COMMUNICATION HEADSETS IN THE WORKPLACE: ACCESSIBILITY TO NOISE EXPOSURE MEASUREMENT IN CANADA

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Résumé

L'utilisation des casques de communication ou autres appareils d'écoute contribuent à l'exposition du bruit des travailleurs, ceux-ci étant sujets à la fois à l'exposition par le signal audio du casque de communication et le bruit ambiant externe. Deux méthodes spécialisées sont décrites dans ISO 11904 pour la mesure directe de l'exposition au bruit sous les casques de communication : la sonde microphonique dans l'oreille et le mannequin acoustique. D'autres normes proposent l'utilisation de techniques plus simples utilisant une oreille artificielle ou une méthode indirecte de calcul (AS/NZS 1269.1, CSA Z107.56). Par contre, il y a présentement peu d'information sur les techniques courantes utilisées par les chercheurs, les audiologistes, les hygiénistes du travail, et autres professionnels pertinents en santé et sécurité au travail. Un questionnaire a été distribué à des intervenants en santé et sécurité au travail et en prévention de perte auditive au Canada afin de documenter leur notion de la problématique, leurs connaissances sur les différents outils de mesure, et leur accès à cet équipement. Les résultats illustrent que les connaissances sur l'équipement de mesure spécialisé et l'accès à l'équipement nécessaire varient selon la formation des professionnels. Ce sondage justifie la nécessité de proposer diverses méthodes de mesure dans les normes pour évaluer l'exposition au bruit provenant des casques de communication afin de répondre aux besoins des différents groupes de professionnels.

Mots clefs: casques de communication, mesures, mannequin acoustique, oreilles artificielles

Abstract

Use of communication headsets and other wearable listening devices can contribute to increased noise exposure at the workplace as users are subjected to both the audio signal from the headset and the surrounding external noise. Two specialized methods are described in ISO 11904 for direct measurement of sound exposure from communication headsets: the Microphone in a Real Ear and the acoustic manikin. Other standards also propose the use of simpler artificial-ear procedures or an indirect calculation method (AS/NZS 1269.1, CSA Z107.56). However, there is currently little information related to the use of all these methods by researchers, audiologists, occupational hygienists, and other relevant professionals. A questionnaire was distributed to stakeholders in occupational health and safety and hearing loss prevention in Canada to document their awareness of the problem, their knowledge of the different measurement tools, and their access to this equipment. Results illustrate that knowledge of specialized measurement techniques and access to the necessary equipment varies significantly depending on the type of training of the different professionals. This survey therefore validates the need to propose several methods in measurement standards to assess noise exposure from communication headset to serve the needs of the different groups of professionals.

Keywords: communication headsets, measurements, acoustic manikin, artificial ears

1 Introduction

Noise-induced hearing loss is often the result of a noisy workplace and is the second most prevalent self-reported work-related injury [1, 2]. Twenty-two million Americans are subjected to hazardous noise levels in their workplace [3]. It has also been estimated that three million Americans can be exposed to high levels of noise due to their use of headsets on the job [4]. Similar figures are currently not available for the Canadian population. Nevertheless, in the past decade, there has been an increase in the use of wired and wireless headsets in various occupational settings worldwide, e.g. in call centres, retail stores and fast food outlets, airport ground and control tower operations, industrial and construction sites, military sites, law-enforcement agencies, etc [5, 6]. Some workers wear noise-reducing headsets or advanced technologies, as exemplified by airline pilots or military personnel, to attenuate the very noisy background and enhance the communication signal. Others, such as call center operators, use hands-free communication headsets or low attenuation devices in an environment where background noise is not as significant.

