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# Development of the hearing protection assessment (HPA-2) questionnaire

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| **Background** | Noise-induced hearing loss (NIHL) remains an important occupational health issue as the second most commonly self-reported occupational injury or illness. The incorrect and inconsistent use of hearing protection devices (HPDs) compromises their effectiveness in preventing NIHL. |
| **Aims** | To describe the development of an easily administered yet robust questionnaire to investigate factors that influence HPD use. |
| **Methods** | A hearing protection assessment (HPA-2) questionnaire was developed using items based on themes identified in our previous research. These fell into two classes: supports and barriers to wearing HPD, which formed two scales within the questionnaire. The questionnaire, which also included demographic items, was administered to workers from 34 manufacturing companies. The internal consistency of the scales was tested, and factor analysis was conducted to investigate the underlying structure of the scales. |
| **Results** | Of the 1053 questionnaires distributed, 555 completed questionnaires were received giving a response rate of 53%. The Cronbach's alpha for the barriers scale ($\alpha$ = 0.740) and supports scale ($\alpha$ = 0.771) indicated strong internal reliability of the questionnaire. The supports and barriers were further described as five key factors (risk justification, HPD constraints, hazard recognition, behaviour motivation and safety culture) that influence hearing protection behaviour. Workers who reported always using HPDs had more supports across these factors, while those who did not always wear HPDs reported more barriers. |
| **Conclusions** | The HPA-2 questionnaire may be useful in both research and interventions to understand and motivate hearing protection behaviour by identifying and targeting supports and barriers to HPD use at different levels of the ecological model. |
| **Key words** | Hazard; health promotion; hearing protection; noise-induced hearing loss; occupational; questionnaire. |

## Introduction

Noise exposure is an occupational health hazard causing hearing loss. Noise-induced hearing loss (NIHL) is the second-most common self-reported occupational injury or illness, accounting for 7% of the total hearing loss in developed countries and 21% in developing countries [1]. It is estimated that between 13.5 and 17.5% of the hearing impaired population in New Zealand (NZ) have an occupational NIHL and up to 26% of hearing impaired people have some hearing loss caused by excessive occupational noise exposure [2]. Hearing loss significantly impairs communication causing personal, professional and social problems for those affected [3]. In addition, NIHL imposes a large financial burden. For example, claims for NIHL compensation and rehabilitation in NZ were reported to be ~US$44m for the year ending 2006 [4].

NZ regulations limit unprotected noise in occupational settings to 85 dBA over an 8-h day with the requirement that preventive measures are employed to protect workers' hearing where noise levels exceeded this

threshold [5]. The use of engineering (reducing noise at source) and administrative (removing worker from excessive noise) controls are the most effective ways to prevent NIHL, but unfortunately, hearing protection devices (HPDs) alone are often relied on to control noise exposure [3]. While the use of hearing protection has been shown to reduce NIHL [6,7], incorrect and inconsistent use of HPDs compromises their effectiveness in preventing hearing loss [3,8]. Our previous qualitative study identified personal and environmental factors as supports or barriers to HPD use [9]. The ecological model for health promotion formed the theoretical basis for a classification of the factors into intrapersonal, interpersonal and organizational levels [10]. We further theorized that personal, socio-cultural and physical environmental factors cut across each level to influence behaviour [11].

Previous studies have used questionnaires aimed at understanding intrapersonal factors related to hearing protection behaviour [12,13], and others have utilized the Health Promotion Model (HPM) [14] to develop questionnaire items eliciting predictors of HPD use with varying results [15–18]. The HPM focuses on individual factors and fails to acknowledge the interrelationship of factors that may influence behaviour [19]. We designed a questionnaire to identify a range of personal and environmental factors drawing on the ecological model to understand hearing protection behaviour. The levels of influence (intrapersonal, interpersonal, organizational, community and policy) reflect the idea that personal and environmental factors at each level are interrelated [20]. This is important because the interaction between individuals and their environment is crucial to the concept of health promotion [19].

