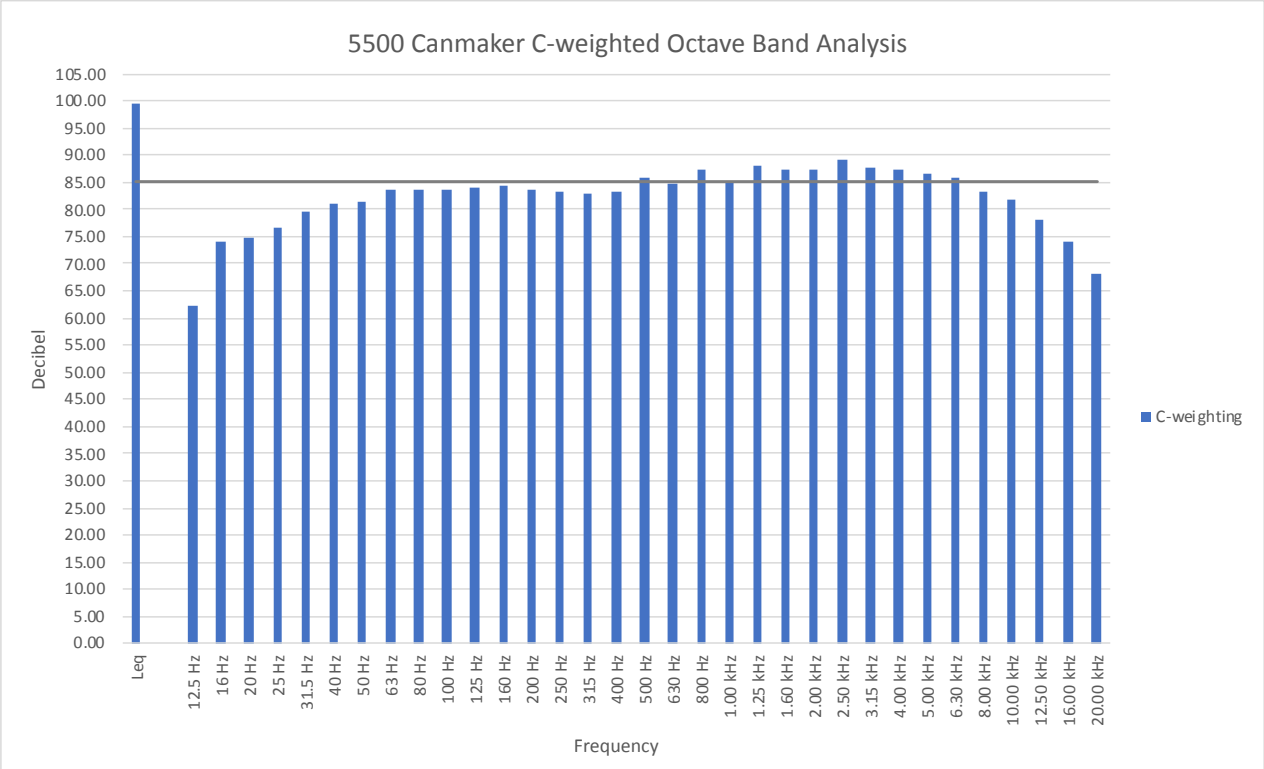

Figure 2. C-weighted Octave Band Results for the 5500 Canmaker

https://doi.org/10.5281/zenodo.10911655

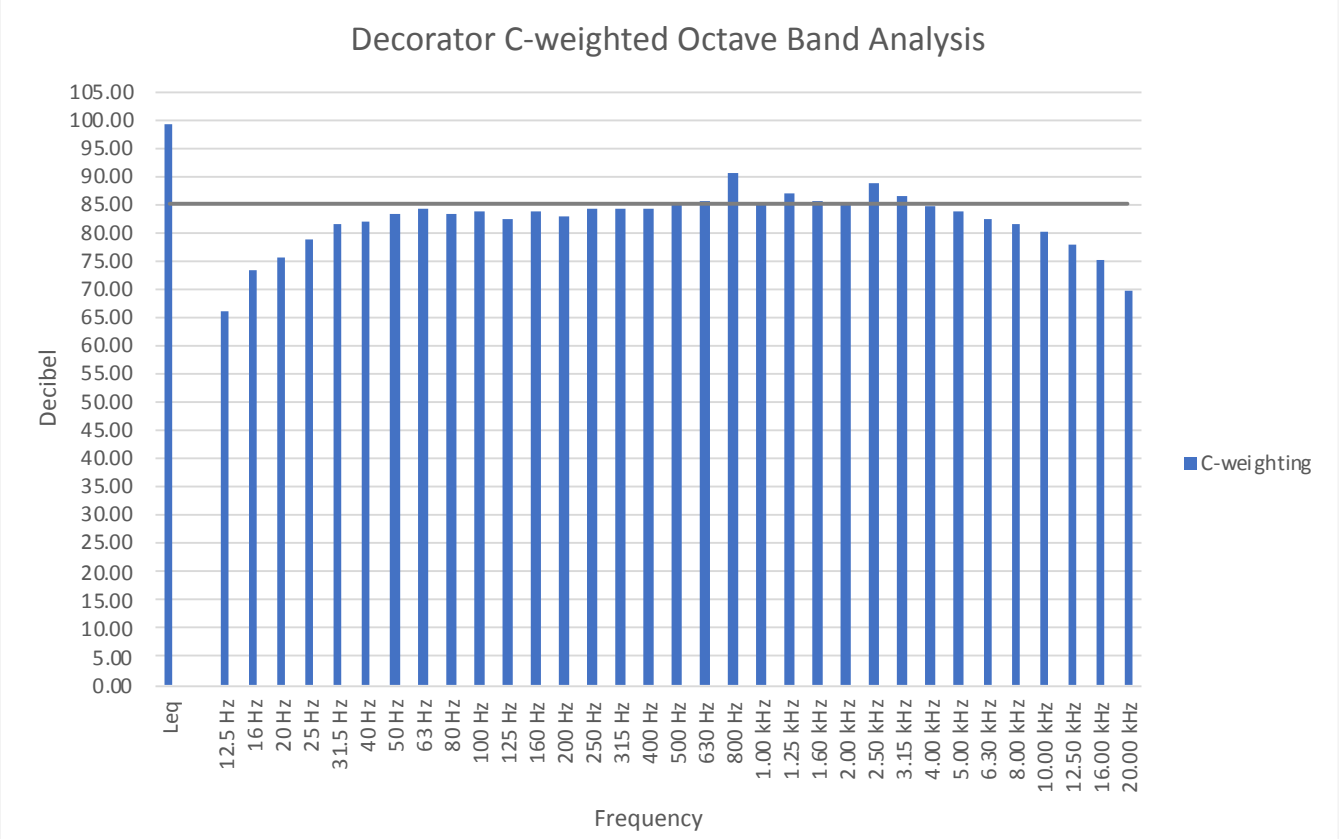

Figure 3. C-weighted Octave Band Results for the Decorator

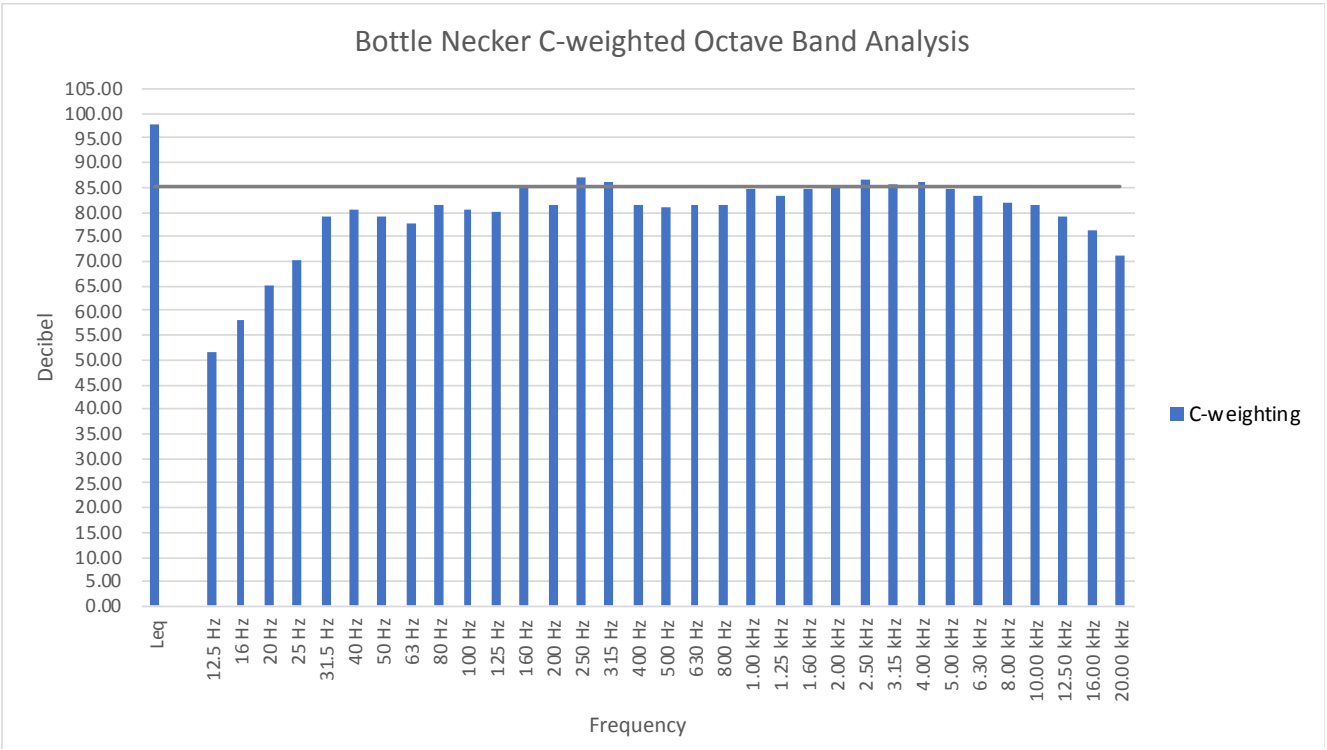

Figure 4. C-weighted Octave Band Results for the Bottle Necker

https://doi.org/10.5281/zenodo.10911655

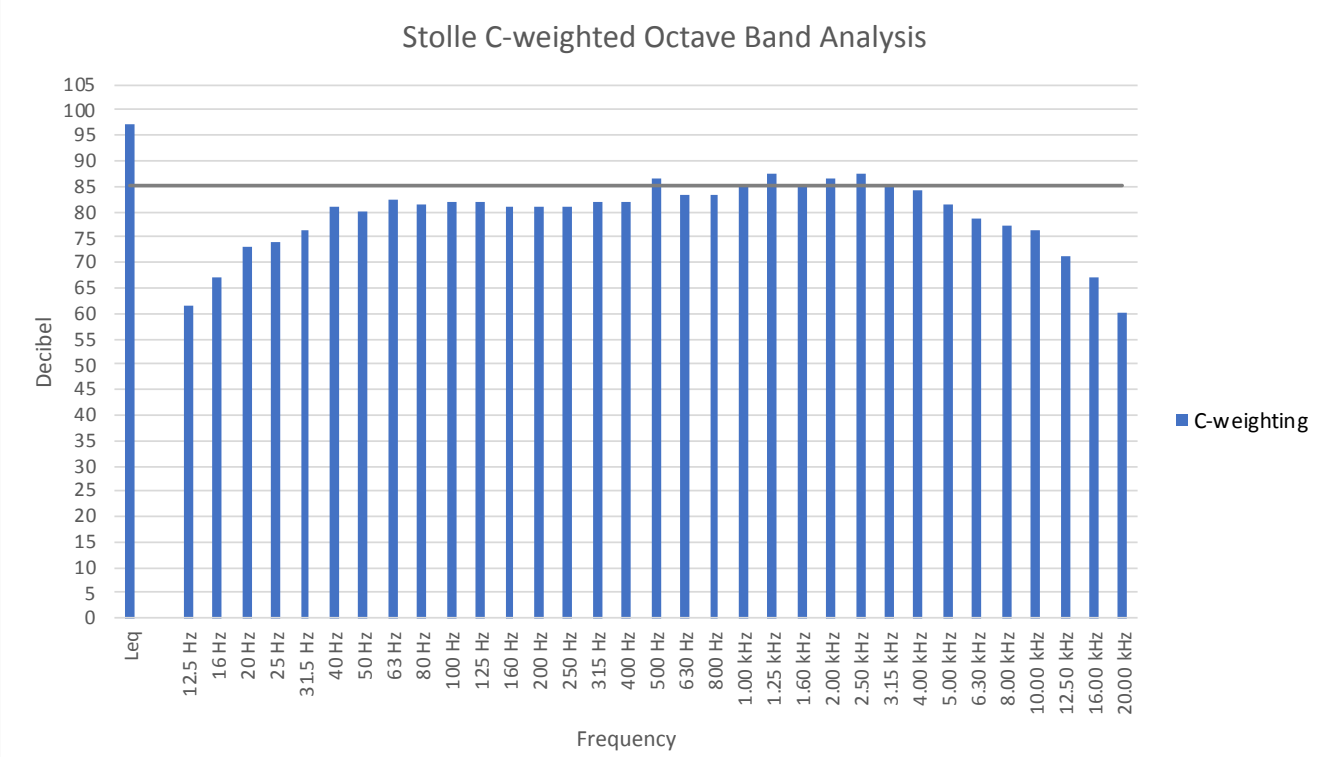

Figure 5. C-weighted Octave Band Results for the Stolle Machine

The Screw Lid Can production area had one machine type that was evaluated using the SLM/OBA since it was the primary noise source in this area: the Minster Shell Press. Unfortunately, the measurement data were lost due to technical error during upload and re-assessment was not possible due to changes in production rate. Therefore, the 1/1 octave band data collected from the personal noise dosimeters worn by the study subjects were used to determine frequency exposures and are summarized in Table 18 in the Personal Dosimetry 1/1 Octave Band Measurements sub section.

