

Lecture Notes in Mechanical Engineering

Mohd Hasnun Arif Hassan

Mohd Nadzeri Omar

Nasrul Hadi Johari

Yongmin Zhong *Editors*

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Lecture Notes in Mechanical Engineering

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Editors

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Preface

Technological advancements have significantly benefited humans. Technology has led to the development of ergonomic tools and equipment that improve human comfort, reduce strain, and enhance overall productivity. From adjustable office chairs to ergonomic keyboards, these innovations promote proper posture and reduce the risk of musculoskeletal disorders. When it comes to road safety, technology has played a pivotal role in saving lives and preventing accidents. Advanced driver assistance systems (ADAS) equipped with sensors, cameras, and artificial intelligence algorithms help detect potential hazards, warn drivers, and even intervene if necessary. In the realm of sports technology, advancements have revolutionized training methodologies and performance analysis. Athletes now have access to wearable devices that monitor their biometric data, providing insights into their physical condition, performance metrics, and injury prevention. Further, technological advancements have led to sophisticated tools and methods for studying the human body's mechanics and movement. High-speed cameras, force sensors, and motion-tracking systems enable researchers to gain deeper insights into human locomotion, joint mechanics, and muscle activation patterns. These findings help design better prosthetics, rehabilitation programs, and ergonomic solutions tailored to individual needs.

The “Unlocking Human Potential: The Future of Human Engineering” symposium seeks to delve into the cutting-edge field of human engineering, exploring the possibilities of augmenting and optimizing human capabilities through advancements in science, technology, and design. This symposium brings together experts from various disciplines to discuss and showcase innovative approaches, methodologies, and ethical considerations in the realm of human engineering. From neuroenhancement to prosthetics, cognitive augmentation to genetic engineering, this symposium aims to stimulate insightful discussions and inspire the creation of a future where human potential knows no bounds.

Pekan, Malaysia

Mohd Hasnun Arif Hassan

Contents

Developing a Survey Tool to Measure Psychosocial Risk and Work Performance at a Workplace	1
Nuruzzakiyah Mohd Ishanuddin, Hanida Abdul Aziz, and Ezrin Hani Sukadarin	
Enhancing Mental Health Through Ambient Lighting	19
Ilhamy Isyraq bin Ahmad Fadzil, Aimi Shazwani Ghazali, Farahiyah Jasni, and Muhammad Hariz bin Hafizalshah	
Parameter Extraction of Muscle Contraction Signals from Children with ASD During Fine Motor Activities	33
Nor Zainah Mohamad, Nur Azah Hamzaid, and Muhammad Haziq Ahmad Fauzi	
Design of Hose Roller for Firefighter: A Fatigue Study	43
Mohammad Luqman Hakim Mustapha, Salwa Mahmood, Helmy Mustafa El Bakri, Ismail Abdul Rahman, Noorul Azreen Azis, and Mohd Rizal Buang	
Noise Risk Assessment on Noise Exposure Among Urban Rail Maintenance Workers Using Personal Monitoring Method	57
M. Mifzal-Nazhan, J. Azlis-Sani, A. Nor-Azali, Y. Nur-Annuar, S. Shahrul-Azhar, and A. Mohd-Zulhelmi	
Bangla Text Summarization Analysis Using Machine Learning: An Extractive Approach	65
Mizanur Rahman, Sajib Debnath, Masud Rana, Saydul Akbar Murad, Abu Jafar Md Muzahid, Syed Zahidur Rashid, and Abdul Gafur	
Human Factors: Drivers' Speed Choice on Relatively Low-Speed Limit Roads	81
Othman Che Puan, Azlina Ismail, Khairil Azman Masri, and Muhammad Shafiq Mohd Rozainee	