The first three levels of the ecological model were investigated in this study in relation to HPD use by workers. The factors present at the 'intrapersonal level' of the model are influenced by knowledge, attitudes, values and skills relating to noise and HPD use. The 'interpersonal level' of the ecological model focuses on the influence of family and co-workers and the social norms prevalent in the workplace [20]. Factors at the 'organizational level' are shaped by the values, policies and action of companies in respect of noise and hearing protection. This provides a multilevel perspective and a basis for developing interventions that promote hearing protection use. Drawing on this knowledge, we describe the development of a quantitative questionnaire to measure the factors that influence HPD use identified by our previous study [9] and its use with a sample of workers in noisy industries. This allowed us to identify a range of supports and barriers to HPD use by workers.

## Methods

A questionnaire made up of items pertaining to factors identified in our previous research [9] was developed with instructions to respondents to respond 'yes' or 'no' for each item as a reason that they would, or would not, wear HPDs when exposed to noise at work. The questionnaire also included demographic items such as gender and age, two items describing attitudes to safety behaviour at work and one item to capture the self-reported frequency of hearing protection use. We wished to develop a questionnaire that could be easily administered in the workplace and therefore produced a two-page self-administered hearing protection assessment (HPA-2) questionnaire focusing on supports and barriers to HPD use (available as Supplementary data at *Occupational Medicine* online). We pre-tested draft versions of the questionnaire in two workplaces to obtain worker feedback on design issues and determine suitability of items. This process helped confirm the items and format of the final version of the questionnaire. The study was approved by the University of Auckland Human Participants Ethics Committee (Ref: 2010/214).

Convenience sampling was used to recruit 34 manufacturing companies. Twenty six of these were contacted via the telephone directory, while the remainder were recruited through a health and safety training company. Most (24) were in the Auckland City region. As our primary interest was understanding workers' perceptions of supports and barriers to HPD use, we did not measure actual noise levels in the different workplaces. We aimed to recruit manufacturing companies that regarded themselves as having a 'high noise level' environment in which employees were required to use HPDs in accordance with health and safety regulations. The companies recruited were sheet metal fabricators, joiners, cement factories and foundries. Employers were given a company participant information sheet (PIS), and the details of the study were explained to them. The employers, and in some cases occupational health and safety personnel, then explained the purpose of the study to the workers and invited interested workers to participate. The workers were also given a subject PIS. The anonymous questionnaires were collected within 2 weeks of distribution. Data collection lasted from July 2011 to March 2012.

An alpha level of 0.05 was adopted for all inferential statistical tests. As HPD use is most effective when worn all the time in excessive noise [21], we compared factors influencing HPD use in workers who reported always using hearing protection with those who did not. The chi-squared test was used to test for differences in reported supports and barriers to HPD use between workers who reported always using HPDs and those who did not always use them. Differences in the number of supports and barriers sub-scales between groups were assessed with the non-parametric Mann–Whitney U test. The reliability analysis using Cronbach's alpha was used to measure internal consistency (reliability) of the questionnaire scales. Factor analysis with an oblique rotation was conducted to investigate

underlying structure of the scales. An examination of the Kaiser–Meyer–Olkin measure of sampling adequacy suggested that the sample was factorable (KMO = 0.808).

## Results

Of the 1053 questionnaires distributed, 555 completed questionnaires were received, a response rate of 53%. The mean age of participants was 42.6 years (SD = 12.5, $N$ = 545, missing data = 10) and 96% were male. Fifty percent of workers reported New Zealand European ethnicity, 10% Maori, 16% Samoan and 7% Cook Island Maori. There was a wide range in reported HPD use when exposed to noise, with 46% of participants indicating they always wore HPDs and 54% reporting not always doing so (22% almost always, 12% usually, 4% often, 12% sometimes and 4% rarely or never). Many respondents (74%) indicated that safety was at the forefront of their minds when working, while 25% thought that other factors limited their ability to work safely even though they considered safety as important. Those who indicated high safety awareness were more likely to report using HPDs ($M$ = 2.14, $s$ = 1.49) than the others ($M$ = 2.51, $s$ = 1.57), $t$ (542) = 2.49, $P < 0.05$. About half the participants believed that injuries occur because people do not take safety seriously (52%), and the other half believed that injuries will always occur no matter how hard people try to prevent them (47%). There was no difference in the mean use of HPDs in these two groups.

