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RESEARCH

Adaptation and content validity of a battery of questionnaires for identifying occupational conditions among Chilean artisanal and small-scale miners

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ABSTRACT

INTRODUCTION Small-scale and artisanal mining are historical activities in Chile that are deeply rooted in the region and economically significant. However, their workers face high levels of exposure to occupational hazards in informal conditions, with no adapted tools for occupational health surveillance. The available instruments are designed for formal companies and do not consider the operational context of artisanal miners.

OBJECTIVE To adapt and validate the content of a battery of questionnaires designed to identify working conditions affecting artisanal and small-scale mining workers in Chile.

METHODS An instrumental study was conducted in four phases: document review of national and international protocols; participatory risk identification with union leaders; development of thematic questionnaires; content validation through the judgment of 25 experts in occupational health, mining, psychometrics, and statistics. One hundred and fifty-five items were evaluated according to criteria of clarity, relevance, sufficiency, and coherence, using Aiken's V coefficient (threshold ≥ 0.80).

RESULTS 87% of the items met the threshold in all four criteria. Aiken's scores ranged from 0.77 to 0.98. The diesel exposure module obtained the highest scores, while the working conditions module showed less clarity (0.77), justifying the modification or elimination of 41% of its items. A new questionnaire on exposure to chemical agents was created by integrating modules. As a result of the adjustment process, the final battery consisted of six thematic questionnaires.

CONCLUSIONS This is the first questionnaire set with favorable content validity to assess working conditions in Chilean artisanal mining, a sector with high labor informality. It represents an initial validation step. Further studies should evaluate reliability, construct validity, and field applicability.

KEYWORDS Occupational health, occupational exposure, mining, surveys and questionnaires, working conditions

INTRODUCTION

Mining constitutes one of the main economic activities in Chile, contributing 14.2% of the national Gross Domestic Product in 2022, and generating a significant proportion of employment in northern and central regions of the country [1]. Within this sector, small-scale and artisanal mining have maintained a historical presence, with strong territorial and cultural roots in areas such as the Atacama, Coquimbo and O'Higgins Regions [2,3]. Despite their economic and social importance, this group has been scarcely considered in public policies, particularly in terms of occupational health and safety.

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MAIN MESSAGES

- Artisanal mining in Chile faces multiple risks without adapted assessment tools.
- This study validated a battery of questionnaires with high acceptance in content validity.
- It is the first contextualized tool for this sector, although its reliability and construct validity still need to be evaluated in the field.

Unlike industrial mining, workers in small-scale mining face conditions of greater vulnerability and simultaneous exposure to multiple occupational hazards. International evidence has documented that artisanal and small-scale mining involves constant exposure to silica-containing dust, noise, toxic chemicals such as mercury, lead or arsenic, vibration, forced postures and thermal overload, among other factors [4–6]. These exposures manifest themselves in an increased burden of occupational disease, including chronic respiratory conditions, hearing impairment, musculoskeletal diseases and progressive neurological damage [7]. In Latin America, recent studies have warned about the precarious conditions under which this type of mining is carried out, characterized by low coverage of occupational surveillance systems and limited access to personal protective equipment [8,9].

There are standardized international instruments for risk assessment in mining [10], guidelines promoted by the International Labor Organization, applied mainly in medium and large operations with formal structures [11]. In Latin America, some countries, such as Peru and Colombia, have developed matrices and forms to characterize the hazards associated with formal mining operations; however, these models have not been designed for informal or artisanal contexts [12,13].

In Chile, the most widespread assessment tools are the surveillance protocols of the Ministry of Health, among which are the Noise Exposure Protocol, the Work-Related Musculoskeletal Disorders Protocol, the Silica Exposure Risk Protocol, the Pesticides and Manual Handling of Loads Protocol [14–20]. These instruments include questionnaires and checklists aimed at companies with technical personnel, standardized records and operational capacity to implement control measures. However, they do not adjust to the conditions of informality, fragmentation of functions and limited technical resources that characterize artisanal miners. Currently, there is no battery of questionnaires adapted to the specific working conditions of small-scale mining in Chile that would allow identifying risks in a comprehensive, rapid and contextualized manner.