Topology Optimization for Custom Bed-Resting Ankle Foot Orthosis	95
Amir Mustakim Ab Rashid, Effi Zuhairah Md Nazid, Muhammad Hazli Mazlan, Azizah Intan Pangesty, and Abdul Halim Abdullah	
Influence of Environmental Factors and Road Characteristics in Commuting Accidents Among Public University Staffs	107
Mohd Najib Yaacob and Khairiah M. Mokhtar	
Effects of Material Properties in Developing the Ear Prosthetics	119
Abdul Halim Abdullah, Mohd Noor Asnawi Mohd Noordin, Suziana Ahmad, Nor Fazli Adull Manan, and Shahrul Hisyam Marwan	
Study of Primary Stability of Hip Implant for Semi Hip Replacement by Using Finite Element Analysis	133
Haslina Abdullah, Mohamad Shukri Zakaria, and Norfazillah Talib	
Investigation of Mental Health Condition Among Factory Worker During Covid pandemic–A Cross-Sectional Study	145
Irna Syahira Hassan, Nur Fazhilah Abdul Razak, Junaidah Zakaria, and Ezrin Hani Sukadarin	
The Influence of Body Balance Towards the Golf Putting Performance	161
Abdul Raouf Abas, Mohd Nadzeri Omar, Nasrul Hadi Johari, and Mohd Hasnun Arif Hassan	
Risk Assessment for Manual Handling Activities in a Dairy Industry ...	173
Khairulhafiy Muhammad Ruzairi, Ezrin Hani Sukadarin, Mirta Widia, and A. Alaman	
Brief Review of Recent Study on Fluid–Structure Interaction Modeling of Blood Flow in Peripheral Arterial Disease	185
M. Firdaus M. Fauzi, Nasrul Hadi Johari, and M. Jamil M. Mokhtarudin	
Head Injury During Heading of Two Types of Sepak Takraw Balls: Analytical Approach	199
Nik M. Haikal M. Hassan, Nasrul Hadi Johari, Mohd Hasnun Arif Hassan, Idris Mat Sahat, Mohd Nazderi Omar, and Zulkifli Ahmad	
Fluid–Structure Interaction (FSI) Modelling in Stenotic Carotid Artery Bifurcation	209
A. Rusydan Alias and Nasrul Hadi Johari	
Prediction of Atherosclerosis in Peripheral Arterial Disease Using Computational Fluid Dynamics Modelling	223
Ukasyah Zulfaqar Shahrulakmar, Nasrul Hadi Johari, Juhara Haron, Chandran Nadarajan, and M. Nadzeri Omar	

Impact Analysis of Motorcycle Helmet: Finite Element Modeling 239
 N. Aimi Huda and M. S. Salwani

The Protective Performance of Different Types of Motorcycle Helmets in Terms of HIC and BrIC 249
 N. Q. Radzuan, M. H. A. Hassan, M. N. Omar, and K. A. Abu Kassim

Measuring Running Performance Through Technology: A Brief Review 263
 Siti Rabiattull Aisha Idris

Experimental Study of Gait Monitoring on Wearable Shoes Insole and Analysis: A Review 273
 Nur Wahida Saadion and Mohd Azrul Hisham Mohd Adib

Preliminary Ergonomics Analysis of Sit-Stand (STS) Desk on the Patient with Lower Back Pain Problem: A Case Study 289
 Muhammad Rafli Salim Hasan Raza,
 Mohd Azrul Hisham Mohd Adib, and Nurul Shahida Mohd Shalahim

Developing a Survey Tool to Measure Human Factors Constructs for Personal Hearing Protector (PHP) Use Among Industrial Workers—First Phase 299
 Nur Syafiqah Fauzan, Mirta Widia, and Ezrin Hani Sukadarin

A Review on the Pedal Error Cases Among Car Drivers in Malaysia ... 313
 Nursya Mimie Ayuny Ismail, Mohamad Zairi Baharom,
 Zulkifli Ahmad, Mohd Hasnun Arif Hassan, Juffrizal Karjanto,
 Zulhaidi Mohd Jawi, and Khairil Anwar Abu Kassim

Study of Anxiety Parameters and Sensors Related to Monitoring the Anxiety Concentration Index Level Among Archer Athletes: A Review 327
 Nur Khalijah Kamarudin, Wan Nurlisa Wan Ahmad,
 and Mohd Azrul Hisham Mohd Adib

EEG and EMG-Based Multimodal Driver Drowsiness Detection: A CWT and Improved VGG-16 Pipeline 339
 Mamunur Rashid, Mahfuzah Mustafa, Norizam Sulaiman,
 and Md Nahidul Islam

Rehabilitation and Gamification Technology Device for Lower Extremities Patient: A Review 351
 Mohd Adib Syazwi Ismail and Mohd Azrul Hisham Mohd Adib

The Importance of Proper Motorcycle Helmet Buckling: A Scientific Study 363
 N. Q. Radzuan, M. H. A. Hassan, M. N. Omar, N. A. Othman,
 M. A. Mohamad Radzi, and K. A. Abu Kassim