Several factors ranging from field logistics to data transformation arise when conducting measurements of noise exposure from headsets [5, 6, 7]. Firstly, workers wearing communication headsets are simultaneously exposed to two sound sources both contributing to the total exposure level: the surrounding workplace noise passing through the headset and the internal audio signals from the device. Secondly, since sound from the headset is produced at or in the ears, the acousto-mechanical properties of the

head, pinna, and ear canal must be considered. Thirdly, in order to achieve a valid assessment, measurements must be carried out in a safe manner while workers are conducting their normal duties. Lastly, after the data is collected, in-ear measurements must be converted to the sound field to enable comparison with occupational noise limits.

As a result of the above factors, and in contrast to general noise measurements surveys conducted with a sound level meter or dosimeter, specialized equipment and techniques are required for occluded-ear sound measurements from communication headsets. Over the last forty years, several studies have focused on noise assessments from communication headsets in various occupational settings using a range of measurement methods [6]. Results from these field studies indicated that noise exposure was often dependent on external background noise and in some cases exceeded regulatory limits.

A range of noise exposure assessment methods, varying widely in complexity and required expertise, have been proposed by different standardization bodies [5, 6, 7]. The International Organization for Standardization describes two techniques for noise measurements under occluded ears: the Microphone in a Real Ear or MIRE (ISO 11904-1) and the acoustic manikin (ISO 11904-2) [8, 9]. Alternative methods using ear simulators and artificial ear procedures have also been standardized (AS/NZS 1269.1, CSA Z107.56-13) [10, 11]. All these techniques are specified in the recently revised CSA Z107.56-13 standard [11]. In addition, this Canadian standard also specifies an indirect calculation method requiring only a sound level meter or noise dosimeter, and necessitating much less expertise.

Stakeholders in occupational health and safety (OHS) and related professionals in hearing loss prevention (HLP) face the constraint of having little access to resources to conduct noise exposure measurements from communication headsets. It is not known if these stakeholders and professionals have access to specialized equipment or if simpler techniques using a sound level meter or noise dosimeter could fill a gap in measurement accessibility.

The goal of this paper is to report on a survey of OHS and HLP professionals in Canada in order to document their awareness on the issue of communication headset noise exposure, their knowledge on the different measurement tools available, and their access to basic and specialized equipment. Stakeholders that may have encountered situations where communication headsets were worn include audiologists, occupational hygienists, health and safety consultants, acoustical consultants, health workers, and other relevant individuals responsible for health and safety in their workplace. Survey results could guide future revisions of noise exposure measurement standards and suggest guidelines on the best practices to adopt according to available resources and the specific training of the various stakeholders.

2 Methods

2.1 Questionnaire Development

A bilingual questionnaire was created focusing on several issues including the level of awareness on the methods of noise exposure assessment with communication headsets, and the access to measurement equipment among OHS and HLP stakeholders in Canada. The English version of the questionnaire was carefully reviewed by three experts in noise in the workplace: two professors in Audiology and Speech-Language Pathology and one professor in Electrical Engineering. The French version of the questionnaire was also reviewed by three experts in the field: two audiologists and one professor in Audiology and Speech-Language Pathology. Both versions were adapted accordingly and comments were integrated to define the final questions. The questionnaire was finalized following a review by a researcher in acoustics and noise.

A total of twenty-five multiple choice, checkbox, and open text box questions were prepared and entered in an online-based platform, FluidSurveys, to create a four-part bilingual questionnaire entitled *Communication Headsets; Use and Noise Measurement in the Workplace / Casques de communication; L'utilisation en milieu de travail et la mesure d'exposition au bruit associée*. The content of the first part, *General Information*, was designed to gather demographic information about the experience, training, and workplace of the respondents. The second section of the questionnaire, *Noise Measurement in the Workplace*, captured their level of awareness on hearing loss prevention and use of communication headsets in the workplace, their knowledge on measurement techniques as well as their access to measurement equipment. The third section of the questionnaire, *Experience in Noise Measurement under Communication Headsets in the Workplace*, was only answered by individuals who confirmed having taken communication headset measurements at least once during their career. The fourth part of the questionnaire surveyed respondents on their opinions regarding the *Availability of Information on Communication Headset Usage in the Workplace*. Table 1 provides the complete list of questions.