In addition, national regulations on working environments, such as Supreme Decree No. 594 of the Ministry of Health, were formulated with large companies in mind and do not take into account the operational realities or productive structures of artisanal mining. The requirements for measuring, evaluating and controlling risks are often unattainable for workers in small or informal operations, which prevents the implementation of effective preventive strategies.

Faced with this scenario, it is urgent to develop specific instruments to identify and categorize occupational risks specific to artisanal mining. A questionnaire adapted to this context can be a key tool to guide occupational health interventions, improve environmental and epidemiological surveillance, and generate data to support more inclusive public policies [11,17].

The present study aims to adapt and validate the content of a questionnaire to identify occupational hazards in artisanal miners in Chile. The instrument was subjected to evaluation by expert judgment, to ensure its clarity, relevance and technical adequacy to the context of small-scale mining. Its application seeks to contribute to the strengthening of occupational health surveillance in one of the most invisible labor sectors in the country.

METHODS

This corresponds to the initial phase of an instrumental study, focusing on the adaptation and validation of a battery of questionnaires on occupational hazards among small-scale and artisanal mining workers in Chile, through expert judgment. The research was developed in four phases:

Phase 1: documentary review

A review of official occupational health surveillance protocols issued by the Ministry of Health and the Institute of Public Health of Chile (Noise Exposure Protocols, Work-Related Musculoskeletal Disorders, Pesticides, Ultraviolet Radiation, Chemical Risks, Silica and Vibration, Method for Qualitative Evaluation of Silica Exposure Risk, ECRES) [14–20], as well as scientific literature and international regulations related to occupational hazards in artisanal mining [21–23].

Phase 2: identification of occupational hazards with small-scale mining workers

With the review carried out in phase 1, the main risks inherent to mining were identified. These were subsequently consulted with the presidents of small mining workers' unions. Their purpose was to corroborate the relevance of the identified occupational risks and select the priority ones [24]. This information was used as the basis for the formulation of items.

Phase 3: development of the battery questionnaires

Based on the inputs collected in the previous phase, a battery of questionnaires was developed. Each focused on a construct associated with a specific occupational risk identified

as a priority in small-scale mining: exposure to noise and acoustic damage, exposure to silica, exposure to pesticides, exposure to biological agents, exposure to diesel, exposure to ultraviolet radiation and heat, and exposure to musculoskeletal disorders. Additionally, a questionnaire on general employment and working conditions was included. Each questionnaire was written in a language understandable to people with different educational levels and was structured based on closed 4-point Likert-type questions, considering the criteria of clarity, relevance, sufficiency and coherence of the items. Each questionnaire included an introduction that contextualized the risk evaluated and clearly defined the instructions for the judges.

The evaluation guideline given to the judges was elaborated considering the proposed methodological criteria [25–27]. This guideline included the following definition for each criterion:

- **Clarity:** is the item written in a way that is understandable to artisanal miners? Consider whether the language is accessible to people with different educational levels.
- **Relevance:** is the item relevant to assessing the specific occupational hazards of artisanal miners?
- **Adequacy:** does the item adequately cover the aspect of risk it is intended to assess?
- **Coherence:** is the item aligned with the general objective of the questionnaire and the risks identified in small-scale mining?

Clarity: is the item written in a way that is understandable to artisanal miners? Consider whether the language is accessible to people with different educational levels.
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Coherence:is the item aligned with the general objective of the questionnaire and the risks identified in small-scale mining?

The evaluation scale used was Likert-type with the following values:

Additionally, each item included a space for judges to provide qualitative comments and suggestions for improvement.