All but two participants in this study endorsed at least one support for HPD use (reasons for wearing HPDs). The three most common reasons for wearing HPDs when it was noisy (Table 1) were for the prevention of hearing loss, adherence to company rules and blocking annoying aspects of excessive noise. Less than half of the workers in this study ($N$ = 228) reported receiving training in using HPDs. A greater percentage of workers who always wore HPDs indicated wanting to preserve hearing for family, recognition and adherence to company rules and receipt of training as supports for their hearing protection behaviour. In contrast, a greater percentage of workers who did not always use HPDs indicated noise created by tasks performed by them or by other workers as their reasons for using hearing protection. Almost two-thirds (355) of the participants reported at least one barrier against HPD use. Of the 200 who did not endorse any barriers, 61% reported always using HPDs. The three commonest reasons for not wearing HPDs were someone else doing a noisy job without warning, communication difficulties and inability to hear warning signals and work process sounds (Table 2).

Wearing HPDs was significantly associated with some barriers against hearing protection behaviour (Table 2). A greater percentage of workers who did not always wear HPDs gave other workers doing something noisy without warning and HPDs being uncomfortable as reasons for not wearing hearing protection. Interestingly, a greater percentage of workers who reported always using HPDs indicated not being clear about when to use HPDs and co-workers finding them funny as barriers to wearing hearing protection. A marginally greater proportion of workers who did not always wear HPDs regarded their inability to communicate and to hear warning signals as reasons for not wearing HPDs.

In order to identify key factors that describe the supports and barriers to HPD use as per the ecological model, factor analysis with an oblique rotation was conducted. When loadings < 0.25 were excluded, the supports and barriers to HPD use loaded onto five factors (Table 3). Eight items loaded onto Factor 1. These items may be regarded as 'excuses' workers make for their inconsistent use of HPDs and this factor was labelled 'Risk justification'. Items loaded for Factor 2, labelled

**Table 1.** Reasons for wearing HPDs at work (supports)

| Supports | Frequency (%), $n$ = 549[a] | Always wear HPD, $n$ = 252 Frequency (%) | Do not always wear HPD, $n$ = 297 Frequency (%) | Chi-square, $\chi^2$ | df | $P$ value |
|---|---|---|---|---|---|---|
| You want your hearing to be good to live a good life with your family | 426 (78) | 209 **(83)** | 217 (73) | 7.64 | 1 | ** |
| It is company rules | 376 (69) | 194 **(77)** | 182 (61) | 15.58 | 1 | *** |
| You have received training to wear them | 228 (42) | 122 **(48)** | 106 (36) | 9.03 | 1 | ** |
| Wear it all the time, even when it is quiet | 124 (23) | 103 **(41)** | 21 (7) | 89.09 | 1 | *** |
| You want to protect your hearing | 497 (91) | 234 (93) | 263 (89) | 2.95 | 1 | NS |
| You are annoyed by the noise | 321 (59) | 147 (58) | 174 (59) | 0.004 | 1 | NS |
| Your boss tells you to | 181 (33) | 88 (35) | 93 (31) | 0.80 | 1 | NS |
| Your workmates remind you to wear them | 128 (23) | 65 (26) | 63 (21) | 1.60 | 1 | NS |
| You are doing a noisy job | 449 (82) | 183 (73) | 266 **(90)** | 26.27 | 1 | *** |
| Other workers are doing a noisy job | 421 (77) | 178 (71) | 243 **(82)** | 9.54 | 1 | ** |

[a]Missing data—6 (1%). NS, non-significant. Significantly greater % of supports in either group is indicated in bold.
Significance: **$P < 0.01$, ***$P < 0.001$.