A Short Review on Development of Table Tennis Robotic Launcher	377
Irlina Jazlin Jamaludin, Zulkifli Ahmad, and Mohamad Zairi Baharom	
Reusability Study of 3D Printing Mould and Resin Casting for Takraw Ball Launcher Wheel	389
Idris Mat Sahat and Nasrul Hadi Johari	
Development of Noise Risk Assessment (NRA) and Management System	399
Kirubalini Asok Kumar, Nur Syafiqah Fauzan, Mirta Widia, Ezrin Hani Sukadarin, Nor Liyana Man, and Mohd Ikhwan Mohd Ibrahim	
Framework of Safety Helmet Compliance Detection and Employee Tracking by Using Quick Response (QR Code) Technology	415
Nuraini Wahidah Rusli, Hanida Abdul Aziz, and Naz Edayu Mat Nawi	
e-HIRARC Tool for Brick Laboratory in Civil Engineering Department at TVET (Technical and Vocational Education Training) Campus	425
Masita Hassan, Hanida Abdul Aziz, and Mohd Zahidi Rahim	
A Review of Biomechanical and Psychosocial Risk Factors Among Workers	437
Khairulhafiy Muhammad Ruzairi, Ezrin Hani Sukadarin, Mirta Widia, and A. Alaman	
Knowledge and Awareness of Road Safety Among University Students	445
Nur Nakhirah Najwa Musni, Wan Norlinda Roshana Mohd Nawi, and Mirta Widia	
Riding Towards Safety: Examining the Patterns of Motorcycle Accidents in Malaysia	455
N. Q. Radzuan, M. H. A. Hassan, M. N. Omar, N. A. Othman, and K. A. Abu Kassim	
Development of Automatic Cervical Brace for Neck Pain Rehabilitation	469
M. Z. Ahmad Fazril, Nur Haizal Mat Yaacob, Norsuhaily Abu Bakar, Mohamad Shaban AlSmadi, and Nasrul Hadi Johari	

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Dr. Mohd Hasnun Arif Hassan earned his first degree in Mechanical Engineering from the Technische Hochschule Bingen, Germany, in 2010. During the final year of his undergraduate study, he was offered a scholarship by Universiti Malaysia Pahang (UMP) to pursue a Master's degree in Mechanical Engineering at the University of Malaya in Kuala Lumpur, which he graduated with distinction in 2012. After that, he embarked on his Ph.D. journey at UMP where he studied about the head injury sustained by soccer players due to heading manoeuvre. He completed his Ph.D. study in 2016 and then continued to serve UMP as a senior lecturer. His research interests include finite element modelling of the interaction between human and sports equipment, instrumentation of sports equipment, and injury prevention particularly with regards to sports and traffic accidents. His work aims to apply engineering principles in sports not only to enhance the performance of an athlete but also to prevent injuries.

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Developing a Survey Tool to Measure Human Factors Constructs for Personal Hearing Protector (PHP) Use Among Industrial Workers—First Phase



Nur Syafiqah Fauzan , Mirta Widia , and Ezrin Hani Sukadarin 

Abstract The survey tool (questionnaire) is one of the most widely used tools to collect data. This paper aims to develop a survey tool of human factors and personal hearing protector (PHP) use among industrial workers. The survey tool is developed based on the combination of the Health Promotion Model (HPM) and Health Belief Model (HBM). Development of the eight main constructs in the survey included narrative literature and qualitative review by the two expert panels of researchers in the related field. Overall, this tool produced good comments from the experts. Some of the items were removed due to poor match in terms of content. This current research is crucial to investigate the factors and PHP usage among targeted industrial workers. This study can serve as the primary instrument for determining the human factors and personal hearing protectors used for industrial workers in various sectors. This survey tool can contribute to an improved understanding of the human factors that may influence the consistent use of PHP in an excessive noise work area.

Keywords Survey tool · Factors · Personal hearing protector · Industrial workers

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299

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1 Introduction

The World Health Organization (WHO) estimated that around 466 million people have hearing loss globally [1]. Besides, Occupational Noise Related Hearing disorders were reported as the highest among other occupational poisoning and disease cases from 2016 until 2019 [2]. The manufacturing sector reported the highest percentage of confirmed occupational poisoning and disease cases in 2019 [3]. A study by Rasasoran et al. [4] shows that a high prevalence of hearing loss was reported among workers in the noise-exposed palm oil industries. On the other hand, the automotive industry in China reported about 62.53% of them exceeded 85 dB(A) of the personal noise level. Most of the excessive noise comes from various automotive industry jobs, such as surface treatment, metal cutting, stamping, grinding, welding, forging, assembly and plastic moulding [5]. Besides the manufacturing industries, other industries, such as the construction industry, were found to have personal noise exposure level issue among both machine and non-machine workers [6].