3.2 Personal Noise Dosimetry

Thirty personal noise samples were collected over five days at the aluminum can manufacturing facility. Twenty of the samples were collected from the Aluminum Bottle production area and the remaining 10 samples were collected from the Screw Lid Can production area. The sample times ranged from 10 hours, 41 minutes to 11 hours, 40 minutes for the 12-hour shifts. Since these sample times were not exactly 8 or 12 hours, the samples were mathematically adjusted to 8 and 12 hours for comparison to 8- and 12-hour TWA standards with the use of Equations 1 and 2 in Table 5. A summary of the personal dosimetry results for the 20 employees sampled in the Aluminum Bottle area are presented in Tables 7 and 8 while the results for the 10 employees working in the Screw Lid Can area are presented in Tables 9 and 10.

https://doi.org/10.5281/zenodo.10911655

Table 7. Aluminum Bottle Employee Personal Dosimetry Results

Sample #	L_{Avg} (PEL)	L_{Avg} (AL)	L_{Avg} (TLV/REL)	L_{ASmax}	L_{Cpk}
1	98.9	99	100.3	126.2	142.7
2	93.9	94	99.8	137.6	146.2
3	97	97.1	98.6	116.2	131.6
4	92.4	92.9	93.7	110.5	145.3
5	98.4	98.5	99.5	113.6	128.9
6	95.6	95.7	97.3	123.4	145.3
7	95.8	95.9	98.2	121.5	135.7
8	93.3	93.3	98	133.4	145
9	94.1	94.2	95.9	111.6	140.7
10	92.8	93.3	96.2	121	136.7
11	97	97.3	98.6	115.7	129.8
12	99.2	99.2	99.8	121	142.8
13	94.8	95.1	97.7	123.9	145.7
14	96.6	96.6	98.2	120.7	140.9
15	99.9	99.9	100.1	111.7	142
16	100.4	100.4	101.1	113	147
17	99.1	99.1	100.6	114.3	134.4
18	96.9	97	98.3	113	130
19	94.1	94.1	95.4	115.8	132.5
20	92.6	92.9	93.2	107	136.9
Average	96.14	96.28	98.03	118.56	139.01

L_{Avg} = Average sound pressure level
L_{ASmax} = Maximum sound pressure level, slow mode, A-weighted
L_{Cpeak} = Peak sound measurement, C-weighted
AL = OSHA Action Level
PEL = OSHA Permissible Exposure Limit
TLV/REL = Threshold Limit Value/Recommended Exposure Level

https://doi.org/10.5281/zenodo.10911655

Table 8. Aluminum Bottle Employee Exposures for TWA (8) and projected TWA (12)

Sample #	TWA 8 (PEL)	Proj. TWA 12 (PEL)	TWA 8 (AL)	Proj. TWA 12 (AL)	TWA 8 (TLV/REL)	Proj. TWA 12 (TLV/REL)
1	101.5	101.8	101.5	101.9	101.9	102.1
2	96.4	96.8	96.5	96.9	101.3	101.6
3	99.5	99.9	99.6	100.0	100.1	100.3
4	94.9	95.3	95.4	101.4	95.2	95.5
5	100.9	101.4	100.9	101.4	101	101.3
6	98.1	98.5	98.1	98.6	98.8	99.1
7	98.3	98.8	98.4	98.8	99.7	100.0
8	95.7	96.2	95.8	96.3	99.4	99.7
9	96.6	97.0	96.7	97.1	97.4	97.6
10	95.3	95.7	95.8	96.2	97.7	97.9
11	99.5	99.9	99.8	100.2	100.1	100.3
12	101.7	102.1	101.7	102.1	101.3	101.6
13	97.1	97.8	97.4	98.1	99	99.4
14	98.8	99.5	98.8	99.5	99.5	99.9
15	102.1	102.8	102.1	102.8	101.5	101.9
16	102.6	103.3	102.6	103.3	102.4	102.9
17	101.4	102	101.4	102.1	102	102.4
18	99.3	99.9	99.3	99.9	99.7	100.0
19	96.4	97	96.4	97.1	96.8	97.2
20	94.9	95.5	95.2	95.9	94.6	95.0
Average	98.6	99.1	98.7	99.5	99.5	99.8

TWA 8 = Time Weighted Average for an eight hour time frame
Projected TWA 12 = Projected Time Weighted Average for a twelve-hour time frame
AL = OSHA Action Level
PEL = OSHA Permissible Exposure Limit
TLV/REL = Threshold Limit Value/Recommended Exposure Level

https://doi.org/10.5281/zenodo.10911655

Table 9. Screw Lid Cap Employee Personal Dosimetry Results

Sample #	L_{Avg} (PEL)	L_{Avg} (AL)	L_{Avg}	L_{ASmax}	L_{Cpk}
1	91.5	92.1	96.9	134.3	142.9
2	86.3	89.4	91.9	120.1	140.3
3	89.3	90.9	94.4	119	144.8
4	85.2	87.6	90.8	113.5	139.5
5	91.1	91.8	94	110.5	139.6
6	86.6	88.5	91.4	117.7	133.2
7	86.5	89.3	91.5	121.8	144.3
8	83.2	87.9	90.2	113.1	136
9	87.6	89.2	92.3	115.2	131.5
10	91.3	92.4	94.2	119.6	138.9
Average	87.86	89.91	92.76	118.48	139.10

L_{Avg} = Average sound pressure level
L_{ASmax} = Maximum sound pressure level, slow mode, A-weighted
L_{Cpeak} = Peak sound measurement, C-weighted
AL = OSHA Action Level
PEL = OSHA Permissible Exposure Limit
TLV/REL = Threshold Limit Value/Recommended Exposure Level

Table 10. Screw Lid Can Employee Exposures for TWA (8) and projected TWA (12)

Sample #	TWA 8 (PEL)	Proj. TWA 12 (PEL)	TWA 8 (AL)	Proj. TWA 12 (AL)	TWA 8 (TLV/REL)	Proj. TWA 12 (TLV/REL)
1	94.1	94.4	94.7	95.0	98.4	98.7
2	89	89.2	92.1	92.3	93.6	93.7
3	91.8	92.2	93.4	93.8	95.9	96.2
4	87.7	88.2	90.1	90.5	92.3	92.5
5	93.8	94.0	94.5	94.7	95.6	95.8
6	89.3	89.5	91.2	91.4	93	93.2
7	88.7	89.5	91.5	92.2	92.8	93.3
8	85.3	86.1	90	90.9	91.4	91.9
9	90	90.5	91.6	92.1	93.8	94.1
10	93.7	94.3	94.8	95.3	95.6	95.9
Average	90.3	90.8	92.4	92.8	94.2	94.5

TWA 8 = Time Weighted Average for an eight-hour time frame
Projected TWA 12 = Projected Time Weighted Average for a twelve-hour time frame
AL = OSHA Action Level
PEL = OSHA Permissible Exposure Limit
TLV/REL = Threshold Limit Value/Recommended Exposure Level

https://doi.org/10.5281/zenodo.10911655

3.3 OSHA Action Level

Of the 20 employees working in the Aluminum Bottle area, 20 of 20 (100%) were exposed to noise levels greater than 85 dBA when evaluated using OSHA AL criteria. Employees in this area were exposed to average decibel levels ranging from 95.2 – 102.6 dBA with a total average of 98.7 dBA when evaluated using an 8-hour TWA. When samples were projected for a 12-hour TWA, the employee exposures ranged from 95.9 – 103.3 dBA with a total average of 99.5 dBA.

Of the 10 employees working in the Screw Lid Can area, 10 of 10 (100%) were exposed to noise levels greater than 85 dBA when evaluated using OSHA AL criteria. Employees in this area were exposed to average decibel levels ranging from 90 – 94.8 dBA with a total average of 92.4 dBA when evaluated using an 8-hour TWA. When samples were projected for a 12-hour TWA, the employee exposures ranged from 90.5 – 95.3 dBA with a total average of 92.8 dBA. To determine the confidence of these findings, a 95% confidence interval along with upper and lower prediction intervals were performed for the TWA (8) and TWA (12) of both production areas (Table 11 and Table 12).

Table 11. OSHA AL TWA (8) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (8)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	98.7	97.6	99.9	93.5	104.0
Screw Lid Can	92.4	91.1	93.7	88.0	96.8

Table 12. OSHA AL TWA (12) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (12)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	99.5	98.4	100.6	94.4	104.6
Screw Lid Can	92.8	91.6	94.1	88.7	97.0

3.4 OSHA Permissible Exposure Level

Of the 20 employees working in the Aluminum Bottle area, 20 of 20 (100%) were exposed to noise levels greater than 90 dBA when evaluated using OSHA PEL criteria. Employees in this area were exposed to average decibel levels ranging from 94.9 – 102.6 dBA with a total average of 98.6 dBA when evaluated using an 8-hour TWA. When the samples were projected for a 12-hour TWA, the employee exposures ranged from 95.3 – 103.3 dBA with a total average of 99.1 dBA.

Of the 10 employees working in the Screw Lid Can area, 10 of 10 (100%) were exposed to noise levels greater than 90 dBA when evaluated using OSHA PEL criteria. Employees in this area were exposed to average decibel levels ranging from 85.3 – 94.1 dBA with a total average of 90.3 dBA when evaluated using an 8-hour TWA. When samples were projected for a 12-hour TWA, the employee exposures ranged from 86.1 – 94.4 dBA with a total average of 90.8 dBA. To determine the confidence of these findings, a 95% confidence interval along with upper and lower prediction intervals were performed for the TWA (8) and TWA (12) of both production areas (Table 13 and Table 14).

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Table 13. OSHA PEL TWA (8) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (8)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	98.6	97.4	99.8	93.1	104.1
Screw Lid Can	90.3	88.2	92.4	83.3	97.3

Table 14. OSHA PEL TWA (12) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (12)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	99.1	97.9	100.3	93.6	104.6
Screw Lid Can	90.8	88.8	92.8	84.1	97.5

3.5 ACGIH Threshold Limit Value and NIOSH Recommended Exposure Limit

Of the 20 employees working in the Aluminum Bottle area, 20 of 20 (100%) were exposed to noise levels greater than 85 dBA when evaluated using ACGIH and NIOSH standards. Employees in this area were exposed to average decibel levels ranging from 94.6 – 102.4 dBA with a total average of 99.5 dBA when evaluated using an 8-hour TWA. When samples were projected for a 12-hour TWA, the employee exposures ranged from 95 – 102.9 dBA with a total average of 99.8 dBA.

Of the 10 employees working in the Screw Lid Can area, 10 of 10 (100%) were exposed to noise levels greater than 85 dBA (10/10) when evaluated using ACGIH and NIOSH standards. Employees in this area were exposed to average decibel levels ranging from 91.4 – 98.4 dBA with a total average of 94.2 dBA when evaluated using an 8-hour TWA. When samples were projected for a 12-hour TWA, the employee exposures ranged from 91.9 – 98.4 dBA with a total average of 94.5 dBA. To determine the confidence of these findings, a 95% confidence interval along with upper and lower prediction intervals were performed for the TWA (8) and TWA (12) of both production areas (Table 15 and Table 16).

Table 15. ACGIH TLV and NIOSH REL TWA (8) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (8)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	99.5	98.5	100.5	94.8	104.2
Screw Lid Can	94.2	92.7	95.7	89.2	99.2

https://doi.org/10.5281/zenodo.10911655

Table 16. ACGIH TLV and NIOSH REL TWA (12) Confidence and Prediction Limits

Aluminum Bottle and Screw Lid Can 95% Confidence and Prediction Limits of TWA (12)					
Category	Average	Lower Confidence	Upper Confidence	Lower Prediction	Upper Prediction
Aluminum Bottle	99.8	98.8	100.8	95.1	104.5
Screw Lid Can	94.5	93.0	96.0	89.6	99.4

3.6 Personal Dosimetry 1/1 Octave Band Measurements

Each personal dosimeter measured 1/1 octave band data to determine the Z-weighted frequencies of exposure to the participants. The sample population average for the octave band measurements are summarized in Table 17 for the Aluminum Bottle employees and Table 18 for the Screw Lid Can employees. In the Aluminum Bottle area, frequencies ranging from 32 – 8,000 Hz all exceeded 85 dB. In the Screw Lid Can area, employees were exposed to noise of 85 dB or greater at frequencies 250 – 1,000 Hz and 4,000 – 8,000 Hz.

Table 17. Aluminum Bottle 1/1 OBA Personal Dosimeters

Metrics	32Hz	63Hz	125Hz	250Hz	500Hz	1,000Hz	2,000Hz	4,000Hz	8,000Hz
LZeq	86.7	88.2	88.6	88.5	91.7	92.0	90.5	90.5	90.0
LZSmax	108.7	107.3	107.3	107.4	113.7	116.2	111.6	111.6	111.4
LZSmin	64.6	60.5	56.9	54.5	51.2	47.1	43.1	40.4	41.0

Table 18. Screw Lid Can 1/1 OBA Personal Dosimeters

Metrics	32Hz	63Hz	125Hz	250Hz	500Hz	1,000Hz	2,000Hz	4,000Hz	8,000Hz
LZeq	83.2	84.0	82.8	85.1	87.2	86.3	84.3	86.4	87.6
LZSmax	107.9	106.9	106.4	106.0	111.9	114.4	107.5	108.3	110.9
LZSmin	62.2	57.6	51.8	48.4	45.1	41.2	37.7	36.8	39.7

4. DISCUSSION

The ultimate purpose of the study was to determine if workers in an aluminum can manufacturing environment were exposed to hazardous levels of noise as defined by OSHA, ACGIH, and NIOSH with subsequent recommendations for noise exposure mitigation. To achieve this purpose, area noise samples were taken from a total of six production machine types across two production areas termed “Aluminum Bottle” and “Screw Lid Can”. Additionally, 20 Aluminum Bottle employees and 10 Screw Lid Can employees were selected for voluntary participation in personal noise sample collection. The average decibel exposures from these samples were used to calculate an eight-hour TWA and a projected twelve-hour TWA. The eight-hour TWA is typically used as a standard measure of employee noise exposure to compare with occupational exposure limits and to determine compliance with those limits. However, since employees at this facility worked 12-hour shifts, projected twelve-hour TWAs were also provided to better estimate their exposures. These adjustments and comparisons were made by following the guidelines set forth by OSHA, NIOSH, and ACGIH.

https://doi.org/10.5281/zenodo.10911655

The C-weighted frequency range of the five machine types in the Aluminum Bottle production area greater than 85 dBC spanned from 63 Hz – 4,000 Hz when assessed using a 1/3 octave band analysis. Furthermore, the average C-weighted sound pressure level ranged from 97.1 dBC – 99.6 dBC. In addition to the SLM data, the personal noise dosimeters recorded an average of 99.8 dBA with a range of 95 dBA - 102.9 dBA and an upper prediction limit of 104.5 dBA when assessed using a projected twelve-hour TWA and ACGIH/NIOSH criteria.

The Screw Lid Can production area SLM data were lost, but OBA 1/1 data from the personal noise dosimeters worn in this area displayed dominant Z-weighted frequencies ranging from 250 Hz – 1,000 Hz and 4,000 Hz – 8,000 Hz. In addition, the personal noise dosimeters recorded an average of 94.5 dBA with a range of 91.9 dBA - 98.7 dBA and an upper prediction limit of 99.4 dBA when assessed using a projected twelve-hour TWA and ACGIH/NIOSH criteria.

The frequency and decibel ranges of both the Aluminum Bottle and Screw Lid Can production areas have been shown to cause damage to human hearing (Berger et. al., 2003). Further, these decibel levels can lead to chronic hypertension, elevated cholesterol (Said et al., 2022) and impact the psychological health of employees by increasing stress and agitation, leading to an increased chance of industrial accidents (Jones, 1981).

Of the 20 employees sampled in the Aluminum Bottle production area, 100% were overexposed to noise per the OSHA PEL, the OSHA AL, the ACGIH TLV and the NIOSH REL. Likewise, of the 10 employees sampled in the Screw Lid Can area, 100% were over exposed to noise per the OSHA PEL, the OSHA AL, the ACGIH TLV, and the NIOSH REL. In summary, 30 of the 30 employees sampled were exposed to noise that was greater than 90 dBA (OSHA PEL) or 85 dBA (OSHA AL, NIOSH REL, ACGIH TLV) as an eight hour TWA; and the employees were exposed to noise that was greater than 82.5 dBA as a projected twelve hour TWA (the exposure limit for a 12-hour shift for the OSHA AL, NIOSH REL, and ACGIH TLV). These findings indicate that all employees must participate in the use of hearing protection under a hearing conservation program and abide by the remainder of OSHA hearing regulations when working in either production area due to an increased risk of NIHL (E.H Berger et. al., 2003; OSHA, 2008). Additionally, further noise mitigation techniques will need to be implemented to decrease production area noise and therefore minimize the personal noise exposures of employees.

4.1 Contributing Noise Exposure Factors

In addition to the tasks and processes described, there are many other factors potentially contributing to the overall noise exposures of the production employees. Two examples of additional noise sources in the production areas were numerous conveyors and industrial trucks which can vary depending on production levels. The Public Address (PA) system produced significant sound levels adding to overall noise levels making worker-to-worker communication difficult resulting in employees raising their voices and reducing distance to communicate verbally.

4.2 Comparison with Relevant Studies

The findings in this study were fairly similar to the results found in other studies on noise exposures in aluminum manufacturing settings. Similar to the findings of Rodriguez et al., (2012), the current study demonstrated that aluminum manufacturing employees are at a greater risk of over exposure to noise. Specifically, employees working near the Printer, Lacquer Spray, and Necker machines were of particular concern due to decibel levels reaching 100 dBA or greater. These conclusions align with the findings of the current study which revealed that each the Minster Cupper Press, 5500 Canmaker, Decorator, Bottle Necker, and Stolle machines produced average noise levels equal to or greater than

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97 dBA. Further, Subramaniam et al. (2018) discovered that metal manufacturing employees are at an increased risk of NIHL which is similar to the findings in this study that demonstrated noise over exposure for employees in aluminum can manufacturing. In addition, Cantley et al., (2015) found that aluminum manufacturing workers are at an increased risk of NIHL when exposed to noise levels as low as 85 dBA. Since employees in the current study had exposure levels that greatly exceeded 85 dBA, the concern for NIHL among the sampled population has validity and noise mitigation is warranted. However, with consideration of Neitzel et al.'s, study in 2019 on metal manufacturing workers, precautions were recommended to ensure that while addressing overexposure risks, employees are not overprotected to the extent that it disrupts their work efficiency and communication.