2.2 Questionnaire Distribution

The questionnaire was delivered to the widest possible array of OHS and HLP stakeholders in Canada covering researchers, practitioners, consultants, and regulators during a seven month period, from May 2013 to November 2013. Associations, professional groups, and other organizations involved in workplace health and safety, hearing loss prevention, and/or occupational noise measurements were targeted. The questionnaire was distributed by the following means: requests through email to a network of the researchers' contacts, hard copies handed-in at professional events, direct requests to members of associations, and invitations through third-party distribution lists via email and/or electronic news bulletins. Table 2 provides the complete list of professional groups, associations and organizations contacted, as well as the events attended, and the respective means of distribution of the questionnaire.

Table 1: Complete list of items presented in the questionnaire.

General Information / Renseignements généraux	
Professional training (college/university degree(s),..).	Open text box
Health and safety training specific to noise exposure, if any.	Open text box
Current workplace (specify if it is in the public or private sector).	Open text box
Current position title.	Open text box
Number of years of experience in health and safety in the workplace.	Open text box
Number of years of experience in health and safety specific to noise exposure in the workplace.	Open text box
Role with regard to health and safety in the workplace.	Multiple choice
Noise Measurement in the Workplace / Mesure du bruit dans le milieu de travail	
How would you judge your level of awareness on noise measurement and hearing loss prevention in the workplace?	Multiple choice
Do you have access to basic equipment (e.g., sound level meter, dosimeter) to measure noise levels in the workplace?	Multiple choice
Select all the equipment that applies and specify the type/manufacturer/model.	Checkboxes
How would you judge your level of awareness on the problem of noise exposure from the use of communication headsets in the workplace?	Multiple choice
How would you judge your level of awareness on the techniques of noise measurement under headphones and communication headsets, more specifically using an acoustic manikin, a microphone in a real ear, or artificial ears?	Multiple choice
Do you have access to specialized equipment (e.g., acoustic manikin, artificial ear, microphone in a real ear) to measure noise levels of sound sources close to the ear (e.g., communication headsets, earphones, hearing aids, etc)?	Multiple choice
Select all the equipment that applies and specify the type/manufacturer/model.	Checkboxes
Have you ever done interventions (e.g., measurements, discussions, proper headset selection) with regard to the use of communication headset in the workplace?	Multiple choice
During your interventions, have you taken measurements of noise exposure under communication headsets?	Multiple choice
Experience in Noise Measurement under Communication Headsets in the Workplace / Expérience de mesure du bruit sous les casques de communication en milieu de travail	
Please select all the workplace environments where you have taken noise exposure measurements from communication headsets.	Checkboxes
In total throughout your career, for approximately how many workers have you taken noise exposure measurements under communication headsets?	Multiple choice
Under which types of communication headset configuration have you taken measurements?	Checkboxes
Under which types of earphones on the communication headsets have you taken measurements?	Checkboxes
Did the communication headsets have the following elements? (Three elements listed in questionnaire)	Multiple choice
What equipment have you used to measure noise exposure under communication headsets?	Checkboxes
Did you correct the measured values to be representative of the worker's exposure? (Three types of corrections listed in questionnaire)	Multiple choice
Did the results obtained from the noise exposure measurements demonstrate that an intervention programme should be put in place in this/these workplace(s)? (Four types of interventions listed in questionnaire)	Multiple choice
Please provide additional information on your experience measuring noise under communication headsets in the workplace.	Open text box
Availability of Information on Communication Headset Usage in the Workplace / Accès à l'information sur les casques de communication en milieu de travail	
Do you see value in increasing the spread of information on communication headsets, noise measurement methods under these devices, and the safe use of these devices, to individuals in the field of health and safety in the workplace?	Open text box
What do you think would be the best way to spread this information to individuals in the field of health and safety? (e.g., workshops, information sheets, etc.).	Open text box

Table 2: Associations, professional groups and organizations contacted, events attended, and means of distribution of the questionnaire.

