SEAFARERS' PERCEPTIONS AND ATTITUDES TOWARD OCCUPATIONAL NOISE EXPOSURE AND ITS HEALTH IMPACTS IN CANADA: A MIXED METHODS STUDY

by

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Abstract

Prolonged exposure to noise levels above 85 A-weighted decibels [dB (A)] poses significant health risks for the working population at sea. This mixed-methods study, employing an online survey and semi-structured online interviews, was conducted to explore noise risk perceptions and self-reported noise-induced health problems. It aims to identify barriers and challenges in preventing noise-related health problems among seafarers in Canada. This study found that seafarers' workplaces are noisy, and they often adapt to these environments with fatalistic behaviors. It also showed that safety concerns lead to the underuse of hearing protection, which is seen as a communication barrier. Seafarers reported both auditory and non-auditory health issues, highlighting barriers such as limited noise control measures, uncomfortable hearing protection devices, and inadequate training. This study showed that seafarers have moderately positive perceptions toward noise reduction and hearing loss prevention. They dislike loud noise and feel highly susceptible to hearing loss based on Health Belief Model indicators. Our study showed that 40% of participants self-reported hearing difficulties, with 52% showing some degree of hearing loss and 16% experiencing severe hearing loss based on the hearing screening inventory questionnaire. Approximately 45% of seafarers reported tinnitus, and 40% experienced unexpected balance problems, in addition to anxiety, stress, sleep disorders, loss of concentration, and fatigue. This study highlights the need for improved occupational health and safety regulation implementation and collaborative efforts to initiate noise-specific education programs to reduce noise and enhance preventive measures in the Canadian maritime sector.

Keywords: seafarers, noise exposure, health impacts, occupational health and safety, noise risk perception

General Summary

Occupational noise exposure onboard is a significant health concern for seafarers. This mixed-methods study investigates how seafarers in Canada perceive noise risks, their self-reported auditory and non-auditory health issues, and the barriers they face in preventing noise-related health problems. Quantitative results indicate that seafarers hold moderately positive perceptions toward noise reduction and hearing loss prevention. They generally dislike loud noise and feel highly susceptible to hearing loss, with many reporting auditory issues such as hearing loss, tinnitus, and balance problems. Qualitative findings reveal that seafarers often work in noisy environments and adapt to these conditions with fatalistic behaviors. Discomfort and safety concerns contribute to the underuse of hearing protection, as it is perceived as a communication barrier. Noise-induced non-auditory problems, including anxiety, stress, loss of concentration, sleep disorders, and fatigue, were commonly reported by interviewed seafarers. These findings highlight the need for improved implementation of occupational health and safety regulations and suggest that collaborative efforts are necessary to develop and implement noise-specific education programs.

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Preface

This thesis has been written as a series of manuscripts in Chapters 4 and 5. Some repetition of introductory and methodological material is unavoidable.

Chapter 4: Hodroj, F., Gao, Z., Sarkar, A., Shan, D. Seafarers' Perceptions and Attitudes Toward Occupational Noise Exposure and Its Health Impacts in Canada: A Quantitative Study

Chapter 5: Hodroj, F., Gao, Z., Sarkar, A. Shan, D. Occupational Noise Exposure Onboard Ships in Canada: A Qualitative Study Exploring Seafarers' Risk Perceptions and Noise-induced Health Impacts

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List of Abbreviations

CMSG: Canadian Merchant Service Guild

CVD: cardiovascular diseases

dB (A): A-weighted decibels

dB (B): B-weighted decibels

dB (C): C-weighted decibels

dB SPL: decibels sound pressure level

dB: decibels

DPOAEs: Distortion Product Otoacoustic Emissions

HBM: Health Belief Model

HSI: Hearing Screening Inventory

ICEHR: Interdisciplinary Committee on Ethics in Human Research

ILO: International Labour Organization

IMO: International Maritime Organization

IP: Internet Protocol

kHz: Kilohertz

MLC: Maritime Labour Convention

NIHL: noise-induced hearing loss

OAE: Otoacoustic emissions

OFI: Ocean Frontier Institute

OHS: Occupational Health and Safety

Pa: Pascals

PICOS: Population, Intervention, Comparator, Outcome, Study Design

PPE: Personal Protective Equipment

SAS: Statistical Analysis System

SCENIHR: Scientific Committee on Emerging and Newly Identified Health Risks

SHCRs: Standardized Hospital Contact Ratios

SIU: Seafarers' International Union

SMS: Safety Management System

SOLAS: Safety of Life at Sea

SPL: Sound Pressure Level

TOAEs: Transient Otoacoustic Emissions

μPa: Micropascals

Chapter 1 Introduction

1.1 Background and Rationale

Occupational noise, defined as any unwanted or harmful sound in the workplace, poses a significant hazard across various industries (Teixeira et al., 2019). Prolonged exposure to loud noise levels is known to cause substantial health issues, affecting not only hearing but also other aspects of physical and mental well-being (Lee et al., 2023). In the maritime industry, noise from engines, machinery, and other operational activities is constant, posing risks for seafarers who work and live in this environment (Karakasnaki et al., 2023).

The health effects of occupational noise can be broadly categorized into auditory and non-auditory impacts. Auditory impacts include noise-induced hearing loss (NIHL) and tinnitus (Pretzsch et al., 2021). NIHL results from damage to the hair cells in the cochlea due to high noise levels, leading to partial or complete hearing loss, which is often irreversible (Nelson et al., 2005). Tinnitus, characterized by persistent ringing or buzzing in the ears, is another common auditory effect that can significantly affect the quality of life (Molaug et al., 2023).

Non-auditory health effects are equally significant, including cardiovascular diseases (CVD), stress, sleep disorders, diabetes, and fatigue. Long-term exposure to high noise levels can increase blood pressure, heart rate, and stress hormone levels, contributing to cardiovascular problems (Münzel et al., 2014). Noise exposure has also been linked to sleep disturbances, leading to inadequate rest and subsequent fatigue, impairing cognitive function and overall well-being (Basner et al., 2014). The stress caused by continuous exposure to loud noise can also result in psychological issues such as anxiety, depression, and decreased concentration (Stansfeld & Matheson, 2003).

Seafarers face unique health challenges due to their constant exposure to high levels of noise from various sources onboard ships, primarily engines and machinery (Badino et al., 2012; Picu, 2020). According to Febriyanto et al. (2024), noise-induced health issues can be classified into two categories: physical problems (such as hearing loss, tinnitus, sleep disturbances, communication difficulties, poor concentration, CVD, dizziness, headaches, and fatigue) and psychological disorders (such as depression, anxiety, and stress). A study analyzing 8,308 audiograms in the French merchant seafarer population reported that marine engineers had the highest incidence of hearing impairment (Lucas et al., 2022). Sunde et al. (2016) revealed that the equivalent noise level and the number of noise events per hour were both associated with increased mobility during sleep, and the number of noise events was associated with decreased sleep efficiency. Another study by Brooks and Greenberg (2022) found that seafarers who experience higher noise and vibration levels are more likely to suffer from negative mental health effects. Stress, anxiety, and depression are categorized as psychological illnesses because they significantly affect an individual's emotional and mental well-being (Brooks & Greenberg, 2022).

Given the significant health risks associated with occupational noise, it is crucial to understand the specific experiences and challenges seafarers face in managing noise exposure. The maritime industry is unique in that seafarers not only work but also live in the same noisy environment, making them particularly vulnerable to the adverse effects of noise. Previous global studies have highlighted excessive noise levels onboard ships (Bocanegra et al., 2023) and the resultant auditory and non-auditory health issues (Sunde et al., 2016; Oldenburg et al., 2020). However, there are limited studies on occupational noise exposure and its health impacts aboard Canadian vessels (Burella & Moro, 2021; Burella et al., 2021; Nakashima et al., 2018).

Additionally, research on risk perceptions, attitudes toward noise exposure, and the barriers faced by the working population at sea in implementing effective noise control practices remains scarce (Yadav et al., 2023).

Canada has the world's longest coastline, measuring 243,042 kilometers (Statistics Canada, 2016), and its marine sector directly employs over 28,000 seafarers while indirectly supporting thousands of additional jobs on land (Transport Canada, 2024a). This underscores the importance of addressing occupational health and safety issues related to noise exposure within this significant workforce. Hence, occupational noise-induced health impacts on Canadian seafarers cannot be overlooked. This study aims to fill this gap by exploring how Canadian seafarers perceive and manage occupational noise exposure, recognize associated health problems, and identify potential barriers and challenges in preventing noise-related health issues. By using a mixed-methods approach that includes a cross-sectional online survey and semi-structured interviews, this research seeks to provide a comprehensive understanding of the issue. The findings are expected to inform the development of targeted interventions and policies to improve occupational health and safety for seafarers, ultimately reducing the prevalence of noise-induced health problems in this population.

1.2 Study Objectives

The first objective of this study was to assess risk perceptions and attitudes towards occupational noise exposure among seafarers in Canada and assess the extent to which they are aware of occupational noise-induced auditory health problems through a cross-sectional online survey.

The second objective was to understand how seafarers in Canada manage noise exposure, mitigate noise-induced health issues, and identify potential barriers and challenges they face in preventing noise exposure onboard through conducting online semi-structured interviews.

1.3 Research Questions and Hypotheses

The following quantitative and qualitative research questions were developed based on evidence from existing literature and identified research gaps:

1.3.1 Quantitative Research Questions and Hypotheses:

1. In terms of noise risk perceptions and awareness of occupational noise exposure and its health impacts, are there any differences among seafarers working in different ship departments in Canada, including engineering, deck, and galley?
2. To what extent are seafarers in Canada aware of occupational noise-induced auditory health impacts?

The following null hypotheses were formulated after reviewing available literature on occupational noise exposure and associated health problems among seafarers:

1. There is no significant difference in noise risk perceptions and/ or awareness of occupational noise exposure and its health impacts among seafarers working in different ship departments in Canada, including engineering, deck, and galley.
2. There is no relationship between seafarers' knowledge of auditory health problems related to occupational noise exposure and factors such as duration of exposure, location, noise level, sociodemographic characteristics, and adherence to occupational health and safety measures onboard.

1.3.2 Qualitative Research Questions:

1. How do seafarers in Canada cope with occupational noise exposure and perceive noise-induced health problems onboard?
2. What challenges and barriers do seafarers face in coping with their perceived occupational noise exposure and noise-induced health problems?

1.4 Thesis Outline

Chapter 2 reviews the existing academic literature on occupational noise exposure aboard ships and its associated health impacts on seafarers.

Chapter 3 outlines the research methods used in this study, incorporating both quantitative and qualitative approaches.

Chapter 4 explores seafarers' risk perceptions toward noise exposure onboard ships in Canada, and it examines self-reported noise-induced auditory health problems.

Chapter 5 examines how Canadian seafarers manage occupational noise exposure onboard, recognize associated health problems, and identify barriers to preventing and controlling noise exposure.

Chapter 4 and Chapter 5 are presented as individual manuscripts, each with its own introduction, methods, results, discussion, and conclusion sections.

Chapter 6 summarizes the major findings, presents a general discussion and conclusion, addresses the study's limitations, and outlines potential areas for future research.

Chapter 2 Literature Review

2.1 Background

Sound is a sensory perception, and complex patterns of sound waves are commonly identified as sources such as music, speech, or noise (Gillespie, 2010). Sound waves are characterized by three key physical properties: frequency, amplitude, and temporal variation. Frequency refers to the number of oscillations per second in a vibratory pattern, while amplitude relates to the pressure exerted by the sound. Temporal variation encompasses aspects like the duration of the sound. Since sound pressure is directly linked to sound intensity (measured in units of power or energy), sound magnitude can be expressed in terms of pressure, power, or energy units (Dobie & Van Hemel, 2004). The way we perceive sound is influenced by both frequency (measured in hertz [Hz]) and the pressure applied to the eardrum (measured in decibels [dB]) (Gillespie, 2010). Additionally, time can be represented in various temporal units or converted into phase, expressed in angular degrees units (Dobie & Van Hemel, 2004).

According to the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR, 2008), the sound pressure level (SPL), or sound exposure, is a property of the sound wave that is frequently used to quantify the amount of sound to which humans are exposed. The human ear is capable of detecting sounds between 20 micropascals (μPa), which represents the hearing threshold, and 20 pascals (Pa), which corresponds to the pain threshold. Due to the impracticality of using such a large scale, a logarithmic scale in decibels (dB) was developed. This scale aligns with both physiological and psychological auditory perceptions. The decibel of SPL is calculated using the formula $20 \log_{10}(p_1/p_0)$, where p_1 represents the observed SPL of a particular sound, and p_0 is a reference value of 20 μPa, which corresponds to the minimum hearing threshold for a healthy adult ear. On this logarithmic scale, the human auditory range spans from 0 decibels sound pressure level (dB SPL) [the hearing threshold] to 120–140 dB SPL [the pain threshold] (SCENIHR, 2008). For instance, leaves fluttering produce a sound pressure level of approximately 20 dB SPL, while a whisper in the ear measures around 30 dB SPL. A normal conversation occurs at about 60 dB SPL, whereas motor vehicles observed closely generate sound pressure levels ranging from 60 to 100 dB SPL. An airplane taking off nearby reaches approximately 120 dB SPL, which is near the threshold of pain at 120–140 dB SPL. The sound pressure of a normal conversation at 60 dB SPL is 100 times greater than that of leaves fluttering at 20 dB SPL. Similarly, the sound pressure of an aircraft taking off nearby at 120 dB SPL is 1,000 times greater than that of a normal conversation at 60 dB SPL (SCENIHR, 2008).

The human ear is not equally sensitive to tones of the same SPL but different frequencies. This subjective perception of sound magnitude is referred to as loudness. Loudness does not correspond directly to SPL and varies across different frequencies. To assess loudness more accurately, isophonic curves are used, which relate SPL in decibels to subjective loudness in phones. The human ear is most sensitive to frequencies around 3-4 kilohertz (kHz) and becomes less sensitive at both lower and higher frequencies. To better reflect human auditory perception, weighting filters are applied in sound-level meters. The A-weighting filter [dB(A)] adjusts measurements to match the ear's sensitivity at approximately 40 phons, emphasizing mid-range frequencies while de-emphasizing low and high frequencies. This makes dB(A) the most commonly used weighting in noise assessments. The B-weighting filter [dB(B)], which is no longer widely used, was designed as an intermediate weighting that mimicked the ear’s response to moderate sound levels. The C-weighting filter [dB(C)] is more suitable for measuring loud sounds and follows the equal-loudness contour of 100 phons. Because the human ear is more resistant to hearing damage at lower frequencies, dB(A) is more appropriate for evaluating the risk of noise-induced hearing loss (NIHL) (SCENIHR, 2008). Therefore, the perceived sound intensity for humans is typically calculated in dB(A) (Gillespie, 2010).

While sounds may be desired, noise usually is not and is often considered a nuisance, being the wrong sound, in the wrong place, at the wrong time (Gillespie, 2010). Noise is one of the most common hazards at both occupational and environmental levels (Wong et al., 2003). A sound level exceeding 85 dB SPL is harmful to health, with the risk further increasing depending on the duration and systematic exposure (Guida et al., 2010), as well as the intensity and frequency of the sound (Branco & Alves-Pereira, 2004). Seafarers are exposed to high occupational noise levels onboard and are vulnerable to various noise-induced health effects (Febriyanto et al., 2024). Continuous loud noise, particularly from engines, can lead to detrimental health outcomes, including both physical and psychological impairments, making the maritime workplace more hazardous than land-based environments (Hystad et al., 2017).

Despite global attention to the issue of occupational noise, research specifically focused on the maritime industry, particularly in the Canadian context, remains limited. This review aims to synthesize current research on noise exposure among seafarers, examining both auditory and non-auditory health impacts and identifying gaps in the literature that this study intends to address.

2.2 Auditory Health Impacts of Noise Exposure

Hearing loss is a condition that occurs when sound transmission from the outer ear to the brain is disrupted. This disruption can occur at any stage, either before or after the cochlea, leading to conductive or sensorineural hearing loss, respectively. If both pre- and post-cochlear sites are affected, the hearing loss is characterized as mixed (Cunningham & Tucci, 2017). Prolonged exposure to high levels of noise can cause irreversible damage to the cochlea, resulting in partial or complete hearing loss (Nelson et al., 2005). In a study of 8,083 seafarers in France, Lucas et al. (2022) found that engine room personnel are particularly vulnerable to hearing loss due to constant exposure to high noise levels, as evidenced by audiometric tests. Their findings indicated that the implementation of International Maritime Organization (IMO) noise control measures and advanced ship designs led to a reduction in hearing loss cases among French seafarers. This highlights the importance of implementing reduction and prevention measures to mitigate noise exposure onboard and its associated health impacts.

Otoacoustic emissions (OAE) testing is a non-invasive and objective method used to assess inner ear function. It measures sound pressure levels in the eardrum, reflecting the responses of the outer hair cells with or without sound stimulation. OAE testing is widely utilized for early screening, accurate diagnosis, and monitoring of hearing health (Suh et al., 2023). Malheiros et al. (2021) used otoscopy to visualize the ear canal and eardrum, helping to identify any obstructions or abnormalities that could affect hearing and ensuring the accuracy of hearing test results. Their study measured transient otoacoustic emissions (TOAEs) and distortion product otoacoustic emissions (DPOAEs), which are sounds generated by the cochlea in response to auditory stimuli. TOAEs are produced in response to brief sounds like clicks and help assess the functioning of the outer hair cells in the cochlea, while DPOAEs are measured in response to two different tones, providing insights into cochlear function at specific frequencies (Malheiros et al., 2021). The results indicated that evoked OAE were more altered in the offshore group than in the onshore group, suggesting that offshore workers experienced greater impairment in cochlear function, likely due to higher levels of occupational noise exposure.

Their study found that the highest proportion of failures in hearing responses occurred at specific frequencies: 4 kHz for TOAEs and 6 kHz for DPOAEs (Malheiros et al., 2021). This suggests that offshore workers are especially vulnerable to hearing impairment in the 4 to 6 kHz frequency range, which is crucial for speech clarity and effective communication. These findings highlight the significance of evaluating the impact of noise exposure in maritime environments (Malheiros et al., 2021).

Sound pressure level (SPL), commonly used to indicate acoustic wave strength, correlates well with human perception of loudness and is measured in decibels (dB) using devices such as noise dosimeters, sound level meters, integrated sound level meters, and data acquisition systems (Long, 2014). In the study by Kapoor et al. (2018), SPL measurements were taken in the engine rooms and other compartments of ships, and hearing tests were conducted on 56 seafarers, including 45 engine room crew members and 11 non-engine room personnel in India. The aim was to assess the impact of ship noise on hearing. The findings revealed that while 73% of non-engine room personnel had normal hearing test results, 24% of the engine room crew showed abnormal results. Notably, no moderate or severe hearing loss was found among the non-engine room personnel. The study highlighted that SPL values in engine rooms frequently exceeded safe limits, ranging between 97.1- 113.9 dB SPL, which is above the regulated upper limit of 90 dB SPL for 8-hour daily exposure. This prolonged exposure, without sufficient hearing protection, significantly increased the auditory risk for engine room personnel (Kapoor et al., 2018).

Hearing loss is a significant noise-induced health effect among seafarers. According to Irgens-Hansen et al. (2015a), hearing loss affected 31.4% of participants, with a higher prevalence among navigators (37.0%) and engine room personnel (38.0%) compared to electricians (23.6%). Similarly, Kaerlev et al. (2008) assessed the risk of noise-induced hearing loss (NIHL) among 8,487 male seafarers in Denmark. Their findings indicated that engine room personnel had significantly higher rates of NIHL compared to other crew members. Interestingly, the study noted that the duration of employment was not directly associated with the development of NIHL. This suggests that factors beyond just time spent in noisy environments, such as the intensity of the noise or the use of protective measures, play a critical role in determining hearing loss risk.

These studies underscore the auditory risks associated with noise exposure onboard in different countries, except Canada; there is a gap in the literature regarding noise exposure measurements and their auditory health impacts on Canadian vessels, as well as Canadian seafarers' awareness and perceptions of the health risks associated with noise.

2.3 Non-Auditory Health Impacts of Noise Exposure

Occupational noise exposure results in several noise-induced non-auditory health problems, including physiological and psychological disorders, as observed in various studies (Nikolic & Nikolic, 2013; Picu et al., 2019; Oldenburg et al., 2020; Irgens-Hansen et al., 2015b). Noise exposure levels that exceed the normal limit of 80 dB (A), according to the European Community Physical Agents Directive and the Merchant Shipping and Fishing Vessels Regulations 2007, by about 1- 5 dB cause annoyance and nuisance among seafarers, interfering with communication and jeopardizing navigation safety (Nikolic & Nikolic, 2013). Irgens-Hansen et al. (2015b) noted that noise negatively impacts cognitive performance among seafarers exposed to levels of 77.1- 85.2 dB(A) or above compared to those exposed to noise levels below 72.6 dB(A). Additionally, a sound pressure level of 92 dB has been linked to sleep disorders, accompanied by increased body temperature and blood pressure among seafarers (Picu et al., 2019). Seafarers reported experiencing psychological stress due to vibration (80.6%), noise (71.8%), and heat (45.7%) in the workplace, with these stressors being more frequent among engine room personnel (83.7%) and significantly less among deck crew (65.4%). They also indicated that noise onboard contributed to sleep problems (Oldenburg et al., 2020).

These studies illustrate the significant non-auditory health impacts of occupational noise exposure on seafarers, including cognitive impairment, sleep disorders, and psychological stress. However, it is important to note that they were conducted outside of Canada and do not specifically address noise risk perceptions among seafarers, highlighting a gap in the research that warrants further investigation in the Canadian maritime context.

2.4 Governance of Occupational Noise on Ships

The International Labour Organization (ILO) plays a crucial role in setting international standards for maritime working conditions, particularly through the *Maritime Labour Convention* (MLC, 2006). Within Title 3 of the MLC, guidelines are provided regarding the placement of facilities away from noisy machinery and emphasize the importance of sound insulation in areas with high noise levels. The ILO's international guidelines on exposure levels, as outlined in the ILO code of practice titled "Ambient Factors in the Workplace" (ILO, 2001), recommend that noise levels in both working and living environments should adhere to established limits. Specifically, a noise level of 85 dB(A) or higher can lead to hearing impairment or deafness from an eight-hour exposure without proper ear protection. Furthermore, the code advises that no worker should enter areas where noise levels exceed 140 dB(A). Additionally, Title 4 of the MLC underscores the importance of continuous monitoring and enhancement of noise protection measures for seafarers to mitigate adverse effects on their hearing, health, and comfort. Recommended strategies include educating seafarers about the dangers of noise, providing approved hearing protection devices, and actively assessing and reducing noise exposure levels across different areas of the ship (MLC, 2006).

Moreover, in 2012, the International Maritime Organization (IMO) adopted the *Code on Noise Levels on Board Ships* (IMO Resolution MSC.337(91)), which is a regulation under the Safety of Life at Sea (SOLAS) Convention that mandates ships be designed to minimize onboard noise and safeguard personnel from excessive sound exposure. This code applies to vessels constructed on or after July 1, 2014, and establishes mandatory maximum noise level limits for various ship areas: for instance, 100 dB(A) in machinery spaces, 85 dB(A) in workshops, and 75 dB(A) in control rooms and accommodation areas. Seafarers should not encounter noise levels exceeding 80 dB(A) over a 24-hour period, and suitable hearing protection is required in environments where sound levels surpass 85 dB(A). Importantly, even with hearing protection, no seafarer should be exposed to noise levels above 120 dB(A) or have a 24-hour equivalent sound level exceeding 105 dB(A) (IMO, 2012).