4.3 Study Limitations

The contributing noise exposures, such as the PA system and industrial trucks, had the potential to impact the overall noise exposure of employees monitored in the current study; however, direct measurements of these processes and/or machines were not obtained. In addition to these additional noise exposure sources, the employees were not directly observed for their entire shifts throughout the day. As a result, it is unknown specifically where the employees were located at any given time throughout the workday. Since their specific locations were not tracked throughout the study, direct comparisons of the data from the personal noise dosimeters could not be related to time spent near specific machines. This uncertainty may also include the possibility of an employee removing the personal dosimeter after placement and then repositioning the device without awareness by the researcher. Lastly, these results are not completely generalizable to the can-making industry sector since there are fluctuations in production levels throughout the year, affecting the frequency of production machinery use.

5. CONCLUSIONS

5.1 Hypotheses Conclusions

The assessments performed in the current study were conducted to answer the hypothesis questions presented by the investigators. Firstly, it was asked if noise emissions from machinery, equipment, and processes in the production area are greater than 85 dB at one meter. The null hypothesis stating that the metal manufacturing equipment noise is less than 85 dB at one meter from machinery was rejected. Secondly, it was asked if production employees were exposed to noise levels that exceed the published occupational exposure limits from OSHA, ACGIH, and NIOSH. Again, the null hypothesis stating that production employees are not exposed to a noise level that exceeds published occupational exposure limits was rejected.

5.2 Recommendations

Several recommendations were made based on the noise samples obtained at the manufacturing facility.

1. Replace machinery enclosures and internal components where feasible (i.e., outer sheet metal and/or internal mechanical components) with materials that have a low acoustic radiation efficiency, such as woven or perforated options. The types of materials (i.e., design or substances) used for the exterior of the machinery greatly impacts the noise produced during production. (Bies et al., 2018). Therefore, the safety team should work with the engineering department to review the exterior and interior aspects of the machinery to determine if feasible options for woven, perforated, or similar design

choices are available to replace existing elements. The previously obtained acoustic sampling should be used during this step.

2. Consider the use of sound absorbing materials. When choosing sound proofing materials to place in the production areas, it is important to choose sound absorbing materials that protect against the frequency ranges associated with each machine type as shown in the results section of this report and summarized below. The previously obtained acoustic sampling should be used in conjunction with the C-weighted SLM data and Z-weighted personal dosimetry data obtained in this study.

    - Minster Cupper Press: 63 Hz – 2,500 Hz
    - 5500 Canmakers: 500 Hz – 6,300 Hz
    - Decorator: 500 Hz – 4,000 Hz
    - Bottle Necker: 160 Hz; 250 Hz – 315 Hz; 2,000 Hz – 4,000 Hz
    - Stolle Machine: 500 Hz; 1,000 Hz – 2,500 Hz
    - Minster Shell Press area: 250 – 1,000 Hz and 4,000 – 8,000 Hz.

3. Determine if adjustments to maintenance schedules need to be made. A discussion with the maintenance team to determine inefficiencies or concerns related to their work flows may help indicate potential options for adjustments in the current maintenance schedules. Increasing regular maintenance on machinery could result in a decrease in average noise exposures and improvements to the overall production process (Verbeek et al., 2017).

4. If feasible, consider adjusting punch press cycle times and minimizing peak impact force. Manufacturing industry noise can be reduced with extensions to a punch press's cycle time and decreases of the peak impact force (Bies et al., 2018).

5. Require employees to wear both earplugs and earmuffs. When projecting for 12-hour shifts and ACGIH/NIOSH criteria, employees in the Aluminum Bottle production area were exposed to a range of 95 – 102.9 dBA with a total average of 99.8 dBA and an upper prediction limit of 104.5 dBA. Additionally, employees in the Screw Lid Can production area were exposed to a range of 91.9 – 98.7 dBA with a total average of 94.5 dBA and an upper prediction limit of 99.4 dBA. Since employees working in both production areas have the potential to exceed 95 dBA for a projected TWA 12, the concurrent use of earplugs and earmuffs should be used (Berger, 1993).

6. Noise reaching the employees' ears should be attenuated to 80 dBA. In the Aluminum Bottle area, there was an upper prediction limit of 104.5, indicating the need for 24.5 dBA attenuation. In the Screw Lid Can area, there was an upper prediction limit of 99.4 dBA, indicating the need for a 19.4 dBA attenuation. However, it is recommended that attenuation with fit testing is monitored closely to not exceed an attenuation level of 70 dBA to avoid disruptions in communication (Neitzel, et al., 2019).

7. Use NRR Ratings for hearing protection but use a 50% or greater derating. Due to inherent inaccuracies in the practical use of hearing protection, it has been determined that a 50% or greater derating is indicated (Berger, 1993). Additionally, the reduction in NRR ratings by 50% is enforced by OSHA requirements. However, OSHA does allow for 5 dB to be added to the NRR rating of the hearing protection with the higher NRR after the 50% adjustment for double hearing protection (OSHA, 2008).

https://doi.org/10.5281/zenodo.10911655

8. Create and train the production employees on standardized hand signals for hazardous situations and indicators for common work tasks. By providing employees with standardized signals, they will not have to solely rely on verbal communication which is limited in the work environment.

9. Have the production employees complete a qualitative and/or quantitative survey on their perceptions of stress and potential solutions. By acknowledging the stress of employees and taking actions to reduce their everyday mental and physical stress, the physiological and physiological impacts associated with noise exposure are reduced (Samuel Melamed et al., 1999).

10. Review current Hearing Conservation Program training and set internally recognized standards for employee comprehension. Given that OSHA requires employers to approach noise in a preventative manner through an HCP, it is vital that the safety team ensure the HCP is adequately established and that employees are participating as required (OSHA, 2008)

5.3 Future Work

This noise exposure assessment evaluated the exposure of workers in an aluminum metal can manufacturing facility and found statistical evidence of over exposure in reference to OSHA, ACGIH, and NIOSH standards. These findings were consistent with evidence provided by similar studies on aluminum manufacturing workers and noise exposures. Since this type of work environment has shown repeated evidence of noise over exposure, specific research on control methods should be performed for the following machine types; Minster Cupper Press, Stolle Machines, 5500 Canmakers, Bottle Necker, Decorator, and Minster Shell Press. By performing detailed research into control methods for these machines, engineers can consider changes in the design stage that will be beneficial for noise reduction. Additionally, precise recommendations for sound absorbing materials can be provided to facilities that are performing production processes with these machine types. Lastly, future researchers should consider performing a study that determines perceived stress levels of aluminum manufacturing workers with correlation to the physical tasks being performed and the exposures to loud noise.

FUNDING

This project was partially funded by the NIOSH Mountain and Plains Education and Research Center, Centers for Disease Control and Prevention, Grant T42OH009229.

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MAIN AUTHOR

Darren Gieseck earned his undergraduate degree in Molecular/Cellular Biology in 2019 from Kent State University and his master's degree is Environmental Health, specializing in Industrial Hygiene, from Colorado State University, in December 2023. Mr. Gieseck is now employed as a Safety Engineer for a munitions facility.

CITATION:

Gieseck, D., Brazile, W., Gutilla, M., Autenrieth, D., & Gilkey, D. (2024). *Employee Noise Exposure and Octave Band Analysis in a Manufacturing Setting*. World Safety Journal, Vol. XXXIII(1), 1–24. https://doi.org/10.5281/zenodo.10911655

World Safety Journal

A peer-reviewed journal,
published by the World Safety Organization

Journal Homepage:
https://worldsafety.org/wso-world-safety-journal/

Evaluating Ergonomic Risk for Nurses During Patient Transfers: A Pilot Study

Madelyn Mariegard, BS, GSP[1], and David Gilkey, D.C., Ph.D., CSP, CPE[1,*]
[1] *Department of Safety, Health and Industrial Hygiene, Montana Technological University, Butte, MT 59701*

KEYWORDS

Nurses
Musculoskeletal Disorders (MSDs)
Patient Transfer
Patient Lift

ABSTRACT

Nurses suffer a disproportionate risk for musculoskeletal injury compared to most other professions. Injury rates are far above the national average and may result in lost time from work, pain and suffering and is likely to shorten the working life of many nurses. Most nursing programs do not teach ergonomic principles and safe patient handling as part of the academic curriculum. The Rapid Entire Body Assessment (REBA) tool was developed by ergonomists for use in the healthcare industry. This pilot study evaluated the risk for musculoskeletal injury during two lifts using REBA, one without a mechanical lift system and one with. Findings suggest that risk increased when using the mechanical lift system. We recommend evidence-based training for all nurses on patient transfer methods and use of all mechanical lift systems.

1. INTRODUCTION

Work-related musculoskeletal disorders (MSDs) are a major problem among hospital personnel, specifically the nursing staff (Gilchrist and Pokorna, 2021; Lin et al., 2020; Soylar and Ozer, 2018; Yasobant, 2014). The primary cause of musculoskeletal injuries (MSIs) in the healthcare workplace results from handling patients (Abedini et al., 2015; Soylar and Ozer, 2018). The overall workload includes frequent patient management including lifting, handling, and repositioning tasks that are required part of the primary services provided in nursing duties. Patent handling can lead to injuries to arm and shoulder strains and sprains, back and neck strains and sprains, and disc injuries (Lin et al., 2020; Soylar and Ozer, 2018; Vinstrip et al., 2020). The low back is the most or second most frequent site of injury (Gilchrist and Pokorna, 2021; Harcombe et al., 2014; Lee, Lee and Harrison, 2022). Nurses are involved in patient transfers from one location to another within the hospital daily and part of their usual job demands. Patients may be assisted in moving to and from their bed, commode, chair, and throughout the hospital for other services. Nurses are given the responsibilities for patient care and management, including lifting, loading, pushing, pulling, transferring, repositioning, and meeting patient needs (Soylar and Ozer, 2018). Nurses frequently encounter circumstances that necessitate assuming awkward postures and high forces that result in risk increases for MSIs (Lee, Lee and Harrison, 2022; Lin et al., 2020; Soylar and Ozer, 2018). The healthcare industry prioritizes the health and well-being of the patient over that of the providers. Despite no lift policies, individual providers tend to do "whatever it takes" to care for and handle

* ***Corresponding Author***: dgilkey@mtech.edu

https://doi.org/10.5281/zenodo.10911792

patients, assisting them in moving from one position or location safely, even at the risk of injury to themselves.

In response to the patient-handling challenges, in the healthcare industry at large and many healthcare facilities have implemented specialized lift-assist systems and tools to aid nurses in effectively moving and handling patients with reduced risk for MSI (Santaguida et al., 2005; Ziam et al., 2020). There is a range of patient-handling equipment available depending on the needs of the nurses, patients, the hospital, the age of the facility, or patients at home. Regardless of the specific type of equipment, these tools were designed to reduce the stress and strain put on nurses, but they do require training on the proper use and maintenance (Santaguida et al., 2005; Ziam et al., 2020). A question arises among safety and health professionals; do these tools effectively reduce musculoskeletal stress to the provider and overall occurrence of MSI and resulting MSD?

Ergonomic assessment tools such as the Rapid Entire Body Assessment (REBA) were designed to address the challenges of evaluating healthcare workers involved in awkward postures while handling patient (Hignett and McAtamney, 2000). The REBA has been used for over two decades successfully to evaluate ergonomic risks associated with patient handling and management (Ayvaz et al., 2023; Raman, Ramlogan, Sweet and Sweet, 2020) and other industries (Hita-Gutiérrez et al., 2020). Janowitz and colleagues (2006) validated the REBA tool using medical personnel from a large cohort of approximately 6,000 workers in the San Francisco Bay area. The investigation evaluated 494 subjects and recorded 14,404 observations. They found good Kappa scores > 0.8 for low back, leg and static postures with decreasing scores for the remainder of variables evaluated. Inter-rater reliability Kappa scores were 0.54 for upper back and 0.66 for lower back. They concluded the tool was valid and useful for evaluating ergonomic risk in the hospital setting.

Another investigation team evaluated 383 nurses using REBA to estimate their risk for MSI (Ayvaz et al., 2023). The researchers found that 92% to 100% of nurses completing a variety of job tasks suffered musculoskeletal pain. Corresponding REBA scores ranged from a low of 5.5 to a high of 10. Researchers concluded that nurses were at medium risk for MSI and that ergonomic assessments should include a quantitative approach such as REBA (Ayvaz et al., 2023).

Another study looked at postures and stresses associated with dental student training. They evaluated 28 third-year dental students and found that the ergonomic assessment tool performed well (Ramam, Ramlogan, Sweet and Sweet, 2020). The inter-rater reliability was good, Kappa 0.625 with p-value < 0.01 and moderate concordance with Kendall's Tau-b of 0.58. The research team concluded that the tool was easy to use and moderately reliable (Ramam, Ramlogan, Sweet and Sweet, 2020).

The REBA ergonomic assessment tool was used in this study because of its appropriateness, history of development, and validity for use in the healthcare setting, see Appendix A. The REBA Excel spreadsheets are available as freeware from a number of sources including, The Ergonomics Center at North Carolina State University (https://www.ergocenter.ncsu.edu/) and at the University of South Florida, USF Health Ergonomics (https://health.usf.edu/publichealth/tbernard/ergotools).

This study investigated the ergonomic risk associated with patient transfers and a local healthcare facility in Southwest Montana, USA. The purpose of this study was to obtain REBA scores from nurses performing patient transfers and to compare scores with and without the use of lift assist devices.

1.1 Research Questions

- What level of risk for MSI do nurses encounter completing patient transfers without using equipment designed to assist in patient lifts?

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- What level of risk for MSI do nurses encounter using the patient transfer equipment designed to assist in patient lifts?
- Will ergonomic assessments using REBA identify similar or different risk levels when using the patient transfer equipment?

1.2 Research MSIs and MSDs in Nursing

Nurses play a vital role within the healthcare industry and suffer a disproportionate burden of MSIs and MSDs (BLS, 2021). The US BLS reported that 44,020 nurses suffered injuries that resulted in 205,780 lost workdays in 2020. A research team investigated workers' compensation claims filed by nurses between 2007 – 2016 in California and found 199,547 cases (Lee, Lee and Harrison, 2022). The cohort included 51,189 nurses across the state. The most frequent body part was the upper extremity, followed by the low back, trunk, shoulder, lower extremities and neck (Lee, Lee and Harrison, 2022).

The typical nurse's job description requires them to perform physically demanding tasks including lifting heavy equipment and helping patients with their transportation needs such as repositioning in bed, moving from bed to a chair, from a chair to a toilet, and therefore back to bed (Soylar & Ozer, 2018; Lee, Lee and Harrison, 2022). Because patient transfer tasks are so physically stressful, many nursing personnel develop MSDs at some point in their career (Lin et al., 2020). The primary injuries are to the lower back, shoulders, and upper extremities (Lee, Lee and Harrison, 2022; Lin et al., 2020). Low back injuries and resulting pain remain the leading cause of early retirement (Goodwin, 2012). MSDs are prevalent between 33% to 88% within the healthcare industry and rank among the high-risk industries for low back disorders and other MSDs (Soylar & Ozer, 2018). These researchers found MSDs among nursing personnel were pervasive around the world and consistently highest in Estonia, Turkey, and Taiwan at 84%, 79.5%, and 76% respectively. Their review study looked at 34 published articles and found most commonly MSDs affected the shoulders, neck, lower back, and upper extremities (Soylar & Ozer, 2018). The researchers identified not only physical factors associated with MSDs but also demographic, organizational, and psychosocial factors that also played a significant role in MSIs leading to MSDs (Soylar & Ozer, 2018).

Paul (2012) completed a study to investigate the awareness among Indian nursing professionals about ergonomics, injury prevention, and safety measures in the workplace. This study also looked at the prevalence of MSDs among the population. Findings revealed that a relationship existed between musculoskeletal complaints and years of experience in nursing p-value < 0.05. He found that with increasing years of experience, the probability of MSD-related complaints increased significantly (Paul, 2012). The cross-sectional observational study was conducted at the Navi Mumbai hospital with 34 full-time nursing professionals (Paul, 2012). A questionnaire was administered covering the awareness of ergonomics in nursing, and safe work practices. All participants completed the Standardized Nordic Questionnaire to identify musculoskeletal injuries and health status including MSD symptoms. The findings from this study revealed 53% demonstrated a lack of awareness regarding ergonomics and safety measures related to MSI, also 75% of the population in this study did not use the proper recommended ergonomic techniques for patient management and assistance (Paul 2012). In addition, it was found that 53% of nurses complained about musculoskeletal injuries, and half of them reported pain in their lower back (Paul, 2012). The researcher found that nurses had poor patient handling techniques that contributed to musculoskeletal discomfort and risk for injury (Paul, 2012).