Therefore, understanding factors that facilitate or hinder specific safety behaviours' performance is crucial [7]. A study by Reddy et al. [8] found that both personal and environmental factors for intrapersonal, interpersonal, organisational, community and policy influenced the use of hearing protectors. A study by Acharya [9] found that using personal protective equipment (PPE) among workers was significantly associated with the gender of the respondents and encouragement to use PPE. Several factors lead to using hearing protectors among workers, such as exposure level, individual risk perceptions, a company's safety climate [10] and social modelling [11]. Nath et al. [12] reported that the significant challenge of issuing personal protective equipment is comfort, and it can be adequate if PPE is worn correctly. Thus, determining factors that play an important role in the usage of PPE is the first step before planning and implementing an intervention to increase PPE use [13].

Thus, this paper aims to present the process of developing a survey tool for measuring human factors and PHP use among industrial workers. The dimensional construct of human factors influencing PHP use among industrial workers was determined. Then, the finalised items within the study construct via qualitative assessment were determined.

2 Materials and Methods

2.1 Survey Tool Development

The survey tool was developed in several stages. First, a survey tool is developed based on the guiding validated framework from the combination of the Health Belief Model (HBM) [14] and the Health Promotion Model (HPM) [15].

Second, a narrative literature review was carried out to identify relevant questions closely related to the main objective of the survey tool development. The questions were adapted and modified from the previous studies. The researchers developed the items of each construct from past research by combining two selected frameworks: The Health Belief Model and the Health Promotion Model.

The two (2) appointed experts reviewed the constructs used in the survey tools. Another previous study used two expert panels to review the instrument before it could be used by the end users [16]. According to Presser et al. [17], the review method assesses any worries associated with the questionnaire in advance of annoying ideas or unsuitable wording of questions. Each expert commented on the modified items and indicated their decision to remove, keep, or modify them [18].

2.2 Conceptual Framework on the Human Factors and Personal Hearing Protector (PHP) Use Among Industrial Workers

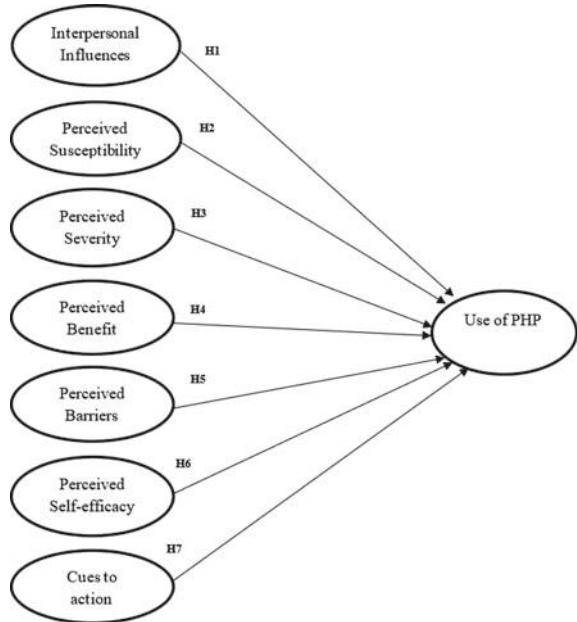
The framework had eight constructs. A theoretical framework on the relationship between human factors and PHP usage among industrial workers was used to develop the survey tool. The independent constructs are the interpersonal influences, perceived susceptibility, perceived severity, perceived benefit, perceived barriers, perceived self-efficacy and cues to action. The dependent construct is the use of PHP (see Fig. 1).

3 Results and Discussion

The developed survey tool consisted of two parts. The first part focuses on sociodemographics. The second part comprised eight study constructs: interpersonal influence, perceived susceptibility, perceived severity, perceived benefit, perceived barrier, perceived self-efficacy, cues to action and use of PHP.