**Table 2.** Reasons for not wearing HPDs when exposed to noise at work (barriers)

| Barriers | Frequency (%), $n$ = 549[a] | Always wear HPD, $n$ = 252 Frequency (%) | Do not always wear HPD, $n$ = 297 Frequency (%) | Chi-square, $\chi^2$ | df | $P$ value |
|---|---|---|---|---|---|---|
| Someone else does something noisy without warning | 144 (26) | 54 (22) | 90 **(30)** | 5.42 | 1 | ** |
| They are uncomfortable | 108 (20) | 39 (16) | 69 **(23)** | 5.19 | 1 | * |
| You cannot communicate properly with other workers | 211 (38) | 87 (35) | 124 (42) | 3.01 | 1 | NS |
| You cannot hear properly to do your work | 132 (24) | 51 (20) | 81 (28) | 3.96 | 1 | NS |
| They get in the way of other safety equipment | 63 (12) | 28 (11) | 35 (12) | 0.05 | 1 | NS |
| You are used to noise at work | 48 (9) | 23 (9) | 25 (8) | 0.09 | 1 | NS |
| Your co-workers often do not wear them | 36 (7) | 21 (8) | 15 (5) | 2.40 | 1 | NS |
| You are not clear as to when you should wear them | 34 (6) | 23 **(9)** | 11 (4) | 6.90 | 1 | ** |
| Your co-workers find it funny when you wear them | 19 (4) | 14 **(6)** | 5 (2) | 6.08 | 1 | * |

[a]Missing data—6 (1%). NS, non-significant. Significantly greater % of barriers in either group is indicated in bold.
Significance: *$P$ < 0.05, **$P$ < 0.01.

**Table 3.** Obliquely rotated component loadings for factors influencing hearing protection behaviour[a]

| Sub-scales of supports and barriers | | |
|---|---|---|
| 1. Risk justification | Co-workers find HPDs funny | 0.878 |
| | Co-workers do not wear HPDs | 0.719 |
| | Not clear when to wear | 0.643 |
| | Used to not wearing HPDs | 0.528 |
| | HPDs are uncomfortable | 0.344 |
| | HPDs get in the way of safety gear | 0.323 |
| | Co-workers doing a noisy job without warning | 0.294 |
| | Wear all the time | 0.258 |
| 2. HPD constraints | Cannot hear machine | 0.672 |
| | Communication | 0.588 |
| | HPDs get in the way of safety gear | 0.281 |
| 3. Hazard recognition | Other workers doing noisy jobs | 0.817 |
| | Workers doing a noisy job | 0.790 |
| | Noise is causing annoyance | 0.453 |
| 4. Behaviour motivation | Hearing preservation to maintain healthy family life | −0.626 |
| | To protect hearing | −0.593 |
| | Workplace rules | −0.331 |
| | Receipt of training | −0.342 |
| 5. Safety culture | Boss reminds to wear HPDs | −0.729 |
| | Workmates remind to wear HPDs | −0.693 |
| | Workplace rules | −0.413 |
| | Receipt of training | −0.386 |

[a]Loadings > 0.25.

'HPD Constraints' related to difficulties faced by workers when wearing HPDs that negatively influenced HPD use in workers. Three items loaded onto a third factor (Hazard Recognition) related to workers' use of hearing protection when exposed to noise and using HPDs to avoid noise annoyance. The four items that loaded onto Factor 4 (Behaviour Motivation) related to influences that acted as a stimulus for hearing protection behaviour. The influence of workplace policies and encouragement towards hearing protection behaviour at Factor 5 was labelled 'Safety Culture'. The item 'wear all the time' was loaded in a reasonably balanced way across the five factors. The loading of 0.258 on factor 1 was highest, but the others ranged from −0.109 to −0.203.

As the two HPD use groups were not normally distributed, a Mann–Whitney U test was performed to test the relationship between HPD use with each supports and barriers sub-scale. The results (Table 4) indicate greater influence of supports (behaviour motivation and safety culture) on those who always wore HPDs and a greater influence of barriers (risk justification and HPD constraints) for those who did not always wear hearing protection.