Another investigation aimed to evaluate the primary causes of lost time due to MSDs for occupations within healthcare (Ngan et al., 2010). The focus of this research was on measuring the relative risks (RR) for MSIs. Researchers found the highest RR of MSIs was among registered nurses and care aids

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at RR 3.16 (2.38–4.18) and RR 3.76 (3.09–4.59) respectively. Comparatively, the BLS reported rates of time lost due to occupational injury were 8.8/100 full-time hospital workers and 13.5/100 for long-term healthcare workers, both rates far above the national average (Dressner and Kissinger, 2018). After the evaluation was complete, the research identified that MSIs were confirmed as the most common type of injury to healthcare workers, making up 83% of all injuries in the industry (Ngan, et al., 2010). These findings remain fairly constant across demographics such as age groups, gender, sub-sector healthcare workers, employment status, and occupation. The injury rates among nurses are higher than many work environments such as mining, construction, and agriculture. This staggering statistic causes us to empathize with the importance of addressing risks associated with MSIs and MSDs (Ngan et al., 2010).

1.3 Old Prevention and Training

Research also revealed that LPNs and CNAs are at highest risk for MSDs (Ngan et al., 2010). These findings indicate that more prevention efforts should be aimed at supporting the safety and health and wellbeing of healthcare workers who work directly with patients. Researchers advocated for programs to be developed and implemented to reduce risk factors and the incidence of MSIs within the healthcare community. They should be tailored toward each person's needs accordingly (Ngan et al., 2010).

A graduate thesis reviewed nursing programs and hospitals in Colorado regarding their education and the role ergonomics plays in MSI prevention for the healthcare industry and best practices (Goodwin, 2012). The thesis assessed musculoskeletal disorders specifically related to the manual handling of patients. The thesis shed light on the lack of training, and the importance of ergonomics training in the healthcare workplace. Without proper training, nurses will always be at higher risk of developing a musculoskeletal injury and MSD despite the tools and resources that were used (Goodwin, 2012).

Goodwin (2012) examined three traditional Bachelor of Science in Nursing programs, and four hospitals from two healthcare systems. A questionnaire was administered to all three facilities regarding the inclusion of evidenced-based training and education in ergonomics for nurses. The surveys revealed that each nursing school acknowledged MSIs are a major problem in the healthcare industry, especially related to patient handling (Goodwin, 2012). Although they recognized the issue, none of the nursing programs used evidence-based curricula to instruct nursing students on preventing MSIs, and ergonomic principles. Only one of the three healthcare systems surveyed reported that they had an established set of policies and procedures for educating nurses on the prevention of MSIs and MSDs when handling patients (Goodwin, 2012).

It was recommended that nursing programs incorporate evidence-based curricula within the program to ensure the delivery of a comprehensive plan for safe patient handling, thus minimizing nurses' exposure to hazardous risk factors and circumstances that ultimately can lead to developing an MSD. Hospitals should also implement a set of written policies and procedures as a part of their new hire process and assess regularly nurses' competencies through employment (Goodwin, 2012).

2. METHODS AND MATERIALS

This research fulfilled the requirements of a Senior Project class at the university. The project proposal was approved by the primary faculty for the course. Participants in this study were recruited as a convenience sample from a local healthcare facility. The investigation included six female nurses between the ages of 28 and 48. All participants signed an informed consent form before participating in the pilot study. See Appendix B for the informed consent.

https://doi.org/10.5281/zenodo.10911792

Participation was voluntary and subjects were told that they could opt out at any time. Lifts were simulated for the study and involved a volunteer rather than a real patient. Lifts were performed with and without lift assist equipment. A "Golvo" lift device or "Sara Steady" and "Gate Belt" are commonly used to aid nurses in a variety of patient lifts, contingent upon the desired destination.

The Sara Steady device provides a stabilized structure for the patient to pull on as they rise. This was used by the patient while the nurse assisted the patient to a standing position. The Golvo system requires the nurse secure the patient with a harness system and the device does the lifting. Each nurse performed both lifts, the first without lift assist, Sara Steady and Gate Belt only, and the second lift was accomplished using Golvo lift assist system. All lifts were video recorded for ergonomic analysis using REBA ergonomic assessment. The REBA Excel files were freeware obtained from the Center for Ergonomics as North Carolina State University: https://www.ergocenter.ncsu.edu/.

Ergonomic assessment risk scores were generated by observing the videotaped simulated patient transfers and completing the REBA worksheet. Each nurse performed two common lifts that nurses accomplish in their daily work. See Appendix A for REBA Evaluation Worksheet. The evaluator made observations and completed the providing input for each factor considered in the REBA evaluation. Key measures focused on postures and loading factors while performing the lift. The Excel spreadsheet generated the REBA scores or risk estimates. Data were analyzed using Minitab Statistical Software, Version 21TM. Mean scores were generated and the paired T-test was used to evaluate differences in mean scores.

3. RESULTS

All six nurses performed both lifts with scores seen in Table 1. The first lift, which consisted of a nurse using a Gate Belt and Sara Steady tool to assist the patient in transferring from a seated position to a standing position. Lift one had a range of 6 – 13 with a mean score of 8.3, see Table 1.

Table 1. REBA Scores for Six Lifts

Nurse	Lift 1- No Assist: REBA Score	Lift 2 – Assisted: REBA Score
1	7	10
2	6	10
3	8	9
4	8	10
5	13	9
6	8	10
Mean	8.33	9.67

No statistically significant difference, p-value 0.88

Figure 1 shows nurse 6 performing lift one. The nurse is lifting the patient using a Gate Belt while the patient is using the Sara Steady to rise to his feet requiring the nurse exert force to assist the patient to a standing position. The second lift consisted of harnessing the patient into a sling from a sitting position and transporting them to a bed using the Golvo lift device. The second lift doesn't require the nurse to lift assist but rather secure the patient in a harness system for a mechanical lift. The second lift had a REBA range of 9 to 10 with a mean score of 9.67.

https://doi.org/10.5281/zenodo.10911792

Figure 1. Lift 1

Figure 2. Lift 2

When looking at the REBA Scores side-by-side, one can see that the majority of lift two scores are higher than lift 1 scores, see Figure 3.

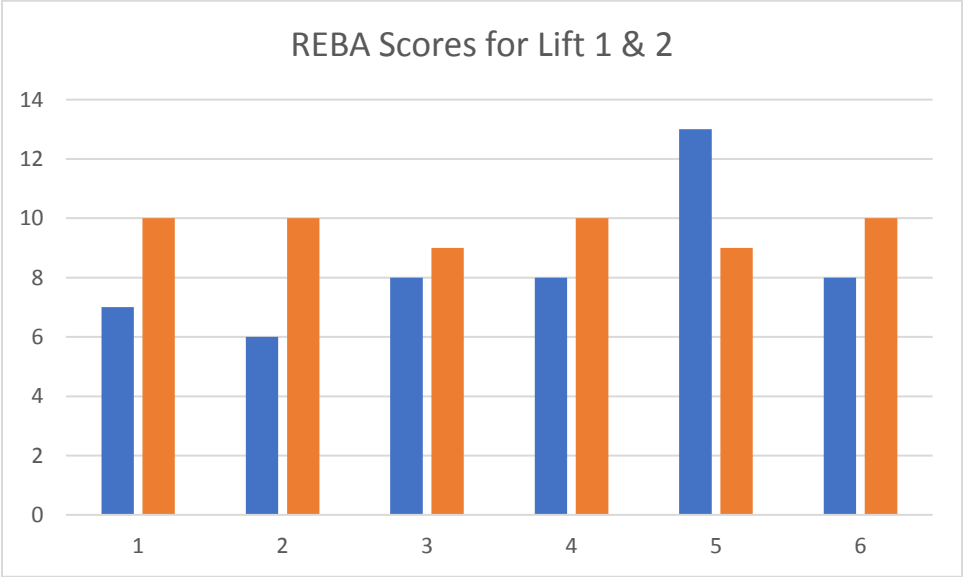

Figure 3. REBA Scores for 6 Lifts - Lift 1 & 2
No statistically significant difference, p-value 0.88

4. DISCUSSION AND LIMITATIONS

The results of this pilot study revealed there was an increase in the REBA risk scores using a no lift system. Both types of lift present risks for developing a musculoskeletal injury. Our REBA scores were consistent with prior research (Ayvaz et al., 2023). Nurses use lift-assist equipment when handling and transferring patients to reduce risks, our findings are contrary to expectations. The findings do not relate to initial expectations, as we anticipated lower REBA scores when using lift-assist equipment. While there was no statistical difference, p-value 0.88, we did not anticipate consistently higher values on lift two. The first style of lift revealed nurses are most at risk for developing a MSD in the shoulder

https://doi.org/10.5281/zenodo.10911792

or upper extremity. The shoulder and upper extremity have been identified as common areas of the body to be injured in patient transfer (Lin et al., 2020). They rely mostly on shoulder strength from one side of their body during this lift to aid patients.

While the results indicated that there is still a considerable risk involved, the averages for lifting styles do not provide a complete representation of all the risk factors, more variables need to be considered such as experience, training, cycle time, number of lifts, and accurate force requirements for each type of transfer. The sample size was small and any inferences should not be made. Nurse six had a REBA score of 13, while the other nurses all had scores less than eight. This outlier may have significantly raised the average, making the lift look of higher risk than it was, and contributed to the lack of differences. Despite this change in patterns, it's important to acknowledge that the majority of nurses completed the patient transfer simulation with high levels of risk regardless of lifting styles. From this investigation, we learned that even with the implementation of tools and equipment to make the transfer safer, without proper training, the nurses can still be at a high risk for developing MSI and MSD.

The second lift had a mean REBA score of 9.67 and a very tight range of 9 to 10. The highest risk involved in this lift occurred when nurses bent down to wrap the harness around patients' legs. The most significant concern in this lift was the risk of injury to the lower back. This is consistent with prior research that identified the low back as the second most common body part injured (Lee, Lee and Harrison, 2022). Lifting the weight of a leg at the angle that feels most natural to these nurses poses a greater risk to their musculoskeletal health. As the risk was high with an able-bodied 150-pound male, this risk would be even greater for a bariatric patient.

Another factor that could have affected the transfer simulation was that some nurses participated toward the end of their shifts when they were fatigued from a full day's work. Thus, they may not have replicated their usual lifting protocols as when managing with actual patients. The recruitment of nurses for participation proved challenging, and those who did take part appeared somewhat rushed and exhausted.

Another factor to consider in the transfer simulation was a 150-pound 22-year-old able-bodied male was used as the false patient. He did not accurately represent the usual patient requiring a transfer. Nurses gauge how much assistance the patient can give them in their lifts, if the patient was a 200-pound person with limited mobility the results may have had a different outcome.

In the future, it is recommended to recruit a larger sample size that includes more nurses in the transfer simulation and collect more information on the nurses such as age, years of experience in their field, lifestyle factors, training history, health status, and any prior injury for a better understanding of the risks involved. It is also recommended to have nurses participate in transfer simulation at the beginning of their shifts when they are more energized and less fatigued and able to participate at higher energy level. It would be best to evaluate practicing nurses handling and transferring actual patients for a more accurate representation of what it is like to lift patients who are not able-bodied or overweight.

5. CONCLUSION

In summary, this research pilot project emphasizes the challenges that the healthcare industry face. MSIs and MSDs are prevalent and there exists an urgent need to develop effective strategies to mitigate ergonomic hazards associated with patient handling and transfer, this should be a top priority. Previous and current research confirms there is a high level of risk to nurses while performing patient lifts,

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which should lead to further investigation and the implementation of effective controls (Lee, Lee and Harrison, 2022).

Based on this pilot research, one solution that could lower the risk is more in-depth training for nurses on the proper use of all lift assist devices used in their facilities. The tools may be effective at reducing risks to both nurse and patient, only if the nurses utilize them properly and safely. Training programs that teach the staff proper ergonomic techniques are essential to the success and well-being of the nurses (Goodwin, 2012). By implementing ergonomic solutions, there can be improvement in nurses's physical health, comfort, and productivity, as well as the safety of the patient.

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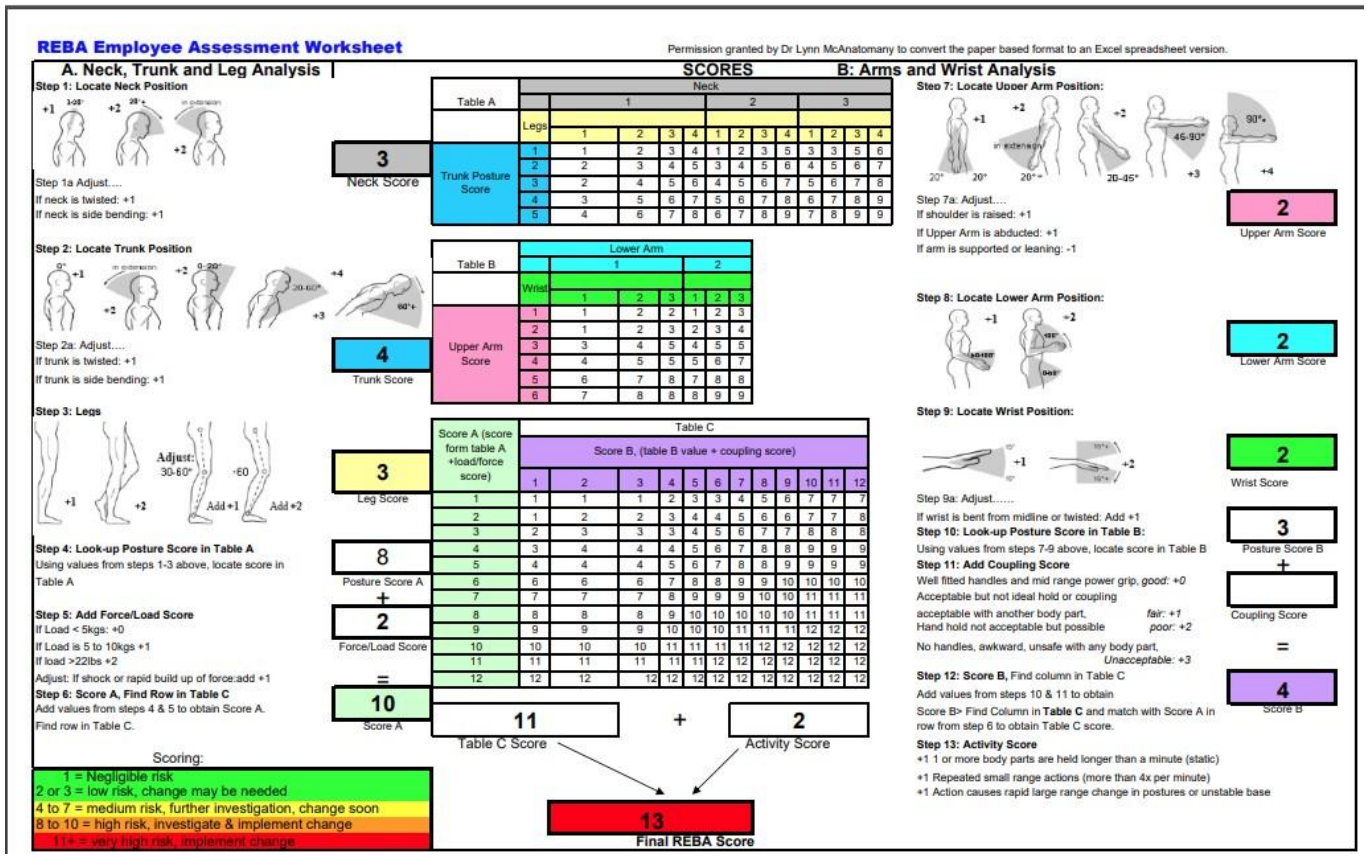
APPENDIX A: REBA Evaluation Worksheet



https://doi.org/10.5281/zenodo.10911792

APPENDIX B: Consent Form

Research Informed Consent

TITLE OF STUDY

Risk Assessment for Healthcare workers during patient transfers using REBA

PRIMARY RESEARCHER

Name Madelyn Mariegard
Department Student at Montana Technological University
Address 1300 W Park St. Butte MT, 59601
Phone (406)431 6204
Email mmariegard@mtech.edu

PURPOSE OF STUDY

The objective of this research is to assess the risk involved in manually handling patients. The method that will be used to quantify risk of injuries is the REBA – Rapid Entire Body Assessment. This is an economic analysis tool that will analyze the level of risk involved that is associated with each specific task. This will also be accompanied by a short qualitative questionnaire.