Phase 4: content validation by expert judgment

The expert judgment methodology was used to evaluate the content validity of the questionnaire battery. Thirty-two experts were invited by non-probabilistic sampling for each criterion. Of these, a total of 25 judges agreed to participate, including experts in occupational health, epidemiology, statistics, psychometrics, occupational health institutions and mining. All of them fully answered the assigned questionnaires to the best of their knowledge (Table 1).

The selection of the expert judges was based on criteria of discipline, academic degree (minimum master's degree), minimum work experience of five years in the area, previous participation in processes related to occupational health, and diverse geographic representation at the national and international level.

Forty-four percent of the participants had a doctoral degree. The most frequent areas of expertise were occupational health (28%), occupational health institutions (24%), and epidemiology (16%). Reported work experience ranged from 6 to 48 years. Sixty-four percent of the participants worked in Santiago, while the rest came from Talca (16%), Atacama (8%), Coquimbo (4%), Antofagasta (4%) and one case from the United States (4%).

The seven experts who did not participate reported a lack of time on their part to respond to the questionnaire analysis. The data were collected and analyzed during 2024 and the first half of 2025.

Each expert judge evaluated the items of the assigned questionnaires, scoring the criteria previously described (Table 2).

Data collection was conducted through an email invitation, which included individual links to the forms hosted on the Google Forms platform. Each expert independently accessed the questionnaires and evaluated each item according to the four established criteria: clarity, relevance, sufficiency and coherence. In addition, a field was provided to incorporate qualitative observations for each item evaluated (Table 3).

Once the collection process was completed, the spreadsheets automatically generated by the platform in Excel format were downloaded. These files included both the assigned scores and the qualitative comments recorded by the judges. All these inputs were subsequently used for the quantitative and qualitative analysis of content validity.

For the quantitative analysis of content validity, content validity indices were calculated for each item and for the overall instrument, with an acceptable value defined as 0.80 or greater. In addition, Aiken's V coefficient was calculated for each item, using a value equal to or greater than 0.80 as the cut-off point, considering also the width of the confidence interval (at 95%). In addition, a qualitative content analysis of the judges' comments was performed to identify suggestions for improvement, comprehension difficulties or irrelevant content.

The study has the approval of the Human Research Ethics Committee of the Faculty of Medicine of the University of Chile (Act No. 137, Project No. 169-2024).

RESULTS

The evaluation by expert judgment allowed us to identify strengths and areas for improvement in the eight questionnaires developed for the characterization of occupational hazards in small-scale mining. A total of 155 items were analyzed using the Aiken V coefficient, considering four criteria: clarity, relevance, sufficiency and coherence (Table 4).

In general, most of the questionnaires obtained acceptable or high average values in all criteria, especially in relevance and coherence, which in all instruments exceeded the threshold of 0.80 (Table 4). The questionnaires on diesel exposure,

Table 1. Characteristics of the expert judges participating in the content validation.