The survey tool applied a 5-point Likert scale. All seven (7) constructs were used scale from 1 (strongly disagree) to 5 (strongly agree). This scale is ranged from 1 (strongly disagree) to 5 (strongly agree), which indicates the respondent's agreement with each item [20]. Besides, the last construct for Personal Hearing Protector use was to use a scale from 1 as 'Never' to a scale of 5 as 'Always'. The Likert scale is one of the most basic and widely used psychometric tools in sociology, psychology, information systems, politics, economics and other fields [21]. 5-point rating scales are less confusing and may boost the response rate.

Fig. 1 Conceptual framework. Adapted from Health Belief Model and Health Promotion Model [14, 15, 19]



3.1 Sociodemographic

The questions for sociodemographic section consists of eighteen (18) questions (gender, age, nationality, marital status, educational level, working experience, type of personal hearing protector, working type, worker’s experience with the ear problem and illnesses, family history of hearing disorder/loss, worker’s audiometric test and hearing re-examination experience, worker’s satisfaction on current PHP and the worker’s position). Table 1 shows the first phase of sociodemographic information is finalised after the qualitative review by the appointed two (2) experts. Overall, items inside this section remain. However, certain items need improvements due to incorrect or overlapping items, and wrong chosen words.

3.2 Analyses of Human Factors Constructs for PHP Use

In the beginning, the total items for this tool are 97 items which cover all the study construct. During the qualitative assessment process, certain items considered perfect matches were maintained as it is, while the items considered moderate matches were maintained after refining some of the sentences. Besides, the items that were considered poor matches by the experts were removed. Items that were consistently deemed unnecessary were removed, and the modified items were altered [18]. After

Table 1 Finalise the first phase of Sociodemographic information

	Sociodemographic	Items
S1	Gender	Male
		Female
S2	Age	≤24 year
		25–34 years
		35–44 years
		≥ 45 years
S3	Nationality	Malaysian
		Non-Malaysian
S4	Marital status	Single
		Married
		Others (widowed, divorced)
S5	Educational level	Primary
		Secondary
		Certificate
		Diploma
		Bachelor degree
		Master Ph.D.
S6	Working experience	≤1 year
		2–5 years
		6–10 years
		≥11 years
S7	Type of personal hearing protector (PHP)	Earplug
		Ear muff
		Combination
S8	Working type	Regularly
		Shift
S9	Do you experience ringing in the ears or sound heard differently in each ear?	Yes
		No
S10	Have you suffered any illness that has affected your hearing (e.g., infection, tinnitus, discharge, etc.)?	Yes
		No
S11	Have you ever had an ear operation or any other major operation that affected your hearing?	Yes
		No
S12	Any family history of hearing loss/disorder?	Yes
		No
S13	Have you had an audiometric test before?	Yes

(continued)

Table 1 (continued)

	Sociodemographic	Items
		No
S14	Have you suffered any illness listed here?	Yes No
S15	If YES , please tick (/) ONE or more illnesses listed here	Vision impairment Alzheimer’s disease Diabetes mellitus Cancer Vertigo Dizziness Psychosocial health Cardiovascular disease Stroke
S16	Experience of hearing re-examination	Yes No
S17	Are you satisfied with your current personal hearing protector?	Yes No Not applicable
S18	Position	Manager Engineers Executive Supervisor Technician Operator General worker

the qualitative assessment, the total items retained for this current study are 79 (see Table 2).

Table 3 shows the finalised first phase of Human Factors Construct for PHP use after considering all the comments by the appointed experts. According to this table, the construct for interpersonal influence has a total of eight (8) items, perceived susceptibility has seven (7) items, perceived severity has eight (8) items, perceived benefit has eight (8) items, perceived barrier eighteen (18) items, perceived self-efficacy have fifteen (15) items, cues to action have ten (10) items and use of personal hearing protector (PHP) have five (5) items.