Association/Groups/Event	Distribution Method of Questionnaire Link
Academics from different universities	Email to a network of contacts
Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA)	Email to members through a third party via a monthly issue of an electronic newsletter
Canadian Audiology Association (CAA)	Email to members through a third party
Canadian Center for Occupational Health and Safety (CCOHS)	Email to a distribution list
Canadian Hearing Report	Email to a distribution list through a third party via a monthly issue of an electronic newsletter. Also posted on social media
Canadian Registration Board of Occupational Hygienists (CRBOH)	Email to contacts
Occupational Hygiene Association of Ontario (OHAO)	Email to members through a third party via a monthly electronic news bulletin
Occupational Hygiene Association of Ontario (OHAO) professional development course attendants	Distribution to event participants
Occupational hygienists in the province of Quebec	Email to contacts through a third party
Ordre des orthophonistes et audiologistes du Québec (OOAQ)	Email to members through a third party via a monthly info-letter
Ordre des orthophonistes et audiologistes du Québec (OOAQ) Colloquium on Hearing Loss in the Workplace	Distribution to event participants
Standardization/Technical committee members	Email to a network of contacts
Sustaining subscribers of the Canadian Acoustical Association	Email to contacts

Distribution of the questionnaire was approved by the Office of Research Ethics and Integrity at the University of Ottawa. Within the FluidSurveys platform, the identity of the respondents of the questionnaire is anonymous. Due to third party distribution, the total number of OHS and HLP stakeholders reached is unknown. From 2009 to 2011, there were approximately 2600 audiologists and speech-language pathologists on record according to Service Canada [12]. Also, based on a Cross Canada Survey conducted in 2010, there were 1760 reported occupational hygienists [13]. The proportion of these professionals active in HLP is however not documented.

3 Results

In all, 93 questionnaires were completed and received. Five questionnaires were removed due to missing information or because they were deemed from an ineligible source (e.g., outside of the country). A total of 88 questionnaires were considered in the data analysis.

3.1 General Information

The respondents' experience in workplace health and safety was distributed nearly uniformly from no experience to over 31 years in the field (Figure 1). Different levels of responsibility were noted across respondents as they were asked to define their role with regard to health and safety (Table 3) within their respective workplaces (Table 4).

Table 3: Role with regard to OHS in the workplace (n = 88).

Role	Respondents
Health and safety consultant	9
Acoustical consultant	8
Responsible for health and safety in my workplace	22
Health worker - Public health sector	21
Health worker - Provincial workplace compensation board	5
Professor or researcher	10
Health worker in private sector	3
Combination of two or more of the roles above	3
Other/Unspecified	6
No answer	1

In terms of health and safety training specific to noise exposure, some respondents attested having taken a course in noise and hearing protection, safe exposure to noise, hearing conservation, noise measurements, or industrial noise reduction as part of their educational degree. Others attributed their specific training or knowledge on noise exposure to their work experience or collaborations. Approximately 10% of respondents noted having no formal training in this area.

Based on the diversity of respondents' professional training, current workplace (Table 4), number of years of experience in health and safety in the workplace (Figure 1), and role with regard to health and safety in their workplace (Table 3), respondents were grouped into four distinct types for subsequent analyses: Researchers (n = 14), Audiologists (n = 32), Occupational Hygienists (n = 18), and Others (n = 24). Individuals in the *Researchers* category were of various educational levels (nine doctoral degrees, two master's degrees, one medical doctor, and two bachelor's degrees) and conducted research in academia or governmental settings in acoustics, noise control, health and safety, or related fields. *Audiologists* were defined as individuals with formal university training in Audiology and who were active practitioners. Of these respondents, thirty-one had a master's degree in Audiology degree and one had a master's degree in Speech-Language Pathology. The *Occupational Hygienists* category included individuals who had a background in health and safety management and control in the workplace, or related fields. Of these respondents, ten held a master's degree, two held a bachelor's degree, and six held a college diploma. The *Others* category was comprised of individuals involved in standardization bodies related to OHS and/or were acoustical consultants. Respondents in this heterogeneous group had attained various levels of education (one doctoral degree, four master's degrees, four bachelor's degrees, ten college diplomas, three with no postsecondary education).