Canada has a relatively comprehensive set of labour standards and maritime OHS regulations. Although OHS usually falls under provincial and territorial jurisdiction in Canada, maritime OHS related to seafarers working in federal waters falls within federal jurisdiction (Barn et al., 2021). The maritime OHS is regulated by the *Canada Labour Code* and overseen by the federal Department of Employment and Social Development Canada (Transport Canada, 2024b). Part 12 of the Maritime OHS Regulations (SOR/2010-120), outlined in Part II of the *Canada Labour Code*, provides a thorough structure for managing noise and vibration in maritime settings. These regulations emphasize the strategic positioning of crew accommodations away from potential noise sources, such as engines and machinery, and mandate the incorporation of acoustic insulation in the construction of bulkheads, deckheads, and decks within areas that generate sound. Furthermore, they recommend establishing soundproof centralized control rooms for personnel working in engine rooms and machinery spaces, where practical. The regulations also focus on insulating workspaces, like machine shops, from ambient noise generated by the engine room, specifying measures to mitigate noise from machinery operation. One of the primary stipulations is that workplace sound levels must remain below 85 dB(A). If this limit cannot be achieved, exposure to certain sound levels must not exceed specified durations within a 24-hour period. For example, sounds measuring between 85 dB(A) and 90 dB(A) can be tolerated for a maximum of 8 hours within a 24-hour span. Exposure to sound levels exceeding 115 dB(A) must be entirely avoided within a 24-hour. Crew accommodations should not expose workers to continuous sound levels above 75 dB(A). In cases where the impulse sound level in the workplace exceeds 140 dB (A), the employer must provide every entering employee with a hearing protector meeting specified standards. This protector must reduce the peak level of impulse sound reaching the employee’s ears to 140 dB (A) or less (Government of Canada, 2022).

A stricter implementation of noise control measures onboard ships, set by organizations such as the IMO and ILO, has led to improvements in hearing protection and soundproofing, as evidenced by studies like Lucas et al. (2022). However, studies examining the extent of implementation of noise control regulations onboard ships remain scarce. Based on the available literature, we could not find studies specifically assessing the effectiveness of Canadian noise control standards aboard Canadian vessels or whether these standards are being properly implemented. Additionally, while the ILO emphasizes the importance of educating seafarers about the dangers of noise onboard, education and awareness of noise-induced health impacts on ships in Canada are underexamined by Canadian standards. This represents a gap that needs to be addressed.

2.5 Research Gaps in the Literature

Internationally, there are many studies on the auditory and non-auditory health impacts of occupational noise among seafarers onboard ships. However, we could not find any research specifically focusing on noise-induced health impacts among seafarers in Canada, nor studies examining their perceptions and attitudes toward noise exposure and how they manage these risks based on this literature review. Although, there is a study on fish harvesters' noise risk perceptions in the Canadian province of Newfoundland and Labrador (Yadav et al., 2023), no similar research has been conducted on Canadian seafarers. The lack of comprehensive studies on noise levels aboard Canadian vessels and their associated health effects presents a critical research gap. Furthermore, there has been limited exploration of the barriers seafarers face in implementing noise control measures and the extent to which existing regulations are implemented on Canadian ships.

2.6 Contribution of this Study

This study aims to address the above gaps by exploring seafarers' risk perceptions toward noise exposure onboard ships in Canada and examining self-reported noise-induced health problems. It will also examine how Canadian seafarers manage occupational noise exposure, recognize associated health issues, and identify barriers to preventing and controlling noise exposure. Using a mixed-methods approach that combines quantitative surveys with qualitative interviews, this research will provide a more comprehensive understanding of the issue. The findings will inform policy and guide the development of targeted interventions to improve occupational health and safety in Canada's maritime industry.

2.7 Summary

Chapter 2 provides an overview of sound-related terminology and a literature review on occupational noise exposure and its health impacts on seafarers. The eligibility criteria of the studies included in the literature review, along with their descriptions, are presented in Appendix A. This appendix also contains two descriptive tables summarizing the relevant studies: the first categorizes studies on noise-related auditory health impacts among seafarers, while the second focuses on noise-related non-auditory health impacts. The following chapter, Chapter 3, outlines the study methodology.

Chapter 3 Methodology

This chapter outlines the theoretical perspectives guiding our study, along with the research framework, which includes the study design, setting, and target population. It also explains the quantitative and qualitative research methods, the instruments used, and the sample selection strategies. Following this, the statistical analysis process and ethical considerations are discussed. Chapter 4 and Chapter 5 present the quantitative and qualitative manuscripts, respectively. Some information from this chapter will be repeated in Chapters 4 and 5; this repetition is unavoidable. More detailed descriptions of the methodology will also be provided in each manuscript.

3.1 Theoretical Perspectives of this Research

3.1.1 Health Belief Model (HBM)

The HBM was initially developed to understand people's failure to adopt disease prevention strategies or screening tests and was later adapted to understand patients' responses to symptoms and adherence to medical treatments. The basic components of the HBM are derived from a well-established body of psychological and behavioral theory, whose various models hypothesize that health-related behavior depends mainly upon two variables: (1) the desire to avoid illness or, conversely, get well if already ill; and (2) the belief that a specific health action will prevent or cure illness (Rosenstock, 1974; Janz & Becker, 1984). The HBM initially suggested that for an individual to take action to avoid illness, they must believe that they are personally susceptible to it, the occurrence of the illness will have at least a moderate impact on some aspect of their life, and making a specific decision will benefit them by limiting or reducing their susceptibility (Rosenstock, 1974). The HBM is important in associating or explaining the acceptance of care recommendations as influenced by five key indicators (Rosenstock, 1974; Janz & Becker, 1984):

1) Perceived benefits refer to an individual's belief in the effectiveness of a particular health behavior taken to reduce or cure illness

2) Perceived barriers refer to the possible downsides of a specific health action that can deter someone from engaging in the recommended behavior

3) Perceived self-efficacy refers to an individual's belief in their capability to successfully execute the behaviors necessary to achieve a specific health outcome

4) Perceived attitude refers to an individual's response to or evaluation of something. In the context of health behavior, attitudes play a role in predicting intentions and behaviors

5) Perceived susceptibility refers to the feeling of being vulnerable to a condition and the extent to which the individual believes he/she is at risk of acquiring it.

The HBM is a crucial framework for understanding health behaviors by focusing on cognitive factors that motivate individuals to take preventive actions (Al-Metwali et al., 2021) and is particularly useful for evaluating health behaviors related to hearing impairments (Meyer et al., 2014; Saunders et al., 2012). Saunders et al. (2013) demonstrated the HBM's value in assessing hearing health beliefs and associating behaviors. The HBM's goal is to enhance health-promoting behaviors by exploring the reasons behind their absence (Al-Metwali et al., 2021). Consequently, the HBM was used in this study to evaluate how Canadian seafarers perceive occupational noise risk, employing a 20-item questionnaire based on the HBM's key indicators.

3.1.2 Health Capital Approach

Michael Grossman's (1972) model of investment in health capital stands as the standard for analyzing health-related behaviors. Its appeal lies in its explicit acknowledgment of the dynamic nature of the problem and the way it allows decisions about health-related behaviors to be framed as part of an intertemporal optimization problem. According to Anna Schneider-Kamp (2020) and Sarwar et al. (2023), knowledge, awareness, training, education, field-specific skills, competencies, personal adaptation, and experience are critical components of health capital influencing individual health-related behaviors. Health capital provides a method for appraising risks associated with an individual's traits, pinpointing shortcomings like insufficient skills, education, or experience in a qualitative risk assessment. This framework considers such risks quantifiable and amenable to measurement (Schneider-Kamp, 2020). The relevant causes of occupational accidents onboard ships are hazards, lack of knowledge, inadequate training, and work environment-related factors (Baker & McCafferty, 2005). The health capital approach emphasizes that personal safety training and education to improve information and awareness are the most suitable ways to decrease workplace risk (Schneider-Kamp, 2020). Training and knowledge can help control hazards but cannot eliminate hazards without employers' investment. Hence, the workplace is an important setting for health protection to prevent occupational injury and accidents and for health promotion to improve overall health and well-being (Stoewen, 2016).

In this study, integrating health capital concepts provides a robust analytical foundation for understanding seafarers' perceptions and attitudes for qualitative thematic data analysis. This integration offers insights into how investments in the workplace by shipowners in health-related knowledge, such as training and education, may influence seafarers' responses to occupational noise exposure and its potential health consequences in the Canadian maritime setting, underscoring the responsibility of employers to create a work environment that safeguards seafarers' health.

3.2 Research Framework

3.2.1 Study design

The present research is a mixed-methods study, which adopts both quantitative and qualitative approaches. A key objective of this study was to assess the risk of noise perception and self-reported noise-induced auditory health problems through disseminating a cross-sectional, descriptive questionnaire-based online survey. This study also aimed to explore seafarers' experiences with noise exposure, onboard noise control prevention and management, and the existing barriers and challenges in preventing noise-induced health effects by conducting semi-structured online interviews among seafarers in Canada.

3.2.2 Study setting

The study was conducted among currently active seafarers working in Canada, including all provinces and territories.

3.2.3 Target population:

Seafarers in Canada who met the following eligibility criteria were considered the target population for this research.

3.2.4 Eligibility Criteria

The eligibility criteria for this research included seafarers who had worked on deck, in the engine room, or in other departments onboard. Participants were required to be between the ages of 18 and 65 years and had to have been actively working as seafarers for one year or more in Canada's fleet. Seafarers were excluded if they were under 18 or over 65, as this research targets the working seafaring population. Most individuals under 18 would have less than one year of experience, while those over 65 are unlikely to be actively working as seafarers, as 65 is a commonly adopted retirement age. Additionally, from a health perspective, further research is needed to explore age-related risks for individuals under 18 and over 65. Therefore, the 18–65 age range is the most appropriate cutoff, as supported by previous studies (Doyle et al., 2016; McVeigh et al., 2019). Additionally, seafarers with a history of working in a noisy environment outside of their seafaring role for one year or more, or those with pre-existing diagnosed hearing problems or noise-induced non-auditory health issues before joining the board as a seafarer, were also excluded from the study.

3.3 Quantitative Research Method

3.3.1 Sample Size

The study population comprised seafarers in Canada, totaling approximately 28,000 active individuals (Transport Canada, 2024a). The Cochran formula, $S = (Z^2 \times P \times (1-P))/M^2$, was utilized to determine the required sample size. For this calculation, a population size (N) of 28,000, a confidence level of 95% (which corresponds to a Z score of 1.96), and a margin of error (M) of 5% (0.05) were utilized. Given the limited evidence on the subject, we assumed the most conservative estimate (P) of 0.5 and assumed an equal distribution for simplicity was applied. The required sample size resulted in a determined sample size of S=384 participants, ensuring a representative subset for the research study.

3.3.2 Study Instrument

The survey was developed using the Qualtrics^{XM} survey platform and employed an anonymous questionnaire consisting of four sections (Appendix C). Section I includes sociodemographic and work characteristics questions (15 in total). Section II contains inquiries related to risk perceptions of occupational noise exposure, assessing perceived benefits of reducing noise, barriers to noise reduction, perceived self-efficacy, attitudes towards noise, and perceived susceptibility (20 statements). Section III encompasses questions on noise-induced auditory health problems, including hearing impairment (3 questions), a hearing sensitivity inventory (12 statements), tinnitus (2 questions), and unexpected body balance problems (4 questions). Finally, Section IV addresses the use of hearing protection devices (8 questions). The survey incorporates various question types, including multiple-choice questions, Likert scale questions, slider scale questions, and short open-ended questions. The questions in this survey are adapted from validated questionnaires used in several relevant studies, and permission to reuse and publish these instruments was obtained from the authors (Tessier-Sherman et al., 2017; Purdy & Williams, 2002; Penson et al., 2020; Coren & Hakstian, 1992).

3.3.3 Sample Selection Strategy

The research flyer was initially disseminated through various social media platforms, primarily LinkedIn, as the first step in participant recruitment. Secondly, Canadian unions and maritime organizations, including the Seafarers' International Union (SIU) of Canada (https://seafarers.ca/) and the Canadian Merchant Service Guild (CMSG) (https://cmsg-gmmc.ca/index.php/en/), which are the two main unions representing seafarers in Canada, as well as The Mission to Seafarers of Canada (https://www.missiontoseafarers.ca/), were contacted to distribute the flyer on their websites and social media channels. These organizations also shared the flyer directly with seafarers through their mailing lists.

3.4 Qualitative Research Method

3.4.1 Sample Size

A sample size of 20 to 40 participants was initially chosen for the qualitative semi-structured interviews, as this range was considered appropriate for achieving the study's objectives. After conducting 23 interviews, sufficient information was gathered regarding seafarers' experiences with occupational noise exposure. This allowed us to reach theoretical saturation, where additional data collection no longer uncovered new properties or provided further theoretical insights into the emerging grounded theory (Saunders et al., 2017). In simpler terms, we reached a saturation point, and gathering more data does not contribute substantially to refining or enhancing our theoretical framework under investigation. It is important to note that the focus of theoretical saturation is more on the adequacy of the sample rather than its sheer size (Bowen, 2008). Hence, the goal is not to collect an extensive amount of data but to ensure that the data collected is rich, diverse, and sufficiently covers the dimensions, enabling a comprehensive understanding of the existing research problem.

3.4.2 Interview Guide

A semi-structured interview guide was designed according to the data collection objective of this study (Appendix D). The researcher explained the aim of the interview to the participants. At the beginning of each interview, several screening questions were asked to confirm that participants were indeed seafarers. These questions covered details about their work experience, including ship type, onboard rank, department, years of seafaring experience, years in their current position, normal duty schedule, and the average length of their voyages. Participants were then asked semi-structured questions about onboard noise exposures, current management and prevention approaches, and existing barriers and challenges in preventing noise-induced health problems. In addition, seafarers were encouraged to share their experiences and provide suggestions to mitigate excess noise exposure and improve legislation, regulation, policy, and practices.

3.4.3 Sample Selection Strategy

The same recruitment strategies used to engage participants for the survey were employed to recruit participants for the interviews.

3.5 Statistical Analysis

In terms of the quantitative analysis, descriptive statistics of the study population were reported. The Statistical Analysis System (SAS)® software was used for data management and analysis in this research. To summarize our study population, percentages/ frequencies, and means/standard deviations, and percentiles were used for categorical variables and continuous variables, respectively. The chi-square test or Fisher's exact test (when the expected cell counts were less than 5) was used for cross-tabulation analysis to determine the association of seafarers' demographics with noise risk perception subscales. A p-value of 0.05 was used to determine if an association was statistically significant.

In terms of the qualitative analysis, all interviews were audio-recorded for transcription and future data analysis, except for one where notes were taken by the first author as the participant did not permit audio recording. The thematic analysis method was employed for qualitative data analysis. Coding and thematic analysis of transcripts were done using the qualitative analysis software ATLAS.ti. The health capital framework was adopted to comprehend how seafarers perceive noise exposure and explore potential barriers in mitigating occupational noise-induced health issues.

3.6 Research Ethics

Given the nature of this research, several ethical considerations were addressed. All participants were treated with respect and courtesy from the outset. An informed consent strategy was implemented for both the survey and the interview, ensuring that the aims and methods of the research were clearly explained to all participants. Participation in this research was entirely voluntary, and participants had the right to skip any survey questions they did not wish to answer. During the interviews, participants were free to decline any questions they preferred not to answer, and they had the right to leave the interview at any time without providing a reason.

All Memorial University research ethics protocols and Tri-Council Policy Statement guidelines were followed to ensure participant confidentiality and anonymity. Survey responses were kept anonymous, with no personally identifiable information, such as names or email addresses, collected. Additionally, pseudonyms were used in all written interview transcripts to protect participant identities. After completing the survey, participants were asked to provide their email addresses for a chance to win one of three Amazon e-gift cards valued at $100. To maintain anonymity, participants were redirected to a separate page, preventing any association between their survey responses and contact information. As compensation for the interviewees' participation and time, they were offered an Amazon e-gift card valued at $50. Participants were also able to withdraw from the study within three months of the interview date without affecting their eligibility for the incentive.

All collected data were securely stored on password-protected electronic devices. The results of this study were used solely for academic purposes, with access to the data restricted to the research team. The quantitative and qualitative consents, research information sheets, and flyer clarified that the study was not required by any employer, organization, or union that disseminated the research information on our behalf. Ethical approval for this research was obtained from the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland on January 5, 2023. The ethics approval letter (ICEHR Number: 20230979-ME) is attached in Appendix B.

As a registered nurse with a background in community health, I am committed to understanding workplace health challenges, including occupational noise exposure. Although I am not part of the seafaring community, my interest in this topic arose from a dedication to improving health outcomes in high-risk occupations. I remained mindful of my position as an outsider and took a reflexive approach to ensure that the voices and experiences of seafarers guided this study. By focusing on their perspectives, I aimed to provide evidence-based insights and draw conclusions rooted in their lived realities, rather than solely relying on external assumptions or theoretical ideas, ultimately contributing to practical improvements in their health and well-being.

3.7. Summary

Chapter 3 describes the theoretical perspective of this research and outlines the research methods used in both the quantitative and qualitative components. The study design, recruitment strategies, and instruments, such as the survey and interview guide, are discussed.

Chapters 4 and 5 are written as a series of manuscripts, each including an introduction, methods, results, discussion, and conclusion.

Chapter 4 presents the survey findings from 367 participants, including demographic information, occupational characteristics, frequency distribution, and cross-tabulation of these findings with the noise perception questionnaire.

Chapter 5 further explores the qualitative results of 23 interviews, highlighting the themes that emerged from the online discussions. Participants were notably eager to share their experiences during the interviews, particularly because occupational noise exposure is often overlooked in the seafaring community. While most participants adhered to the interview script, some deviated slightly to offer additional insights. These deviations were still relevant to the study, providing valuable depth to the data collected.

Chapter 4 Seafarers' Perceptions and Attitudes Toward Occupational Noise Exposure and Its Health Impacts in Canada: A Quantitative Study

Unpublished, prepared in manuscript format for future publication

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FH: Conceptualization, Methodology, Investigation, Analysis, Writing.

ZG: Methodology, Review and Editing, Supervision.

AS: Conceptualization, Methodology, Review and Editing, Supervision.

DS: Conceptualization, Methodology, Resources, Review and Editing, Supervision, Project Administration, Funding Acquisition.

Abstract

Occupational noise exposure onboard is a significant health concern for seafarers, potentially leading to auditory and non-auditory health problems. This study aimed to assess risk perceptions and attitudes towards occupational noise exposure among seafarers in Canada and evaluate their knowledge of self-reported noise-induced auditory health problems through a cross-sectional descriptive online survey, which included 367 responses for final analysis. Based on the Health Belief Model, findings revealed that perceived benefits, barriers, and self-efficacy scores indicated that seafarers have moderately positive perceptions toward noise reduction and hearing loss prevention. The perceived attitude and susceptibility scores showed that participants generally disliked loud noise and perceived their susceptibility to hearing loss as quite high. Around 40.3% of the participants reported having hearing difficulties. According to the hearing screening inventory, 52.2% had some degree of hearing loss [25 decibels (dB) or more], and 15.5% had more severe hearing loss [55 dB or more]. Approximately 45% of the participants reported having tinnitus, and 40% reported experiencing unexpected balance problems. Additionally, 66% of the participants reported that their hearing protection is a communication barrier at their workplace, and 60.8% reported that it causes discomfort. In conclusion, gaps in perception and behavior highlight the need for targeted educational interventions to enhance protective behaviors and improve occupational health and safety to prevent noise-induced health impacts.

Keywords: seafarers, noise exposure onboard, health impacts, noise risk perceptions, noise prevention

4.1 Introduction

Seafaring is one of the most dangerous occupations globally, involving physical, ergonomic, chemical, and biological hazards, as well as psychological and social challenges. These include falls from heights, falling overboard, exposure to harmful substances, being struck by chains, slips, trips, and the risks associated with tasks such as cleaning tanks and performing maintenance and repair work in the engine department (Çakir, 2019; Jeżewska et al., 2015). These hazards and challenges can lead to occupational accidents, injuries, and diseases (Sagaro et al., 2021). Seafarers usually spend six to 11 months onboard a ship, where they are continuously exposed to a hazardous working environment with high noise levels due to the 24/7 nature of ship operation (Kim & Jang, 2018). They, especially the engine crew, are frequently exposed to high noise levels, with the engine room being the primary source of noise on board and having the highest noise levels (Oldenburg et al., 2020; Picu et al., 2019; Turan et al., 2011).

Occupational noise represents a major risk factor for seafarers. It can result in auditory conditions such as noise-induced hearing loss (NIHL), which occurs more frequently in seafarers working in the engine department compared to other crew members (Lucas et al., 2022; Kaerlev et al., 2008; Irgens-Hansen et al., 2015a). Hui (2019) also identified that exposure to occupational noise leads to tinnitus among seafarers onboard.

Occupational noise exposure onboard also leads to non-auditory health effects among seafarers. Long-term exposure to noise on ships contributes to increased psychological stress. This problem was reported by the engine room crew (83.7%) and deck crew (65.4%) (Oldenburg et al., 2020). Picu et al. (2019) found that noise levels of 92 A-weighted decibels (dB (A)) exceeding the safe limits of 80-85 dB (A) lead to seafarers’ sleep disorders, accompanied by increased body temperature and blood pressure. Noise exposure during sleep can disrupt the circadian rhythm of seafarers, exacerbating fatigue levels (Cui et al., 2022). Occupational noise exposure onboard is argued to be a critical risk factor for cardiovascular diseases (CVD) among the seafaring population (Oldenburg, 2014).

Workplace noise causes annoyance and interferes with seafarers' communication, which jeopardizes navigation safety (Nikolic & Nikolic, 2013). Che-Ishak et al. (2019) stated that poor communication due to background noise leads to misunderstandings, mistakes, and, ultimately, accidents in the maritime industry. In the maritime industry, characterized by high-risk working conditions, a hazardous environment impacts not only the health and well-being of seafarers but also potentially affects the overall safety of the ship (Baygi et al., 2020). Occupational noise is identified as one of the environmental factors contributing to accidents onboard, as highlighted by Husna et al. (2020).

Promoting education and awareness about the harmful effects of noise is crucial, as it influences noise-associated risk health behaviors (Alnuman & Ghnimat, 2019). Evoy and Case (2022) emphasized the importance of developing prevention or educational materials to improve seafarers' health and wellness. Educational training on the importance of hearing protection for seafarers exposed to occupational noise is crucial (Rocha et al., 2011). While many studies have provided insights into the noise levels onboard and various auditory and non-auditory health problems associated with occupational noise exposure at sea, there is a lack of research on seafarers' risk perceptions of noise exposure onboard. Despite the existence of standards regulating noise levels on board Canadian vessels, seafarers' risk perceptions of workplace noise and its health impacts are underexamined. To address these research gaps, a quantitative research approach was conducted between 2022 and 2023 to a) assess if there are any differences among seafarers working in different ship departments in Canada, including engineering, deck, and galley, in terms of risk perceptions and awareness towards occupational noise exposure and its health impacts; and b) assess the extent to which seafarers in Canada are aware of occupational noise-induced auditory health problems. The following null hypotheses were developed after reviewing the available literature on occupational noise exposure and associated health problems among seafarers: a) There is no significant difference in noise risk perceptions and/or awareness of occupational noise exposure and its auditory health impacts among seafarers working in different ship departments in Canada, including engineering, deck, and galley; and b) the extent of seafarers' knowledge of self-reported health problems related to occupational noise exposure is not influenced by factors such as duration of exposure, location, noise level, sociodemographic characteristics, and adherence to occupational health and safety measures onboard.

4.2 Materials and Methods

4.2.1 Study Design and Participants

A cross-sectional, descriptive questionnaire-based online survey was used for this study. The study was conducted among currently active seafarers working in Canada, including all provinces and territories. Eligible participants had to be between 18 and 65 years old, working on deck, in the engine room, or in other departments onboard, and actively employed as seafarers in Canada's fleet for one year or more. Those with a history of working in noisy environments other than as seafarers onboard for one year or more and those with pre-existing diagnosed hearing problems or noise-induced non-auditory health problems before joining as seafarers were not eligible to participate in the study.