The reliability of the two scales (supports and barriers) for HPD use was tested. Items from the supports scale ($\alpha = 0.771$) had good internal consistency as did items in the barriers scale ($\alpha = 0.740$). All items except one appeared to be worthy of retention. The greatest increase in alpha would come from deleting item: wear all the time (Table 5). This item had a low item-total correlation of 0.197, whereas others were in the range 0.3–0.5. On this basis and because of its unreliable factor loading, the item 'wear all the time' was dropped from the questionnaire.

## Discussion

This study found that the HPA-2 questionnaire had strong internal reliability when measuring supports and barriers to HPD use in workers. The Cronbach's alpha for the barriers scale was $\alpha = 0.740$ and for the supports scale was $\alpha = 0.771$ where Cronbach's alpha values close to 0.80 for a given scale are considered reliable [22]. The questionnaire also demonstrated statistically significant differences in supports, barriers and respective sub-scales to HPD use in workers. In addition, supports and barriers exist across different levels of the ecological model and interact with each other to influence hearing protection behaviour. The finding that only 46% of workers reported always wearing HPDs when exposed to noise is of concern, especially since HPDs are most effective when worn all the time in excessive noise [21]. Not surprisingly workers with a positive attitude to safety were more likely to practice hearing protection behaviour than those with negative attitudes. However, it is of concern that almost half the respondents suggested workplace injuries will always occur despite preventive efforts, given that workers' perceptions of safety and risk influence personal protective behaviour such as the use of HPDs [23].

The five factors describing the supports and barriers (risk justification, HPD constraints, hazard recognition, behaviour motivation and safety culture) exist within different levels of the ecological model interacting with each other to influence hearing protection behaviour (Figure 1). This study shows that behaviour motivation and safety culture are supports that influence workers who always wear HPDs more than workers who do not (Table 4). Conversely, those who did not always wear HPDs indicated barriers (risk justification and HPD constraints) more than those who always did. Risk justification underlies the intra- and interpersonal levels of the model formed by individual attributes and external influences. These attributes provide workers with justification for not wearing HPDs when exposed to noise and appear to reflect shared attitudes across the workforce. Furthermore, workers with low frustration tolerance towards HPD use may be more likely to magnify the discomfort and not tolerate it despite the long-term benefits [24], thus negatively influencing hearing protection behaviour [25]. The inability to hear machine signals and communication difficulties highlight intra- and interpersonal limitations associated with HPDs. On the other hand, the perception of noise as a debilitating hazard and nuisance is a supporting influence to hearing protection behaviour at the intrapersonal level.

**Table 4.** The relationship between supports and barriers sub-scales and HPD use (Mann–Whitney U test)

| | HPD use ($n = 549$)[a] | Mean rank | Mann–Whitney U | $Z$ | $P$ |
|---|---|---|---|---|---|
| Supports | Not always | 265 | 34 569 | −1.554 | NS |
| | Always | 286 | | | |
| Behaviour motivation | Not always | 250 | 29 912 | −4.221 | *** |
| | Always | 305 | | | |
| Safety culture | Not always | 257 | 31 933 | −3.039 | ** |
| | Always | 297 | | | |
| Hazard recognition | Not always | 285 | 34 407 | −1.786 | NS |
| | Always | 263 | | | |
| Barriers | Not always | 301 | 29 684 | −4.342 | *** |
| | Always | 244 | | | |
| Risk justification | Not always | 298 | 306 945 | −4.029 | *** |
| | Always | 248 | | | |
| HPD constraints | Not always | 288 | 33 653 | −2.234 | * |
| | Always | 260 | | | |

[a]Not always: $n = 287$ (54%); always: $n = 252$ (46%); missing data: 6 (1%). NS, non-significant.
Significance: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