Table 4: Current workplace of respondents (n = 88).

Sector	Workplace	Respondents
Public	University	9
	Workplace Health and Safety	7
	Transportation/Utilities	9
	Health Care/Clinical	13
	Other/Unspecified	28
Private	Health Care/Clinical	9
	Company/Manufacturer/Plant	13

3.2 Noise Measurement in the Workplace

In the second part of the questionnaire, respondents were asked to provide information on their level of awareness on hearing loss prevention, on the problem of noise exposure from headsets, and on the techniques of noise measurement from headsets. Group results are presented in Figure 2.

Across groups, respondents generally assessed their level of awareness on noise measurement and hearing loss prevention in the workplace mainly from good to excellent (Figure 2). When asked more specifically about their level of awareness on the problem of noise exposure from the use of communication headsets, respondents reported having mostly little awareness on the topic (Figure 2). Regarding the specific techniques of noise measurement from communication headsets (e.g., acoustic manikin, microphone in a real ear, artificial ears), the level of awareness varied widely between groups (Figure 2). *Researchers* indicated that they had little to excellent awareness; *Audiologists* mostly little or good awareness; *Occupational Hygienists* and *Others* little or no awareness.

Access to basic equipment for the measurement of noise levels in the workplace and to specialized equipment for the measurement of sound sources close to the ears differed across categories of respondents (Table 5). At least one basic noise measurement tool (i.e., sound level meter and/or noise dosimeter) was accessible to all *Researchers*,

all *Occupational Hygienists*, a third of the *Audiologists*, and half of the individuals in the *Others* group. Access to specialized equipment was not as common. Most *Researchers* (11/14) had access to an acoustic manikin, a type of artificial ear, and/or a MIRE system. About half of the *Audiologists* (14/31) had access to an acoustic manikin, a type of artificial ear or more predominantly to a MIRE system such as found in hearing aid electro-acoustic analysers (e.g., Verifit®, Fonix, Affinity, OTOPro). Few individuals in *Others* (3/24) had access to an acoustic manikin, a type of artificial ear, or a MIRE system. None of the 18 *Occupational Hygienists* had access to any of these specialized measurement tools.

3.3 Noise Measurement from Communication Headsets in the Workplace

Respondents were asked about their experience carrying out interventions related to the use of communication headsets in the workplace (i.e., measurements, discussions on safe use of headsets, selection of headsets). Of the 88 respondents, 50 had never been involved in such situations. Among the remaining 38 individuals, only three respondents (two *Researchers*, one *Audiologist*) had carried out noise measurements from communication headsets in the workplace at least once during their career. These three cases specified having collected such measurements for a range of 1 to 35 workers in specific settings including call centers, airports, and/or in a clinical setting. The two *Researchers* respondents attested to the need for noise reduction interventions for some of the workplaces where they had conducted their measurements. They emphasized the importance of conducting such noise evaluations.

3.4 Information on Communication Headset Usage in the Workplace

In the last part of the questionnaire, respondents were asked about their views for spreading knowledge on noise measurement methods suitable for communication headsets in the workplace. Most respondents (96%) agreed that there is value in spreading information on this topic. Respondents commented on the lack of information and resources available to relevant OHS stakeholders on this problem. In particular, they indicated that there is a lack of information provided to, or discussed with, the workers.

Respondents indicated that there is a misconception of the risks involved in the use of communication headsets in occupational settings. Factors such as headset attenuation, signal to noise ratio, and daily duration of the signal in the headset, for example, are reported not being considered.