Classification	Expert area	Profession	Highest academic degree	Working place	Years of experience	City of work
Statistician 1	Statistics	Statistician	Doctor	University	33	Santiago
Epidemiologist 1	Epidemiology	Nurse	Doctor	University	26	Santiago
Psychometrist 1	Psychometrics	Psychologist	Doctor	University	24	Santiago
Epidemiologist 2	Epidemiology	Nutritionist	Magíster	University	14	Santiago
Statistician 2	Statistics	Statistician	Doctor	University	10	Talca
Occupational health institution 1	Health Institution	Occupational Therapist	Magíster	Private occupational health institution	25	Santiago
Mining 1	Mining	Nurse	Licentiate	Mining	45	Antofagasta
Statistician 3	Statistics	Mathematician	Doctor	University	30	Talca
Occupational Health 1	Occupational Health	Medical-Health Practitioner	Licentiate	University	39	Santiago
Epidemiologist 3	Epidemiology	Biologist	Doctor	University	26	Talca
Occupational health 2	Occupational Health	Dental Surgeon	Magíster	Public occupational health institution	14	Santiago
Mining 2	Mining	Chemical Engineer	Graduate	Mining	25	Coquimbo
Occupational Health Institution 2	Health Institution	Biochemist	Magíster	Public occupational health institution	33	Santiago
Occupational Health 3	Occupational Health	Epidemiologist	Doctor	University	48	Estados Unidos
Occupational Health Institution 3	Health Institution	Environmental Engineer	Master	Public occupational health institution	14	Santiago
Occupational Health Institution 4	Health Institution	Environmental Engineer	Master	Public occupational health institution	25	Santiago
Occupational health institution 5	Health Institution	Kinesiologist	Master	University	15	Santiago
Occupational health 4	Occupational Health	Kinesiologist	Doctor	University	22	Santiago
Psychometrist 2	Psychometrics	Psychologist	Doctor	University	20	Talca
Occupational health 5	Occupational Health	Sociologist	Master	University	10	Copiapo
Occupational health institution 6	Health Institution	Risk Prevention Engineer	Bachelor	Public occupational health institution	14	Santiago
Epidemiologist 4	Epidemiology	Health Physician	Doctor	University	43	Santiago
Occupational health 6	Occupational Health	Veterinary Doctor	Graduate	University	15	Santiago
Occupational health 7	Occupational Health	Biologist	Doctor	University	33	Santiago
Mining 3	Mining	Civil Engineer	Magíster	Mining	6	Copiapo

Source: Prepared by the authors of this study.

musculoskeletal disorders and pesticides showed the best results, with high levels of agreement among the judges and no deleted items. In the case of the questionnaire on diesel exposure, all its items reached V values above 0.90.

The questionnaire on general employment and work conditions was the one that showed the greatest difficulties in terms of clarity (V = 0.77), which led to adjusting or eliminating part of its items. A similar situation occurred with the noise exposure questionnaire, where although the averages were adequate, a significant proportion of items were modified or relocated to other, more specific sections. An example of this is the items of this questionnaire that evaluated chemical risk, which were transferred to the pesticide exposure risk questionnaire, resulting in a new questionnaire called "chemical risk". To this new questionnaire, items related to the risk of exposure to diesel were also added.

Along the same lines, 12 items were eliminated and another 47 were transferred from the original set (Table 5). In addition, 10 items from questionnaire 1 on general employment and working conditions were moved to the health condition questionnaire, which are not part of this battery. In noise questionnaire 4, 7 items were moved to the general health condition questionnaire and 10 items were moved to the new chemical agent exposure questionnaire, together with the pesticide exposure questionnaire and the diesel exposure questionnaire. On the other hand, 95 items were modified, mainly due to recommendations related to wording, conceptual precision or relevance in the context of small mining sites.

The qualitative comments of the experts enabled us to identify technical terms that were not easily understood, ambiguous response scales, and the need to include examples tailored to the workers' experiences. The modifications

Table 2. Number of experts per questionnaire with their respective percentage of participation by discipline.

Questionnaire	Statistics n (%)	Epidemiologists n (%)	Psychometricians n (%)	Health institution n (%)	Mining experts n (%)	Occupational health n (%)	Total N
General employment and working conditions	3 (30)	3 (30)	1 (10)	1 (10)	1 (10)	1 (10)	10
Exposure to UV radiation and heat	1 (11)	2 (22)	1 (11)	1 (11)	2 (22)	2 (22)	9
Exposure to silica	1 (11)	3 (33)	1 (11)	1 (11)	1 (11)	2(22)	9
Noise exposure and hearing health	1 (11)	2 (22)	1 (11)	2 (22)	1 (11)	1 (11)	8
Musculoskeletal Disorders Risk Conditions	1 (12.5)	2 (25)	2 (25)	1 (12.5)	0 (0)	2 (25)	8
Exposure to diesel fuel	1 (11)	2 (22)	2 (22)	2 (22)	1 (11)	1 (11)	9
Exposure to biological agents	1 (12.5)	3 (37.5)	2 (25)	1 (12.5)	0 (0)	1(12.5)	8
Pesticide exposure	1 (12.5)	2 (25)	2 (25)	0 (0)	1 (12.5)	2 (25)	8

UV, ultraviolet.
Source: Prepared by the authors of this study.