**Table 5.** Corrected item-total correlation of items describing influence on hearing protection behaviour

| Reasons for wearing HPDs at work (supports to HPD use) (Cronbach's alpha = 0.771) | Corrected item-total correlation |
|---|---|
| Your boss tells you to | 0.452 |
| When you are doing a noisy job | 0.474 |
| When other workers are doing noisy jobs | 0.488 |
| You want to protect your hearing | 0.309 |
| You are annoyed by the noise | 0.453 |
| You want your hearing to be good for your family | 0.485 |
| Your workmates remind you to wear them | 0.493 |
| It is company rules | 0.479 |
| You have received training to wear them | 0.537 |
| You wear them all the time, even when it is quiet | 0.197 |
| **Reasons for not wearing HPDs at work (barriers against HPD use) (Cronbach's alpha = 0.740)** | **Corrected item-total correlation** |
| You are not clear when to wear them | 0.509 |
| You cannot hear properly to do your work | 0.455 |
| You cannot communicate properly with other workers | 0.370 |
| They are uncomfortable | 0.426 |
| They get in the way of other safety equipment | 0.465 |
| You are used to noise at work | 0.485 |
| Your co-workers often do not wear them | 0.554 |
| Your co-workers find it funny when you wear them | 0.613 |
| Someone else is doing something noisy without warning | 0.258 |

The enforcement of workplace safety rules and facilitation of safety training by management (organizational level) is an important factor influencing hearing protection behaviour [17]. This, together with peer and management support/modelling (interpersonal level) help form a positive safety culture. Behaviour motivation is reflected at each level supporting positive hearing protection behaviour. For example, at the interpersonal level, social networks and the provision of social support such as friends and family affect the health and behaviour of individuals through direct and indirect interactions [20]. There appears to be reciprocal determinism whereby interactions between the worker and the environment across different levels of the model influence behaviour [20]. For example, encouraging safety culture (training, rules and support) at the organizational level positively affects behaviour motivation and hazard recognition at the intrapersonal and interpersonal levels, while mitigating risk justification and HPD constraints to influence positive hearing protection behaviour in workers.

Our research involved convenience sampling and voluntary participation. This may have led to selection bias in the types of company (e.g. level of enforcement and size) and worker who volunteered to take part. On the other hand, research involving coercion (e.g. by enforcement authorities) would not necessarily produce more accurate data because people would fear the repercussions of saying that they did not conform to noise regulations. We did not conduct noise level measurements for each company, instead basing the inclusion criterion on the companies' requirements for workers to wear HPDs at work upon noise exposure since the focus of the research was to understand why workers did not wear HPD when they were expected to do so. We relied on self-reporting of HPD use and people are known to over-report hearing protection behaviour [26–28]. In addition, self-reported HPD use in variable noise is not as accurate as data from steady noise exposure environments [28]. However, by designing the scale measuring HPD use with multiple options that we subsequently categorized as 'not all the time', we hoped to mitigate this bias to some extent. Previous research has indicated that responses to scales are affected by the number of alternatives available [29], so our scale should perform better than a simple yes/no question. We also utilized a general measure for HPD use rather than a more specific variable such as a given day/week as reported elsewhere [28].

We investigated only three levels of the ecological model. The community level needs further investigation of social norms regarding noise acceptability. This could be incorporated with findings from this study to target future intervention programmes. The policy level is covered by the code of practice for management of noise in workplaces [5], but current and future research will inform the re-evaluation of policies and practices.

A practical strength of the HPA-2 questionnaire is that it is time efficient and appropriate for respondents of most educational levels. Furthermore, the relatively clear concepts made it easy to translate this questionnaire into four different languages commonly used in New Zealand (Samoan, Tongan, Cook Island Maori and Niuean) although the non-English translations were not required in practice since all participants elected to complete the questionnaire in English.

This research drew on factors that influence hearing protection behaviour at different levels of the ecological model to form a quantitative questionnaire measuring the supports and barriers to HPD use. Reliability and validity of the supports and barriers to HPD use were good. Furthermore, the validity of the supports and barriers incorporated in this questionnaire is supported by previous research undertaken by the authors [9]. The HPA-2 questionnaire may be useful in both research and interventions to understand and motivate hearing protection behaviour. In addition, the questionnaire allows