Table 2 Changes the number of items in the study construct after qualitative content validation

No.	Human factors (construct)	Items (prior expert review)	Source	Items retained for the current study	Source
		No of items		No of items	
1	Interpersonal influence (II)	10	[13, 22, 23]	8	[13, 22, 23]
2	Perceived susceptibility (PS)	9	[23, 24]	7	[23, 24]
3	Perceived severity (PV)	10	[23–25]	8	[23–25]
4	Perceived benefit (PB)	14	[22–30]	8	[23, 28, 31]
5	Perceived barrier (PR)	20	[13, 22, 23, 25–28]	18	[13, 22, 23, 28, 31]
6	Perceived self-efficacy (PSE)	17	[13, 22, 23, 26, 28, 32]	15	[13, 22, 23, 28, 31, 32]
7	Cues to action (CA)	12	[23, 29]	10	[23, 29]
8	Use of personal hearing protector (PHP)	5	[33, 34]	5	[33, 34]
Total of items		97		79	

4 Conclusion

The first phase of survey tools for measuring the human factors constructs for PHP use among industrial workers was successfully developed via qualitative content validation by the two (2) experts. However, other studies conducted content validity using a quantitative approach [35]. This study manages to develop eight human factor constructs consisting of 79 items, including interpersonal influence, perceived susceptibility, perceived severity, perceived benefit, perceived barrier, perceived self-efficacy, cues to action and use of personal hearing protector (PHP). The sociodemographic parts are successfully developed, consisting of eighteen (18) items.

However, there are some highlights to be noted every time the content validation is planned; (1) the survey tool/questionnaire has to be translated and used in a dual language in English and Malay before it will be given to the targeted group, (2) provide a guide to the respondents on how to fill the survey questionnaire form and (3) involvement of experienced industrial practitioner such as safety officer as

Table 3 Finalise first phase research construct of Human Factors for PHP use

Question	Response options
<i>(1) Interpersonal Influence</i>	
II1	My team leader often uses a personal hearing protector when exposed to a noisy workplace
II2	My co-workers often use personal hearing protectors when exposed to a noisy workplace
II3	My co-workers expect me to wear a personal hearing protector when I am in a noisy work environment
II4	My family members encourage me to use a personal hearing protector when I am in a noisy work environment
II5	My supervisor expects me to wear a personal hearing protector when I am in a noisy work environment regularly
II6	Everyone in this company expects me to wear a personal hearing protector regularly
II7	My co-worker expects me to wear a personal hearing protector every day
II8	My company management encourages me to wear a personal hearing protector every day
<i>(2) Perceived Susceptibility</i>	
PS1	I believe my chances of developing a hearing loss problem are high
PS2	I worry about getting a hearing loss problem
PS3	I know people in this career field who got a hearing loss problem
PS4	Small exposures to noise hazards won't me to a hearing loss problem
PS5	Everybody can get hearing loss problems, including office workers
PS6	I am at risk of a hearing loss problem
PS7	I can have a hearing loss problem even without experiencing any signs or symptoms
<i>(3) Perceived Severity</i>	
PV1	The thought of getting a hearing loss problem deeply concerns me
PV2	If I developed a hearing loss problem, my career would be in jeopardy
PV3	Problems I would experience from the hearing loss problem would last a long time
PV4	A hearing loss problem will lead to permanent changes in my health
PV5	My financial security would be endangered if I developed a hearing loss problem

(continued)

Table 3 (continued)

Question		Response options
PV6	I am afraid to even think about getting a hearing loss problem	
PV7	There are no drugs to manage hearing loss problems	
PV8	Hearing loss complications would endanger my problem	
<i>(4) Perceived Benefit</i>		
PB1	Feeling safe while wearing a personal hearing protector	1. Strongly Disagree 2. Disagree 3. Neither Agree nor Disagree 4. Agree 5. Strongly Agree
PB2	Feeling useful while wearing a personal hearing protector	
PB3	Wearing a personal hearing protector will prevent future hearing problems for me	
PB4	A personal hearing protector prevents exposure to the noise hazards I am around on the job	
PB5	I benefit from wearing a personal hearing protector	
PB6	I think wearing a personal hearing protector every time I am in loud environments is important	
PB7	I am convinced I can prevent hearing loss by wearing hearing protectors whenever I am in loud environments	
PB8	If I wear a personal hearing protector, I can protect my hearing	
<i>(5) Perceived Barrier</i>		
PR1	Wearing a personal hearing protector is uncomfortable	1. Strongly Disagree 2. Disagree 3. Neither Agree not Disagree 4. Agree 5. Strongly Agree
PR2	I think using a personal hearing protector will slow my speed	
PR3	A personal hearing protector limits my ability to hear what I want to hear	
PR4	I think it will be hard to hear warning signals (like backup beeps) if I am wearing hearing protectors	
PR5	I don't feel like wearing a personal hearing protector at the workplace	
PR6	I think earmuffs make my head sweat too much	
PR7	Personal hearing protectors are uncomfortable to wear	
PR8	A personal hearing protector limits my ability to communicate with others	
PR9	Wearing a personal hearing protector is annoying	
PR10	The size of the personal hearing protector is not fit for me, so I don't wear it	
PR11	I don't like to wear anything on my ears while performing a job task	
PR12	I think a personal hearing protector puts too much pressure on my ears	