4.2.2 Sample Size

The study population comprised seafarers in Canada, totaling approximately 28,000 active individuals (Transport Canada, 2024a). The Cochran formula, $S= (Z^2 \times P \times (1-P))/M^2$, was utilized to determine the required sample size. For this calculation, a population size (N) of 28,000, a confidence level of 95% (which corresponds to a Z score of 1.96), and a margin of error (M) of 5% (0.05) were utilized. Given the limited evidence on the subject, we assumed the most conservative estimate (P) of 0.5 and assumed an equal distribution for simplicity were applied. The required sample size resulted in a determined sample size of S=384 participants, ensuring a representative subset for the research study.

4.2.3 Sample Selection Strategy

The research flyer was initially disseminated through various social media platforms, primarily LinkedIn, as the first step in participant recruitment. Secondly, Canadian unions and maritime organizations, including the Seafarers' International Union (SIU) of Canada (https://seafarers.ca/) and the Canadian Merchant Service Guild (https://cmsg-gmmc.ca/index.php/en/), which are the two main unions representing seafarers in Canada, as well as The Mission to Seafarers: Canada (https://www.missiontoseafarers.ca/), were contacted to distribute the flyer on their websites and social media channels. These organizations also shared the flyer directly with seafarers through their mailing lists.

4.2.4 Ethics

A strategy of informed consent was adopted for the survey, ensuring that the aim and methods of the research were clearly communicated to all participants in the consent form, along with access to the survey information sheet. Participation in this research was entirely voluntary.

All Memorial University of Newfoundland ethics research protocols were followed to maintain the confidentiality of participants' information. The results of this study were intended for academic purposes only. Ethical approval for this research was obtained through the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland on January 5, 2023. The ethics approval letter (ICEHR Number: 20230979-ME) is attached in Appendix B.

4.2.5 Theoretical Framework: Health Belief Model (HBM)

The HBM was initially developed to understand people's failure to adopt disease prevention strategies or screening tests and was later adapted to understand patients' responses to symptoms and adherence to medical treatments. The basic components of the HBM are derived from a well-established body of psychological and behavioral theory, whose various models hypothesize that health-related behavior depends mainly upon two variables: (1) the desire to avoid illness or, conversely, get well if already ill; and (2) the belief that a specific health action will prevent or cure illness (Rosenstock, 1974; Janz & Becker, 1984). The HBM initially suggested that for an individual to take action to avoid illness, they must believe that they are personally susceptible to it, the occurrence of the illness will have at least a moderate impact on some aspect of their life, and making a specific decision will benefit them by limiting or reducing their susceptibility (Rosenstock, 1974). The HBM is important in associating or explaining the acceptance of care recommendations as influenced by five key indicators (Rosenstock, 1974; Janz & Becker, 1984): 1) **Perceived benefits** refer to an individual's belief in the effectiveness of a particular health behavior taken to reduce or cure illness; 2) **Perceived barriers** refer to the possible downsides of a specific health action that can deter someone from engaging in the recommended behavior; 3) **Perceived self-efficacy** refers to an individual's belief in their capability to successfully execute the behaviors necessary to achieve a specific health outcome; 4) **Perceived attitude** refers to an individual's response to or evaluation of something. In the context of health behavior, attitudes play a role in predicting intentions and behaviors; and 5) **Perceived susceptibility** refers to the feeling of being vulnerable to a condition and the extent to which the individual believes he/she is at risk of acquiring it (Figure 4.1).

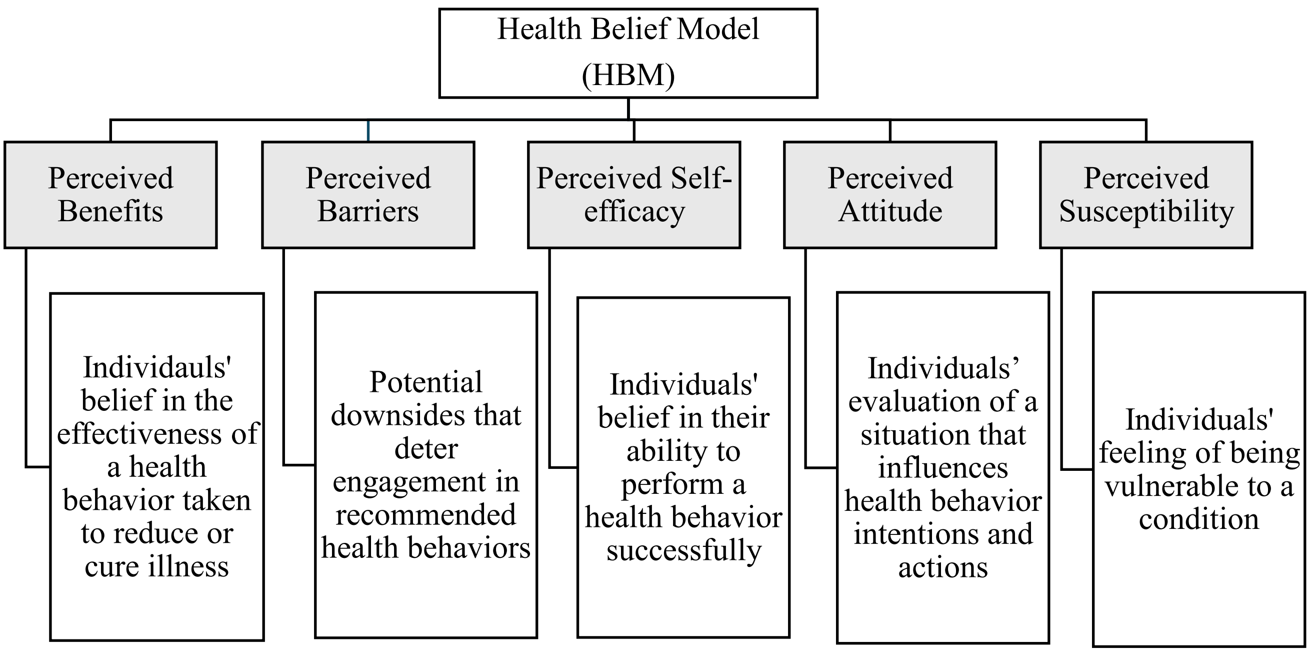

Figure 4.1 *The five key indicators of the Health Belief Model (HBM).*

The HBM is a crucial framework for understanding health behaviors by focusing on cognitive factors that motivate individuals to take preventive actions (Al-Metwali et al., 2021) and is particularly useful for evaluating health behaviors related to hearing impairments (Meyer et al., 2014; Saunders et al., 2012). Saunders et al. (2013) demonstrated the HBM's value in assessing hearing health beliefs and associating behaviors. The HBM's goal is to enhance health-promoting behaviors by exploring the reasons behind their absence (Al-Metwali et al., 2021).

Consequently, the HBM was used in this study to evaluate how Canadian seafarers perceive occupational noise risk, employing a 20-item questionnaire based on the HBM's key indicators.

4.2.6 Study Instrument

The survey was developed using the Qualtrics^{XM} survey platform and employed an anonymous questionnaire consisting of four sections (Appendix C). Section I includes sociodemographic and work characteristics questions (15 in total). Section II contains inquiries related to risk perceptions of occupational noise exposure, assessing perceived benefits of reducing noise, barriers to noise reduction, perceived self-efficacy, attitudes towards noise, and perceived susceptibility (20 statements). Section III encompasses questions on noise-induced auditory health problems, including hearing impairment (3 questions), a hearing sensitivity inventory (12 statements), tinnitus (2 questions), and unexpected body balance problems (4 questions). Finally, Section IV addresses the use of hearing protection devices (8 questions). The survey incorporates various question types, including multiple-choice questions, Likert scale questions, slider scale questions, and short open-ended questions. The questions in this survey are adapted from validated questionnaires used in several relevant studies, and permission to reuse and publish these instruments was obtained from the authors (Tessier-Sherman et al., 2017; Purdy & Williams, 2002; Penson et al., 2020; Coren & Hakstian, 1992).

4.2.7 Data Management and Quality Control Procedures

A total of 1,089 surveys were received. Quality control procedures were applied to identify potential fraudulent surveys completed by survey bots or bad actors (Figure 4.2). The detailed three-phase hierarchical screening strategy was implemented (Table 4.1).

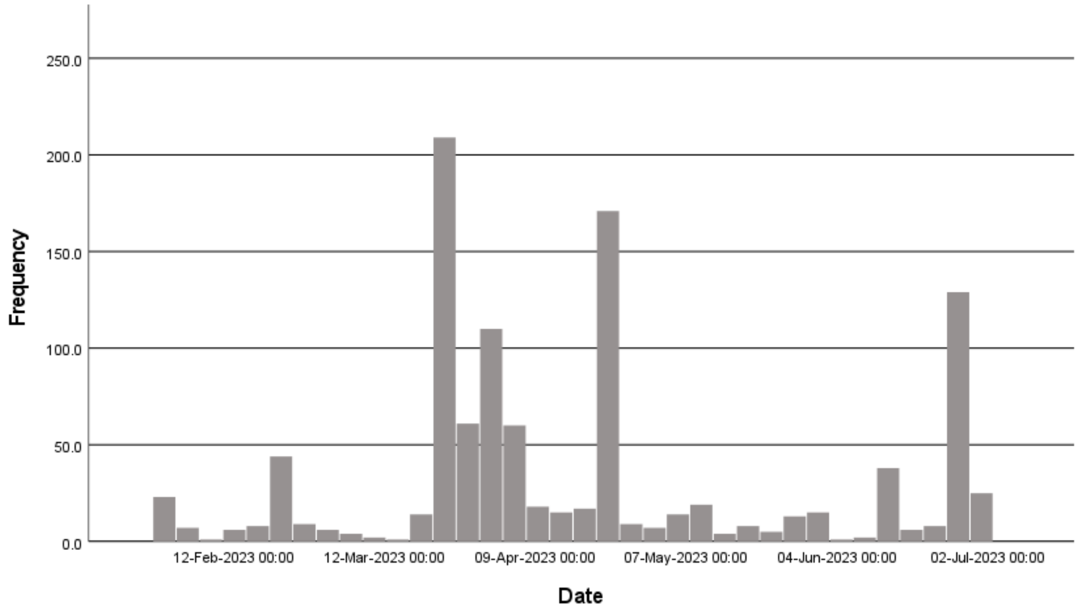

Figure 4.2 *Frequency distribution of survey start dates and time (n = 1089) with peaks indicating possible survey bot attacks.*

During the first phase of screening, 288 surveys were excluded from analysis based on exclusion criteria established a priori (Table 4.1). Participants who declined to consent to the survey or did not meet the study's eligibility criteria were excluded. Other exclusion criteria included surveys with identical Internet Protocol (IP) addresses and overlapping times, seafarers who reported seafaring work experience greater than their age (Age-seafaring work experience differential), and seafarers who reported current job experience exceeding their entire seafaring work experience (Seafaring work experience-current job position differential), as these are impossible/ineligible cases. Surveys with null data entry, which contribute zero information to the survey, were also excluded. Phase II of screening excluded surveys with any of the following exclusion criteria: surveys with identical start times (n=239), duration of completion less than 165.40 seconds (lower 2.5 percentile calculated from the 801 surveys that passed the first screening) (n=20), duplicated text within one field across more than one survey (n=63), or surveys showing high similarity (n=38). Phase III of screening excluded surveys with identical start times and stop times that were within one minute (60 seconds) of each other (n=74). The total number of surveys included in the final analysis is n=367.

A comparative analysis of the demographic variables was conducted between the 38 surveys classified as highly similar, which were excluded during Phase II of the data screening, and the final set of 367 included surveys. This analysis aimed to assess for selection bias and determine whether excluding these 38 surveys from the analysis was appropriate. Upon performing chi-square and t-tests, we found that the p-values for all demographic variables, except for one, were greater than 0.05. This indicates no statistically significant differences between the two groups for most variables. Since only one variable out of multiple showed a statistically significant difference between the two groups, it appears less likely that significant selection bias is affecting the analysis. Consequently, we are inclined to maintain the exclusion of these 38 surveys from the final analysis. Therefore, the total number of surveys included in the final analysis is 367.

Table 4.1 Survey data screening process.

Phase I: 1089 surveys Exclusion criteria (any of the below factors)	Reason	n
Consent (One survey ID as spam)	Ethics requirement	111
Identical IP, overlapping time	Impossible cases	17
Age (<18 years old or > 65 years old)	Eligibility	2
Province of residency (outside Canada)	Eligibility	7
Age, seafaring work experience differential	Impossible cases	1
Seafaring work experience, current job position differential	Impossible cases	37
Survey progress (zero contribution)	Null data entry	113
Total removed in Phase I		**288**
Phase II: 801 surveys Exclusion criteria (any of the below factors)	**Reason**	**n**
Start Time identical	Impossible cases	239
Duration*	Impossible cases	20
Text within one field duplicated across >1 survey	Fraudulent entries	63
Highly similar surveys	Fraudulent entries	38
Total removed in Phase II		**360**
Phase III: 441 surveys Exclusion criteria	**Reason**	**n**
Start times identical AND Stop times within 60 seconds	Fraudulent entries	
Total removed in Phase III		**74**
Total removed in all phases (Phase I +Phase II+ Phase III)		**722**
Surveys included for analysis		**367**

Phase II: *Completed in less than 165.40 seconds (lower 2.5 percentile calculated from the 801 surveys that passed the first screening).

4.2.8 Statistical Analysis

Descriptive statistics of the study population were reported. The Statistical Analysis System (SAS)® software was used for data management and analysis in this research. To summarize our study population, percentages/ frequencies, means/ standard deviations, and percentiles were used for categorical variables and continuous variables, respectively. The chi-square test or Fisher's exact test (when the expected cell counts were less than 5) was used for cross-tabulation analysis to determine the association of seafarers' demographics with noise risk perception subscales. A p-value of 0.05 was used to determine if an association was statistically significant.

4.3 Results

4.3.1 Seafarers' Sociodemographic

Based on the mean age of the participants, seafarers were categorized into two age groups: younger adults (under 40 years old) and older adults (40 years and above). Most participants are younger adults (88%) and males (79%). The participants' current Canadian province or territory of residence was grouped into five regions. The first group is Pacific Canada, which includes British Columbia. The second group is the Prairie Provinces, consisting of Alberta, Saskatchewan, and Manitoba. The third group is Central Canada, including Ontario and Quebec. The fourth group is Atlantic Canada, which includes New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island. The fifth group is the Territories, consisting of Yukon, Northwest Territories, and Nunavut. The highest percentage of participants resided in Atlantic Canada (30%), followed by Central Canada (26%). Marital status response choices were grouped into four categories: Common-Law/Married, Never Married/Single, Separated/Divorced/Widowed, and Prefer not to Say. Most participants were either in a common-law relationship or married (66%).

Approximately 48% of participants worked in the engineering department, while around 40% worked in the deck department, and a minority (12%) worked in the galley. The different ranks of seafarers onboard were classified into four groups based on their noise exposure. The first group included Masters/Captains. The second group comprised Deck Officers, including

Chief Officer, Second Officer, and Third Officer. The third group consisted of Engineering Officers and Engine Room Ratings, which included Chief Engineer, Second Engineer, Third Engineer, Fourth Engineer, and Mechanical Assistant. The fourth group included Non-Engine Room Ratings, such as Bridge Watchman, Deckhand, Ordinary Seaman, and Cook. Most participants (44%) were categorized as engineering officers and engine room ratings.

Regarding the primary Canadian marine shipping region of operation, the highest number of participants (38%) operated in the Pacific West Coast Region, followed by 30% in the Atlantic Region. Participants worked on various ship types, with the most common being container ships (34%), general cargo ships (32%), and bulk carriers (29%). Education levels were grouped into two categories: up to high school (less than secondary school or a high school diploma) and above high school (some postsecondary education or a postsecondary certificate, diploma, or degree). Most participants (82%) had education levels above high school.

Based on the mean years of seafaring experience, participants were categorized into those with less than 10 years of experience and those with 10 years or more. Most seafarers had less than 10 years of experience (79%). Similarly, years in the current job position were grouped into less than 5 years and 5 years or more, with most seafarers (66%) having been in their current position for less than 5 years. Seafarers were also asked about their previous occupations before joining the maritime industry. The top 10 previous occupations were reported, with the largest group being students (29%), followed by 14% who worked in the shipping industry, and 11% who were unemployed. These previous occupations were classified into noisy, possibly noisy, and non-noisy environments. Most participants worked in non-noisy occupations before becoming seafarers (45%), followed by 29% in possibly noisy occupations and 23% in noisy environments.

The average length of voyage duty was categorized into less than two months (one month, six weeks) and two months or more (three months, six months). More than half of the participants (55%) reported an average voyage length of two months or more. Regarding normal duty schedules, most participants (56%) worked 6 hours on and 6 hours off, followed by 25% who worked 12 hours on and 12 hours off. A summary of the descriptive statistics for the occupational characteristics of seafarers is presented in Table 4.2.

Table 4.2 *Descriptive statistics for occupational characteristics of seafarers.*

Demographics of seafarers		Frequency	Percentage
Current Rank/ Job Position Group on Ship			
- Engineering Officers and Engine Room Ratings		153	44%
- Non-engine Room Ratings		99	28%
- Deck Officers		77	22%
- Master/ Captain		20	6%
Canadian Marine Shipping Region of Operation			
- Pacific West Coast Region		131	38%
- Atlantic Region		105	30%
- Great Lakes/ St. Lawrence Seaway		94	27%
- Northern Region (Includes both The Western Arctic and The Eastern Arctic)		19	5%
Ship type (Select all that apply)	Container Ship	118	34%
	General Cargo Ship	113	32%
	Bulk Carrier	101	29%
	Passenger Ship/ Ferry	82	23%
	Reefer	40	11%
	Oil Tanker	40	11%
	Supply Ship	38	11%
	Chemical and Product Tanker	30	9%

Demographics of seafarers		Frequency	Percentage
	Government Vessel (Icebreaker/ Research Vessel/ Motor Lifeboat)	27	8%
	Gas Tanker (LNG)	20	6%
	RO-RO	18	5%
	Tugboat	17	5%
	Other Tanker	9	3%
Average Length of Voyage Duty Group			
- Two months or more		193	55%
- Less than two months		156	45%
Normal Duty Schedule			
- 6 hours on, 6 hours off		195	56%
- 12 hours on, 12 hours on		89	25%
- 4 hours on, 8 hours off		61	17%
- Other (8 hours a day)		7	2%

4.3.2 Noise Risk Perception

The noise perception questionnaire consists of 20 statements, which are divided into five subscales based on the HBM. These subscales include perceived noise benefits (4 statements), perceived barriers to noise reduction and prevention of hearing loss (5 statements), perceived self-efficacy in reducing noise exposure and noise levels (4 statements), attitude towards noise (3 statements), and perceived noise susceptibility to hearing loss (4 statements). A seven-point Likert scale (1 = Strongly agree, 2 = Agree, 3 = Somewhat agree, 4 = Neither agree nor disagree, 5 = Somewhat disagree, 6 = Disagree, and 7 = Strongly disagree) was used to record the responses. Five statements (statements 1 to 4 and statement 12) in the noise risk perception questionnaire were reversed for scoring purposes. After reversing the scores, a high score (7) indicates that subjects consider noise reduction beneficial, perceive barriers to be minimal, have high self-efficacy, hold a negative attitude toward noise (dislike noise), and perceive high susceptibility to hearing loss.

The central tendency and dispersion parameters were computed by adding the responses to the various subscales of the noise risk perception questionnaire. According to the study's results, perceived benefits, barriers, and self-efficacy scores ranged between 3 and 5, indicating that seafarers have a moderately positive attitude and perceptions toward noise reduction and hearing loss prevention. The perceived attitude and susceptibility scores ranged between 4 and 5, showing that participants generally disliked loud noise and perceived their susceptibility to hearing loss as quite high. The data in Table 4.3 represent observations of seafarers' noise risk perception scores.

Table 4.3 *Descriptive statistics of the five subscales of the noise risk perception questionnaire.*

Descriptive statistics		**Subscale1: Perceived Benefits**	**Subscale2: Perceived Barriers**	**Subscale3: Perceived self-efficacy**	**Subscale4: Perceived attitude**	**Subscale5: Perceived susceptibility**
Total (N)	**Valid**	353	352	352	352	350
	Missing	1	2	2	2	4
Mean		5.1	3.6	3.9	4.5	4.5
Median		5.3	3.6	3.8	4.7	4.5
Std. Deviation		1.2	1.14	0.8	1.6	1.6
Percentiles	**25th**	4.3	2.8	3.3	3	3.3
	75th	6	4.4	4.5	6	6

The perceived benefit subscale responses, which consist of items 1 to 4, are summarized in Table 4.4. Most participants (70% to 75%) agreed that a quieter work environment would reduce work-related stress and improve their well-being. However, approximately 9% to 16% of respondents expressed a lack of interest in the anticipated benefits of a noise-free work environment. Approximately 67% and 70% of seafarers agreed that noise adversely affects their ability to concentrate or think at work and has health implications beyond hearing. Conversely, approximately 14% to 20% disagreed with the idea that noise impairs their ability to focus or think and that it has negative health effects beyond those related to hearing.

Table 4.4 *Perceived benefits of noise reduction (Statements 1 to 4).*

Perceived Benefits	Work would be less stressful if it was quieter.	I will feel better if my workplace is less noisy.	Noise stops me from being able to think or focus on work.	Noise has bad effects on my health other than hearing.
Frequency (percentage)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Strongly agree	57 (16)	71 (20)	50 (14)	50 (14)
Agree	120 (34)	113 (32)	90 (26)	106 (30)
Somewhat agree	70 (20)	82 (23)	94 (27)	90 (26)
Neither agree nor disagree	44 (13)	33 (9)	47 (13)	55 (16)
Somewhat disagree	28 (8)	29 (9)	39 (11)	30 (9)
Disagree	19 (5)	17 (5)	22 (6)	15 (4)
Strongly disagree	14 (4)	7 (2)	10 (3)	5 (1)
Total	352 (100)	352 (100)	352 (100)	351 (100)

The results of the perceived barriers to noise reduction and hearing loss prevention are shown in Table 4.5. Between 42 % and 62 % of respondents agreed with statements 5 to 9. Around 62 % of them assented to the idea that hearing protectors prevent them from hearing what they want in their workplace, and 59 % find them uncomfortable. Additionally, roughly 60% of the participants agreed that they lack the time to address noise-related issues at work, while 42 % of their coworkers appeared indifferent to workplace noise concerns, as reported by the participants. Approximately 13% to 21% expressed neutral opinions on these matters. Around 46% of participants concurred that vessel owners exhibited a lack of concern regarding occupational health and safety (OHS), whereas 41 % of them disagreed with this statement.

Table 4.5 *Perceived barriers to noise reduction and hearing loss prevention (Statements 5 to 9).*

Perceived Barriers	I do not have time to do anything about the noise at work.	Hearing protectors stop me from hearing what I want to hear.	Hearing protectors are uncomfortable.	Vessel owners are not interested in occupational health and safety.	My mates at work don't worry about noise.
Frequency (percentage)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Strongly agree	28 (8)	30 (9)	28 (8)	23 (7)	17 (5)
Agree	96 (27)	91 (26)	90 (26)	60 (17)	66 (19)
Somewhat agree	85 (24)	96 (27)	89 (25)	77 (22)	64 (18)
Neither agree nor disagree	73 (21)	50 (15)	63 (18)	46 (13)	56 (16)
Somewhat disagree	30 (9)	36 (10)	31 (9)	60 (17)	61 (17)
Disagree	29 (8)	36 (10)	38 (11)	57 (16)	70 (20)
Strongly disagree	9 (3)	12 (3)	12 (3)	28 (8)	17 (5)
Total	350 (100)	351 (100)	351 (100)	351 (100)	351 (100)

In terms of perceived self-efficacy in reducing noise exposure at work, respondents reached a consensus on three statements: 67% acknowledged their inability to reduce noise in their work setting, 80% expressed confidence in their ability to use hearing protectors, including earmuffs or earplugs, and 68% accepted the challenge of creating quieter equipment. Approximately 9% to 16% of respondents expressed a neutral viewpoint for the four statements within this subscale. However, opinions varied when participants were asked about using hearing protectors correctly, with approximately 46% expressing uncertainty about using them properly, while around 41% disagreed with this statement (Table 4.6).