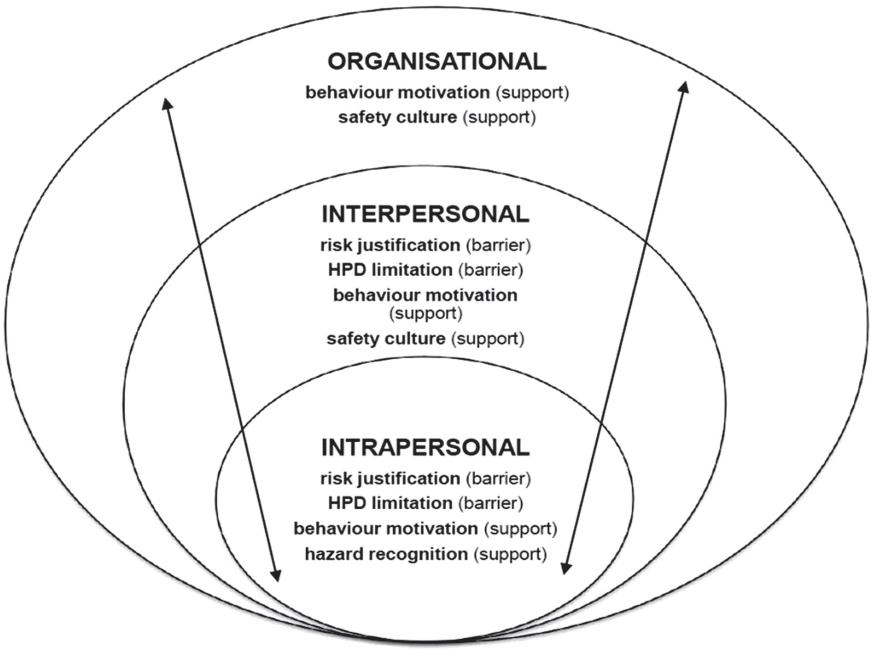


**Figure 1.** The five factors acting as supports and barriers to HPD use interacting across three levels of a modified version of the ecological model for hearing protection behaviour.

identification of supports and barriers at different levels of the ecological model that may be targeted when developing hearing protection interventions.

## Key points

- The Cronbach's alpha for the barriers scale ($\alpha = 0.740$) and supports scale ($\alpha = 0.771$) indicated strong internal reliability of the questionnaire.
- Workers who reported always using hearing protection devices had more supports influencing their behaviour, while those who did not always wear hearing protection devices reported more barriers to their use.
- The hearing protection assessment questionnaire may be useful in both research and interventions to understand and motivate hearing protection behaviour by identifying and targeting supports and barriers to hearing protection device use at different levels of the ecological model.

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## Conflicts of interest

None declared.

## References

1. Nelson DI, Nelson RY, Concha-Barrientos M, Fingerhut M. The global burden of occupational noise-induced hearing loss. *Am J Ind Med* 2005;**48:**446–458.
2. Thorne PR, Welch D, Grynevych A *et al. Noise Induced Hearing Loss: Epidemiology and Noise Exposure—Research Programme Report to ACC and Department of Labour*. Auckland: University of Auckland, 2011.
3. Morata TC. Hearing disorders. In: Levy BS, Wegman DH, Baron SL, Sokas RK, eds. *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury*. Philadelphia: Lippincott Williams & Wilkins, 2006; 587–596.
4. Thorne PR, Ameratunga SN, Stewart J *et al.* Epidemiology of noise-induced hearing loss in New Zealand. *N Z Med J* 2008;**121:**33–44.
5. New Zealand Department of Labour. *Approved Code of Practice for the Management of Noise in the Workplace*. Wellington: Occupational Safety & Health Service, Department of Labour, 1996.
6. Rabinowitz PM, Galusha D, Dixon-Ernst C, Slade MD, Cullen MR. Do ambient noise exposure levels predict hearing loss in a modern industrial cohort? *Occup Environ Med* 2007;**64:**53–59.
7. Heyer N, Morata TC, Pinkerton LE *et al.* Use of historical data and a novel metric in the evaluation of the effectiveness of hearing conservation program components. *Occup Environ Med* 2011;**68:**510–517.
8. Earshen JJ. Noise. In: Levy BS, Wegman DH, Baron SL, Sokas RK, eds. *Occupational and Environmental Health:*