PROCEDURES

In the initial phase of our study, we will administer a survey to six participating nurses. This survey consists of four questions, two of which pertain to the depth of their training received during their nursing education, while the remaining two focus on training prior to commencing employment. These inquiries are fundamental in establishing a comprehensive understanding of the participants' educational and professional backgrounds, thereby providing the necessary context for the subsequent simulation phase.
Following the completion of the questionnaire, the participating nurses will partake in a simulated exercise. This simulation involves the execution of two patient lifts by each nurse. It is noteworthy that, for these simulations, we will employ a volunteer as the standardized patient. This approach is adopted to maintain a consistent factor throughout the simulations: the patient's characteristics. This consistency is imperative to isolate and scrutinize the impact of the nurses' training and experience on their performance in patient lifts.

Page 1 of 3

CONFIDENTIALITY

Please do not write any identifying information.

Every effort will be made by the researcher to preserve your confidentiality including the following:

- Assigning code names/numbers for participants that will be used on all research notes and documents
- Keeping notes, interview transcriptions, and any other identifying participant information in a locked file cabinet in the personal possession of the researcher.

Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk.

CONTACT INFORMATION

If you have questions at any time about this study, or you experience adverse effects as the result of participating in this study, you may contact the researcher whose contact information is provided on the first page. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the Primary Researcher directly by telephone at (406) 431 6204 or at the following email address (mmariegard@mtech.edu).

VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Participant's Signature _____ Date _____

Researcher's Signature _____ Date _____

Page 2 of 3

MAIN AUTHOR

Madelyn Mariegard, BS, GSP is a recent graduate in Occupational, Safety and Health from Montana Technological University. She completed two internships during her studies, learning much about confined space safety, emergency action plan, SDSs, safety culture, construction hazards and safety training. She has joined Kellanova as their Environmental Safety and Health Specialist. Madlyn finds her work a great experience and is learning much. She will be working with a team to roll out a natural resource conservation program.

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CITATION:

Mariegard, M., & Gilkey, D. (2024). *Valuating Ergonomic Risk for Nurses During Patient Transfers: A Pilot Study*. World Safety Journal, Vol. XXXIII(1), 25–34. https://doi.org/10.5281/zenodo.10911792

World Safety Journal

A peer-reviewed journal,
published by the World Safety Organization

Journal Homepage:
https://worldsafety.org/wso-world-safety-journal/

Overcoming Hurdles: The Crucial Obstacles in Cultivating Corporate Safety Culture!

Harbans Lal[1,*] and E.M. Choueiri[2]

[1] *Professor of Psychology (Retd.), SNDT Women's University; Director, Forum of Behavioural Safety, Mumbai, India*

[2] *WSO Board Member and Liaison Officer to the United Nations; Professor at several Lebanese universities*

KEYWORDS

Safety culture
Leadership commitment
Employee engagement
Risk tolerance
Communication

ABSTRACT

This paper goes into the critical yet difficult task of developing a strong corporate safety culture within firms. Recognizing the vital role of such a culture in guaranteeing employee well-being and economic success, it identifies and analyses numerous major barriers to its growth. These hurdles range from leadership commitment and staff engagement to regulatory concerns, risk tolerance, communication barriers, resource restrictions, training deficiencies, technological adaptation challenges, and external influences. The paper's goal in thoroughly exploring each obstacle is to shed light on the complexity involved and provide insights into effective techniques for overcoming them. By addressing these challenges head on, organizations may prepare the way for the formation of a deeply entrenched safety culture, supporting a work environment in which workers' health and security are prioritized.

1. INTRODUCTION

Corporate safety culture is a cornerstone of any successful firm, acting as a compass to direct operations toward the preservation of human life and well-being. A shared commitment to prioritizing safety above all else forms the foundation of a strong safety culture. It develops an environment in which employees feel appreciated, empowered, and protected. However, despite its undeniable importance, establishing and maintaining such a culture is a diverse and difficult challenge.

At the heart of these challenges is the question of leadership commitment. Initiatives aimed at enhancing safety are likely to fail unless organizational leaders commit to them unwaveringly. However, getting genuine commitment from leadership is difficult in many circumstances, as conflicting agendas and short-term objectives sometimes eclipse long-term safety goals.

Furthermore, staff engagement and participation emerge as critical components in developing a robust safety culture. Encouraging frontline staff to actively participate in safety initiatives not only increases their efficacy but also promotes a sense of ownership and responsibility. Nonetheless, impediments like apathy, fear of retaliation, and a lack of trust frequently prevent effective employee participation.

* ***Corresponding Author***: kailahl@hotmail.com

https://doi.org/10.5281/zenodo.10911860

Another important problem is establishing a balance between just complying with safety laws and instilling a deeper, intrinsic commitment to safety ideals. Although compliance is essential, fostering a culture based on genuine commitment requires a fundamental change in attitudes and behaviors towards safety. However, implementing this transition is difficult given competing organizational agendas and incentives to emphasize productivity and revenue over safety concerns.

In addition, the topic of risk tolerance is prominent in the corporate environment, with firms struggling to balance the need for risk management with the persistent pursuit of business goals. The temptation to cut corners, ignore safety rules, or take unwarranted risks in the name of expediency endangers the integrity of safety cultures.

Communication breakdowns and reporting flaws compound these issues, preventing the flow of critical safety information throughout the company. Inadequate communication channels, along with a reluctance to disclose safety issues, provide fertile ground for accidents and incidents to go unnoticed or unreported.

Fostering a strong safety culture becomes even more difficult when faced with resource limits, organizational structure difficulties, and resistance to technological improvements. However, by identifying, analyzing, and tackling these challenges head-on, organizations can begin to pave the way for a culture in which safety is not only a priority but an ingrained value knit into the fabric of the organizational ethos. This article delves into these critical challenges, providing insights and techniques for negotiating the difficulties that come with establishing a company safety culture.

2. OBJECTIVES

The aim of this study was:

- to analyze the impact of leadership commitment on the development and sustainability of corporate safety culture, with a focus on identifying barriers to achieving genuine dedication from organizational leaders.
- to examine the role of employee engagement and participation in fostering a culture of safety within organizations, explore strategies to overcome barriers such as apathy, fear of reprisal, and lack of trust.
- to differentiate between mere compliance with safety regulations and the cultivation of a deeper, intrinsic commitment to safety principles, assess the challenges inherent in promoting a culture rooted in genuine commitment.
- to investigate the complexities surrounding risk tolerance within organizations and the consequent implications for safety culture, with a focus on strategies for striking a balance between risk management and business objectives.
- to explore the impact of communication breakdowns and reporting deficiencies on corporate safety culture, identify barriers to effective communication, and develop strategies for enhancing reporting mechanisms.
- to assess the challenges posed by resource constraints, organizational structure complexities, and resistance to technological advancements in the cultivation of a robust safety culture, we offer practical approaches for overcoming these obstacles.

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- to highlight the importance of ongoing training and education in sustaining a culture of safety, examine common training deficiencies, and recommend strategies for enhancing training programs.
- to investigate the influence of external factors such as regulatory compliance requirements and industry pressures on corporate safety culture, explore strategies for navigating these external influences while maintaining a focus on safety.
- to provide actionable insights and practical recommendations for organizations seeking to overcome the identified obstacles and cultivate a culture where safety is ingrained as a core organizational value.
- to contribute to the body of knowledge surrounding corporate safety culture by offering a comprehensive analysis of the crucial obstacles hindering its development and sustainability, with the ultimate goal of promoting safer work environments and protecting the well-being of employees.

To meet the aims, a literature review and a longitudinal action survey were conducted. The survey included interviews with 306 managers from various industries, as well as field trips to 47 locations (see Table 1). Executives, supervisors, heads of departments (HOD), and Environment, Health, and Safety (EHS) specialists from both the private and public sectors made up the study sample.

Table 1. Type of interviewees and industrial sectors

Industry	Directors/HODs	Operation Managers	EHS Professionals
Chemical manufacturing (12 locations)	20	26	30
Construction (14 locations)	24	32	34
Oil and Gas (10 locations)	21	22	24
Power and Steel (11 locations)	20	27	26

We conducted the study using random sampling. Primary data collection included 90 interviews and 60 training sessions and discussions. The study lasted for nearly two years, from 2021 to 2023, and included in-depth, open-ended questions and personal interviews. The interviews and discussions centered on the problems of establishing a safety culture in the industrial sector. The following sections present the findings of the literature review and survey.

3. LACK OF LEADERSHIP COMMITMENT

Leadership commitment serves as the foundation for a strong business safety culture. However, one of the most significant hurdles to establishing such a culture is the widespread lack of unwavering dedication among organizational leaders. Without genuine commitment from the highest levels of management, safety efforts risk being dismissed as simply lip service, with no meaningful action or impact.

Safety objectives often lag behind short-term financial benefits or operational savings, leaving organizational leaders torn between competing priorities. Such cases push safety efforts to the background, diminishing their effectiveness and eroding trust in the organization's commitment to employee well-being.

https://doi.org/10.5281/zenodo.10911860

Furthermore, a lack of visible leadership support might convey to staff that safety is not a top priority, leading to complacency and disdain for safety rules. When leaders fail to support safety as a core company value, employees are less likely to take safety precautions seriously, increasing workplace risks and hazards.

Creating a culture that views safety as non-negotiable and ingrained in the organization's DNA is necessary to address the issue of leadership commitment. This demands not only vocal leadership support, but also actual actions that indicate a genuine commitment to putting safety first. Leaders must set an example by actively participating in safety efforts and openly advocating for a safe workplace.

Moreover, creating leadership commitment entails linking safety objectives with broader corporate goals and objectives, emphasizing the mutually beneficial relationship between safety, productivity, and profitability. By demonstrating the practical benefits of investing in safety, leaders can gain greater buy-in and support from stakeholders at all levels of the business.

Ultimately, overcoming the obstacle of lack of leadership commitment requires a cultural shift within organizations, where safety is elevated to the forefront of decision-making processes and embedded into the fabric of the organizational ethos. By fostering a culture where safety is valued, championed, and prioritized by leadership, organizations can lay the foundation for a safer, healthier, and more productive work environment for all employees.

4. EMPLOYEE ENGAGEMENT AND PARTICIPATION

Employee engagement and participation are critical components in the development of a strong business safety culture. However, organizations frequently face major challenges in developing meaningful participation from their workers in safety efforts. One of the most difficult obstacles is overcoming employee apathy or disengagement, in which workers may regard safety protocols as burdensome or unnecessary to their everyday responsibilities. Concerns about potential retaliation for reporting safety hazards can also foster a culture of fear, preventing open communication and active involvement.

To solve these issues, firms should emphasize efforts to actively involve and empower their employees in safety-related activities. This entails building channels for open communication and feedback in which employees feel free to express their concerns, suggestions, and observations about safety without fear of repercussions. Building trust between management and staff is critical because it generates a sense of psychological safety, allowing people to speak out about possible hazards or safety lapses.

Furthermore, firms can improve employee engagement by incorporating frontline workers in the decision-making process for safety policies, procedures, and programs. By obtaining feedback from individuals directly affected by safety rules, organizations can ensure their realism, relevance, and effectiveness. Empowering employees to take ownership of safety develops a sense of accountability and responsibility, which drives collective efforts toward a safer workplace.

Training and education are also important for increasing staff engagement and participation in safety activities. Comprehensive safety training programs provide personnel with the knowledge and skills required to detect hazards, assess risks, and follow safety standards. Additionally, constant training keeps staff knowledgeable about new safety procedures, technologies, and best practices, supporting a culture of continuous improvement and vigilance.

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Organizations must also acknowledge and celebrate employees' efforts to ensure safety, whether through recognition programs, prizes, or incentives. Organizations highlight the importance of human responsibility in ensuring a safe work environment by recognizing and rewarding safety-promoting behaviors and motivating employees to actively participate in safety programs.

Finally, promoting employee engagement and participation in safety programs necessitates a multidimensional approach that emphasizes open communication, trust-building, empowerment, and recognition. Organizations may utilize their workforce's collaborative efforts to build safer, healthier, and more resilient workplaces by actively integrating them in the safety process and fostering a culture in which safety is everyone's responsibility.

5. COMPLIANCE vs. COMMITMENT

Compliance versus commitment is a critical distinction in corporate safety culture, distinguishing between simple conformity to safety laws and a deeper, intrinsic commitment to safety values. Adhering to safety regulations is clearly important, but it often fails to foster a culture that fully embraces safety as a key organizational value. Instead, a culture based on true commitment needs a paradigm shift in attitudes and actions toward safety, going beyond statutory requirements to include a proactive approach to risk mitigation and hazard prevention.

One of the most difficult obstacles to developing a culture of commitment is overcoming businesses' predisposition to prioritize compliance over actual dedication to safety. In many circumstances, firms may regard compliance as a checkbox exercise, focused exclusively on satisfying minimal regulatory obligations rather than proactively identifying and addressing potential safety risks. This narrow focus on compliance can foster a culture of mediocrity, in which safety is considered a checkbox rather than a critical component of organizational operations.

Furthermore, achieving true commitment to safety necessitates a concerted effort to inculcate a feeling of personal responsibility and ownership in employees at all levels of the business. Unlike compliance, which is often motivated by external pressures or requirements, commitment to safety comes from within, with individuals taking proactive steps to identify and mitigate safety hazards in their particular roles and responsibilities. This change toward intrinsic motivation necessitates creating a culture in which employees feel empowered to raise safety issues, take the initiative in making safety improvements, and hold themselves and their coworkers accountable for safety performance.

Organizations can set the tone for a culture in which safety is not only a priority but an embedded value that pervades all aspects of organizational operations by displaying leadership's steadfast commitment to safety through both words and deeds. In addition, firms must engage in comprehensive training and education programs to provide staff with the knowledge, skills, and resources they need to meet safety standards and identify possible dangers. Organizations that emphasize the importance of proactive risk management and hazard prevention can encourage employees to become active participants in the safety process, resulting in continual improvement and innovation in safety processes.

In summary, while compliance with safety rules is an essential starting point, meaningful progress in developing a safety culture is dependent on instilling a deeper, inherent commitment to safety principles. Organizations can create safer, healthier, and more resilient workplaces by moving beyond the limitations of compliance and embracing a culture of commitment. Employee well-being is vital.

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6. RISK TOLERANCE AND PRESSURE

Risk tolerance and pressure are key barriers to developing a good corporate safety culture, as firms frequently struggle to strike a delicate balance between effectively managing risks and accomplishing business objectives. In many industries, there is a prevalent culture of risk tolerance in which the quest for production, efficiency, and profitability occasionally takes precedence over safety concerns. This risk tolerance culture can take many forms, including cutting corners, disregarding safety regulations, and accepting unwarranted risks in the pursuit of operational goals.

One of the most significant issues related to risk tolerance is the inherent tension between safety and production. Organizations may be under pressure to meet tight deadlines, meet customer expectations, or maintain a competitive advantage, resulting in a mindset that emphasizes short-term profits over long-term safety concerns. Employees in such environments may feel obliged to take risks or disregard safety regulations in order to achieve corporate goals, jeopardizing the integrity of the safety culture.

Furthermore, organizational leaders may unintentionally create a culture of risk tolerance through their actions, decisions, and communication styles. When executives prioritize production targets or financial metrics over safety outcomes, they communicate to staff that safety is negotiable and that taking risks is acceptable as long as they provide results. This normalization of risk-taking behavior can erode trust in safety protocols and undermine efforts to foster a culture that prioritizes safety above all else.

Addressing the issue of risk tolerance necessitates a holistic approach that includes not only reevaluating organizational priorities and values, but also cultivating a culture that incorporates safety into all aspects of decision-making and operations. Organizations must recognize that safety and productivity are not mutually exclusive goals, but rather complementing ones that may be met through proactive risk management and hazard prevention.