In order to increase the spread of knowledge on the problem of communication headsets in the workplace and related noise measurements, respondents suggested various methods of information diffusion. Firstly, one respondent mentioned that the standardization and regulation bodies could help diffuse the information. Secondly, several respondents indicated that stakeholders in OHS could be reached through such methods as formal group settings (e.g., conferences), written documents (e.g., information, brochures,

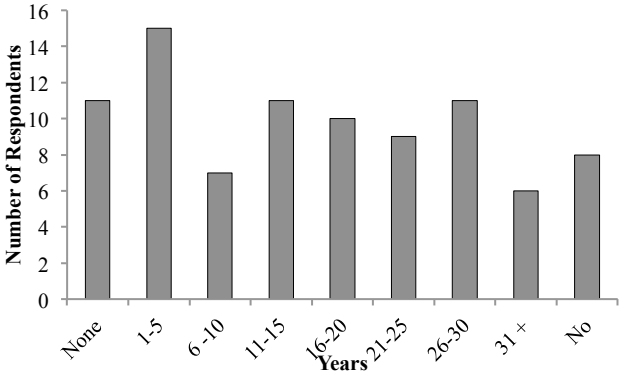

Figure 1: Distribution of the number of years of experience of respondents in health and safety in the workplace (n = 88).

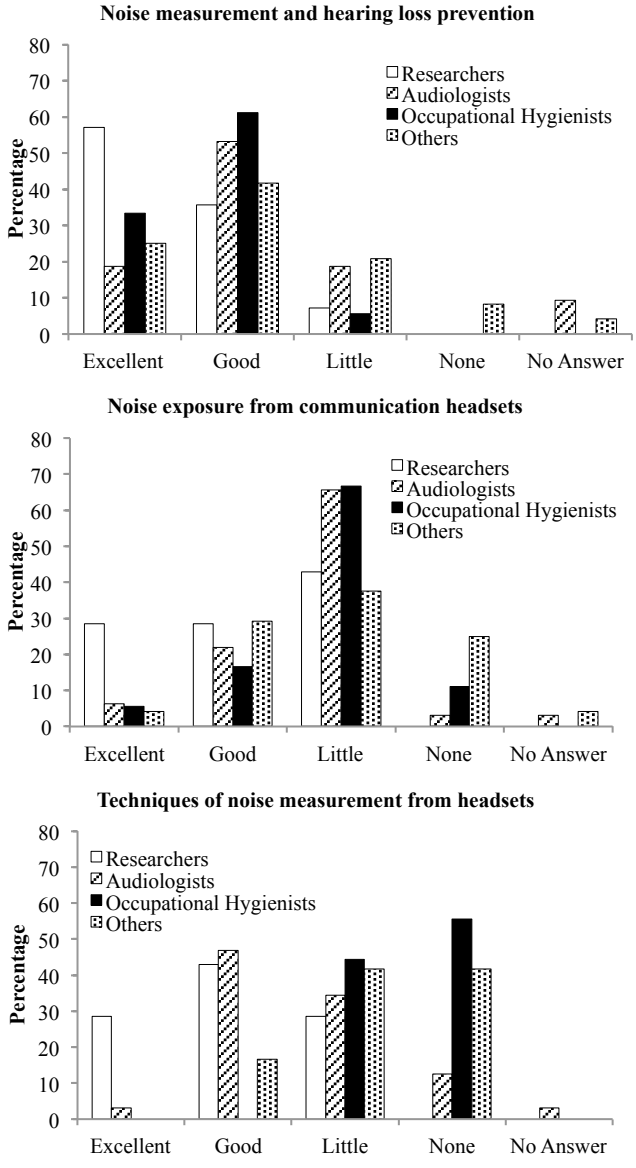

Figure 2: Level of awareness on: noise measurement and hearing loss prevention in the workplace; the problem of noise exposure from the use of communication headsets in the workplace; and the techniques of noise measurement from headphones and communication headsets, more specifically using an acoustic manikin, a microphone in a real ear, or artificial ears.