Table 4.6 *Perceived self-efficacy in being able to reduce noise levels and noise exposure (Statements 10 to 13).*

Perceived Self-efficacy	I cannot reduce noise at work.	I am not sure that I can use hearing protectors correctly.	I know how to use my earmuffs or earplugs.	It is difficult to make equipment quieter.
Frequency (percentage)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Strongly agree	38 (11)	24 (7)	79 (23)	46 (13)
Agree	106 (30)	57 (16)	130 (37)	116 (33)
Somewhat agree	90 (26)	81 (23)	70 (20)	78 (22)
Neither agree nor disagree	55 (16)	47 (13)	33 (9)	47 (14)
Somewhat disagree	25 (7)	48 (14)	22 (6)	35 (10)
Disagree	29 (8)	60 (17)	8 (2)	25 (7)
Strongly disagree	7 (2)	34 (10)	9 (3)	4 (1)
Total	350 (100)	351 (100)	351 (100)	351 (100)

In terms of participants' responses regarding their perceived attitudes toward workplace noise exposure, notably, between 45% and 59% of participants expressed disagreement with all the statements in this subscale, indicating that seafarers hold a negative attitude toward occupational noise and have an aversion to loud noise in their work environment. Approximately 13% to 17% expressed a neutral opinion on these matters. Around 45% of participants disagreed with the statement, “The noise at work does not bother me.” Furthermore, approximately 53% and 59% of seafarers disagreed with the statements regarding their willingness to work in a noisy environment and their belief that they could work more efficiently in such conditions (Table 4.7).

Table 4.7 *Perceived attitude to noise exposure (Statements 14 to 16).*

Perceived Attitude	**The noise at work does not bother me.**	**I like my workplace when it is noisy.**	**I work better if the workplace is noisy.**
Frequency (percentage)	**N (%)**	**N (%)**	**N (%)**
Strongly agree	22 (6)	14 (4)	16 (5)
Agree	60 (17)	47 (14)	40 (12)
Somewhat agree	60 (17)	44 (12)	39 (11)
Neither agree nor disagree	51 (15)	58 (17)	47 (13)
Somewhat disagree	44 (13)	43 (11)	43 (12)
Disagree	76 (22)	81 (23)	80 (23)
Strongly disagree	38 (10)	64 (19)	85 (24)
Total	351 (100)	351 (100)	350 (100)

Regarding participants' perceptions of their susceptibility to hearing loss, most respondents (48% - 57%) disagreed with all the statements in this subscale, indicating a high perceived vulnerability to hearing loss in their workplace. Approximately 12% to 17% expressed a neutral opinion on these matters. Conversely, around 32% and 35% agreed that their hearing would not be damaged by workplace noise and that there would be no difference in their hearing ability if the workplace were quieter. Similarly, 31% and 35% agreed that loud noise at work does not affect hearing in old age, and that noise only affects individuals with sensitive ears (Table 4.8).

Table 4.8 *Perceived susceptibility to hearing loss from noise (Statements 17 to 20).*

Perceived Susceptibility	**My hearing will not be damaged by noise at work.**	**It will make no difference to my hearing if it is quieter at work.**	**Listening to loud noise at work does not affect hearing in old age.**	**The noise only affects hearing in people with sensitive ears.**
Frequency (Percentage)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Strongly agree	16 (5)	24 (7)	13 (4)	20 (6)
Agree	54 (16)	50 (14)	43 (13)	57 (16)
Somewhat agree	37 (11)	50 (14)	45 (14)	45 (13)
Neither agree nor disagree	51 (14)	54 (17)	42 (12)	40 (12)
Somewhat disagree	53 (15)	34 (10)	42 (12)	38 (11)
Disagree	62 (18)	74 (21)	74 (20)	68 (19)
Strongly disagree	76 (21)	64 (17)	90 (25)	82 (23)
Total	349 (100)	350 (100)	349 (100)	350 (100)

Converting Likert Scale Responses of the Noise Risk Perception Questionnaire into a Dichotomized Scale:

We converted the 7-point Likert scale (1= Strongly agree, 2= Agree, 3=Somewhat agree 4=Neither agree nor disagree, 5=Somewhat disagree, 6= Disagree, 7=Strongly disagree) into a dichotomized scale (agree and not agree) by categorizing responses 1 to 3 as agree and responses 4 to 7 as not agree (Table 4.9). We combined the neutral opinions “neither agree nor disagree” with “not agree” responses based on the assumption that respondents who select “neither agree nor disagree” do not express a clear agreement with the statement being assessed and the term “not agree” reflects a broader range of responses that might include neutrality or ambiguity. As a result, we grouped them with the “not agree” category to avoid further reducing the frequency and to facilitate comparisons using Chi-square/ Fisher's exact test (Jeong & Lee, 2016).

Dichotomizing data into “agree” and “not agree” makes the interpretation of the results meaningful while yielding similar results. Several studies in the literature have demonstrated that dichotomous or trichotomous scales perform favorably compared to the Likert scale. This suggests that simplifying scales has the potential to replace the original scale, particularly during data analysis (Dolnicar & Grun, 2007; Dolnicar & Grun, 2009; Dolnicar et al., 2011; Jeong & Lee, 2016; Percy, 1976). Additionally, Dolnicar et al. (2011) noted that managerial interpretations do not significantly differ between binary and Likert scale answer formats. Responses exhibit equal reliability, and the binary format is perceived as quicker and less complex. As a result, in all subsequent association analyses in this section, we used the Chi-square/ Fisher's exact test to determine the association between the clear-cut opinions (agree or not agree) of noise risk perception subscales and the appropriate demographic variable.

Table 4.9 *Conversion of 7-Point Likert Scale to Binary Scale (Coding: 1-3 as "Agree" and 4-7 as "Not Agree").*

Original 7-Point Likert Scale	**Converted Binary Scale**
1. Strongly Agree, 2. Agree, 3. Somewhat Agree	Agree
4. Neither Agree nor Disagree, 5. Somewhat Disagree, 6. Disagree, 7. Strongly Disagree	Not Agree

Among both younger and older adults, the majority agree with perceived noise benefits, with 94% of younger adults and 93% of older adults agreeing. However, approximately 67% expressed dissatisfaction with the perceived barriers, while 82% expressed dissatisfaction with the perceived self-efficacy statements. Similarly, a significant portion of the participants (75% and 76%) did not agree with the statements in perceived attitude and perceived susceptibility, respectively. The association between perceived benefits, perceived self-efficacy, perceived susceptibility, and age groups was found to be statistically insignificant ($p>0.05$). However, there was a statistically significant difference between perceived attitude, perceived barriers, and age groups ($p<0.05$) (Table 4.10).

Table 4.10 *Association of noise risk perceptions with age groups.*

Subscales	Responses	Age Group		Total	P-value (2-sided)
		Younger Adults (Less than 40 years old)	Older Adults (40 years old or more)		
		N (%)	N (%)		
Perceived Benefits	**Agree**	290 (94)	40 (93)	330 (94)	0.741
	Not Agree	19 (6)	3 (7)	22 (6)	
	Total	309 (100)	43 (100)	352 (100)	
Perceived Barriers	**Agree**	109 (35)	8 (19)	117 (33)	0.037
	Not Agree	200 (65)	35 (81)	235 (67)	
	Total	309 (100)	43 (100)	352 (100)	
Perceived Self-efficacy	**Agree**	59 (19)	6 (14)	65 (19)	0.531
	Not Agree	250 (81)	37 (86)	287 (81)	
	Total	309 (100)	43 (100)	352 (100)	
Perceived Attitude	**Agree**	83 (27)	5 (12)	88 (25)	0.0373
	Not Agree	226 (73)	38 (88)	264 (75)	
	Total	309 (100)	43 (100)	352 (100)	
Perceived Susceptibility	**Agree**	79 (26)	5 (12)	84 (24)	0.055
	Not Agree	230 (74)	38 (88)	268 (76)	
	Total	309 (100)	43 (100)	352 (100)	

Table 4.11 shows that most participants (94%) agreed with perceived benefit statements across the three department categories. However, dissatisfaction was prevalent among participants regarding perceived barriers (66%) and perceived self-efficacy (81%) statements, spanning all department categories. Similarly, a substantial 75% of participants did not agree with perceived attitude statements, with the highest level of disagreement (27%) observed among seafarers in the engineering department. Additionally, participants expressed significant disagreement (76%) with perceived susceptibility statements. The association between noise perception subscales and department categories was found to be statistically insignificant ($p>0.05$) among all subscales except for the perceived barrier subscale, where the p-value is 0.045, indicating a statistically significant association between the perceived barriers of noise

reduction and department categories. The engineering department and galley have the highest percentage of perceived barriers compared to the deck department.

Table 4.11 *Association of noise risk perceptions with ship departments.*

Subscales	Responses	Department			Total	P-value (2-sided)
		Deck Department	Engineering Department	Galley		
		N (%)	N (%)	N (%)		
Perceived Benefits	**Agree**	128 (92)	156 (94)	43 (98)	327 (94)	0.477
	Not Agree	11 (8)	10 (6)	1 (2)	22 (6)	
	Total	139 (100)	166 (100)	44 (100)	349 (100)	
Perceived Barriers	**Agree**	36 (26)	64 (39)	17 (39)	117 (34)	0.045
	Not Agree	103 (74)	102 (61)	27 (61)	232 (66)	
	Total	139 (100)	166 (100)	44 (100)	349 (100)	
Perceived Self-efficacy	**Agree**	28 (20)	29 (18)	8 (18)	65 (19)	0.825
	Not Agree	111 (80)	137 (82)	36 (82)	284 (81)	
	Total	139 (100)	166 (100)	44 (100)	349 (100)	
Perceived Attitude	**Agree**	33 (24)	45 (27)	10 (23)	88 (25)	0.769
	Not Agree	106 (76)	121 (73)	34 (77)	261 (75)	
	Total	139 (100)	166 (100)	44 (100)	349 (100)	
Perceived Susceptibility	**Agree**	29 (21)	46 (28)	9 (21)	84 (24)	0.335
	Not Agree	110 (79)	120 (72)	35 (79)	265 (76)	
	Total	139 (100)	166 (100)	44 (100)	349 (100)	

Most participants (94%) across all rank groups agreed with the statements related to perceived benefits. Conversely, 66% and 81% of participants among all rank groups expressed dissatisfaction with the statements regarding perceived barriers and perceived self-efficacy, respectively. Similarly, 75% and 76% of participants did not agree with statements regarding perceived attitude and perceived susceptibility, respectively. The association between noise perception subscales and the rank categories on the ship was found to be statistically insignificant ($p>0.05$) (Table 4.12).

Table 4.12 Association of noise risk perceptions with rank on ship groups.

Subscales	Responses	Rank Groups				Total	P-value (2-sided)
		Deck Officers	Engineering Officers and Engine Room Ratings	Master / Captain	Non-engine room ratings		
		N (%)	N (%)	N (%)	N (%)		
Perceived Benefits	Agree	73 (95)	141 (92)	18 (90)	95 (96)	327 (94)	0.473
	Not Agree	4 (5)	12 (8)	2 (10)	4 (4)	22 (6)	
	Total	77 (100)	153 (100)	20 (100)	99 (100)	349 (100)	
Perceived Barriers	Agree	27 (35)	53 (35)	4 (20)	33 (33)	117 (34)	0.632
	Not Agree	50 (65)	100 (65)	16 (80)	66 (67)	232 (66)	
	Total	77 (100)	153 (100)	20 (100)	99 (100)	349 (100)	
Perceived Self-efficacy	Agree	17 (22)	28 (18)	0 (0)	20 (20)	65 (19)	0.099
	Not Agree	60 (78)	125 (82)	20 (100)	79 (80)	284 (81)	
	Total	77 (100)	153 (100)	20 (100)	99 (100)	349 (100)	
Perceived Attitude	Agree	20 (26)	41 (27)	4 (20)	23 (23)	88 (25)	0.892
	Not Agree	57 (74)	112 (73)	16 (80)	76 (77)	261 (75)	
	Total	77 (100)	153 (100)	20 (100)	99 (100)	349 (100)	
Perceived Susceptibility	Agree	24 (31)	38 (25)	3 (15)	19 (19)	84 (24)	0.246
	Not Agree	53 (69)	115 (75)	17 (85)	80 (81)	265 (76)	
	Total	77 (100)	153 (100)	20 (100)	99 (100)	349 (100)	

Based on the number of years of experience seafarers have, two categories were formed: less than 10 years of experience and 10 years or more of experience. Over 90% of the participants in both experience categories expressed satisfaction with the perceived benefits statements, with 94% among participants with less than 10 years of experience and 92% among participants with more than 10 years of experience. Approximately 67% of the participants did not agree with the perceived barriers statements, while around 82% expressed dissatisfaction with the self-efficacy statements. Additionally, a significant proportion of the participants did not agree with the statements in perceived attitude (75%) and perceived susceptibility (76%). The p-value among all subscales is greater than 0.05, except for perceived susceptibility, which indicates that the association between the noise perception subscales, except for perceived susceptibility, and the experience categories are statistically insignificant (Table 4.13).

Table 4.13 *Association of noise risk perceptions with years of seafaring experience group.*

Subscales	Responses	Experience Years Group		Total	P-value (2-sided)
		Less than 10 years	10 years or more		
		N (%)	N (%)		
Perceived Benefits	**Agree**	261 (94)	69 (92)	330 (94)	0.433
	Not Agree	16 (6)	6 (8)	22 (6)	
	Total	277 (100)	75 (100)	352 (100)	
Perceived Barriers	**Agree**	97 (35)	20 (27)	117 (33)	0.213
	Not Agree	180 (65)	55 (73)	235 (67)	
	Total	277 (100)	75 (100)	352 (100)	
Perceived Self-efficacy	**Agree**	56 (20)	9 (12)	65 (18)	0.131
	Not Agree	221 (80)	66 (88)	287 (82)	
	Total	277 (100)	75 (100)	352 (100)	
Perceived Attitude	**Agree**	75 (27)	13 (17)	88 (25)	0.098
	Not Agree	202 (73)	62 (83)	264 (75)	
	Total	277 (100)	75 (100)	352 (100)	
Perceived Susceptibility	**Agree**	73 (26)	11 (15)	84 (24)	0.046
	Not Agree	204 (74)	64 (85)	268 (76)	
	Total	277 (100)	75 (100)	352 (100)	

Education levels were classified into two categories: up to high school and above high school education. More than 90% of participants agreed with the perceived benefit statements in both categories. The association between the perceived benefits of noise reduction and education was found to be statistically significant ($p < 0.05$). While responding to perceived barrier statements, approximately 67% of the participants did not agree. Similarly, between 75% and 82% of participants did not agree with the statements on perceived self-efficacy, perceived attitude, and perceived susceptibility. The association between noise perception subscales, except perceived benefits, was found to be statistically insignificant ($p > 0.05$) (Table 4.14).

Table 4.14 *Association of noise risk perceptions with education group.*

Subscales	Responses	Education Group		Total	P-value (2-sided)
		Up to high school	Above high school		
		N (%)	N (%)		
Perceived Benefits	**Agree**	54 (87)	276 (95)	330 (94)	0.036
	Not Agree	8 (13)	14 (5)	22 (6)	
	Total	62 (100)	290 (100)	352 (100)	
Perceived Barriers	**Agree**	20 (32)	97 (34)	117 (33)	1
	Not Agree	42 (68)	193 (66)	235 (67)	
	Total	62 (100)	290 (100)	352 (100)	
Perceived Self-efficacy	**Agree**	8 (13)	57 (20)	65 (19)	0.279
	Not Agree	54 (87)	233 (80)	287 (81)	
	Total	62 (100)	290 (100)	352 (100)	
Perceived Attitude	**Agree**	12 (19)	76 (26)	88 (25)	0.332
	Not Agree	50 (81)	214 (74)	264 (75)	
	Total	62 (100)	290 (100)	352 (100)	
Perceived Susceptibility	**Agree**	16 (26)	68 (24)	84 (24)	0.743
	Not Agree	46 (74)	222 (76)	268 (76)	
	Total	62 (100)	290 (100)	352 (100)	

The average length of the voyage was classified into two categories: voyages of less than two months and voyages of two months or more. Most participants (94%) expressed satisfaction with the perceived benefit statements. However, approximately 66% and 81% of the participants did not agree with the statements on perceived barriers and perceived self-efficacy, respectively. Similarly, many participants (75%) in both voyage categories did not agree with the perceived attitude statements. Additionally, around 76% of participants showed dissatisfaction with the perceived susceptibility statements, with 76% of participants in the less than two months voyage category and 76% of participants in the two months or more voyage category. The association between noise perception subscales and average voyage categories was found to be statistically insignificant ($p > 0.05$) (Table 4.15).

Table 4.15 *Association of noise risk perceptions with an average length of the voyage of duty group.*

Subscales	Responses	Average Voyage Group		Total	P-value (2-sided)
		Less than two months	Two months or more		
		N (%)	N (%)		
Perceived Benefits	**Agree**	147 (94)	180 (93)	327 (94)	0.826
	Not Agree	9 (6)	13 (7)	22 (6)	
	Total	156 (100)	193 (100)	349 (100)	
Perceived Barriers	**Agree**	45 (29)	72 (37)	117 (34)	0.111
	Not Agree	111 (71)	121 (63)	232 (66)	
	Total	156 (100)	193 (100)	349 (100)	
Perceived Self-efficacy	**Agree**	30 (19)	35 (18)	65 (19)	0.891
	Not Agree	126 (81)	158 (82)	284 (81)	
	Total	156 (100)	193 (100)	349 (100)	
Perceived Attitude	**Agree**	35 (22)	53 (28)	88 (25)	0.321
	Not Agree	121 (78)	140 (72)	261 (75)	
	Total	156 (100)	193 (100)	349 (100)	
Perceived Susceptibility	**Agree**	37 (24)	47 (24)	84 (24)	0.901
	Not Agree	119 (76)	146 (76)	265 (76)	
	Total	156 (100)	193 (100)	349 (100)	

Approximately 93% of participants agreed with the perceived benefits statements. Similarly, around 66% and 81% of participants expressed agreement with the statements on perceived barriers and perceived self-efficacy, respectively. Three-quarters of the participants agreed with the perceived attitude and perceived susceptibility statements. The associations between all noise risk perception subscales and the normal duty schedule categories were found to be statistically insignificant ($p > 0.05$) (Table 4.16).

Table 4.16 *Association of noise risk perceptions with normal duty schedule.*

Subscales	Responses	Normal Duty Schedule			Total	P-value (2-sided)
		4 hours on, 8 hours off shifts per 24 hours	6 hours on, 6 hours off shifts per 24 hours	12 hours on, 12 hours off shifts per 24 hours		
		N (%)	N (%)	N (%)		
Perceived Benefits	**Agree**	59 (95)	185 (92)	85 (94)	329 (93)	0.227
	Not Agree	3 (5)	16 (8)	5 (6)	24 (7)	
	Total	62 (100)	201 (100)	90 (100)	353 (100)	
Perceived Barriers	**Agree**	40 (65)	131 (66)	62 (69)	233 (66)	0.715
	Not Agree	22 (35)	69 (34)	28 (31)	119 (34)	
	Total	62 (100)	200 (100)	90 (100)	352 (100)	
Perceived Self-efficacy	**Agree**	45 (73)	162 (81)	79 (88)	286 (81)	0.122
	Not Agree	17 (27)	38 (19)	11 (12)	66 (19)	
	Total	62 (100)	200 (100)	90 (100)	352 (100)	
Perceived Attitude	**Agree**	48 (77)	137 (69)	75 (83)	260 (75)	0.054
	Not Agree	14 (23)	63 (31)	15 (17)	92 (25)	
	Total	62 (100)	200 (100)	90 (100)	352 (100)	
Perceived Susceptibility	**Agree**	48 (77)	142 (72)	74 (82)	264 (75)	0.263
	Not Agree	14 (23)	56 (28)	16 (18)	86 (25)	
	Total	62 (100)	198 (100)	90 (100)	350 (100)	

4.3.3 Self-reported Hearing Difficulty

Around 60% of the participants reported no difficulty in hearing, while 40% reported having hearing difficulties. Of the participants, 65% reported having undergone a hearing test, with 77% of these tests being provided by the employer (Figure 4.3).

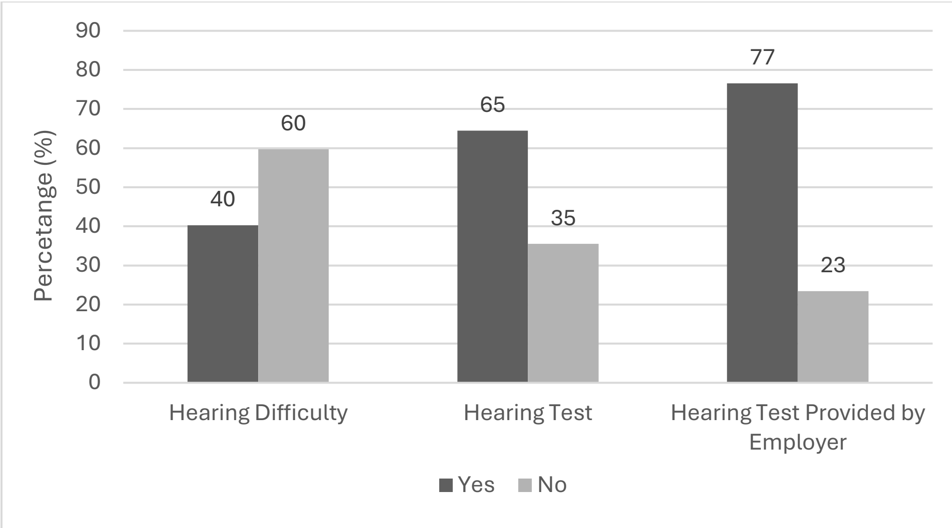

Figure 4.3 *Percentages of hearing status questions.*

4.3.4 Hearing Screening Inventory (HSI)

The HSI questionnaire consists of 12 questions on a 5-point Likert scale (Table 4.17). To score the HSI, one takes a simple sum of the 12-item responses. For Questions 1, 5, and 6, responses are scored from 1 for "Never," 2 for "Seldom," 3 for "Occasionally," 4 for "Frequently," and 5 for "Always." For Questions 2, 3, 4, 7, and 8, responses are reverse scored from 1 for "Always" up to 5 for "Never." For Questions 9 through 12, scoring ranges from 1 for "Good" to 5 for "Very Poor." This procedure yields a consistent scale score in which higher totals indicate self-reports of poorer hearing ability. Based on the HSI scale total, predicted best-ear sensitivity can be determined with 92% accuracy. An HSI scale total between 12 and 27 indicates normal hearing. A total between 28 and 37 suggests a hearing loss of 25 dB or more, which can affect conversational hearing. A total of 38 or more indicates a hearing loss of 55 dB or more.