In addition, firms must provide their staff with the resources, support, and training they need to effectively identify and mitigate risks. Organizations can foster a culture of safety by investing in thorough safety training programs, supporting open communication lines, and encouraging employees to report safety problems without fear of retaliation.

Moreover, corporate leaders must set a good example by displaying a firm commitment to safety through their words and actions. Leaders may set the tone for a culture of safety by prioritizing safety in their decision-making processes, allocating resources to support safety initiatives, and actively engaging with employees on safety issues.

To summarize, overcoming the challenges of risk tolerance and pressure necessitates a purposeful effort to alter corporate objectives, attitudes, and behaviors toward a culture that prioritizes safety above all else. Organizations may create safer, healthier, and more resilient environments for their employees by understanding and proactively addressing the inherent dangers associated with a tolerance culture.

7. COMMUNICATION AND REPORTING

Communication and reporting are critical components in developing a strong company safety culture, acting as key avenues for information exchange, hazard identification, and safety concern resolution. However, businesses frequently face major impediments to effective communication and reporting processes, limiting their capacity to identify and resolve safety issues in a timely manner. One common

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barrier is a lack of open communication channels, which may cause employees to be reluctant or unable to express their safety concerns for fear of retaliation, perceived futility, or insufficient communication tools.

Furthermore, organizational hierarchies and power dynamics can increase communication barriers, resulting in a culture in which lower-level employees may feel disempowered or marginalized in their ability to raise safety issues with management. Under such circumstances, the chain of command may misconstrue or repress safety-related information, leading to a gap between frontline workers and corporate decision-makers.

Moreover, reporting shortcomings pose a substantial barrier to efficient safety management because businesses may lack standardized reporting methods, tools, or incentives to encourage employees to report safety events, near misses, or hazards. Organizations that do not disclose safety data accurately and on time may fail to spot developing trends, assess risks, and implement remedial steps, leaving them vulnerable to accidents or incidents.

To address the communication and reporting dilemma, a multidimensional approach is required, including the establishment of an organizational culture of open communication, trust, and transparency. Organizations must provide methods for employees to report safety issues anonymously and without fear of reprisal or retaliation, and guarantee that all reports are handled seriously and addressed immediately.

In addition, firms must invest in thorough training programs that educate employees on the necessity of reporting safety occurrences and dangers, as well as provide them with the skills and tools they need to do so successfully. By fostering a culture that encourages, respects, and rewards safety reporting, organizations empower employees to actively discover and resolve safety hazards.

Additionally, firms must use technology to expedite reporting procedures, automate data collection, and enable real-time communication between employees and management. Organizations may improve the accessibility and usefulness of safety data by establishing user-friendly reporting systems and dashboards, allowing them to make better-informed decisions and manage risks more effectively.

Finally, good communication and reporting are critical components of a successful corporate safety culture, allowing firms to discover hazards, assess risks, and take corrective action in a timely manner. Organizations may build safer, healthier, and more resilient workplaces for their employees by removing communication and reporting barriers and cultivating a culture in which safety is everyone's responsibility.

8. ORGANIZATIONAL STRUCTURE AND RESOURCES

Organizational structure and resources have a crucial role in the establishment and maintenance of a good corporate safety culture. The organization's structure, including its hierarchy, communication channels, and decision-making procedures, can help or hinder the implementation of safety initiatives. Complex organizational structures with several layers of management can impede effective communication and collaboration, making it difficult to disseminate safety information and execute safety standards consistently across all levels of the business.

Furthermore, resource restrictions, such as budgetary constraints or insufficient manpower, can significantly impede the implementation of comprehensive safety programs and initiatives. Without adequate funding, firms may struggle to invest in critical safety equipment, training programs, or technological solutions required to eliminate hazards and guarantee a safe working environment.

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Similarly, a lack of human resources, such as safety professionals or dedicated safety committees, might limit an organization's capacity to establish and implement effective safety policies and procedures.

Moreover, organizational cultures that stress productivity and efficiency over safety may worsen the issues related to organizational structure and resources. In such cultures, safety may be considered an afterthought or a barrier to operational goals, resulting in a lack of investment in safety resources and an unwillingness to devote appropriate time or attention to safety-related issues.

Addressing the difficulties of organizational structure and resources necessitates a strategic approach that prioritizes collaboration, transparency, and resource allocation. Organizations must evaluate their current organizational structure and discover possibilities to streamline communication channels, lower bureaucratic hurdles, and empower employees at all levels to play an active part in safety management.

In addition, firms must prioritize the provision of resources to support safety activities, ensuring that adequate money is committed for safety training, equipment, and technology. Investing in safety resources not only indicates an organization's dedication to safety, but it also helps to reduce risks and prevent costly accidents or incidents in the long run.

Further, firms can use technology to speed safety management processes, increase data collection and analysis, and foster employee communication and collaboration. By introducing user-friendly safety management systems and digital technologies, organizations can transcend some of the limits imposed by organizational structure and resource constraints, allowing for more efficient and effective safety management procedures.

Finally, firms must acknowledge that developing a strong corporate safety culture necessitates a willingness to overcome the challenges given by organizational structure and resources. Organizations can build safer, healthier, and more resilient workplaces for their employees by cultivating a safety-conscious culture, investing in critical resources, and employing technology to streamline safety management operations.

9. TRAINING AND EDUCATION

Training and education are critical components of developing a strong corporate safety culture, as they provide employees with the knowledge, skills, and awareness required to detect hazards, assess risks, and follow safety regulations. Comprehensive safety training programs are the foundation of good safety management, providing employees with the knowledge and resources they need to do their tasks safely and effectively. Training programs, which range from basic safety orientation for new recruits to specialized training on specific hazards or job responsibilities, play an important role in ensuring that employees are appropriately equipped to negotiate the intricacies of the workplace while minimizing risks to their health and safety.

Furthermore, continuing education and training are critical for fostering a culture of continual improvement and vigilance in safety management. As technologies, processes, and regulatory requirements advance, firms must ensure that their staff are up-to-date on the most recent safety standards, procedures, and best practices. Regular training sessions, workshops, and refresher courses assist in reinforcing essential safety ideas, addressing developing safety concerns, and fostering an environment of lifelong learning and development among employees.

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Moreover, training and education are effective instruments for fostering a culture of accountability and responsibility within safety management. Organizations enable employees to take an active role in ensuring a safe workplace by providing them with the knowledge and skills they need to detect and report safety concerns. Training programs that emphasize the necessity of reporting safety concerns, near misses, and incidents contribute to a culture that values open communication and transparency, allowing businesses to address possible risks before they become significant incidents or accidents.

To optimize the success of training and education activities, firms must personalize their programs to their employees' individual needs and requirements. This may include completing extensive assessments of job responsibilities, dangers, and skill gaps to identify areas where extra training or resources are required. Additionally, employers must ensure that training programs are accessible, engaging, and relevant to employees' roles and responsibilities, including hands-on exercises, real-world scenarios, and interactive learning experiences whenever possible.

Finally, investing in comprehensive training and education programs is not just a legal and moral requirement for businesses, but also a wise commercial decision. Organizations may reduce the risk of workplace accidents and injuries, absenteeism, and turnover and boost productivity and morale by providing employees with the knowledge, skills, and tools they require to work safely. In addition, by building a safety culture through training and education, employers demonstrate their dedication to their employees' well-being while also creating a happy and sustainable work environment for everyone.

10. TECHNOLOGICAL ADVANCEMENTS AND ADAPTATION

Technological improvements create both possibilities and problems in the field of corporate safety culture, providing creative ways to improve safety management procedures but also creating barriers to acceptance and adaptation. From advanced monitoring systems and wearable devices to predictive analytics and virtual reality training, technology has the potential to transform how employers discover, assess, and reduce workplace safety concerns. Organizations can use cutting-edge technologies to improve the efficiency, accuracy, and effectiveness of their safety management operations, resulting in safer and healthier work conditions for their employees.

However, the rapid speed of technological innovation can pose difficulties for businesses attempting to incorporate and integrate new safety solutions into their operations. One of the most significant barriers is change resistance, which occurs when employees are unwilling to adopt new technology because of concerns about job security, privacy, or their capacity to adapt to unfamiliar systems. Furthermore, organizations may face logistical problems while implementing and integrating new technology, such as compatibility issues with existing systems, data management concerns, and limited resources.

Moreover, the complexity and cost of implementing modern safety technology may present challenges for organizations, particularly small and medium-sized businesses with limited budgets and resources. While the initial investment in technology may be large, firms must consider the long-term benefits and possible ROI in terms of improved safety outcomes, lower accident rates, and increased productivity and efficiency. Additionally, companies must ensure that they have the required infrastructure, support, and training in place to fully realize the value and effectiveness of new safety technology.

To address the challenges of technological growth and adaptability, companies must take a deliberate and proactive approach to technology adoption. This includes doing extensive assessments of their safety requirements, identifying areas for improvement, and investigating alternative technical solutions that are consistent with their goals and priorities. Moreover, firms must prioritize

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communication, cooperation, and change management methods to engage employees in the adoption process, resolve concerns, and build an environment of innovation and continuous development.

In addition, companies can use partnerships and collaborations with technology suppliers, industry groups, and research institutes to stay up-to-date on the newest advances in safety technology and have access to expertise and resources to help with implementation. Organizations may ensure that their staff have the knowledge and skills they need to properly exploit new technologies and realize their potential advantages in improving safety management practices by investing in continual training and education.

Finally, technological innovations have the ability to significantly modify corporate safety culture and improve workplace safety outcomes. Organizations may use technology to create safer, healthier, and more resilient work environments for their employees by embracing innovation, overcoming challenges, and cultivating a culture of adaptation and continuous improvement.

11. EXTERNAL FACTORS AND INDUSTRY PRESSURES

External influences and industry pressures have a substantial impact on company safety culture, influencing organizational priorities, practices, and perceptions of safety. Regulatory compliance requirements, for example, are a critical external aspect that firms must consider in their attempts to guarantee workplace safety. Compliance with occupational health and safety rules is not just a legal requirement, but also a fundamental component of good company governance. However, staying on top of increasing regulatory requirements and ensuring compliance can be difficult for firms, especially in industries with complicated regulatory landscapes or constantly changing legislative contexts.

Further, industrial demands and competitive dynamics might alter organizational attitudes and behaviors toward safety. Organizations may face pressure to prioritize productivity, efficiency, and cost-effectiveness over safety considerations in highly competitive industries with thin profit margins and high market demands. Tight deadlines, production quotas, and customer expectations can cultivate a culture that views safety as a hindrance to operational goals instead of a fundamental corporate value. Such situations may motivate businesses to take shortcuts, disregard safety regulations, or take unnecessary risks to fulfill business objectives, thereby jeopardizing the integrity of the safety culture.

Moreover, industry norms and peer pressures can influence corporate attitudes toward safety, since firms frequently compare themselves to industry standards and best practices. Businesses may find it challenging to establish a safety culture and convince stakeholders of the significance of investing in safety efforts in industries that do not prioritize safety or normalize unsafe practices. Industries with strong safety cultures and proactive safety management procedures, on the other hand, may set a good example for others to follow, resulting in overall gains in safety performance.

Managing the challenges created by external variables and industry constraints necessitates a multidimensional approach that includes proactive risk management, strategic stakeholder involvement, and a commitment to continuous improvement. Organizations must stay up-to-date on legislative developments and industry trends and adjust their safety management processes accordingly to ensure compliance and risk mitigation. Furthermore, firms must prioritize communication, collaboration, and knowledge-sharing with industry peers, regulatory agencies, and other stakeholders in order to establish a safety culture and encourage collective efforts to improve safety results.

In addition, firms can set themselves apart from their competitors by taking a proactive approach to safety management and showing leadership in fostering safety excellence. By investing in comprehensive safety programs, employing innovative safety technologies, and cultivating a culture

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that embeds safety as a key organizational value, organizations can enhance their reputation, mitigate risks, and gain a competitive advantage in the marketplace.

Finally, while external forces and industry pressures may pose problems for firms attempting to create a strong corporate safety culture, they also provide opportunities for innovation, collaboration, and improvement. Organizations can create safer, healthier, and more resilient workplaces for their employees by recognizing the influence of external factors, understanding industry dynamics, and taking proactive measures to address challenges, all while positioning themselves for long-term success and sustainability.

12. CONCLUSION

In conclusion, building a strong corporate safety culture is critical for firms committed to prioritizing employee well-being and guaranteeing long-term company success. Throughout this examination of critical challenges to safety culture, it is clear that leadership commitment, employee engagement, compliance versus commitment, risk tolerance, communication, organizational structure and resources, training and education, technological advancements, and external factors all play important roles in shaping safety culture dynamics.

Leadership commitment develops as the basis for establishing the tone for company values and priorities. Without genuine commitment from leaders, safety programs risk being viewed as mere lip service. Similarly, employee involvement is critical because empowered employees are more likely to actively participate in safety activities and contribute to a strong safety culture.

The distinction between compliance and commitment emphasizes the necessity of developing intrinsic motivation and values-based approaches to safety. While compliance serves as a starting point, actual commitment needs a cultural transformation toward proactive risk management and hazard prevention.

Striking a balance between productivity goals and safety considerations is necessary to address risk tolerance and pressure, ensuring that operational goals do not compromise safety. Effective communication and reporting channels are essential for recognizing hazards and taking remedial actions, while organizational structure and resources must support safety programs with streamlined processes and enough investment.

In addition, training and education programs provide personnel with the knowledge and skills required to effectively traverse safety difficulties, while technological breakthroughs provide novel solutions to improve safety management procedures. However, overcoming opposition to change and ensuring effective adaptation are critical to fulfilling technology's full promise of enhancing safety outcomes.

External influences and industry forces also influence safety culture dynamics, with regulatory compliance, industry norms, and competitive pressures shaping organizational attitudes and behaviors toward safety. Organizations may negotiate these external effects by remaining informed, engaging stakeholders, and implementing a proactive approach to safety management.

In summary, tackling the critical challenges to corporate safety culture necessitates a collaborative effort at all levels of the organization, from leadership commitment to frontline staff participation. Organizations can develop a culture in which safety is not only a priority but an embedded value that pervades all aspects of organizational operations by recognizing these difficulties, comprehending their implications, and adopting strategic solutions. Organizations may build cultures in which people feel appreciated, empowered, and protected by working together and continuously improving, ultimately achieving long-term success and sustainability.

https://doi.org/10.5281/zenodo.10911860

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MAIN AUTHOR

Dr. Harbans LAL earned a Master's degree in Psychology from Guru Nanak Dev University and a Ph.D. from Tata Institute of Social Sciences, Mumbai, India. He has been at SNDT Women's University and the Central Labor Institute, Mumbai, for over 28 years. He represented India at Conferences in New York, Berlin, Muscat, Rome, New Zealand, Japan, London, Dubai, Cairo, and Sydney. He is the Editor of the Journal of Psychosocial Research, and serves as Director of the Forum of Behavioral Safety. He has conducted over 1000 behavioral safety programs for the industry.

CITATION:

Lal, H., & Choueiri, E. (2024). *Overcoming Hurdles: The Crucial Obstacles in Cultivating Corporate Safety Culture!* World Safety Journal, Vol. XXXIII(1), 35–47. https://doi.org/10.5281/zenodo.10911860

World Safety Journal

A peer-reviewed journal,
published by the World Safety Organization

Journal Homepage:
https://worldsafety.org/wso-world-safety-journal/

LGBTQ+ Realities: A Comprehensive Exploration of Challenges, Opportunities, and International Perspectives in the MENA Region

Elias M. Choueiri[1,*]
[1] *WSO Board Member and Liaison Officer to the United Nations;*
Professor at several Lebanese universities

KEYWORDS

LGBTQ+
Middle East
North Africa
MENA

ABSTRACT

Historical, legal, social, and cultural considerations create a complicated terrain for the LGBTQ+ community in the Middle East and North Africa (MENA) area. This article presents an overview of LGBTQ+ rights and experiences in the MENA region. Religious and cultural traditions frequently influence the region's traditional ideas about gender and sexuality. However, the impact of colonialism and globalization has created new dynamics that support and challenge LGBTQ+ identities.

Legally, the MENA region takes a variety of approaches to LGBTQ+ issues, with some countries criminalizing same-sex relationships and others making progress toward legal recognition and protection. Nonetheless, prejudice and violence against LGBTQ+ individuals continue, fueled by societal shame and long-standing conventions. Despite these obstacles, the region has seen the rise of LGBTQ+ activism, with grassroots organizations and movements fighting for equal rights and visibility.