(continued)

Table 3 (continued)

Question		Response options
PR13	A personal hearing protector interferes with my ability to do my job	
PR14	A personal hearing protector is not always available to me	
PR15	My co-workers would make fun of me for wearing a personal hearing protector	
PR16	I would need to develop a new habit of wearing a personal hearing protector, and that is difficult	
PR17	A personal hearing protector is expensive	
PR18	There are disadvantages to wearing a personal hearing protector	
<i>(6) Perceived Self-efficacy</i>		
PSE1	If using a personal hearing protector was comfortable, I would definitely use it	1. Strongly Disagree 2. Disagree 3. Neither Agree nor Disagree 4. Agree 5. Strongly Agree
PSE2	If a personal hearing protector was easy to obtain, I would definitely use it	
PSE3	I know when I should use a hearing protector	
PSE4	I can wear a personal hearing protector regularly in a noisy workplace	
PSE5	I wear a personal hearing protector regularly, even though my colleagues around me are not in the habit of wearing a personal hearing protector	
PSE6	When my personal hearing protector is not functioning, I will inform my supervisor to get a new one for me	
PSE7	I can inspect or check for any defects in the personal hearing protector before wearing it	
PSE8	I am sure how to tell when a personal hearing protector needs to be replaced	
PSE9	I can wear a personal hearing protector properly	
PSE10	I can wear a personal hearing protector even if I have to wear other personal protective equipment (PPE)	
PSE11	I am confident the usage of a personal hearing protector can reduce the noise exposure to me	
PSE12	I am confident that I will remember to use a personal hearing protector when I am exposed to noise hazards	
PSE13	I am confident I can obtain the proper personal hearing protector when I am exposed to noisy hazards at work	
PSE14	I am confident that my job performance will not be adversely impacted by wearing a personal hearing protector	
PSE15	I am confident that after wearing the proper PHP throughout my career will help prevent me from getting a hearing loss issue	
<i>(7) Cues to Action</i>		

(continued)

Table 3 (continued)

Question		Response options
CA1	A reminder from my supervisor every day would be important to wear of personal hearing protector	1. Strongly Disagree 2. Disagree 3. Neither Agree nor Disagree 4. Agree 5. Strongly Agree
CA2	Inspection from my supervisor would improve my wear of personal hearing protectors	
CA3	The fact that OSHA fines me or my employer for not wearing a personal hearing protector is important	
CA4	Posters in my workplace would serve as important reminders to wear personal hearing protectors	
CA5	The threat of disciplinary action is an important factor in ensuring I wear a personal hearing protector	
CA6	Having a personal hearing protector at the location of the hazard is critical to ensure that I wear it	
CA7	If I see others wearing personal hearing protectors in my area, then it reminds me to use them	
CA8	Regular and frequent education on the importance of personal hearing protectors improves how often I wear them	
CA9	My supervisor sets the example of wearing a personal hearing protector when being exposed to hazards	
CA10	Training provided by my supervisor about PHP and the importance of personal hearing protectors was helpful	
<i>Use of Personal Hearing Protector (PHP)</i>		
UP1	How often do you wear personal hearing protectors during the past week when in high-noise areas?	1. Never 2. Rarely 3. Sometimes 4. Very Often 5. Always
UP2	How often do you wear personal hearing protectors during the past month when in high-noise areas?	
UP3	How often do you wear personal hearing protectors during the past three months when in high-noise areas?	
UP4	How often are you aware of the compliance of wearing a personal hearing protector when working in an excessive noise area?	
UP5	How often do you make sure that your personal hearing protector is well-fitted?	

an appointed expert panel in reviewing the content of the questionnaire. Before distributing the finalised survey tool (questionnaire), a briefing must be conducted on the targeted respondents to ensure workers’ understanding in answering the questions. The consent form must be given to the respondent to ensure the participants understand and know the study’s purpose before carrying out the sampling process.

Therefore, this survey tool can contribute toward an improved understanding of the human factors that may influence the consistent use of PHP among workers working in an excessively noisy work area.

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