Table 4.17 *Frequency and percentage distribution of responses to the Hearing Screening Inventory (HSI) questionnaire.*

Hearing Screening Inventory	**Frequency (Percentage)**					**Total**
Part 1	**Never (or almost never)**	**Seldom**	**Occasionally**	**Frequently**	**Always (or almost always)**	
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
1.Have you ever bothered by feelings that your hearing is poor?	78 (23)	75 (22)	78 (23)	91 (26)	21 (6)	343 (100)
2.Is your reading or studying easily interrupted by noises in nearby rooms?	47 (14)	71 (21)	81 (24)	98 (28)	46 (13)	343 (100)
3.Can you hear the telephone ring when you are in the same room in which it is located?	32 (10)	51 (15)	50 (14)	133 (39)	77 (22)	343 (100)
4.Can you hear the telephone ring when you are in the room next door?	36 (11)	70 (20)	80 (23)	107 (31)	50 (15)	343 (100)
5. Do you find it difficult to make out the words in recordings of popular songs?	70 (21)	113 (33)	63 (18)	65 (19)	32 (9)	343 (100)
6.When several people are talking in a room, do you have difficulty hearing an individual conversation?	81 (24)	87 (25)	84 (25)	72 (21)	18 (5)	342 (100)
7.Can you hear the water boiling in a pot when you are in the kitchen?	36 (11)	69 (20)	63 (19)	119 (35)	54 (15)	341 (100)
8.Can you follow the conversation when you are at a large dinner table?	21 (6)	69 (20)	91 (27)	110 (32)	52 (15)	343 (100)

Part 2	Good	Average	Slightly Below Average	Poor	Very Poor	Total
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
9.Overall, I would judge my hearing in my right ear to be…	110 (32)	127 (37)	55 (16)	41 (12)	9 (3)	342 (100)
10.Overall, I would judge my hearing in my left ear to be…	114 (33)	112 (33)	80 (23)	29 (9)	8 (2)	343 (100)
11.Overall, I would judge my ability to make out speech or conversation to be …	120 (35)	120 (35)	68 (20)	25 (7)	10 (3)	343 (100)
12.Overall, I would judge my ability to judge the location of things by the sound they are making alone to be… (For example, to identify the location of a fridge/dishwasher machine by listening to its sound alone)	115 (34)	121 (35)	63 (18)	41 (12)	3 (1)	343 (100)

After obtaining the frequency of each statement, we added the sum of the 12 statements for each participant to predict their hearing sensitivity. According to the scores on the hearing screening inventory, 32% of participants were found to have normal hearing, 52% had some degree of hearing loss (25 dB or more), and 16% had more severe hearing loss (55 dB or more) (Table 4.18).

Table 4.18 *The results of predicted hearing sensitivity were based on the* HIS score.

Predicted hearing sensitivity based on the total score of HSI	**Score 12 to 27**	**Score 28 to 37**	**Score 38 or more**	**Total**
	Normal hearing	**Hearing loss of 25 dB or more (some conversational hearing loss)**	**Hearing loss of 55 dB or more**	
Frequency (Percentage)	111 (32%)	179 (52%)	53 (16%)	343 (100)

After having the frequency of self-reported hearing difficulty by seafarers and obtaining the frequency of hearing sensitivity based on the scores of the HSI, we performed the chi-square test to determine the association between hearing screening inventory results and self-reported hearing difficulty by the participants (Table 4.19). Among those identified with normal hearing based on the hearing screening inventory score (32%), a significant proportion (44%) reported no hearing difficulty, while a smaller but still considerable percentage (14%) reported experiencing hearing difficulty. Conversely, among individuals identified with a hearing loss of 25 dB or more (52%), 46 % reported no hearing difficulty, while 62 % reported experiencing hearing difficulty. Furthermore, among those identified with a more significant hearing loss of 55 dB or more (16%), a small proportion (10 %) reported no hearing difficulty, while a larger percentage (24%) reported experiencing hearing difficulty. These findings suggest that seafarers need to do regular hearing tests because there is a significant difference between perceived and measured hearing ability.

With a p-value of 0.0001, which is highly statistically significant, these results indicate strong evidence of an association between the hearing screening inventory results and the reported presence or absence of hearing difficulty among participants. This underscores the effectiveness of the hearing screening inventory in identifying individuals at risk of hearing difficulty.

Table 4.19 *Chi-square test between HSI results and self-reported hearing difficulty.*

Hearing Screening Inventory Score	Hearing Screening Inventory Results	Hearing Difficulty		Total
		No	Yes	
		N (%)	N (%)	N (%)
12 to 27	Normal	91 (44)	20 (14)	111 (32)
28 to 37	Hearing loss of 25 dB or more	93 (46)	86 (62)	179 (52)
38 or more	Hearing loss of 55 dB or more	20 (10)	33 (24)	53 (16)
Total (N%)		204 (100)	139 (100)	343 (100)

4.3.5 Tinnitus

Approximately 55% of the participants reported that they do not have tinnitus. In contrast, around 45% of the participants reported having tinnitus, with 22% of them stating that their tinnitus loudness is 7 out of 10, the highest percentage, while only 1% reported their tinnitus as 1 out of 10, the lowest percentage (Figure 4.4).

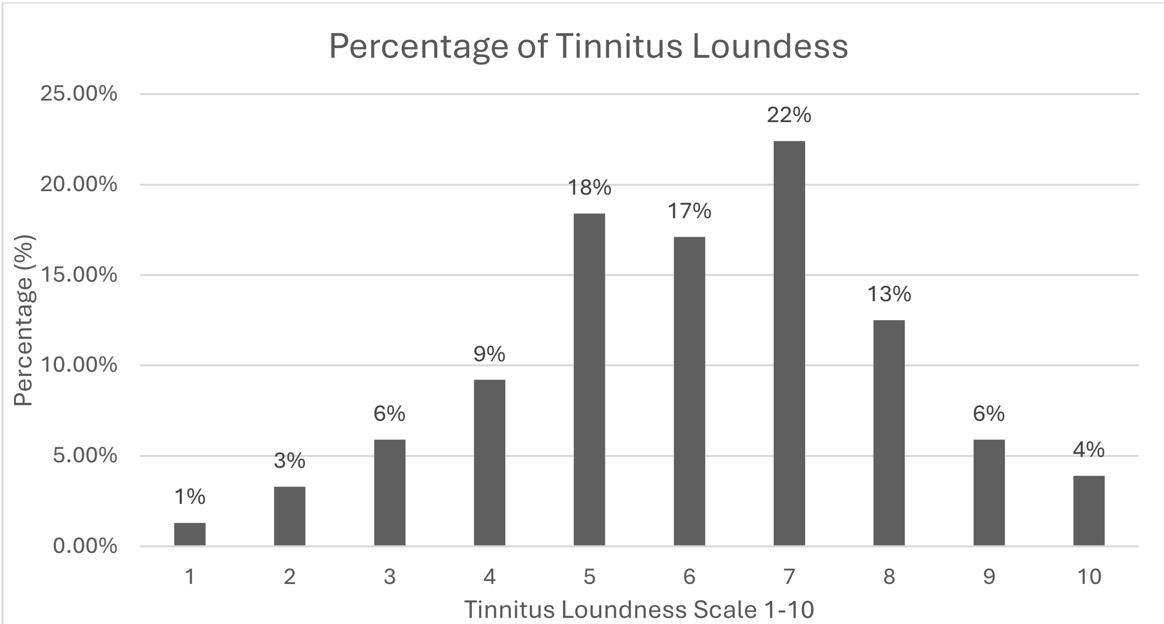

Figure 4.4 *Percentage distribution of tinnitus loudness based on a scale from 1 to 10.*

4.3.6 Unexpected Balance Problems

Approximately 40% of the participants reported experiencing unexpected balance problems, while 60% stated they had not encountered any such issues. Among those who experienced unexpected balance problems, approximately 52% reported light-headedness or faintness, 50% reported unsteadiness, 37% reported vertigo (spinning), and 13% reported falling frequently (Figure 4.5). Of those who reported unexpected balance problems, 76% received treatment, while 34% did not. Among those treated, 22% reported that their cause of balance problem was onboard noise exposure, as diagnosed by specialists, the second-highest percentage after the 33% attributed to an unknown cause (Table 4.20).

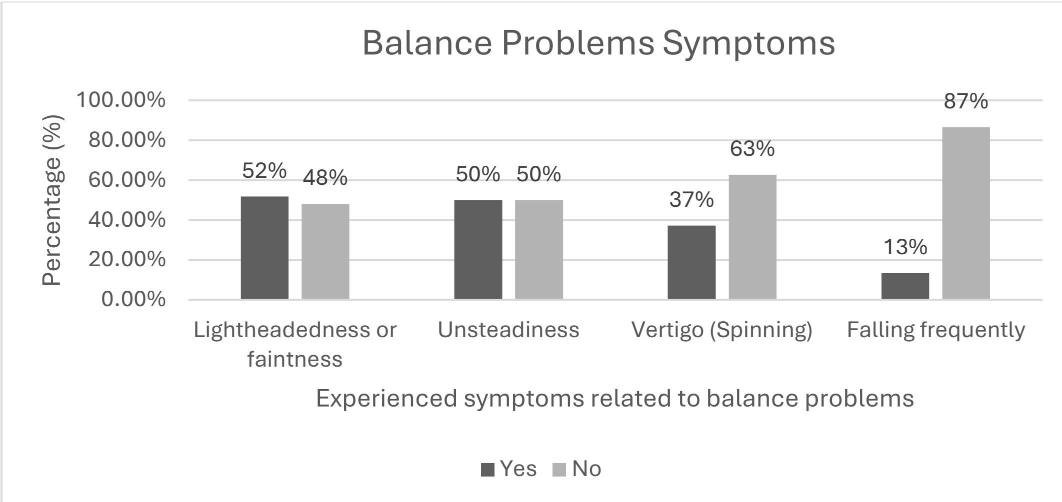

Figure 4.5 *Experienced symptoms related to balance problems.*

Table 4.20 *Frequency and percentage of the diagnosed cause of balance problem by a specialist.*

Diagnosed cause of Balance problems by specialist	Frequency	Percentage
Unknown	25	33 %
Onboard Noise Exposure	16	22 %
Work-related Exhaustion and Sleep Problems	8	11 %
Hearing Difficulties	5	7 %
Tympanitis (inflamed tympanic membrane, also known as the eardrum)	4	5 %
Meniere's syndrome (Vertigo)	3	4 %
Stress	3	4 %
Scoliosis (abnormal S-shaped or C-shaped curve of the spine)	2	3 %
Adverse Drug Reaction	2	3 %
Cardiovascular Disease	2	3 %
Earwax Buildup	1	1 %
Tinnitus	1	1 %
Body Dehydration	1	1 %
Allergy	1	1 %
Autism	1	1 %
Total	75	100 %

4.3.7 Hearing Protection Use

Regarding the frequency of using hearing protection during work, 4% reported that they never used hearing protection, 53% reported that they use hearing protection occasionally, and 43% always use hearing protection. The most common types of hearing protection used are inserted earplugs (52%) and earmuffs (29%), whereas the less commonly used ones are canal caps (4%) and custom molded (15%). Additionally, 69% reported that their hearing protection filters the right amount of noise. However, 23% reported that it underprotects (filters out too little noise), and 8% reported that it overprotects (filters out too much noise). Furthermore, 66% of the participants reported that their hearing protection is a communication barrier at their workplace, while 34% of them said no.

On average, participants wear their hearing protection during their work shift for 4.9 hours, and on average, they remove and put their hearing protection back in approximately 5 times a day. The participants reported that they remove their hearing protection because they are out of the noisy environment (37%), experience hearing protection discomfort including annoyance, pain, or itchiness (36%), and for communication and safety purposes (27%). Moreover, 61% of the participants reported that their hearing protection causes discomfort, while only 39% reported no discomfort. Among those who reported hearing protection discomfort, 49% reported that this discomfort is in both ears, 26% in the left ear only, and 25% in the right ear only.

4.4 Discussion

The way seafarers perceive occupational noise exposure risks is influenced by factors such as job tenure, the effectiveness of training and management, and their own safety attitudes and behaviors. Effective initiation of safety training and preventive measures requires identifying various types of risks and understanding how employees recognize, interpret, and respond to these hazards. Recognizing the relationships between risk behavior, identification, awareness, and exposure is crucial for effective risk reduction and management (Thepaksorn et al., 2018). In this study, perceived benefits, barriers, and self-efficacy scores indicate that seafarers have moderately positive perceptions toward noise reduction and hearing loss prevention. The perceived attitude and susceptibility scores show that participants generally disliked loud noise and perceived their susceptibility to hearing loss as quite high. The findings also reveal significant concerns regarding the auditory health effects of noise exposure onboard among seafarers.

Seafarers' attitudes and behaviors play a significant role in developing health risks, the consequences of those risks, and related adverse outcomes (Yuen et al., 2020). If seafarers perceive themselves as susceptible to the adverse health effects of noise and view these effects as severe, they are more likely to take action to mitigate these risks, especially if they believe that the benefits of such actions outweigh the barriers. In this study, perceived benefits, barriers, and self-efficacy scores ranged between 3 and 5, indicating that seafarers have moderately positive attitudes and perceptions toward noise reduction and hearing loss prevention. The perceived attitude and susceptibility scores ranged between 4 and 5, showing that participants generally disliked loud noise and perceived their susceptibility to hearing loss as quite high.

The perceived benefits subscale assessed seafarers' beliefs about the advantages of a quieter work environment. Most participants (70% to 76%) agreed that a quieter work environment would reduce work-related stress and improve their well-being, aligning with the HBM’s notion that perceived benefits motivate health-related behaviors (Champion, 1984). However, 9% to 16% of participants showed a lack of interest in these benefits, indicating variability in health beliefs. Studies highlight that workers who strongly believe in the benefits of preventive actions are more likely to adhere to such behaviors, underscoring the importance of perceived benefits in promoting health activities (Shahnazi et al., 2020; Rosenstock, 1974).

The association between perceived benefits and sociodemographic characteristics, including age, ship department, rank on the ship, experience, average length of voyage, and normal duty schedule, revealed no statistically significant differences among these categories, except for education. There is a statistically significant difference in perceived benefits between seafarers with up to a high school education and those with education beyond high school. Specifically, individuals with higher education levels (above high school) (95%) are significantly more likely to agree on the benefits of noise reduction compared to those with lower levels of education (up to high school) (87%). This indicates that education level influences the perception of the benefits of noise reduction (Punjani & Mahadevan, 2022; Donadiki et al., 2014). Hence, higher and better education could enable seafarers to take action to address occupational risks related to noise.

A significant proportion of respondents, ranging from 42% to 62%, agreed with statements indicating barriers such as discomfort with hearing protectors, lack of time to address noise-related issues, and perceived indifference from coworkers towards workplace noise concerns. These findings can be understood through the HBM, where perceived barriers are recognized as obstacles that can hinder individuals from engaging in health-promoting behaviors (Rosenstock, 1974). In this context, seafarers' perceptions of discomfort with protective equipment and organizational attitudes towards OHS reflect significant barriers that may deter them from actively seeking noise reduction measures. Addressing these barriers through targeted interventions and improving organizational support for OHS could enhance seafarers' engagement in protective behaviors against noise exposure.

The association between perceived barriers and sociodemographic characteristics, including rank on the ship, seafaring experience, education, average length of voyage, and normal duty schedule, showed no statistically significant differences, except for age and department. There is a statistically significant difference in perceived barriers to noise reduction and hearing loss prevention between different age groups. Specifically, 35% of younger adults (less than 40 years old) agreed with the identified barriers, compared to 19% of older adults (40 years old or older). This disparity suggests that younger seafarers perceive these barriers more significantly than their older counterparts. Such findings can be interpreted through the lens of the HBM, emphasizing how varying perceptions of barriers may influence age-specific health behaviors and the uptake of preventive measures. Addressing these age-related perceptions through targeted interventions could enhance overall engagement in protective behaviors against noise exposure among seafarers. Additionally, a statistically significant difference exists in perceived barriers to noise reduction and hearing loss prevention across different ship departments. Specifically, 39% of respondents from the engineering department and galley agreed with the identified barriers, compared to 26% from the deck department. This difference suggests that seafarers in the engineering department and galley perceive these barriers more significantly than those in the deck department, possibly due to their higher exposure to noise from machinery and engines, which may make noise reduction measures more challenging to implement in their work environments.

Seafarers' perceptions of self-efficacy in reducing noise exposure at work can be understood using the HBM, which provides a framework for understanding beliefs about one's ability to take action and achieve desired outcomes (Rosenstock, 1974). The consensus among respondents regarding their confidence in using hearing protectors (79%) and willingness to adapt equipment for quieter operations (68%) reflects a moderate to high level of self-efficacy in these areas. However, the acknowledgment by 67% of respondents that they are unable to reduce noise in their work setting suggests a perceived barrier influenced by factors such as workplace conditions or equipment limitations. The varying opinions on the correct use of hearing protectors, with 46% uncertain, indicate a need for targeted interventions to improve skills and knowledge in this area. Enhancing self-efficacy through training and supportive workplace policies can empower seafarers to adopt effective noise reduction behaviors, thereby promoting their OHS aboard ships. The association between self-efficacy and all sociodemographic characteristics showed no statistically significant differences.

The responses from participants regarding their perceived attitude toward workplace noise exposure highlight a generally negative sentiment among seafarers. A significant majority, ranging from 45% to 60%, disagreed with statements indicating tolerance or acceptance of workplace noise, reflecting a strong aversion to loud noise environments. This negative attitude can be interpreted through the HBM, where attitudes toward health risks (in this case, noise exposure) influence behavioral responses (Saunders et al., 2014). Seafarers' reluctance to tolerate or find efficiency in noisy conditions underscores a perceived severity of noise as a health hazard and aligns with the HBM's construct of perceived severity. Addressing these negative attitudes through interventions that emphasize the adverse health impacts of noise and promote strategies for noise reduction could help improve seafarers' attitudes and behaviors toward occupational noise exposure.

The association between perceived attitude and sociodemographic characteristics found no statistically significant differences, except for age. Specifically, there is a statistically significant difference in attitudes toward workplace noise between age groups. Notably, 88% of older seafarers (40 years or older) are more likely to be bothered by noise at work compared to 73% of younger seafarers (less than 40 years old), who tend to be less bothered by noise. This difference suggests that age influences seafarers' perception of and response to occupational noise, highlighting the need for targeted interventions based on age-related attitudes and perceptions. Older adults may be more bothered by workplace noise due to age-related changes in hearing sensitivity, making them more susceptible to discomfort from loud environments. Additionally, prolonged exposure to occupational noise over time may contribute to cumulative hearing damage, increasing their awareness and sensitivity to noise-related disturbances.

The participants' perceptions of their susceptibility to hearing loss provide significant insights within the framework of the HBM. Most respondents (49% to 59%) disagreed with statements suggesting low susceptibility, indicating an awareness of their high vulnerability to hearing loss in their noisy work environment. This aligns with the HBM's construct of perceived susceptibility, which posits that individuals who believe they are at risk are more likely to engage in preventive behaviors (Rosenstock, 1974). However, the agreement by 22% to 36% of participants that noise would not damage their hearing or that a quieter environment would not improve their hearing indicates a concerning underestimation of noise-related risks among a significant minority. Similarly, 29% and 35% of participants believed that loud noise does not affect long-term hearing or only affects those with sensitive ears. These mixed perceptions highlight the need for targeted educational interventions to increase awareness of noise risks and enhance seafarers' engagement in hearing protection practices. Enhancing perceived susceptibility through tailored communication strategies can be crucial in fostering protective behaviors and reducing the incidence of NIHL in maritime settings.

The association between perceived susceptibility and sociodemographic characteristics is statistically insignificant, except for working experience. The data reveal a statistically significant difference in perceived susceptibility to hearing loss across different seafaring experience groups. Specifically, 26% of participants with less than 10 years of experience agreed with statements indicating low susceptibility to hearing loss, compared to only 15% of those with 10 years or more of experience. Conversely, 74% of less experienced seafarers did not agree, compared to 85% of more experienced seafarers. This suggests that more experienced seafarers perceive themselves to be at a higher risk of hearing loss. The greater recognition of hearing loss risk among more experienced seafarers could lead to a higher likelihood of engaging in protective measures. In contrast, the lower perceived susceptibility among less experienced seafarers highlights the need for targeted educational efforts to raise awareness and promote preventive behaviors within this group.

Seafarers working in noisy environments are at increased risk of hearing impairment (Lucas et al., 2022). In our study, 40% of seafarers reported hearing loss, which is consistent with a cross-sectional descriptive-analytical study conducted in a harbor in Southern Iran in 2020, which found approximately 39% of seafarers with hearing loss (Esmaeili et al., 2022). Hearing loss of 25 dB or more is classified as mild hearing loss. This means that a person may have difficulty hearing faint or distant speech, particularly in noisy environments (Coren & Hakstian, 1992). Conversations in quieter settings may still be manageable, but soft sounds or speech from a distance may be harder to discern (Olusanya et al., 2019). Hearing loss of 55 dB or more is considered moderate to severe. At this level, understanding normal speech without amplification or hearing aids becomes challenging (Coren & Hakstian, 1992). Individuals with this degree of hearing loss typically struggle to hear everyday conversations, even in quieter settings and may require hearing aids or other interventions to improve communication (Olusanya et al., 2019). Our study's HSI results reveal that 52% of participants have a hearing loss of 25 dB or more, 16% have a hearing loss of 55 dB or more, and only 32% have normal hearing. NIHL accounts for 40% of recognized occupational diseases, making it the most prevalent (Zahnert, 2011). The primary causative factor is the amount of energy transferred into the inner ear, which is a combination of noise intensity and duration. Hearing impairment typically arises after years of exposure to noise levels exceeding 85 dB throughout the working day (Zahnert, 2011). Previous studies also indicate that NIHL may result from traumatic impulse noise > 140 dB, causing acute permanent hearing loss, or from prolonged exposure to lower noise levels (Mäntysalo & Vuori, 1984).

Comparing self-reported hearing loss with HSI results, we found that 14% of participants who reported hearing loss had normal hearing based on the HSI. This discrepancy suggests that factors other than pure auditory sensitivity may influence self-reported hearing difficulties, such as ear infections, or non-auditory factors, such as socioeconomic issues, psychological factors, or healthcare utilization (Choi et al., 2019). Conversely, 46% and 10% of participants who reported no hearing loss were categorized with hearing loss of 25 dB or more and 55 dB or more, respectively, based on the HSI. This variation could be attributed to several reasons. First, hearing loss can occur gradually over time, making it less noticeable initially (Cunningham & Tucci, 2017). Second, there may be a stigma associated with hearing impairment, leading individuals to deny or downplay their symptoms to avoid social repercussions (Manchaiah et al., 2015). Third, individuals with hearing loss often develop coping strategies, such as lip-reading or asking for repetition, which can mask the extent of their impairment (Helvik et al., 2007; Curti et al., 2019). Fourth, hearing abilities can vary depending on environmental factors like background noise or speaker clarity, leading to inconsistent self-assessments (Jafari et al., 2019). Finally, misunderstandings or lack of awareness about the criteria used to assess hearing loss can contribute to inaccurate self-reports (Carlson et al., 2022).

Tinnitus is the conscious perception of sound without an external auditory stimulus, often experienced as ringing or buzzing (Esmaili & Renton, 2018). It is directly related to noise exposure (Engdahl et al., 2012). There is a 70% increased risk of developing tinnitus with a positive history of occupational noise exposure compared to those without such a history (Coles, 1984). Tinnitus is typically self-reported and is primarily subjective (Esmaili & Renton, 2018). In the current study, 45% of participants reported having tinnitus, with most (22%) rating their tinnitus loudness as 7 out of 10. Tinnitus and NIHL are among the most frequently reported complaints by seafarers exposed to occupational noise (Kaerlev et al., 2008; Irgens-Hansen et al., 2015a; Arnardottir et al., 2022; Hui, 2019). Some studies, such as Griest and Bishop (1998), suggest that tinnitus may be an early sign of hearing loss, particularly NIHL. Forsell et al. (2017) evaluated 1,963 web questionnaires in the Swedish fleet and found a significant association between onboard noise exposure and tinnitus or impaired hearing.

The data indicates that 40% of seafarers reported experiencing unexpected balance problems. Common symptoms include light-headedness (52%), unsteadiness (50%), vertigo (37%), and frequent falling (13%). Among those treated for balance issues, 22% attributed the cause to onboard noise exposure, highlighting the significant impact of occupational noise on balance health. This finding aligns with studies showing that chronic exposure to high noise levels can affect vestibular function and lead to balance disorders (Stewart et al., 2020). The high percentage of unknown causes (33%) suggests that noise-induced balance problems may often be underdiagnosed or misattributed (Das et al., 2022).