The LGBTQ+ community's barriers to healthcare, education, and work highlight the importance of ongoing advocacy and assistance. However, prospects for development do exist, aided by increased international attention and solidarity. International organizations and non-governmental organizations (NGOs) play an important role in advancing LGBTQ+ rights in the MENA region, while global LGBTQ+ movements help to shape local narratives and promote inclusivity.

To summarize, while considerable challenges exist, there is hope for the growth of LGBTQ+ rights in the MENA region. By tackling legal hurdles, challenging societal attitudes, and promoting inclusive policies, LGBTQ+ individuals across the area have the opportunity for greater acceptance and equality.

1. INTRODUCTION

The MENA region includes a wide range of cultures, languages, and customs, but it also has complex ideas regarding gender and sexuality. In recent years, conversations about LGBTQ+ rights and identities have gained increased prominence throughout the region. However,

* ***Corresponding Author***: elias.choueiri@gmail.com

https://doi.org/10.5281/zenodo.10911940

navigating this terrain necessitates a grasp of the historical, legal, social, and cultural aspects that influence LGBTQ+ individuals' experiences.

Traditional values and religious views have historically influenced the MENA region, leading to the marginalization and stigmatization of LGBTQ+ individuals. Legislative frameworks that criminalize same-sex relationships in several countries have reinforced these beliefs, creating significant barriers to the recognition and protection of LGBTQ+ rights. Despite these challenges, the region has not been immune to worldwide trends toward greater acceptance and visibility of LGBTQ+ identities.

In this context, it is critical to investigate the historical foundations of attitudes regarding gender and sexuality in the MENA region, as well as the role of colonialism and globalization in creating modern perceptions. Understanding the interplay of these elements allows us to get insight into the obstacles that LGBTQ+ individuals experience, as well as the chances for advancement in the region. This article lays the groundwork for a more in-depth investigation of LGBTQ+ rights and experiences in the MENA region, emphasizing the complexity and nuances that define this changing landscape.

2. OBJECTIVES

The objectives of this paper are multifaceted, aiming to provide a comprehensive understanding of LGBTQ+ issues within the MENA region. Specifically, the aim of this paper was:

- to examine the historical context surrounding attitudes towards gender and sexuality in the MENA region, tracing the origins of traditional norms and religious beliefs that have influenced societal perceptions of LGBTQ+ individuals.
- to analyze the legal landscape pertaining to LGBTQ+ rights across MENA countries, highlighting variations in laws and policies regarding same-sex relationships, discrimination, and gender identity recognition.
- to explore the social attitudes and cultural context that shape the lived experiences of LGBTQ+ individuals in the MENA region, including the prevalence of stigma, discrimination, and violence, as well as emerging narratives of acceptance and resistance.
- to investigate the emergence of LGBTQ+ activism within the MENA region, identifying key organizations, movements, and strategies employed to advocate for equal rights, visibility, and inclusion.
- to assess the challenges faced by LGBTQ+ individuals in accessing essential services such as healthcare, education, and employment, and to identify opportunities for addressing these disparities through policy reforms and community-based interventions.
- to examine the role of international perspectives and global LGBTQ+ movements in shaping discourse and advocacy efforts within the MENA region, identifying avenues for collaboration and support in advancing LGBTQ+ rights and social justice initiatives. Through these objectives, this study aims to contribute to a deeper understanding of LGBTQ+ issues within the MENA region and to inform advocacy efforts, policy reforms, and social interventions aimed at promoting equality, dignity, and respect for all individuals, regardless of sexual orientation or gender identity.

To meet the aims, a literature review was conducted to identify published peer-reviewed articles documenting LGBTQ+ advocacy in the MENA region, the results of which are detailed in the following.

https://doi.org/10.5281/zenodo.10911940

3. HISTORICAL CONTEXT

The historical context of ideas toward gender and sexuality in the MENA region is complex and firmly based on cultural, religious, and societal conventions. Different civilizations and empires, each with its own impact on social structures and views about gender roles and sexual activity, have influenced the region throughout history.

Documents from pre-Islamic Arabia documented various forms of gender and sexuality, including the presence of transgender individuals and same-sex couples. However, as Islam spread throughout the seventh century, traditional interpretations of Islamic teachings began to impact attitudes toward gender and sexuality, frequently supporting heteronormative ideas and prescribing stringent gender roles.

Over the years, Islamic jurisprudence evolved, including interpretations of religious scriptures that shaped legal and social views about sexuality. While certain historical Islamic communities were more accepting of non-normative gender and sexual manifestations, others penalized same-sex unions and nonconforming behaviors.

Colonialism complicated the landscape of gender and sexuality in the MENA region by imposing European legal systems and moral standards. Victorian-era attitudes on sexuality frequently stigmatized non-heteronormative activities, contributing to the marginalization of LGBTQ+ individuals in indigenous communities.

Following the end of colonialism, several newly independent nations in the MENA region struggled to define their national identities, frequently emphasizing traditions and cultural history. As a result, laws and social conventions governing gender and sexuality reflected a mix of indigenous traditions, religious teachings, and colonial legacies, resulting in a complicated tapestry of attitudes and practices.

In conclusion, a complex and diverse tapestry of influences, including pre-Islamic customs, Islamic teachings, colonial impositions, and present national identities, shape the historical background of gender and sexuality in the MENA region. Understanding the historical trajectory is critical for contextualizing current views and policies toward LGBTQ+ individuals in the region.

4. LEGAL LANDSCAPE

The legal landscape for LGBTQ+ rights in the MENA region is defined by a diversified set of laws and regulations that differ greatly from nation to nation. Many legal frameworks in the region are based on strongly rooted cultural and religious norms, which frequently impact legislation and enforcement around gender and sexuality.

In several MENA countries, laws explicitly ban same-sex partnerships, frequently using religious interpretations to justify punitive penalties. These laws may include imprisonment, corporal punishment, and, in severe situations, the death penalty. Such legal consequences violate LGBTQ+ people’s human rights while also contributing to pervasive stigma and discrimination, leading many to live in fear and secrecy.

In contrast, only a few MENA countries have taken steps to recognize and safeguard the rights of LGBTQ+ individuals. This includes legal measures that decriminalize same-sex relationships, prevent discrimination based on sexual orientation or gender identity, and allow transgender individuals to have their gender identity legally recognized. Even in these nations, public attitudes and cultural norms frequently lag behind legal improvements, making it difficult to administer and enforce LGBTQ+ rights on a consistent basis.

https://doi.org/10.5281/zenodo.10911940

Furthermore, the legal environment for LGBTQ+ individuals in the MENA region is complex due to the convergence of national, customary, and religious laws, as well as the impact of international human rights norms. While some governments have accepted international treaties protecting LGBTQ+ people's rights, such as the Universal Declaration of Human Rights, others continue to resist external pressure to implement reforms, citing sovereignty and cultural relativism.

Cultural, religious, political, and international elements complicate the legal situation for LGBTQ+ rights in the MENA region overall. While some governments have made strides toward greater recognition and protection of LGBTQ+ rights, major hurdles remain in achieving equality and justice for LGBTQ+ individuals throughout the region.

5. SOCIAL ATTITUDES AND CULTURAL CONTEXT

Social attitudes and cultural background significantly influence LGBTQ+ people's experiences in the MENA region. Traditional standards and religious teachings frequently shape society's expectations about gender roles and sexual behavior, resulting in LGBTQ+ individuals being marginalized and stigmatized. In many parts of the MENA region, homosexuality and non-normative gender identities are considered taboo, with LGBTQ+ individuals encountering discrimination, harassment, and even violence on a daily basis.

Religious influences, particularly those of Islam, Christianity, and Judaism, determine cultural attitudes toward LGBTQ+ individuals in the MENA region. Different communities interpret religious scriptures differently, with some adopting more liberal attitudes and others adhering to conservative readings that condemn same-sex relationships and gender nonconformity. Religious leaders and institutions frequently play an important role in enforcing societal norms and attitudes, further marginalizing LGBTQ+ individuals, and preventing open conversations about sexuality and gender diversity.

Social stigma around LGBTQ+ identities in the MENA region can have serious effects on people's mental health, relationships, and opportunities. Many LGBTQ+ individuals face rejection from their families, communities, and religious institutions, which leads to feelings of isolation and alienation. Fear of persecution or violence may lead some individuals to hide their sexual orientation or gender identity, limiting their capacity to live truthfully and access critical support systems.

Despite these hurdles, there are pockets of resistance and action throughout the MENA region, where LGBTQ+ individuals and allies are fighting to change mainstream attitudes and promote acceptance and inclusion. However, progress is typically slow and incremental, as cultural norms and religious teachings continue to have a strong influence on public debate and policymaking. Efforts to advance LGBTQ+ rights must navigate a complicated landscape of cultural sensitivities, striking a balance between human rights promotion and respect for varied religious and cultural traditions.

6. LGBTQ+ ACTIVISM

LGBTQ+ activism in the MENA region has grown in reaction to the issues that LGBTQ+ individuals confront, including discrimination, stigma, and legal persecution. Despite major obstacles, grassroots organizations, advocacy groups, and individuals have worked relentlessly to advance LGBTQ+ populations' equal rights, visibility, and inclusion throughout the region.

Diversity and perseverance are major elements of LGBTQ+ activism in the MENA region. Activists come from many different backgrounds, including LGBTQ+ individuals, allies, human rights activists, and progressive religious leaders. They use a variety of techniques, including organizing protests and

https://doi.org/10.5281/zenodo.10911940

awareness campaigns, as well as giving social services and legal assistance to individuals in need. These efforts seek to question cultural views, push for legislation reforms, and create safe spaces for LGBTQ+ individuals to openly express themselves.

In recent years, LGBTQ+ activism in the MENA region has made greater use of digital platforms and social media to raise awareness, exchange stories, and mobilize support. Online activism allows individuals to interact across boundaries, avoiding authoritarian governments' limits on free expression and assembly. However, it exposes activists to threats such as monitoring, online harassment, and censorship, emphasizing the importance of digital security and solidarity within the LGBTQ+ community.

Despite major hurdles, LGBTQ+ advocacy in the MENA region has seen notable achievements. Some countries have seen gradual changes in legislation and policies, such as the legalization of same-sex relationships, the acceptance of gender identity, and enhanced protection from discrimination. These accomplishments demonstrate the tenacity and persistence of LGBTQ+ activists, as well as the growing global support for LGBTQ+ rights.

However, LGBTQ+ advocacy in the MENA region continues to confront significant challenges, such as legislative prohibitions, societal stigma, and conservative opposition. Many activists face persecution, detention, and violence for their advocacy work, leading others to operate illegally or seek asylum in other countries. Nonetheless, the struggle for LGBTQ+ rights in the MENA region continues, driven by a conviction in all people's inherent dignity and equality, regardless of sexual orientation or gender identity.

7. CHALLENGES AND OPPORTUNITIES

LGBTQ+ individuals face numerous challenges and opportunities in the MENA region, which reflect the complex interplay of cultural, legal, and socioeconomic variables. One of the most significant issues for LGBTQ+ individuals is the widespread stigma, discrimination, and violence they confront on a daily basis. Societal attitudes frequently promote traditional standards that marginalize and exclude LGBTQ+ individuals, causing widespread anxiety, isolation, and mental health difficulties.

Access to critical services such as healthcare, education, and work is another major barrier for LGBTQ+ individuals in the MENA region. Discrimination and prejudice can hinder people's prospects for personal and professional growth, aggravating existing inequities and inequalities. Moreover, legal frameworks in many MENA countries do not effectively protect LGBTQ+ individuals from discrimination and violence, compounding their vulnerability.

Despite these challenges, there are opportunities for growth and transformation. Increased international attention and solidarity have put pressure on MENA governments to address human rights breaches and provide protections for LGBTQ+ individuals. Regional and international organizations, as well as civil society groups, play critical roles in promoting LGBTQ+ rights and assisting individuals in need.

Furthermore, the rise of LGBTQ+ activism in the MENA region indicates a burgeoning movement for change. Grassroots organizations, advocacy groups, and individuals work relentlessly to question cultural norms, fight for legislative changes, and establish safe spaces for LGBTQ+ individuals to openly express themselves. These initiatives not only raise awareness about LGBTQ+ problems but also foster a sense of belonging and solidarity among disenfranchised individuals.

https://doi.org/10.5281/zenodo.10911940

In addition, advances in technology and communication have made it easier for LGBTQ+ individuals in the MENA region to communicate with one another, share resources, and mobilize support than ever before. Digital platforms and social media offer opportunities for advocacy, storytelling, and networking, allowing individuals to defy preconceptions and magnify their voices on a global level.

While problems remain, there is potential for improvement and advancement of LGBTQ+ rights throughout the MENA region. By removing legal impediments, challenging societal attitudes, and promoting inclusive policies and practices, there is hope for a future in which LGBTQ+ individuals can live authentically, free of discrimination and violence.

8. INTERNATIONAL PERSPECTIVES

International perspectives have an important role in shaping the debate and advocacy efforts surrounding LGBTQ+ rights in the MENA region. Human rights organizations, non-governmental organizations (NGOs), and diplomatic institutions from all over the world frequently offer assistance, financing, and experience to local LGBTQ+ activists and organizations operating in the MENA region. Their involvement helps to amplify marginalized populations' voices, raise awareness about human rights breaches, and put pressure on governments to meet their international duties.

Furthermore, international institutions like the United Nations and the European Union have played important roles in advancing LGBTQ+ rights on a worldwide level. Through resolutions, reports, and advocacy campaigns, these organizations have emphasized the significance of recognizing and defending LGBTQ+ people's rights, including in the MENA region. Moreover, international laws and conventions, such as the Universal Declaration of Human Rights and the International Covenant on Civil and Political Rights, establish a framework for holding governments accountable for how they treat LGBTQ+ individuals.

Moreover, worldwide LGBTQ+ groups and networks help to shape dialogue and advocacy efforts in the MENA region. Solidarity actions, awareness campaigns, and cultural exchanges help connect LGBTQ+ communities all over the world, providing moral support and inspiration to activists in the MENA region. These links also allow for the exchange of strategies, resources, and best practices for advancing LGBTQ+ rights in many cultural contexts.

However, worldwide perspectives on LGBTQ+ issues in the MENA region face significant hurdles. Cultural sensitivities, geopolitical tensions, and fears about neocolonialism can all impede efforts to interact with local communities and accomplish significant change. In addition, some governments in the MENA region see foreign support for LGBTQ+ rights as interfering with their internal affairs, resulting in reactions and limits on civil society activism.

Despite these limitations, international viewpoints are still critical for advancing LGBTQ+ rights in the MENA region. International players can help to create a more inclusive and equitable future for LGBTQ+ individuals throughout the area by encouraging conversation, forming coalitions, and harnessing global solidarity.

9. CONCLUSION

To summarize, the landscape of LGBTQ+ rights in the MENA region is defined by a complex interplay of historical, legal, social, and cultural variables. Traditional conventions, religious beliefs, and colonial legacies have all contributed to widespread stigma, discrimination, and violence against LGBTQ+

https://doi.org/10.5281/zenodo.10911940

individuals. Despite these hurdles, grassroots activity, international backing, and technological developments have enabled growth and change.

The struggle for LGBTQ+ rights in the MENA region continues, powered by the tenacity and perseverance of activists and communities. While legal reforms and public attitudes may take time to adapt, small steps forward offer promise for a future in which LGBTQ+ individuals can live openly and freely without fear of persecution or prejudice.

International perspectives play an important role in amplifying marginalized populations' voices, increasing awareness about human rights breaches, and forcing governments to uphold their international duties. International players can help to create a more inclusive and equitable future for LGBTQ+ individuals in the MENA region by encouraging discourse, forming coalitions, and harnessing global solidarity.

Finally, the pursuit of LGBTQ+ rights in the MENA region is more than just legislative reforms or policy changes; it is a basic struggle for dignity, equality, and respect for all people, regardless of sexual orientation or gender identity. As the globe works to make progress toward LGBTQ+ inclusion and acceptance, it is critical to acknowledge and support the efforts of activists and communities in the MENA region who are working relentlessly to establish a more just and equal society for all.