*Recognizing and Preventing Disease and Injury*. Philadelphia: Lippincott Williams & Wilkins, 2006; 312–321.
9. Reddy RK, Welch D, Thorne P, Ameratunga S. Hearing protection use in manufacturing workers: a qualitative study. *Noise & Health* 2012;**14:**202–209.
10. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q* 1988;**15:**351–377.
11. Sallis JF, Owen N, Fisher EB. Ecological models of health behaviour. In: Glanz K, Rimer BK, Viswanath K, eds. *Health Behaviour and Health Education: Theory Research and Practice*. San Francisco: John Wiley & Sons, Inc, 2008; 465–485.
12. Arezes PM, Miguel AS. Does risk recognition affect workers' hearing protection utilisation rate? *Int J Ind Ergonom* 2006;**36:**1037–1043.
13. Purdy S, Williams W. Development of the noise at work questionnaire to assess perceptions of noise in the workplace. *Occup Health Safety—Aust NZ* 2002;**18:**77–83.
14. Pender NJ, Pender AR. *Health Promotion in Nursing Practice* 2nd edn. Norwalk: Appleton & Lange, 1987.
15. Lusk SL, Ronis DL, Kerr MJ, Atwood JR. Test of the health promotion model as a causal model of workers use of hearing protection. *Nurs Res* 1994;**43:**151–157.
16. Lusk SL, Ronis DL, Hogan MM. Test of the health promotion model as a causal model of construction workers' use of hearing protection. *Res Nurs Health* 1997;**20:**183–194.
17. Edelson J, Neitzel R, Meischke H *et al.* Predictors of hearing protection use in construction workers. *Ann Occup Hyg* 2009;**53:**605–615.
18. Raymond DM, Hong O, Lusk SL, Ronis DL. Predictors of hearing protection use for Hispanic and non-Hispanic White factory workers. *Res Theory Nurs Pract* 2006;**20:**127–140.
19. King PM. Health promotion—the emerging frontier in nursing. *J Adv Nurs* 1994;**20:**209–218.
20. Simons-Morton BG, McLeroy KR, Wendel ML. *Behavior Theory in Health Promotion Practice and Research*. Burlington: Jones & Bartlett Learning, 2012.
21. Williams W. Is it reasonable to expect individuals to wear hearing protectors for extended periods? *Int J Occup Saf Erg* 2009;**15:**175–181.
22. Field AP. *Discovering Statistics Using SPSS: (and Sex, Drugs and Rock'n'Roll)*. London: SAGE, 2005.
23. Arezes PM, Miguel AS. Risk perception and safety behaviour: a study in an occupational environment. In: Soares CG, Zio E, eds. *Safety and Reliability for Managing Risk*. Vols 1–3. London: Taylor & Francis Ltd, 2006; 1243–1248.
24. Branch R, Willson R. *Cognitive Behavioural Therapy For Dummies*. Chichester: John Wiley & Sons, 2010.
25. Kushnir T, Lela A, Alexandra N, Anna S, Svetlana P, Chava P. Dysfunctional thinking patterns and immigration status as predictors of hearing protection device usage. *Ann Behav Med* 2006;**32:**162–167.
26. Neitzel R, Seixas N. The effectiveness of hearing protection among construction workers. *J Occup Environ Hyg* 2005;**2:**227–238.
27. Hansia MR, Dickinson D. Hearing protection device usage at a South African gold mine. *Occup Med-Oxford* 2010;**60:**72–74.
28. Griffin SC, Neitzel R, Daniell WE, Seixas NS. Indicators of hearing protection use: self-report and researcher observation. *J Occup Environ Hyg* 2009;**6:**639–647.
29. Maydeu-Olivares A, Kramp U, Garcia-Forero C, Gallardo-Pujol D, Coffman D. The effect of varying the number of response alternatives in rating scales: experimental evidence from intra-individual effects. *Behav Res Methods* 2009;**41:**295–308.