Despite the availability of hearing protection, 53% of seafarers use it only occasionally, indicating potential underutilization of protective measures. The preference for earplugs (52%) and earmuffs (29%) suggests variability in comfort and practicality, which might influence usage frequency. Furthermore, 66% of participants view hearing protection as a communication barrier that can compromise operational efficiency and safety, aligning with Yadav et al.'s (2023) research. Their study found that fish harvesters chose not to use hearing protection devices on board due to concerns about safety since wearing hearing protection leads to difficulties in communication and increases the potential for accidents and injuries.

Most of the participants (61%) experience ear discomfort while using hearing protection devices, potentially reducing compliance with protective measures and highlighting the need for more comfortable and effective hearing protection solutions. The perception that hearing protection under-protects (23%) or overprotects (8%) noise further underscores the need for tailored interventions to balance protection and usability. These findings align with previous studies that have reported various reasons for workers' unwillingness to use hearing protection devices, such as their inability to communicate when using the devices, feelings of discomfort, and bulky and inconvenient equipment (Copelli et al., 2021; Ahmed, 2012; Reddy et al., 2012; Tinoco et al., 2019).

Internationally, the *Maritime Labour Convention* (MLC, 2006) recommends measures encompassing education on noise dangers, providing hearing protection, and reducing noise exposure in various ship areas. It also encourages employers to provide comprehensive training for workers exposed to significant noise levels, covering the effective use of hearing protection devices. Similarly, at the Canadian level, Part 12 of the *Maritime Occupational Health and Safety Regulations* (SOR/2010-120), as detailed in Part II of the *Canada Labour Code*, mandates strategic placement of crew accommodation away from potential noise sources like engines and machinery. It also requires the use of acoustic insulation in the construction of bulkheads, deckheads, and decks within sound-producing spaces. The regulations also advocate for soundproof centralized control rooms for engine-room personnel in engine rooms and machinery spaces, where feasible. Regulations extend to insulating working spaces, such as machine shops, from general engine-room noise, with specific measures outlined for reducing noise generated by machinery operation. This part also outlines regulations concerning workplace sound levels. The primary requirement is to maintain a sound level below 85 dB (A) in the workplace. If it is not feasible to stay below this limit, employees must not be exposed to specific sound levels for durations exceeding set limits within a 24-hour period. For instance, exposure to sound levels between 85 dB (A) and 90 dB (A) has a maximum duration of 8 hours per employee within 24 hours. Sound levels exceeding 115 dB (A) must be avoided entirely within a 24-hour. Crew accommodation must not expose employees to a continuous sound level exceeding 75 dB (A). In cases where the impulse sound level in the workplace exceeds 140 dB (A), the employer must provide every entering employee with a hearing protector meeting specified standards. This protector must reduce the peak level of impulse sound reaching the employee's ears to 140 dB (A) or less (Government of Canada, 2022). However, our study findings suggest that while these occupational and health safety standards exist, practical challenges in implementation persist, necessitating enhanced strategies to improve compliance and address comfort and communication barriers to protect seafarers' hearing health effectively and promote overall safety onboard.

4.5 Limitations and Further Study

This study focuses exclusively on currently active seafarers, excluding inactive seafarers, which may be a limitation. Additionally, the sample distribution was not a truly random sample of seafarers, which may be a limitation. The study is also non-diagnostic, relying solely on self-reported assessments from participants, which can introduce bias and inaccuracies, as participants may misreport or misinterpret their symptoms. Without objective diagnostic measures, the study may lack precision in confirming health impacts such as hearing loss, reducing the reliability of its findings. For future research, a better understanding of hearing loss among seafarers could be achieved through physical examinations and the collection of clinical data on hearing loss via audiometric testing.

4.6 Conclusion

Seafarers exposed to noise reported auditory issues, including hearing loss, tinnitus, and unexpected body balance problems. The findings reveal various beliefs and attitudes toward occupational noise exposure and its health concerns. Hearing protection often causes discomfort and acts as a communication barrier. The perceived risk of noise and the health consequences experienced by Canadian seafarers highlight the need for a more comprehensive exploration of noise-related safety issues. This exploration should consider variables such as biophysical, environmental, structural, and human resources, as well as their interactions within the context of industrial and policy transitions.

A collaborative partnership involving the government, employers, and stakeholders is essential to initiate an educational program about the dangers of noise and the importance of preventive measures, such as wearing hearing protection. Cultivating a safety culture onboard is crucial. At the same time, employers should consider providing comfortable, advanced-designed hearing protection that allows for safety, hearing, and communication. Additionally, implementing noise preventive measures discussed in international and Canadian OHS standards, such as noise insulation and proofing materials in ship construction, is imperative.

Declaration of Competing Interest:

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

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Chapter 5 Occupational Noise Exposure Onboard Ships in Canada: A Qualitative Study Exploring Seafarers' Risk Perceptions and Noise-induced Health Impacts

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Abstract

Prolonged exposure to noise levels above 85 A-weighted decibel [dB (A)] poses significant health risks for seafarers, including auditory issues such as noise-induced hearing loss and tinnitus, as well as non-auditory problems like annoyance, loss of concentration, stress, cardiovascular diseases, sleep disorders, and fatigue. This study applied qualitative semi-structured interviews to explore how Canadian seafarers manage occupational noise exposure onboard, recognize associated health problems, and identify barriers to preventing and controlling noise exposure. Our study findings suggest that onboard noise is not appropriately controlled in Canadian fleets, as per the applicable occupational health and safety (OHS) standards. In this research, seafarer interviewees reported a noisy workplace and involuntary adaptation over time. The accounts of seafarers indicate a fatalistic attitude to tolerate loud noise. Navigation safety concerns lead seafarers to avoid using hearing protection equipment onboard. The seafarer interviewees report both auditory and non-auditory health issues in this study. The main barriers for seafarers to effectively control occupational noise exposure include limited noise control measures, uncomfortable hearing protection devices, and a lack of regular ship-specific training and education programs. The study recommends 1) the implementation of OHS regulations needs to be enhanced, 2) a safety culture promoting active co-management of noise control by employers and seafarers; 3) the employers, unions, and the government should collaboratively review current preventive measures and initiate education and training programs to ensure sufficient resources and accurate knowledge for seafarers to mitigate the impacts of noise exposure on board.

Keywords: seafarers, noise exposure onboard, health impacts, occupational health and safety regulations, noise prevention

5.1 Introduction

5.1.1 Background

Exposure to occupational noise is a significant risk factor for various health problems, including noise-induced hearing loss (NIHL), tinnitus, fatigue, annoyance, hypertension, ischemic heart disease, cognitive impairment, stress, and sleep disturbances (Basner et al.,2014; Government of Canada, 2023; Sheppard et al., 2020). Seafarers, particularly engine crew members, are frequently exposed to high levels of noise. According to Oldenburg et al. (2020), person-related physical measurements revealed that noise exposure was especially pronounced among engine room personnel, who were exposed to an average noise level of 96 dB(A). In contrast, deck crew and nautical officers were exposed to average noise levels of 83 dB(A) and 77 dB(A), respectively. The engine room remains the primary source of noise on board, with workplace-related measurements recording the highest noise levels in the engine room at 104 dB(A), followed by 81 dB(A) in the workshop and 77 dB(A) on deck, irrespective of the voyage episode (Oldenburg et al., 2020).

Seafarers' auditory health problems caused by occupational noise exposures have been widely reported in previous studies. Seafarers of engine departments have a higher risk of NIHL than other crew members on board. Irgens-Hansen et al. (2015a) found that the prevalence of NIHL was significantly higher among navigators (37.0 %) and engine room personnel (38.0 %) than electricians (23.6 %). Occupational noise exposure can cause tinnitus among exposed workers (Abbate et al., 2005). Hui (2019) found that tinnitus among seafarers is associated with occupational noise exposure onboard.

Occupational noise exposure onboard also leads to non-auditory health effects among seafarers. Chronic exposure to noise on ships contributes to increased psychological stress. This problem was reported by the engine room crew (83.7%) and deck crew (65.4%) (Oldenburg et al., 2020). Picu et al. (2019) found that noise levels of 92 dB (A) exceeding the safe limits of 80-85 dB (A) lead to seafarers' sleep disorders, accompanied by increased body temperature and blood pressure. Noise exposure during sleep can disrupt the circadian rhythm of seafarers, exacerbating fatigue levels (Cui et al., 2022). Occupational noise exposure onboard is argued to be a critical risk factor for cardiovascular diseases among the seafaring population (Oldenburg, 2014).

Workplace noise causes annoyance and interferes with seafarers' communication, which jeopardizes navigation safety (Nikolic & Nikolic, 2013). Che-Ishak et al. (2019) stated that poor communication due to background noise leads to misunderstanding, mistakes, and, ultimately, accidents in the maritime industry. In the maritime industry, characterized by high-risk working conditions, a hazardous environment is formed, impacting not only the health and well-being of seafarers but also potentially affecting the operation and safety of the ship (Baygi et al., 2020). Occupational noise is identified as one of the environmental factors contributing to accidents onboard, as highlighted by Husna et al. (2020).

5.1.2 Regulatory Review: Governance of Occupational Noise on Ships

A review of the regulations addressing occupational noise exposure among seafarers was performed. The review explored both international standards and Canadian legislative instruments, aiming to examine the management of onboard noise exposure and identify potential gaps in existing occupational noise regulations in the Canadian maritime setting. For the legal doctrinal analysis, the official websites of the following organizations were explored to find the relevant regulations: the International Labor Organization (ILO) (https://www.ilo.org/global/standards/lang--en/index.htm), the International Maritime Organization (IMO) (https://www.imo.org/en/KnowledgeCentre/Pages/Default.aspx), and Transport Canada (https://tc.canada.ca/en/corporate-services/acts-regulations).

Our regulatory review begins by examining international standards set by the ILO and the IMO, providing a foundation for understanding global expectations regarding seafarer safety and noise mitigation. Subsequently, the spotlight shifts to the Canadian context, delving into regulations under the *Canada Labour Code*.

The ILO plays a pivotal role in establishing global standards for maritime working conditions, notably through the *Maritime Labour Convention* (MLC, 2006). Title 3 of the MLC includes guidelines for the placement of facilities away from noisy machinery and emphasizing insulation in sound-producing spaces. The limits for noise levels in working and living spaces should conform to the ILO international guidelines on exposure levels, including those in the ILO code of practice entitled "Ambient factors in the workplace" (ILO, 2001). According to this code, a noise level of 85 dB (A) and above can cause hearing impairment and deafness from an eight-hour daily exposure to an unprotected ear. This code recommends that no worker should enter an area where the noise level exceeds 140 dB (A). Additionally, Guideline B4.3.2, Title 4 of the MLC emphasizes the need for ongoing review and improvement of noise protection for seafarers, addressing the adverse effects on their hearing, health, and comfort. It recommends measures such as educating seafarers about noise dangers, providing approved hearing protection, and assessing and reducing noise exposure levels in various ship areas (MLC, 2006). The IMO adopted, in 2012, a regulation in the International Convention for the Safety of Life at Sea (SOLAS) to require ships to be constructed to reduce onboard noise and to protect personnel from noise, in accordance with the *Code on Noise Levels on Board Ships*. The Code sets out mandatory maximum noise level limits for different areas on board ships. For example, the maximum limit is 100 dB (A) in machinery spaces, 75 dB (A) in control rooms, 85 dB (A) in workshops, and 75 dB (A) in accommodation. Seafarers should not be exposed to noise exceeding 80 dB (A) within a 24-hour period. Suitable hearing protection must be used in areas where sound levels exceed 85 dB (A). No seafarer, even with hearing protectors, should be exposed to levels exceeding 120 dB (A) or a 24-hour equivalent sound level exceeding 105 dB(A) (IMO, 2012).

Canada has a relatively comprehensive set of labour standards and maritime OHS regulations. Although OHS usually falls under provincial and territorial jurisdiction in Canada, maritime OHS related to seafarers working in federal waters falls within federal jurisdiction (Barn et al., 2021). The maritime OHS is regulated by the *Canada Labour Code* and overseen by the federal Department of Employment and Social Development Canada (Transport Canada, 2024b). Part 12 of the Maritime OHS Regulations (SOR/2010-120), as detailed in Part II of the *Canada Labour Code*, provides a comprehensive framework for addressing noise and vibration prevention in maritime environments. Specifically, these regulations mandate strategic placement of crew accommodation away from potential noise sources like engines and machinery. It also requires the use of acoustic insulation in the construction of bulkheads, deckheads, and decks within sound-producing spaces. The regulations also advocate for soundproof centralized control rooms for engine-room personnel in engine rooms and machinery spaces, where feasible. Regulations extend to insulating working spaces, such as machine shops, from general engine-room noise, with specific measures outlined for reducing noise generated by machinery operation. This part also outlines regulations concerning workplace sound levels. The primary requirement is to maintain a sound level below 85 dB (A) in the workplace. If it is not feasible to stay below this limit, employees must not be exposed to specific sound levels for durations exceeding set limits within a 24-hour period. For instance, exposure to sound levels between 85 dB (A) and 90 dB (A) has a maximum duration of 8 hours per employee within 24 hours. Sound levels exceeding 115 dB (A) must be avoided entirely within a 24-hour. Crew accommodation must not expose employees to a continuous sound level exceeding 75 dB (A). In cases where the impulse sound level in the workplace exceeds 140 dB (A), the employer must provide every entering employee with a hearing protector meeting specified standards. This protector must reduce the peak level of impulse sound reaching the employee's ears to 140 dB (A) or less (Government of Canada, 2022).

5.1.3 Study Objectives

A few empirical studies have explored seafarers' risk perceptions of noise exposure and its associated adverse health effects in the workplace. Promoting education and awareness about the harmful effects of noise is crucial, as it influences noise-associated risk health behaviors (Alnuman & Ghnimat, 2019). Evoy and Case (2022) emphasized the importance of developing prevention or educational materials to improve seafarers' health and wellness. While many studies have provided insights into the noise levels onboard and various auditory and non-auditory health problems associated with occupational noise exposure at sea (Yadav et al., 2023; Burella et al., 2021; Burella et al., 2019), there is a lack of research on seafarers' risk perceptions of noise exposure onboard. Despite the existence of OHS standards regulating noise levels on board Canadian vessels, seafarers' risk perceptions of workplace noise, its health impacts, and the challenges they face in addressing the risk of noise exposure are underexamined. To address these research gaps, a qualitative research approach was conducted between 2022 and 2023 to a) explore noise risk perceptions among seafarers in Canada, b) understand how seafarers in Canada manage noise exposure, mitigate noise-induced health issues, and identify potential barriers and challenges they face in preventing noise exposure onboard.

5.2 Materials and Methods

5.2.1 Semi-structured Interviews

The study employed a qualitative research method by conducting semi-structured interviews with seafarers about their onboard noise exposures, current management, and prevention practices of noise exposure, as well as identifying existing barriers and challenges in preventing noise-induced health problems. Additionally, seafarers were encouraged to share their experiences and provide suggestions to mitigate excess noise exposure and improve legislation, regulation, policy, and management practices (see Appendix D).

5.2.2 Research Ethics

The Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland granted ethics approval for this research (ICEHR Number: 20230979-ME) on January 5, 2023 (see Appendix B). A strategy of informed consent was implemented for the interviews, with a commitment to maintaining the confidentiality of participants by removing all identifying information related to interviewees. Pseudonyms were used in the manuscript to protect their identities further.

5.2.3 Recruitment Strategy

The research flyer was initially disseminated through various social media platforms, primarily LinkedIn, as the first step in participant recruitment. Secondly, Canadian unions and maritime organizations, including the Seafarers' International Union (SIU) of Canada (https://seafarers.ca/) and the Canadian Merchant Service Guild (https://cmsg-gmmc.ca/index.php/en/), which are the two main unions representing seafarers in Canada, as well as The Mission to Seafarers: Canada (https://www.missiontoseafarers.ca/), were contacted to distribute the flyer on their websites and social media channels. These organizations also shared the flyer directly with seafarers through their mailing lists. Due to the challenge of differentiating between seafarers recruited through unions/organizations and those from social media while considering privacy and confidentiality, additional measures were implemented to verify participant eligibility. At the beginning of the interview, several screening questions were asked to ensure that participants were indeed seafarers. These questions covered details about their work experience, including ship type, onboard rank, department, years of seafaring experience, years in their current position, normal duty schedule, and the average length of their voyages.

5.2.4 Data Collection

Qualitative data were collected through online Zoom interviews, each lasting 1 to 1.5 hours. Participants were offered a $50 Amazon e-gift card as compensation for their time. Seafarer interviewees, aged between 18 and 65 years old, working on deck, in the engine room, or other departments onboard, and actively employed as seafarers in Canada's fleet for one year or more, were included in the study. Those with a history of working in noisy environments other than as seafarers onboard for one year or more and those with pre-existing diagnosed hearing problems or noise-induced non-auditory health problems before joining as seafarers were excluded.

Twenty-three interviews were conducted between April and June 2023. The interviewed seafarers had a collective experience ranging from 2 to 35 years and had worked in various positions onboard, bringing their expertise to different types of ships, including oil tankers, bulk carriers, container ships, icebreakers, and more (see Table 5.1). All interviews were audio-recorded for transcription and future data analysis, except for one where notes were taken by the first author as the participant did not permit audio recording. The thematic analysis method was employed for qualitative data analysis. The health capital framework was adopted to comprehend how seafarers perceive noise exposure and explore potential barriers in mitigating occupational noise-induced health issues.

Table 5.1 *Seafarers' Demographics and Occupational Characteristics.*

Pseudonym	Gender	Rank/ job position	Working experience in years	Ship type currently working on
Alexander	Male	Engine cadet	1	Oil tanker
Ben	Male	Chief officer	7	Icebreaker
Christopher	Male	Labor worker	4	Cruise ship
Sophia	Female	Assistant cook	2	Cruise ship
Dave	Male	Second engineer	5	Commercial ship
David	Male	Engine cadet	2	Bulk carrier
Eric	Male	Second engineer	16	Tanker
Ethan	Male	Captain	15	Container ship
Gabriel	Male	Engineer	9	Platform survivor vessel Supply vessel
George	Male	Chief officer	9	Passenger vessel
Jack	Male	Captain	24	Tugboat
Jackson	Male	Marine safety inspector	13	Container ship Bulk carrier
James	Male	Captain	17	Cement carrier
Kyle	Male	Second officer	9	Cargo ship
Martin	Male	Second officer	9	Bulk carrier
Michael	Male	Watch keeper	7	Coast guard ships
Susan	Female	Navigation officer	5.5	Ice breaker
Mike	Male	Chief engineer	33	Ice breaker
Noah	Male	Third engineer	6	Chemical tanker
Oliver	Male	Forth engineer	2	Supply vessel
Sebastian	Male	Captain	11	Oil tanker
Thomas	Male	Ice navigator	35	Ice breaker
William	Male	Chief engineer	34	Liquid asphalt tanker ship

5.3 Results

5.3.1 Health Capital: A Theoretical Framework for Exploring Seafarers' Risk Perceptions of Noise Exposure Onboard

Michael Grossman's (1972) model of investment in health capital stands as the standard for analyzing health-related behaviors. Its appeal lies in its explicit acknowledgment of the dynamic nature of the problem and the way it allows decisions about health-related behaviors to be framed as part of an intertemporal optimization problem. According to Anna Schneider-Kamp (2020) and Sarwar et al. (2023), knowledge, awareness, training, education, field-specific skills, competencies, personal adaptation, and experience are critical components of health capital influencing individual health-related behaviors. Health capital provides a method for appraising risks associated with an individual's traits, pinpointing shortcomings like insufficient skills, education, or experience in a qualitative risk assessment. This framework considers such risks quantifiable and amenable to measurement (Schneider-Kamp, 2020). The relevant causes of occupational accidents onboard ships are hazards, lack of knowledge, inadequate training, and work environment-related factors (Baker & McCafferty, 2005). The health capital approach emphasizes that personal safety training and education to improve information and awareness are the most suitable ways to decrease workplace risk (Schneider-Kamp, 2020). Training and knowledge can help control hazards but cannot eliminate hazards without employers' investment. Hence, the workplace is an important setting for health protection to prevent occupational injury and accidents and for health promotion to improve overall health and well-being (Stoewen, 2016).

In this study, integrating health capital concepts provides a robust analytical foundation for understanding seafarers' perceptions and attitudes for qualitative thematic data analysis. This integration offers insights into how investments in the workplace by shipowners in health-related knowledge, such as training and education, may influence seafarers' responses to occupational noise exposure and its potential health consequences in the Canadian maritime setting, underscoring the responsibility of employers to create a work environment that safeguards seafarers' health.

5.3.2 Semi-structured Interview Findings

Based on the health capital theoretical framework and our qualitative data, the following themes were developed:

Theme 1: Excessive Noise Exposure and its Induced Health Impacts

Out of 23 participants, 18 expressed concerns about the loudness of their workplace onboard ships, attributing it mainly to the ship's engines and onboard machinery during working and resting hours. Additionally, seafarers highlighted other sources of noise, including foghorns, ship movements, staff activities, phone rings, and alarms. For example, a seafarer working on a cruise vessel, Christopher, said, *"So, there's usage of heavy machinery… and that's where the noise comes from."* Ethan, a captain of a container vessel, commented, *"Actually, the main source of noise in the ship is from the engine; you know, when the engine is running, it is really noisy."*

Occupational noise-induced auditory and non-auditory health impacts were explored with the interviewees. Out of the 23 interviewed seafarers, 13 reported having no hearing issues. Four participants mentioned that, although they do not have a hearing problem, they are aware of other seafarers who do. Three seafarers reported brief episodes of tinnitus occurring when exposed to loud noises, subsiding within minutes of leaving the noisy environment. Two participants admitted to experiencing tinnitus, and four participants reported hearing difficulties. George disclosed experiencing both tinnitus and hearing issues, attributing them to working for six months on an extremely loud vessel. Christopher, reflecting on a 5-year career, mentioned,

> *"There's some change in my hearing ability because I have been working for five years ...Like I can't concentrate on more than three different noises when they are there at high pitch volume."*

Seafarers reported various non-auditory health issues resulting from exposure to a noisy work environment, including sleep disturbances, annoyance, stress, fatigue, loss of concentration, and headaches. Two seafarers admitted to experiencing nearly all these health impacts at different times and frequencies. Three seafarers provided insights as below:

> *"I exhibited annoyance. And I've exhibited frustration, and like an uncharacteristic personality trait when I've been exposed to noise for a long time, you know." (James)*

> *"I worked on a seismic boat… It was very loud. I found it's very hard to sleep there. And I mean no one would say the sleep is refreshing. Sleeping here is not like sleeping at home." (Ben)*

> *"The vibration that's happening through the entire ship because of the noise and the moving of the machinery fatigues you…." (Eric)*

Furthermore, seafarers explained how loud noise impacted communication, necessitating speaking louder, causing a loss of concentration, misunderstandings of instructions, leading to challenges with colleagues, emotional distress, and increased susceptibility to occupational hazards, resulting in errors and incidents. Ethan shared,

> *"Sometimes, while we are working and operating different navigation equipment, we may misunderstand the message, especially when alarms are on in shallow water. The alarms really bother us and affect concentration. Once we were trying to communicate with the officer in the engine room, and he didn't hear us. So, he didn't follow the instructions, and the ship line was broken."*

Theme 2: Resilience in Noisy Environments: Adaptation and Strategies

Most participants agree that their workplace is noisy, but they have become accustomed and adapted to loud and noisy working environments as time passes in their careers. Dave stated, "*I wasn't feeling very comfortable with the noise when I started working as a seafarer. Then I got used to it."*

When asked if seafarers were bothered by the noise in their workplace, William replied, *"No, noise is a form and part of my work, and it's needed. So, it's something that you have to adjust to...".*

When asked how seafarers cope with workplace noise, most participants admitted to using hearing protection such as earplugs and earmuffs. Seven of 23 seafarers noted that they usually move away from the noise's source. Alexander stated, *"Usually when it's getting too unbearable, I ask for permission to move away from the source of the noise."*

Two seafarers described trying to limit their exposure time, with William mentioning, *"The turbochargers are very noisy…So, you can minimize your exposure time beside them."*

Seafarers also shared other strategies they use to reduce noise onboard and prevent disturbances. For example, Ben employs strategies like keeping doors closed, pulling curtains, and using makeshift solutions like stuffing papers to dampen noise from rattling bulkheads and deckheads in their cabins. Oliver suggests turning off certain types of machinery to reduce noise, while Thomas emphasizes operational sensitivity, attempting to limit noisy tasks to waking hours to avoid disturbing others' sleep.