Table 5: Access to basic (e.g., sound level meter, dosimeter) and specialized (e.g., acoustic manikin, microphone in a real ear, artificial ears) noise measurement equipment. Note: One audiologist did not answer the question on specialized equipment.

Categories	Basic Equipment		Specialized Equipment	
	Yes	No	Yes	No
Researchers	14	0	11	3
Audiologists	11	21	14	17
Occupational Hygienists	18	0	0	18
Others	12	12	3	21

articles in magazines and journals, websites), online media (e.g., webinars, videos), and professional development courses or active workshops. In addition, the benefit of including formal or online training and certification exams on the topic was noted. Thirdly, a few respondents mentioned that manufacturers and distributors could include more information on the safe use of communication headsets (e.g., with regard to signal to noise ratio) with their products.

4 Discussion

Due to complicated field logistics, specialized measurement tools, and complex data transformation steps, measurement of sound under headphones and headsets is a challenging task. In anticipation of the measurement difficulties and the wide range of expertise of potential users of the measurement tools, CSA Z107.56-13 defined several methodologies for noise measurements from communication headsets. At the time of publication of the revision of the standard in August 2013, little information was known about the prospective users of the different measurement methods. The present study, carried out from May 2013 to November 2013, documents the level of expertise of OHS and HLP stakeholders in Canada for making noise measurements with headsets, and the accessibility of basic and specialized equipment by these potential users of the standard. More specifically, this work allows gaining more insight into the different needs and technical expertise among relevant stakeholders in the field of health and safety or hearing loss prevention in Canada.

Results from the questionnaire indicated that knowledge on the techniques of noise measurement with communication headsets and access to specialized equipment varies significantly according to the different types of stakeholders in OHS and HLP (i.e., *Researchers*, *Audiologist*, *Occupational Hygienists*, *Others*). While most *Researchers* have access to some form of specialized equipment (e.g., acoustic manikin, artificial ear, MIRE, and/or F-MIRE), other specialized tools are more accessible to *Audiologists* (e.g., hearing aid analysers). In contrast, *Occupational Hygienists* did not report having access to any specialized measurement tool (Table 5). Still, this group of professionals may be required by their task description to take noise measurements in occupational settings including the assessment of noise from communication headsets. However, given their good overall awareness of issues pertaining to noise measurement and hearing loss prevention (Figure 2), and their access to basic measurement equipment such as a noise dosimeter or sound level meter (Table 5), an alternative measurement method is warranted for these professionals. To fill this need, CSA Z107.56-13 proposes a simple calculation method that requires the use of a sound level meter or noise dosimeter and computation steps based on an equation that considers the external background noise level, the noise reduction of the device, and the relationship between the listening volume set by the user and the residual noise under the headset [11]. On the other hand, *Audiologists* and *Researchers* may find specialized measurement methods to be more suitable for their needs. Given the heterogeneous characteristics of the participants in the *Others* category (primarily individuals involved in standardization bodies related to OHS and acoustical consultants), it is difficult to anticipate their preferred measurement method. However, only 13% of them reported having access to specialized equipment and the CSA Z107.56-13 calculation method may also be warranted for this group.

The results of this survey therefore validate the need to propose several direct specialized methods and indirect calculation procedures for communication headset noise exposure assessments, tailored to different groups of professionals and taking into account their respective role, expertise, and access to equipment.

5 Conclusion

In general, there is a wide range of expertise regarding noise measurement from communication headsets. Furthermore, access to basic and specialized equipment varies across the different types of professionals in Canada. Despite the diversity of training across OHS and HLP stakeholders that can be involved in communication headset interventions, there is certain homogeneity within groups of professionals. This validates the need to develop guidelines and training material specific to each group of stakeholders. Further research is also needed regarding the compatibility of the different measurement methods, which is largely un-documented.

Acknowledgements

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