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AUTHOR

Prof. Dr. Elias M. CHOUEIRI has been very active in academic and research settings for over 35 years. He is the author/co-author of over 20 books and booklets, and hundreds of refereed publications, technical reports, conference presentations and newspaper articles. He has won more than 20 awards for his scholarship, and has held faculty and managerial positions at several public and private institutions in Lebanon and the USA. He is a member of the WSO Board of Directors, and serves as WSO Liaison Officer to the United Nations. Besides, he assumes the roles of Director of the WSO National Office for Lebanon, Chairperson of the WSO Highway Transportation Committee, and Chairperson of the WSO Transportation of Dangerous Goods Committee.

CITATION:

Choueiri, E. (2024). *LGBTQ+ Realities: A Comprehensive Exploration of Challenges, Opportunities, and International Perspectives in the MENA Region*. World Safety Journal, Vol. XXXIII(1), 48–56. https://doi.org/10.5281/zenodo.10911940

World Safety Organization (WSO)

The WSO was founded in 1975 in Manila, The Republic of the Philippines, as a result of a gathering of over 1,000 representatives of safety professionals from all continents at the First World Safety and Accident Prevention Congress. The WSO World Management Center was established in the United States of America in 1985 to be responsible for all WSO activities, the liaison with the United Countries, the co-operation with numerous Safety Councils, professional safety/environmental (and allied areas) organizations, WSO International Chapters/Offices, Member Corporations, companies, groups, societies, etc. The WSO is a non-profit, non-sectarian, non-political organization dedicated to: ***"Making Safety a Way of Life … Worldwide."***

World Safety Organization Activities

WSO publishes WSO Newsletters, World Safety Journal, and WSO Conference Proceedings.

WSO provides a network program linking various areas of professional expertise needed in today's international community.

WSO develops and accredits educational programs essential to national and international safety and establishes centers to support these programs.

WSO receives proposals from professional safety groups/ societies for review and, if applicable, submits them to the United Countries for adoption.

WSO presents annual awards: The James K. Williams Award, Glenn E. Hudson International Award, J. Peter Cunliffe Transportation Award, Concerned Citizen, Concerned Company/Corporation, Concerned Organization, Educational Award, WSO Chapter/National Office of the Year, and Award for Achievement in Scientific Research and Development.

WSO provides recognition for safety publications, films, videos, and other training and media materials that meet the WSO required educational standards.

WSO establishes and supports divisions and committees to assist members in maintaining and updating their professional qualifications and expertise.

WSO has Chapters and National/International Offices located throughout the world, providing contact with local communities, educational institutions, and industrial entities.

WSO organizes and provides professional support for inter- national and national groups of experts on all continents who are available to provide expertise and immediate help in times of emergencies.

Benefits of Membership

WSO publishes the "WSO Consultants Directory" as a service to its Members and to the Professional Community. Only Certified Members may be listed.

WSO collects data on the professional skills, expertise, and experience of its Members in the WSO Expertise Bank for a reference when a request is received for professional expertise, skill, or experience.

WSO provides a network system to its Members whereby professional assistance may be requested by an individual, organization, state, or country or a personal basis. Members needing assistance may write to the WSO with a specific request, and the WSO, through its Membership and other professional resources, will try to link the requester with a person, organization, or other resource which may be of assistance.

WSO provides all Members with a Membership Certificate for display on their office wall and with a WSO Membership Identification Card. The WSO awards a Certificate of Honorary Membership to the corporations, companies, and other entities paying the WSO Membership and/or WSO Certification fees for their employees.

Members have access to WSO Newsletters and other member- ship publications of the WSO on the WSO website, and may request hard copies by contacting the WSO World Management Center. Subscription fees apply to certain publications.

Members are entitled to reduced fees at seminars, conferences, and classes given by the WSO. This includes local, regional, and international programs. When Continuing Education Units (CEUs) are applicable, an appropriate certificate is issued.

Members who attend conferences, seminars, and classes receive a Certificate of Attendance from the WSO. For individuals attending courses sponsored by the WSO, a Certificate of Completion is issued upon completion of each course.

Members receive special hotel rates when attending safety pro- grams, conferences, etc., sponsored by the WSO.

Membership

The World Safety Organization has members who are full time professionals, executives, directors, etc., working in the safety and accident prevention fields, including university professors, private consultants, expert witnesses, researchers, safety managers, directors of training, etc. They are employees of multinational corporations, local industries, private enterprises, governments, and educational institutions. Membership in the World Safety Organization is open to all individuals and entities involved in the safety and accident prevention field, regardless of race, color, creed, ideology, religion, social status, sex, or political beliefs.

Membership Categories

Associate Membership: Individuals connected with safety and accident prevention in their work or individuals interested in the safety field, including students, interested citizens, etc. **Affiliate Membership**: Safety, hazard, risk, loss, and accident prevention practitioners working as full time practitioners in the safety field. Only Affiliate Members are eligible for the WSO Certification and Registration Programs. **Institutional Membership**: Organizations, corporations, agencies, and other entities directly or indirectly involved in safety activities and other related fields. **Sustaining/Corporate Member**: Individuals, companies, corporations, organizations or other entities and selected groups, interested in the international effort to "Make Safety A Way of Life ... Worldwide."

The WSO Membership Application is included on the following pages and is also available on the WSO website: https://worldsafety.org/quick- downloads/

WSO – Application for Membership

[✓]	Application Fee	$20.00 USD
[ ]	Associate Membership	$65.00 USD
[ ]	Affiliate Membership	$90.00 USD
[ ]	Institutional Membership*)	$195.00 USD
[ ]	Corporate Membership*)	$1000.00 USD

*) In case of institution, agency, corporation, etc., please indicate name, title, and mailing address of the authorized representative.

(Please print or type.)

NAME (Last, First, Middle) [ ] Mr. [ ] Ms. [ ] Mrs. [ ] Dr. [ ] Engr.

BIRTHDATE:

POSITION/TITLE:

COMPANY NAME AND ADDRESS: [ ] Preferred

HOME ADDRESS: [ ] Preferred

BUSINESS PHONE: | FAX:

CELL PHONE: | HOME PHONE:

E-MAIL ADDRESS(ES):

PROFESSIONAL MEMBERSHIP(S), DESIGNATION(S), LICENSE(S):

EDUCATION (degree(s) held):

REFERRAL

If you were referred by someone, please list his/her name(s), chapter, division, etc.:

WSO Member: _____

WSO Chapter: _____

WSO Division/Committee: _____

Other: _____

PLEASE specify your area of professional expertise. This information will be entered into the WSO "Bank of Professional Skills," which serves as a pool of information when a request for a consultant/information/expertise in a specific area of the profession is requested.

- [ ] Occupational Safety and Health (OS&H)
- [ ] Environmental Safety and Health (EH&S)
- [ ] Fire Safety/Science (FS&S)
- [ ] Safety/Loss Control Science (S&LC)
- [ ] Public Safety/Health (PS&H)
- [ ] Construction Safety (CS)
- [ ] Transportation Safety (TS)
- [ ] Industrial Hygiene (IH)
- [ ] Product Safety (PRO)
- [ ] Risk Management (RM)
- [ ] Hazardous (Toxic) Materials Management (HAZ)
- [ ] Nuclear Safety (NS)
- [ ] Aviation Safety (AS)
- [ ] Ergonomics (ERG)
- [ ] Petroleum (PS)
- [ ] Oil Wells (OW)
- [ ] Other: _____

PAYMENT OPTIONS

For secure Credit Card Payment, please visit the SHOP on WSO's website (https://worldsafety.org/shop) and select "WSO Membership Application Fee" to make your payment. You will receive an emailed invoice for the Membership Fee upon approval.

Check or Money Order payable to WSO may be mailed with application packet to: WSO-WMC, Attn: Membership Coordinator, PO Box 518, Warrensburg MO 64093 USA. International postal money orders or bank drafts with a U.S. routing number are acceptable for applicants outside the United States. For alternate payment arrangements, please contact WSO-WMC.

Annual dues hereafter will be billed and payable on the anniversary date of your membership. **U.S. funds only.**

By submitting this application, you are accepting that WSO will use the information provided to perform an independent verification of employer, credentials, etc.

Mail or email completed form, along with current résumé/CV:

WSO World Management Center
PO Box 518 | Warrensburg, Missouri 64093 USA
Phone 660-747-3132 | FAX 660-747-2647 | membership@worldsafety.org

Student Membership Application

WORLD SAFETY ORGANIZATION

Instructions | Complete all applicable fields and mail to **WSO World Management Center, PO Box 518, Warrensburg, MO 64093 USA**, email to **membership@worldsafety.org**, or fax to **1-660-747-2647**. For assistance completing this application, please call **1-660-747-3132**, or email questions to **membership@worldsafety.org**.

Membership Level | Choose One

❑ **College/University Student Membership – FREE**

*You will receive all member benefits including subscriptions to **WSO World Safety Journal** and **WSO NewsLetter**, as well as access to **WSO's Mentor Program**.*

❑ **Middle/High School Student Membership – FREE**

*You will receive all member benefits including subscription to **WSO World Safety Journal** and **WSO NewsLetter**, excluding access to **WSO's Mentor Program**.*

Last Name/Family Name

First Name/Given Name | Initial | ❑ M ❑ F (Gender)

Birthdate MM / DD / YYYY *(Application must include exact birthdate with year to be processed.)*

Current Street Address ❑ On Campus ❑ Off Campus *(Attach separate sheet if you need more room for your address.)*

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ❑ Landline ❑ Mobile (Type)

Permanent Street Address

City | State/Province | Country

Zip/Postal Code | Telephone Number (including area code) | ❑ Landline ❑ Mobile (Type)

Send mail to: ❑ Current Address ❑ Permanent Address

Email Address(es)

COLLEGE/UNIVERSITY STUDENT

Category: ❑ Undergraduate ❑ Graduate/Post-Graduate

Degree(s) Sought/Obtained

Name of College/University | Campus

MIDDLE / HIGH SCHOOL STUDENT

❑ I am a Middle Schooler in: ❑ 6th Grade ❑ 7th Grade ❑ 8th Grade

❑ I am a High School: ❑ Freshman ❑ Sophomore ❑ Junior ❑ Senior

Name of School

Approximate Date of Graduation (MM / YYYY)
(For High School and College/University students, application must include approximate date of graduation to be processed.)

If you were referred by someone, please list name(s), chapter, division, etc.:

WSO Member: _____

WSO Chapter/National Office: _____

WSO Division/Committee: _____

Other: _____

What Interests You?

Please specify your area(s) of interest. These areas of interest will allow you to connect with others who share similar interests throughout the world.

[ ] Occupational Safety and Health (OS&H)
[ ] Environmental Safety and Health (EH&S)
[ ] Fire Safety/Science (FS&S)
[ ] Safety/Loss Control Science (S&LC)
[ ] Public Safety/Health (PS&H)
[ ] Construction Safety (CS)
[ ] Transportation Safety (TS)
[ ] Industrial Hygiene (IH)
[ ] Product Safety (PRO)
[ ] Risk Management (RM)
[ ] Hazardous (Toxic) Materials Management (HAZ)
[ ] Nuclear Safety (NS)
[ ] Aviation Safety (AS)
[ ] Ergonomics (ERG)
[ ] Petroleum (PS)
[ ] Oil Wells (OW)
[ ] Other: _____

Required Signatures & Permissions

I subscribe to the above record and when approved will be governed by the Constitution and By-Laws of WSO and its Code of Ethics as I continue as a member. I furthermore agree to promote the objectives of the WSO wherever and whenever possible.

X _____ Applicant Signature | Date

***FOR MID/HIGH SCHOOLERS ONY**: WSO subscribes to the Family Educational Rights and Privacy Act (FERPA) philosophy in protecting student privacy and information. WSO may disclose "directory" information such as a student's name, WSO Student Chapter affiliation, name of school, grade in school, etc., along with group or individual photos in WSO NewsLetters, NewsFlashes, eNews, on WSO website, and on WSO's social media accounts.*

❑ My student has permission to participate as outlined above.

❑ My student has permission to participate with exclusions:

_____

X _____ Parent/Guardian Signature (Mid/High Student) | Date

X _____ WSO Student Chapter Mentor Signature **[IF APPLICABALE]** | Date

WSO – National Offices

WSO National Office for Algeria
c/o Institut des Sciences et de la Technologie (I.S.T.)
attn.: Mr. Ferhat Mohia, Director
contact: ferhatmohia@yahoo.fr

WSO National Office for Australia
c/o Curtin University of Technology
attn.: Dr. Janis Jansz, Director
contact: j.jansz@curtin.edu.au

WSO National Office for Austria
c/o Payesh System Mehr Engineering Company
attn.: Dr. Majid Alizadeh, Director
contact: majidealizadeh@gmail.com

WSO National Office for Cameroon
c/o Cameroon Safety Services
attn: Mr. Clement B. Nyong, Director
contact: ny.clement@yahoo.com

WSO National Office for Canada
c/o Apex One Management Group
attn.: Mr. Michael Brown, Director
contact: michael.brown@worldsafetycanada.ca | mike@apexone.com
website: worldsafetycanada.ca

WSO National Office for Ghana
c/o Ghana National Fire Service
attn.: Mr. Peter Oko Ahunarh, Director
contact: pahunarh23@gmail.com

WSO National Office for India
c/o Indian Society of Safety Engineers (I.S.S.E)
attn.: Mr. T. Shankar, Director
contact: support@worldsafety.org.in

WSO National Office for Indonesia
c/o Prosafe Institute
attn.: Mr. Soehatman Ramli, Director
contact: soehatmanramli@yahoo.com

WSO National Office for Iran
c/o Payesh System Mehr Engineering Company
attn.: Mrs. Fatemeh Gilani, Director
contact: gilani@imsiran.ir

WSO National Office for Iraq
c/o NAYA Engineering Services & Training
attn.: Dr. Eng. Khaldon Waled Suliman, Director
contact: naya_engineering_services@yahoo.com

WSO National Office for Lebanon
c/o Ministry of Transport
attn.: Dr. Elias M. Choueiri, Director
contact: elias.choueiri@gmail.com

WSO National Office for Myanmar
c/o Win Oshe Services Co., Ltd
attn.: Mr. Win Bo, Director
contact: winbo@osheservices.com

WSO National Office for Nigeria
c/o DanaRich Creative Concept, LTD
attn.: Mr. Soji Olalokun, WSO-RSD, Director
contact: info@worldsafety.org.ng
website: worldsafety.org.ng

WSO National Office for Pakistan
c/o Greenwich Training & Consulting
attn.: Mr. Tayyeb Shah, Director
contact: doctimes@gmail.com

WSO International Office for Philippines
attn.: Engr Alfredo A. De La Rosa Jr., Director
contact: info@wsophil.org

WSO National Office for Saudi Arabia (KSA)
c/o The Academy of Sciences for Medical Education
attn.: Mr. Rocky Binuya, Director
contact: info@aos-ksa.com | binuya.rocky@gmail.com
website: https://aos-ksa.com/en

WSO National Office for United Arab Emirates (UAE)
c/o Tatweer Industrial Inspection & Training Services LLC
attn.: Miss Nazya Robin, Quality Manager & Director
contact**:** info@tiits.ae

WSO National Office for Vietnam
c/o Safety Training & Consulting Limited
attn.: Mr. Binh Pham, WSO-CSI(ML), Director
contact**:** binh.pt@worldsafety.org.vn
binh.pt@safety.edu.vn
website: worldsafety.org.vn

World Safety Organization

Code of Ethics

Members of the WSO,
by virtue of their acceptance of membership
into the WSO,
are bound to the following Code of Ethics
regarding their activities associated with the WSO:

Members must be responsible for
ethical and professional conduct in relationships
with clients, employers, associates, and the public.

Members must be responsible for professional competence in
performance of all their professional activities.

Members must be responsible
for the protection of professional interest, reputation, and
good name of any deserving WSO member
or member of other professional organization involved in
safety or associate disciplines.

Members must be dedicated to professional development of new
members in the safety profession
and associated disciplines.

Members must be responsible
for their complete sincerity in professional service to the
world.

Members must be responsible for continuing improvement and
development of professional competencies
in safety and associated disciplines.

Members must be responsible
for their professional efforts to support the WSO motto:

"Making Safety a Way of Life…Worldwide."

Published by the WSO National Office for Lebanon
www.worldsafety.org
info@worldsafety.org | elias.choueiri@gmail.com