Theme 3: Occupational Safety and Health: Values in Conflict

Most seafarers mentioned that their job requires them to be cautious because it is a high-risk working environment. They emphasized that safety is their top priority and that wearing hearing protection devices may affect their safety. Wearing hearing protection serves as a communication barrier and heightens the risk of occupational hazards due to difficulties in hearing alarms, following required instructions, or understanding the messages conveyed. David stated, "*...sometimes I need to remove the earplugs to hear others, especially if we're doing a heavy task when it's very noisy around. Because I need to communicate and understand the given instructions to avoid risk and problems.*"

Furthermore, seafarers discussed their desire to protect their hearing, but at the same time, they expressed concerns about risking their overall safety. For instance, Jackson discussed how the policy requires the use of all personal protective equipment (PPE), including glasses, earmuffs, and helmets. However, due to discomfort and poor compatibility caused by the lack of well-integrated PPE, some individuals compromise by wearing only certain components, like earmuffs without helmets. Jackson highlights companies' reluctance to invest in compatible gear, contradicting the safety policies they enforce and risking individuals' safety during accidents.

Theme 4: Gaps in Safety Training and Management for Noise Protection

Ten out of 23 seafarers noted that health protection from noise exposure onboard was not considered during their training or courses required for seafaring, as Jackson stated,

> *"When you go for seafarer training, they mostly teach us how to perform medical first aid, how to jump into the water during survival draft training, and how to fight a fire. However, there is no training and not much awareness regarding hearing protection; you know, they don't provide training courses on it."*

Three seafarers do not remember whether they received training or courses for occupational health protection from noise exposure onboard, with George mentioning,

> *"I don't remember ever receiving any actual training on the impacts and results of not protecting your hearing and why it's important."*

Others stated that they received some form of training and information on this matter, as David expressed, *"We undergo some sort of training; we are being trained on how to use the PPE and the importance of using hearing protection."*

Regarding noise protection management, most seafarers use hearing protection, such as earmuffs, earplugs, and custom-molded earplugs, with availability varying by department and job position. Some seafarers mentioned having sufficient PPE, including hearing protection devices, while others noted it depends on the company budget. However, some outlined a deficiency in fostering a culture that ensures all crew members feel comfortable accessing and using these supplies. This occasionally led to individuals forgoing necessary safety gear due to reluctance or perceived inconvenience, as expressed by James:

> *"We had sufficient safety supplies on board to meet what would be considered a regulatory requirement. But we did not have a culture around distributing them that made all crew members feel like they were readily accessible and available…."*

Fifteen out of 23 participants acknowledge noise control measures are included in the safety management system (SMS), but two highlight potential gaps in reporting and acknowledgment of noise exposure incidents despite the presence of safety measures, including signage and PPE. Additionally, three of them admitted to a recurring theme of limited awareness or consideration of noise-related issues in routine communication and reporting procedures, as noted by Sebastian: *"It is included in the safety management system, but it's not really an issue that's brought up very often on board for communications."*

Theme 5: Barriers and Challenges in Noise Prevention

Numerous barriers and challenges impede the reduction of noise exposure and the prevention of occupational noise-induced health impacts on board. The seafarers emphasize that many individuals lack knowledge about the proper use of hearing protection devices and are unaware of the adverse effects of noise exposure. They believe that education can address this gap and are calling for more stringent enforcement of regulations and broader awareness campaigns covering the full scope of the consequences of noise exposure. Ultimately, this would foster a culture of respect for hearing protection and health among crew members. David stated,

> *"I think more education and awareness for people onboard is needed because I can see many people don't know how to use the earplugs and when to use them. Some they don't know what the effect of noise on them is."*

They also noted the need for ship-specific training focusing on protection from occupational noise onboard. Martin said, *"I think ship-specific training would be valuable. Talking about the areas on board that are noisy, what protections are available, where it's* *located, as well as just an overall knowledge of how to communicate when you're wearing this hearing protection."*

Seafarers emphasize the employer's responsibility to invest in quieter machinery and ship redesign for noise reduction, including advanced soundproofing measures. They also stress the importance of providing comfortable hearing protection devices, suggesting the adoption of new technologies like noise-canceling earmuffs, communication headsets, and advanced designs to avoid practical limitations in certain work situations, especially when entering tiny spaces in the engine room while wearing earmuffs. Ben stated,

> *"Comfort is a big one because people want to be comfortable while they're working. And if you get a big bulky thing over your ears, sometimes that's not comfortable because it can get hot, and you can't hear other people around you."*

In addition, seafarers stated that companies often prioritize cost-cutting over implementing effective safety measures focusing on profits rather than crew well-being. They expressed skepticism about the efficacy of preventive measures such as safety stickers, viewing them as a superficial way for companies to appear compliant with safety regulations without making substantial improvements or investments in addressing noise-related issues. They stated,

> *"Actually, no one cares; this is because they don't want to spend much. If you push them, they will do something. Otherwise, nobody does something. If they know that there will be a check or inspection of the ship, then they will start to do something." (Ethan)*
>
> *"It (safety against noise) is just expensive, and companies are cheap. I can say no sticker is helpful. All it is fake safety put out. That's cheaper than doing an actual*

fix. A sticker is a great way to make it look like you're doing something without having to do anything." (James)

Three seafarers highlighted unions' limited influence in addressing noise-related issues. They noted that while unions advocate for safety gear, they lack the authority to enforce noise regulations with employers, hindering their ability to effect substantial change unless laws become more robust. Eric said, *"The only difference they could make is if the employer does not want to supply the safety gear. That would be about the extent that I think the unions could really go."*

5.4 Discussion

Occupational noise exposure poses a significant risk to the health and well-being of seafarers, leading to issues such as hearing loss, tinnitus, sleep disturbances, communication difficulties, poor concentration, dizziness, depression, anxiety, headaches, fatigue, and stress. (Febriyanto et al., 2024). The present study observes the influence of occupational noise exposure on the health and well-being of seafarers, exploring how modified behavior and adjustment to a risky environment can lead to enduring disabilities, including hearing impairment. This study also highlights the potential negative consequences of improper policy and regulation enforcement, compelling workers to adapt to unsafe conditions. Our study indicated that certain seafarers opted not to use hearing protection as a safety precaution to avoid miscommunication and potential accidents. The findings suggest that seafarers adjusted to the noisy surroundings and adapted to the noise. Additionally, the research noted a lack of knowledge among seafarers regarding occupational noise exposure and its associated health risks.

Seafarers work in a noisy environment, which is harmful to their health and well-being (Slišković & Penezić, 2015). In this study, most of the interviewed seafarers noted that the ship's engines and onboard machinery were the main contributors to noise during their working and resting hours. They also pointed out other noise sources onboard, including foghorns, ship movement, ice-breaking noise, staff moving around, phone rings, and alarms in their cabins. Interviewed seafarers have voiced concerns about the loudness of their workplace, specifically noting exposure to loud noise in the engine room more than in other areas on board. According to the literature, engine rooms on many ships exhibit noise levels surpassing 100 dB (A), with variations depending on the location on board (Oldenburg et al., 2020; Picu et al., 2019; Turan et al., 2011). Picu and Rusu (2020) measured the noise levels on two vessels traveling on the Danube River and found that the permissible sound level was exceeded by at least 28% in the engine rooms and at least 16% in the control rooms for both ships. These findings align with our study, indicating that seafarers work in noisy environments, with the highest noise levels found in engine rooms.

In the findings of this study, some seafarers reported auditory health problems, attributing them to occupational noise onboard, including hearing loss and tinnitus. A recent retrospective study among French merchant seafarers supports our findings, confirming that working in noisy environments, notably in engine rooms, significantly increases the risk of hearing impairment (Lucas et al., 2022). Tinnitus is an internal auditory sensation that is perceived without external stimuli (Vanneste & De Ridder, 2012). It is often described as ringing, buzzing, or whistling. It can be unilateral or bilateral, and continuous or intermittent (Hoth, 2005). In the current study, seafarers with tinnitus describe it as ringing in their ears, while others characterize it as a sound of metal clanging, albeit from a further distance. Tinnitus and NIHL are among the most frequently reported complaints by seafarers exposed to occupational noise (Kaerlev et al., 2008; Irgens-Hansen et al., 2015a; Arnardottir et al., 2022; Hui, 2019). Tinnitus of short duration, lasting up to 15 minutes, may occur following only a few minutes of exposure to intense noise (Atherley et al., 1968). In our findings, three seafarers reported experiencing brief episodes of tinnitus that manifest when exposed to loud noises and subside within minutes of no longer being in a noisy environment.

Seafarers face various noise-induced non-auditory health problems such as stress, sleep disturbances, and cognitive impairment (Oldenburg et al., 2020; Carotenuto et al., 2012). In our findings, seafarers reported heightened stress levels, particularly after prolonged exposure to noise. High-pitched noises onboard are identified as significant physical conditions affecting seafarers' mental health (Brooks & Greenberg, 2022). Our study revealed that seafarers grapple with emotional challenges due to working in a noisy environment, as the need to speak loudly to communicate leads to feelings of repetition and frustration. Sunde et al. (2016) found that the number of noise events was associated with decreased sleep efficiency among seafarers in the Royal Norwegian Navy. Additionally, Cui et al. (2022) supported this observation, indicating that seafarers desire longer sleep duration to alleviate anxiety and irritability caused by increased engine noise. These findings align with our study, where seafarers described how noise exposure affected their sleep quality, emphasizing that sleeping onboard is never akin to sleeping at home, and the quality of sleep is not refreshing.

Fatigue has been identified as a primary contributor to safety deterioration in the maritime industry (Akhtar & Utne, 2015). Maritime accident studies, such as Fan et al.'s (2020) analysis of maritime reports from the Transportation Safety Board of Canada and Maritime Investigation Agency of British Columbia between 2012 and 2017, found that 13.46% of accidents were attributed to seafarers' fatigue and sleep-related issues. Sleep quality problems, such as sleep deprivation or extended time awake due to ship engine noise, are significant contributors to fatigue among seafarers (Hystad & Eid, 2016; Jensen & Oldenburg, 2020). Our study aligns with these findings, where seafarers reported sleep disturbances and fatigue due to loud noise exposure. Additionally, Hystad and Eid (2016) found that seafarers exposed to high noise levels were easily annoyed, resulting in diminished cognitive resources. Sleeplessness derived from high noise exposure also contributed to anxiety, affecting the central nervous system and reducing performance on vigilance tasks (Warm et al., 2008). Our study supports these findings, where seafarers noted that noise exposure in their workplace caused annoyance and anxiety, leading to a loss of concentration during tasks on board and increasing the risk of occupational accidents and hazards.

The present study focuses on the behavior of seafarers in tolerating noise and adapting to the loud maritime environment. The acceptance of noise is viewed as a gradual process that can be understood through the health capital approach. Coping mechanisms are strategies or behaviors individuals employ to deal with and navigate challenges, adversity, setbacks, or difficult situations. These mechanisms are utilized to manage stress, emotions, and the demands of various circumstances (Sarwar et al., 2023). Some scholars have identified components of health capital as coping mechanisms, emphasizing their importance as strategies to overcome challenges in the maritime industry (Doyle et al., 2016; Salzar et al., 2019; Mendoza et al., 2021; Sarwar et al., 2023). However, this contrasts with our findings, where seafarers' adaptation to a noisy environment and their behavior of tolerating noise at work can have negative health consequences and jeopardize their safety and well-being. Some interviewees mentioned that they had grown accustomed to the noise. This illustrates that coping mechanisms developed in such situations can result in working in a hazardous environment due to attempts to trivialize the risk (Power, 2008). One seafarer noted that exposure to noise is unavoidable in certain situations. Another seafarer stated that noise doesn't bother them and that it is a form and part of their work, which they consider necessary. This indicates that seafarers have adapted to the environment and learned to tolerate loud noise, displaying fatalistic behavior. Fatalism, in this context, refers to the belief that accidents and illnesses are natural consequences of work. Consequently, individuals who have developed risk-related health behaviors associated with occupational noise may believe that injuries and sickness are an inevitable outcome of their work. Fatalism poses a challenge to occupational safety, as individuals with fatalistic attitudes accept severe accidents and injuries as unavoidable (Williams & Purdy, 2005). Researchers have noted that fatalism can obstruct the safety training process by discouraging at-risk workers from adopting proper protective measures (Williams & Purdy, 2005; Üngüren et al., 2017; Håvold et al., 2017). The health capital approach explains how education, training, and awareness can serve as tools for health investment (Grossman, 1972). Investing in regular education and training sessions for seafarers could assist them in recognizing noise-related health concerns and seeking early medical care. While many seafarers report having attended general safety training, they often deny receiving specific training on noise exposure onboard and its related health risks. Hence, there is a need for regular training and educational programs to enhance awareness regarding noise exposure and its adverse health impacts.

Seafaring is recognized as a perilous occupation due to a combination of various physical and psychosocial exposures and hazards (Havold, 2005; Nielsen, 1999). In this study, seafarers emphasize the imperative of caution and alertness, acknowledging the inherently high-risk nature of their jobs. While prioritizing safety, many express reservations about the use of hearing protection devices, citing concerns about potential compromises in safety. They argue that such devices introduce a communication barrier among workers, heightening the risks of occupational hazards and other safety issues. This communication challenge extends to difficulties in hearing alarms, following essential instructions, and understanding conveyed messages. Mishearing or misunderstanding verbal orders is identified as the primary cause of up to 70% of maritime accidents (Galieriková, 2019). In addition, seafarers have highlighted their avoidance of wearing hearing protection devices due to discomfort, such as ear pressure and pain, as well as their perceived lack of effectiveness and practicality in certain work situations, like entering tight spaces in the engine room while wearing earmuffs. They have noted that disposable earplugs are the most common and readily available onboard due to their affordability, but their discomfort negatively affects their effectiveness. This discomfort includes annoyance, pain, pressure, and irritation. This discomfort stems from biomechanical and thermal interactions with the ear canal, influenced by factors such as work duration and individual ear morphology (Poissenot-Arrigoni et al., 2023).

Seafarers also highlight the obstacle created by the lack of compatibility and discomfort resulting from different safety equipment components such as helmets, earmuffs, and glasses. They emphasize the demand for more integrated and comfortable safety equipment options, ensuring seafarers can adhere to safety protocols effectively while minimizing discomfort and potential safety risks. Poissenot-Arrigoni et al. (2023) recommended that manufacturers design hearing protection devices considering comfort aspects and that safety professionals propose to workers the hearing protection devices most adapted to them and their work environment. They outlined that the availability of PPE, including hearing protection devices onboard, depends on the job position, department, and ship budget. One seafarer highlighted that despite the ship having enough safety equipment to meet regulatory standards, there is a shortfall in fostering a culture that ensures all crew members feel comfortable accessing and using these provisions. This gap could potentially lead individuals to abstain from using essential safety gear due to reluctance or perceived inconvenience. Initiatives for OHS aimed at reducing noise exposure and preventing hearing loss in the workplace must consider the broader safety context of the organization. Workplace noise prevention programs are unlikely to result in behavioral changes unless the organization's safety culture is also addressed (Williams & Purdy, 2005).

Internationally, the MLC (2006) recommends measures encompassing education on noise dangers, providing hearing protection, and reducing noise exposure in various ship areas. It also encourages employers to provide comprehensive training for workers exposed to significant noise levels, covering the effective use of hearing protection devices. However, in our current study findings, several seafarers note a lack of implementation of these regulations because they were simply given hearing protectors without adequate training; one mentioned not knowing how to put in earplugs initially until observing another seafarer and seeking guidance. They emphasize that it is the employers' responsibility to provide education and awareness for the use of PPE, highlighting a deficiency in education on how, when, and where to use hearing protectors. Additionally, seafarers stress the need for ship-specific training, focusing on noisy areas on board, the availability of protections, and effective communication while wearing hearing protection. They express that employers are responsible for investing in communication headsets that provide hearing protection and enable effective communication while safeguarding hearing in loud environments. In addition, the *Code of Noise on Board Ships* covers only noise sources related to the ship, such as machinery and propulsion, but does not include wind, wave, ice-breaking noise, alarms, and public address systems (IMO, 2012). In this study, interviewed seafarers noted exposure to noise beyond engines and machinery, including alarms, ice-breaking noise, foghorns, and phone rings. This finding underscores the need to update existing regulations to reflect current noise conditions onboard ships and adjust ship designs to consider noise from other sources, such as ice-breaking activities.

At the Canadian level, Part 12 of the *Maritime Occupational Health and Safety Regulations* (SOR/2010-120), detailed in Part II of the Canada Labour Code, requires the use of sound-absorbing materials in the construction of bulkheads, deckheads, and decks within sound-producing spaces (Government of Canada, 2022). In our study, seafarers emphasize the importance of employers implementing these regulations to address noise issues effectively. They stress the need for shipowners to invest in newer, quieter equipment and redesign ships for noise reduction. This includes implementing soundproofing measures like walls, bulkheads, and decks to effectively address ongoing loud noise issues in their workplaces. They state that larger companies prioritize cost-cutting over implementing effective safety measures due to perceived expenses. Additionally, there is skepticism about the efficacy of safety stickers, viewed as a superficial way for companies to appear compliant with safety regulations without substantial investments in addressing noise-related issues. Hence, there is a growing concern about a profit-over-health-and-safety culture. Berg (2013) suggests that sustaining a safety culture requires consistent training, persistent awareness of cultural changes, and an ongoing commitment to continuous improvement.

Trade unions may have a significant potential to improve conditions for workers by seeking to establish higher standards for wages, advocating for limits on working hours, promoting workplace hazard protections, and addressing various other factors (Hagedorn et al., 2016). However, in our study, some seafarers highlighted that unions have limited impact on noise-related issues because they lack the authority to compel employers to reduce noise and implement OHS regulations due to legal limitations.

5.5 Limitations and Future Study

The current research contributes to existing knowledge on noise exposure and its associated health risks among seafarers. The study findings provide valuable insights for seafarers, seafaring agencies, safety instructors, and regulatory bodies, potentially informing new policies or amendments to existing ones. Additionally, it highlights the challenges, barriers, and gaps that stakeholders must address. Due to time constraints, online interviews were conducted with seafarers. For future investigations into onboard noise risks and their health implications among seafarers, it is recommended to conduct focus groups with seafarers and interviews with members of maritime organizations, OHS experts, as well as federal regulatory bodies or authorities such as Transport Canada.

5.6 Conclusion

The current research findings highlight that onboard noise exposure is a significant health issue requiring prompt attention from relevant authorities. Seafarers acknowledge the noisy nature of their workplace but have adapted to it, developing fatalistic behaviors that expose them to more occupational hazards, including accidents and illnesses. The research also reveals gaps in how employers have implemented OHS regulations. Shipowners and employers should ensure seafarers have access to the proper PPE and comply with all other regulations to manage noise exposure and prevent its health impacts.

This study recommends a collaborative partnership involving the government, employers, maritime organizations, and unions to initiate education and training programs aimed at helping seafarers understand occupational noise risks and adopt preventive measures to mitigate their impacts. It also suggests fostering a robust safety culture within the maritime industry, emphasizing the collective commitment to safety, encouraging proactive measures, continuous improvement, and shared responsibility among all stakeholders. Ultimately, this contributes to the effective implementation of noise prevention measures and creates a safer and healthier working environment for seafarers.

Declaration of Competing Interest:

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

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Chapter 6 Major Findings, General Discussion and Conclusion, Limitations, and Scope for Future Work

6.1 Major Findings

The current research findings highlight that onboard noise exposure is a significant health issue requiring prompt attention from relevant authorities, including the Canadian Government and Transport Canada. The quantitative results indicate that perceived benefits, barriers, and self-efficacy scores suggest Canadian seafarers have moderately positive perceptions toward noise reduction and hearing loss prevention. The perceived attitude and susceptibility scores show that participants generally dislike loud noise and perceive their susceptibility to hearing loss as quite high. The findings also reveal significant concerns regarding the auditory health effects of noise exposure onboard Canadian vessels. Seafarers exposed to noise reported auditory issues such as hearing loss, tinnitus, and unexpected balance problems. Hearing protection often causes discomfort and acts as a communication barrier. The perceived risk of noise and the health consequences experienced by Canadian seafarers highlight the need for a more comprehensive exploration of noise-related safety issues. This exploration should consider variables such as biophysical, environmental, structural, and human resources, as well as their interactions within the context of industrial and policy transitions.

The qualitative results revealed that seafarers acknowledge the noisy nature of their workplace but have adapted to it, developing fatalistic behaviors that expose them to more occupational hazards, including accidents and illnesses. The seafarers interviewed reported both auditory health issues, such as hearing loss and tinnitus, and non-auditory health issues related to noise exposure onboard, including sleep disturbances, annoyance, stress, fatigue, loss of concentration, and headaches. They also restrict the use of hearing protection equipment on board due to safety concerns. The research highlights gaps in how employers have implemented OHS regulations. Shipowners and employers should ensure that seafarers have access to proper PPE and comply with all other regulations to manage noise exposure and prevent its health impacts. The main barriers to effectively controlling occupational noise exposure for seafarers include limited noise control measures, uncomfortable hearing protection devices, and a lack of regular ship-specific training and education programs.

6.2 General Discussion and Conclusion

This study effectively addresses the critical research gaps identified in Chapter 2 of the literature review by examining seafarers' noise risk perceptions and the auditory and non-auditory health impacts of occupational noise exposure onboard ships in Canada. It explores how these seafarers manage such exposure, recognize related health issues, and identify barriers to preventing and controlling noise.

The findings reveal significant sociodemographic differences in seafarers' noise risk perceptions and awareness of auditory health issues. Specifically, seafarers with higher levels of education were more likely to acknowledge the benefits of noise reduction, indicating that enhanced education promotes greater awareness and increases the likelihood of taking protective measures against occupational noise. In contrast, younger seafarers were more likely to perceive barriers to noise reduction compared to their older counterparts, highlighting the need for age-specific interventions to foster protective behaviors. Moreover, significant differences were noted across various ship departments, with individuals in engineering and the galley reporting greater perceived barriers to noise reduction than those in the deck department. This underscores the importance of tailoring targeted interventions to meet the specific needs and perceptions of different ship departments. Additionally, seafarers with less than 10 years of experience exhibited a lower perceived susceptibility to hearing loss than those with more experience, emphasizing the necessity for educational initiatives aimed at increasing awareness among newer seafarers about the risks associated with occupational noise. The study also indicated that older seafarers are more likely to be affected by workplace noise, which stresses the need for interventions that address age-related attitudes toward occupational noise exposure. Collectively, these findings suggest that sociodemographic factors such as age, education, work experience, and ship department significantly influence seafarers' perceptions of noise risks and their awareness of related health issues.

Therefore, the evidence gathered leads to the rejection of the hypotheses concerning noise risk perceptions and the awareness of occupational noise exposure among seafarers in different ship departments, as well as the influence of various factors on their understanding of self-reported auditory health problems. This research contributes to existing knowledge on noise exposure and its associated health risks among seafarers. The study findings provide valuable insights for seafarers, seafaring agencies, safety instructors, and regulatory bodies, potentially informing new policies or amendments to existing ones aimed at improving occupational health and safety within Canada's maritime industry. Additionally, it highlights the challenges, barriers, and gaps that stakeholders must address. This study recommends a collaborative partnership involving the government, employers, maritime organizations, and unions to initiate education and training programs aimed at helping seafarers understand occupational noise risks and adopt preventive measures to mitigate their impacts. It also suggests fostering a robust safety culture within the maritime industry, emphasizing the collective commitment to safety, encouraging proactive measures, continuous improvement, and shared responsibility among all stakeholders.

Ultimately, this contributes to the effective implementation of noise prevention measures and creates a safer and healthier working environment for seafarers.

6.3 Limitations

This study focuses exclusively on currently active seafarers, excluding inactive seafarers, which could be a limitation because they might provide different perspectives on the long-term health impacts of occupational noise onboard. Additionally, the sample distribution was not a truly random sample of seafarers, which may be a limitation. The study is also non-diagnostic, relying solely on self-reported assessments from participants, which can introduce bias and inaccuracies, as participants may misreport or misinterpret their symptoms. In the qualitative research, time constraints limited us to conducting only online interviews with seafarers.

6.4 Scope for Future Work

For future research, a better understanding of hearing loss among seafarers could be achieved through physical examinations and the collection of clinical data via audiometric testing. Additionally, future studies may focus on ascertaining the probable relationship between noise exposure onboard ships in Canada and non-auditory health problems. It is recommended that measurable data be obtained; for example, measuring blood pressure to assess hypertension and performing polysomnography tests to evaluate sleep quality (Corlateanu et al., 2017) among exposed seafarers could provide valuable insights. Future investigations into onboard noise risks and their health implications should include focus groups with seafarers and interviews with members of maritime unions, organizations, occupational health and safety experts, as well as federal regulatory bodies such as Transport Canada.

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Appendix A: Literature Review's Studies Criteria and Descriptions

1. Eligibility Criteria for Relevant Articles

The eligibility criteria were established prior to the literature search, following the Population, Intervention (Exposure), Comparator, Outcome, and Study Design (PICOS) framework (Schardt et al., 2007). The population included seafarers aged 18 years or older with occupational exposure to noise. The intervention or exposure focused on occupational noise onboard ships, while the comparator involved seafarers not exposed to noise. The outcomes of interest included adverse auditory and non-auditory health effects. Studies with any quantitative or qualitative design, such as cross-sectional studies, cohort/observational studies, or reviews, were included. Conversely, case series, editorial pieces, news articles, conference abstracts, and book reviews were excluded. Articles addressing health effects resulting from occupational noise exposure among seafarers were included, while those that focused solely on noise exposure aboard ships without reporting health effects in seafarers, as well as in vitro and animal research, were excluded. A computerized search for relevant studies was conducted using the following databases: PubMed, Embase, SCOPUS, and Google Scholar between September 14 and September 20, 2022. Due to time constraints, a manual search for additional relevant studies and screening for grey literature was not performed.

2. Description of Relevant Articles

The initial literature search resulted in 91 articles. After removing 26 duplicates, 66 titles and abstracts were included for Level 1 screening. Of these, 17 were considered potentially relevant documents for further review. Following Level 2 screening, 9 publications were included for data synthesis. Population characteristics, publication year, methods, and significant outcomes of the studies selected for this review are summarized in Tables 1 and 2. All the included studies employed a cross-sectional design (n=9).

The publication dates of the articles were not set as a filter during the search, allowing for the inclusion of studies regardless of their publication year. The included studies were published between 2008 and 2022. Among them, two studies were conducted in Norway (n=2) (Irgens-Hansen et al., 2015a; Irgens-Hansen et al., 2015b). The remaining studies comprised one each from France (Lucas et al., 2022), Denmark (Kaerlev et al., 2008), India (Kapoor et al., 2018), Brazil (Malheiros et al., 2021), Montenegro (Nikolic & Nikolic, 2013), the Romanian Danube segment (Picu et al., 2019), and Germany (Oldenburg et al., 2020). Sample sizes ranged from 3 to 8,487 participants (Kaerlev et al., 2008; Picu et al., 2019). The studies were categorized into two groups: those describing noise-related auditory health impacts among seafarers (Table 1) and those describing noise-related non-auditory health impacts (Table 2).

__Table 1__ Studies describing noise-related auditory health impacts among seafarers.

First Author & Country	Year	Demographic information [N, gender, age (years)]	Methods	Outcome
Lucas et al. & France	2022	8083 seafarers, Males (6874), Females (1434), age <30 - >40 years	-Audiometric tests to assess hearing impairment	- Age, years of experience, and working in an engine room are risk factors for hearing impairment - NIHL has considerably improved due to stricter regulations in ship soundproofing and the change in the types of propulsion
Malheiros et al. & Brazil	2021	85 seafarers, both genders, 20 - 49 years	-Cross-sectional quantitative study between offshore and onshore workers - Semi-open questionnaire -Inspection of the external auditory canal through otoscopy - Otoacoustic emissions (OAE) testing	-Evoked otoacoustic emissions were more altered in the offshore group than in the onshore group -Highest proportion of failures occurring at frequencies of 4 kilohertz (kHz) for transient otoacoustic emissions (TOAEs) and 6 kHz for distortion product otoacoustic emissions (DPOAEs) in the offshore group
Kapoor et al. & India	2018	56 seafarers (45 engine room crew, 11 non-engine room personnel)	-Sound pressure level (SPL) measurement - hearing threshold measurements to assess the effect of ship noise on the hearing acuity of workers	-73% of the non-engine room crew presented normal hearing test -24% of the engine room crew presented abnormal hearing test - SPL values were within the safe limits when the ship was in the stationary phase but exceeded while sailing

First Author & Country	Year	Demographic information [N, gender, age (years)]	Methods	Outcome
Irgens-Hansen et al. & Norway	2015a	605 seafarers, Males (569), Females (36), age 19-62 years	- Audiometric test - Questionnaire on noise exposure and health	- Hearing loss among 31.4 % of participants - Prevalence of hearing loss was higher among navigators (37.0 %) and engine room personnel (38.0 %) than electricians (23.6 %)
Kaerlev et al. & Denmark	2008	8,487 seafarers, Males	Assessment of standardized hospital contact ratios (SHCRs)	-Increased risk rates of NIHL in engine room personnel -Duration and length of employment were not associated with the NIHL

Table 2 *Studies describing noise-related non-auditory health impacts among seafarers.*

First Author & Country	**Year**	**Demographic information [N, gender, age(years)]**	**Methods**	**Outcome**
Oldenburg et al. & Germany	2020	104 seafarers, Males, age 20–62 years	- noise, vibration, and climatic parameters measurements -interview	- Reported psychological stress due to vibration (80.6%), noise (71.8%), and heat (45.7%) in the workplace - Stress due to noise exposure was frequent among engine room personnel (83.7%) and significantly less among deck crew (65.4%) - several crew members stated sleep problems caused by noise onboard
Picu et al. & Romanian Danube segment/ Danube river	2019	3 seafarers	-SPL and vibration measurements - Body temperature and blood pressure measurements - Analysis of periods of activity and sleep by means of actigraphy	- SPL of 92 dB and vibration contributed to the sleep disorder - sleep disorder accompanied by increased body temperature and blood pressure

First Author & Country	Year	Demographic information [N, gender, age(years)]	Methods	Outcome
Irgens-Hansen et al. & Norway	2015 b	87 seafarers, Males (80), Females (7) age: 31 ± 9 years	-individual noise exposure level measurement - cognitive performance assessed by a visual attention test and response time	-Response time was significantly increased among personnel exposed to >85.2 dB(A) and 77.1-85.2 dB(A) compared to personnel exposed to <72.6 dB(A)
Nikolic et al. & Montenegro	2013	seafarers on ferryboat "Kamenari"	- Noise risk assessment in five different locations on a ferryboat - Several noise exposure level measurements	- Noise exposure level exceeded the limit by about 1-5 dB [84.5 dB (A)] - Main sources of excessive noise: diesel engine, exhaust system and structural noise - Noise causes nuisance among sailors - Noise interferes with crew communication and jeopardizes navigation safety

Appendix B: Ethics Approval Letter

MEMORIAL UNIVERSITY

Interdisciplinary Committee on Ethics in Human Research (ICEHR)

St. John's, NL Canada A1C 5S7
Tel: 709 864-2561 icehr@mun.ca
www.mun.ca/research/ethics/humans/icehr

ICEHR Number:	**20230979-ME**
Approval Period:	January 5, 2023 – January 31, 2024
Funding Source:	OFI [RIS# 20200928; Moro]
Responsible Faculty:	Dr. Desai Shan Division of Community Health and Humanities
Title of Project:	*Seafarers' Perceptions and Attitudes towards Occupational Noise Exposure and Its Health Impacts in Canada: A Mixed-Methods Study*

January 5, 2023

Mrs. Fatima Hassan Hodroj
Division of Community Health and Humanities, Faculty of Medicine
Memorial University

Dear Mrs. Hodroj:

Thank you for your correspondence addressing the issues raised by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) for the above-named research project. ICEHR has re-examined the proposal with the clarifications and revisions submitted, and is satisfied that the concerns raised by the Committee have been adequately addressed. In accordance with the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2)*, the project has been granted *full ethics clearance* for **one year**. ICEHR approval applies to the ethical acceptability of the research, as per Article 6.3 of the *TCPS2*. Researchers are responsible for adherence to any other relevant University policies and/or funded or non-funded agreements that may be associated with the project. If funding is obtained subsequent to ethics approval, you must submit a Funding and/or Partner Change Request to ICEHR so that this ethics clearance can be linked to your award.

The *TCPS2* **requires** that you **strictly adhere to the protocol and documents as last reviewed** by ICEHR. If you need to make additions and/or modifications, you must submit an Amendment Request with a description of these changes, for the Committee's review of potential ethical concerns, before they may be implemented. Submit a Personnel Change Form to add or remove project team members and/or research staff. Also, to inform ICEHR of any unanticipated occurrences, an Adverse Event Report must be submitted with an indication of how the unexpected event may affect the continuation of the project.

The *TCPS2* **requires** that you submit an Annual Update to ICEHR before **January 31, 2024**. If you plan to continue the project, you need to request renewal of your ethics clearance and include a brief summary on the progress of your research. When the project no longer involves contact with human participants, is completed and/or terminated, you are required to provide an annual update with a brief final summary and your file will be closed. All post-approval ICEHR event forms noted above must be submitted by selecting the ***Applications: Post-Review*** link on your Researcher Portal homepage. We wish you success with your research.

Yours sincerely,

James Drover, Ph.D.
Vice-Chair, Interdisciplinary Committee on Ethics in Human Research

JD/bc

cc: Supervisor – Dr. Desai Shan, Division of Community Health and Humanities
Director, Research Initiatives and Services

Appendix C: Questionnaire

Seafarers' Perceptions and Attitudes Toward Occupational Noise Exposure and Its Health Impacts in Canada: A Mixed Methods Study

I. Sociodemographic information and work history

1. **Gender:**
   a. Male
   b. Female
   c. Other (Please specify) ……………………
   d. Prefer not to say

2. **Age: ……………………………………**

3. **Which province or territory do you live in?**
   a. Alberta
   b. British Columbia
   c. Manitoba
   d. New Brunswick
   e. Newfoundland and Labrador
   f. Northwest Territories
   g. Nova Scotia
   h. Nunavut
   i. Ontario
   j. Prince Edward Island
   k. Quebec
   l. Saskatchewan
   m. Yukon
   n. Other (Please specify) ………………………………….

4. **Which of these best describes the general area where you live?**
   a. Urban
   b. Rural
   c. Other (Please specify) …………………………………

5. **What is your marital status?**
   a. Married
   b. Common-Law
   c. Separated/ Divorced
   d. Single
   e. Widowed

f. Never married
g. Prefer not to say
h. Other (Please specify) …………………………………………

6. In what department do you work on the ship?

a. Deck department
b. Engineering department
c. Galley
d. Other (Please specify) ………………………………………

7. What is your current rank on the ship?

a. Master / Captain
b. Chief Officer
c. Second Officer
d. Third Officer
e. Chief Engineer
f. Second Engineer
g. Third Engineer
h. Fourth Engineer
i. Cook
j. Deckhand
k. Ordinary Seaman
l. Bridge Watchman
m. Mechanical Assistant
n. Other (Please specify) ……………………………………………

8. What types of ship do you work on? (Can choose multiple response.)

a. Container Ship
b. Bulk Carrier
c. RO-RO
d. Reefer
e. General Cargo Ship
f. Passenger Ship/ Ferry
g. Oil Tanker
h. Chemical And Product Tanker
i. Gas Tanker (LNG)
j. Other Tanker
k. Supply Ship
l. Tugboat
m. Other (Please specify) ………………………………………

9. Which of the following Canadian marine shipping regions have you worked primarily as a seafarer since January 2020?

a. Pacific West Coast Region

b. Great Lakes/ St. Lawrence Seaway
c. Atlantic Region
d. Northern Region (Includes both the Western Arctic and The Eastern Arctic)
e. Other (Please specify) ………………………………

10. What is your highest educational level?

a. Less than secondary (high) school graduation
b. Secondary (high) school diploma or equivalent
c. Some postsecondary education
d. Postsecondary certificate, diploma or degree
e. Others (Please specify) ………………………………………….

11. How long have you been working as a seafarer (in years)? ……………………….

12. How long have you been in your current job position (in years)? ……………….

13. What did you do before working as a seafarer? Please specify.

………………………………………………………………………………………

14. What is the average length of your voyage of duty?

a. One-month
b. Six weeks
c. Three months
d. Six months
e. Other (Please specify) …………………………………….

15. What is your normal duty schedule?

a. 4 hours on, 8 hours off
b. 6 hours on, 6 hours off
c. 12 hours on, 12 hours off
d. Other (Please specify) ……………………………….

II. Noise Risk Perception

We are interested in what you think about noise at your workplace. Statements about noise at work are mentioned below. Please mark each statement with **one** response **only**.

	Strongly agree	**Agree**	**Somewhat agree**	**Neither agree nor disagree**	**Somewhat disagree**	**disagree**	**Strongly disagree**
1. Work would be less stressful if it was quieter.	7	6	5	4	3	2	1

2. I will feel better if my workplace is less noisy.	7	6	5	4	3	2	1
3. Noise stops me from being able to think.	7	6	5	4	3	2	1
4. Noise has bad effects on my health other than hearing.	7	6	5	4	3	2	1
5. I do not have time to do anything about the noise at work.	1	2	3	4	5	6	7
6. Hearing protectors stop me from hearing what I want to hear.	1	2	3	4	5	6	7
7. Hearing protectors are uncomfortable.	1	2	3	4	5	6	7
8. Management is not interested in Occupational Health and Safety.	1	2	3	4	5	6	7
9. My mates at work don't worry about noise.	1	2	3	4	5	6	7
10. I cannot reduce noise at work.	1	2	3	4	5	6	7
11. I am not sure that I can use hearing protectors correctly.	1	2	3	4	5	6	7
12. I know how to use my earmuffs or earplugs.	7	6	5	4	3	2	1

13. It is difficult to make equipment quieter.	1	2	3	4	5	6	7
14. The noise at work does not bother me.	1	2	3	4	5	6	7
15. I like it when it is noisy.	1	2	3	4	5	6	7
16. I work better if it is noisy.	1	2	3	4	5	6	7
17. My hearing will not be damaged by noise at work.	1	2	3	4	5	6	7
18. It will make no difference to my hearing if it is quieter at work.	1	2	3	4	5	6	7
19. Listening to loud noise at work does not affect hearing in old age.	1	2	3	4	5	6	7
20. Noise only affects hearing in people with sensitive ears.	1	2	3	4	5	6	7

III. Auditory health

1. **Do you feel you are having any difficulty hearing?**
   a. Yes
   b. No

2. **Have you ever had a hearing test?**
   a. Yes
   b. No

3. **If you had a hearing test, was it provided through your employer?**
   a. Yes
   b. No

4. The following questions are about hearing sensitivity screening.
Please mark each question with **one** response **only**.

Part 1	**Never (or almost never)**	**Seldom**	**Occasionally**	**Frequently**	**Always (or almost always)**
Have you ever bothered by feelings that your hearing is poor?	**1**	**2**	**3**	**4**	**5**
Is your reading or studying easily interrupted by noises in nearby rooms?	**5**	**4**	**3**	**2**	**1**
Can you hear the telephone ring when you are in the same room in which it is located?	**5**	**4**	**3**	**2**	**1**
Can you hear the telephone ring when you are in the room next door?	**5**	**4**	**3**	**2**	**1**
Do you find it difficult to make out the words in recordings of popular songs?	**1**	**2**	**3**	**4**	**5**
When several people are talking in a room, do you have difficulty hearing an individual conversation?	**1**	**2**	**3**	**4**	**5**
Can you hear the water boiling in a pot when you are in the kitchen?	**5**	**4**	**3**	**2**	**1**
Can you follow the conversation when you are at a large dinner table?	**5**	**4**	**3**	**2**	**1**
Part2: For the last four questions use these labels as your answers	**Good**	**Average**	**Slightly Below Average**	**Poor**	**Very Poor**
Overall, I would judge my hearing in my right ear to be...	**1**	**2**	**3**	**4**	**5**

Overall, I would judge my hearing in my left ear to be…	**1**	**2**	**3**	**4**	**5**
Overall, I would judge my ability to make out speech or conversation to be …	**1**	**2**	**3**	**4**	**5**
Overall, I would judge my ability to judge the location of things by the sound they are making alone to be… (for example, to identify the location of a fridge/dishwasher by listening to the sound alone)	**1**	**2**	**3**	**4**	**5**

5. **Do you have any tinnitus (ringing in the ears) or other noises in your ear/s?**
    a. Yes
    b. No

→if no, please skip to question 7.

→if yes, please answer the following:

6. **Please choose the number that best describes the loudness of your usual tinnitus on the scale below:**

1	2	3	4	5	6	7	8	9	10

Very quiet Intermediate Very Loud

7. **Have you ever had any unexpected problems with balance?**
    a. Yes
    b. No

→If no, please skip to the following section IV (Hearing Protection Use)

→If yes, please answer the following question (8/ 9/ 10):

8. If yes, have you experienced any of these symptoms? (Select all that apply.)
   a. Lightheadedness or faintness
   b. Unsteadiness
   c. Vertigo (spinning)
   d. Falling frequently

9. If yes, have you been treated for this?
   a. Yes
   b. No

10. If yes, give the cause diagnosed by a specialist if known:
…………………………………………………………………………………………………

IV. Hearing protection use:

1. While at work, how often do you wear your hearing protection?
   a. Always
   b. Occasionally
   c. Never

2. Please check the primary type of hearing protection that you use
   a. Insert ear plugs
   b. Custom molded
   c. Muffs
   d. Canal caps
   e. Other (Please specify) ………………………………………..

3. How well do you feel that your hearing protection protects you from noise, on average?
   a. Under protects (filters out too little noise)
   b. Right amount of protection
   c. Overprotects (filters out too much noise)

4. Does using a hearing protection device cause any communication difficulties?
   a. Yes
   b. No

5. On average, how long do you wear your hearing protection during your work shift? ___________ hours

6. On average, how many times a day do you remove and put your hearing protection back in? _________times

Can you explain why you remove it?
………………………………………………………………………………………………
………………………………………………………………………………………………

7. **Does your hearing protection cause discomfort?**
    a. Yes
    b. No

→ If yes, answer question 8.
→ If no, skip to the final two questions related to the lucky draw.

8. **If yes, was/is the discomfort in one ear or both ears?**
    a. Left ear only
    b. Right ear only
    c. Both ears

- **Would you like to enter the lucky draw and have a chance to win one of three Amazon e-gift cards valued at $100?**
  Please provide your contact information through this separate link (Link)

- **Would you like to participate in a follow-up interview?**
  If yes. Please leave your contact information through this link (Link)
  If no. Thank you very much for joining this study.

Appendix D: Interview Guide

Occupational Noise Exposure Onboard Ships in Canada: A Qualitative Study Exploring Seafarers' Risk Perceptions and Noise-induced Health Impacts

This interview schedule consists of:

- **the opening:** welcoming the participant/providing a brief explanation about the interview/ thanking the participant
- **the main body:** participant's background/health impact of occupational noise/ hearing protection use/ safety training and management/ existing barriers and challenges to occupational health protection
- **the closing:** participant comments/ suggestions/ recommendations/ answering any questions that may be asked by the participant/ thanking the participant again

The opening:

- Thank the participant at the beginning.
- Tell them that this interview aims to understand occupational noise exposure and its impact on seafarers' health.
- Remind the participant that their participation is voluntary and that they can stop any time they want.
- Remind the participant that their identity information will not be revealed, and all responses will be anonymized.
- Remind the participant that they can skip any questions they do not wish to answer, and they can withdraw from the interview anytime without giving any explanation.

The main body

Background

1. **Can you please tell me about yourself?**

    a. What type of ship do you work on?

    b. What is your position/rank on board, and which department (engine, deck, galley or else)

    c. How long have you been working as a seafarer?

    d. How long have you been in your current job position?

    e. Can you tell me about your normal duty schedules on board and the average lengths of your voyage of duty?

Impact of occupational noise exposure

2. Does noise at the workplace bother you? Can you give me some examples of noise exposures you have?
3. In your opinion, what are the primary noise sources at your worksite during your work hours and rest hours?
4. Does noise interfere with your work? Can you explain how?
5. Have you experienced any health problems due to noise at work? If yes, what are they?
6. Have you experienced any of the following problems because of noise exposure onboard?

    a. Annoyance

    b. Stress

    c. Headache

    d. Emotional challenges

e. Sleep disturbance

f. Communication difficulties

g. Fatigue

h. Physical performance affected

i. Decision-making ability affected

j. Tinnitus (noise in your ear or head)

k. Changes in your voice volume

<Can you tell me more about xxx?>

Hearing protection use

7. What equipment and devices are available onboard for noise protection during work and rest hours? Can you show me a picture (if doing it online)

8. How do you protect yourself from loud noise at the worksite? Any different measures you follow during working hours and rest hours?

9. Do you regularly wear hearing protection devices, when exposed to high/harmful noise levels?

10. How well do you feel that your hearing protection protects you from noise? Do you think it filters the right amount of noise? Does it affect communication at workplaces?

11. Do you feel comfortable while wearing hearing protection devices? If it is not comfortable for you, can you tell me what type of discomfort you feel?

Safety Training and Management

12. Is occupational health protection from noise exposure covered in any of your training or courses required for seafarers? If yes,

a. Who arranges this training for you?

b. Are these training helpful for you to cope with the actual challenges at work?

13. In addition to using hearing protector, are there any other measures you can take to protect yourself from noise exposure?

    a. Can you please explain this to me?

    b. Can you give some examples?

14. Do you have sufficient PPE (including hearing protection devices) supplies on board, including earplugs, semi-insert earplugs, and earmuffs? Alternatively, any other equipment other than hearing protectors?

15. Has your shipowner/s helped you with the above challenges? If yes, then how?

16. Has the noise exposure included in the safety management system (incident reporting and safety communication) on board, and can you tell me more about this?

Self-reported health concerns related to noise exposure:

17. Did you notice any change in your hearing ability due to noise exposure onboard?

18. Have you previously had a hearing test? Would you mind sharing the result with me?

19. Is there any impact of this on your family and your relationships?

20. Have you ever considered leaving the ship or quitting your work as a seafarer due to noise concerns onboard?

21. If you were thinking about leaving the sector, what would be the reasons? Can you tell me if that is related to noise or if there are other reasons?

22. In your opinion, what are the obstacles and challenges in preventing noise-related harm to people or seafarers onboard in a shipping sector?

    a. At the law/policy level

b. At the Employer/Company level

c. At the Union level, if you are a union member

d. At the individual level

23. If there is one thing that could help you reduce the noise you work in, what would it be?

24. Are you covered by workers' compensation or supplementary health insurance? If yes, did you claim hearing loss in the past?

The closing:

Final comments:

- Do you have any suggestions? What measures may help you to prevent noise-related health problems?
- Is there anything else that you would like to share with us?

Once again, thank you for providing your valuable time and input for this study.

If you wish to be kept informed of the study's final results, please provide your email address. We will send you a copy of the journal paper once it is accepted for publication.
This research is a master's thesis, and it will be publicly available on the web page of Queen Elizabeth Library II (QEII) of Memorial University in the thesis collection/research repository section at https://research.library.mun.ca/.