Table 3. Summary of the battery of questionnaires evaluated.

Questionnaire	Construct evaluated	Dimensiones observadas	N° of items	No. of expert judges
General employment and working conditions	Working conditions in contexts of informality	Employment, working, sanitary and environmental conditions.	32	10
Exposure to UV radiation and heat	Perception of exposure to thermal and radiation conditions	Exposure to UV radiation and heat, use of PPE, health associated with radiation and heat.	21	9
Exposure to silica	Perception of respiratory risk associated with silica dust exposure	Occupational exposure to dust, control and prevention measures, use of personal protective equipment, access to silica monitoring.	17	9
Noise exposure and hearing health	Perception of exposure to occupational noise and auditory effects	Occupational exposure to high intensity, continuous and impulsive noise, use of personal protective equipment.	40	8
Musculoskeletal Disorders Risk Conditions	Perception of exposure to occupational noise and auditory effects	Vibration, load handling, static postures, and musculoskeletal pain.	21	8
Exposure to diesel fuel	Perceived exposure to diesel exhaust fumes	Use of diesel in machinery and ventilation.	4	9
Exposure to biological agents	Perceived exposure to biohazards from animal or zoonotic contact	Contact with vectors and animals, zoonotic risk.	7	8
Exposure to chemical agents (pesticides)	Perception of occupational exposure to chemical substances	Use, application, protection and health effects of pesticides and heavy metals.	14	8

UV, ultraviolet. PPE, personal protective equipment.
Source: Prepared by the authors fo this study.

Table 4. Evaluation of content validity by criterion according to the questionnaire.

Questionnaire	Number of items used	Clarity V (CI 95%)	Relevance V (CI 95%)	Sufficency V (CI 95%)	Coherence V (CI 95%)	% ítems with 4 criteria V ≥ 0.80
General employment and working conditions	32	0.77 (0.59 to 0.87)	0.88 (0.73 to 0.95)	0.80 (0.64 to 0.90)	0.87 (0.72 to 0.94)	56.3% (n = 18)
Exposure to UV radiation and heat	21	0.83 (0.66 to 0.93)	0.95 (0.81 to 0.98)	0.88 (0.71 to 0.95)	0.92 (0.77 to 0.97)	76.2% (n = 16)
Exposure to silica	17	0.85 (0.68 to 0.94)	0.90 (0.74 to 0.96)	0.89 (0.72 to 0.95)	0.83 (0.74 to 0.96)	100% (n = 17)
Noise exposure and hearing health	40	0.87 (0.69 to 0.94)	0.95 (0.8 to 0.98)	0.86 (0.69 to .95)	0.89 (0.73 to 0.95)	72.5% (n = 29)
Musculoskeletal Disorders Risk Conditions	21	0.94 (0.77 to 0.98)	0.95 (0.81 to 0.96)	0.95 (0.79 to 0.99)	0.98 (0.83 to 0.99)	95.2% (n = 20)
Exposure to diesel fuel	4	0.91 (0.74 to 0.97)	0.99 (0.86 to 0.99)	0.94 (0.78 to 098)	0.98 (0.85 to 0.99)	100% (n = 4)
Exposure to biological agents	7	0.89 (0.73 to 0.96)	0.90 (0.74 to 0.96)	0.82 (0.6 to 0.92)	0.88 (0.72 to 0.96)	85.7% (n = 6)
Exposure to chemical agents (pesticides)	13	0.89 (0.71 to 0.96)	0.93 (0.76 to 0.98)	0.84 (0.68 to 0.90)	0.92 (0.74 to 0.97)	100% (n = 13)

UV, ultraviolet. CI, confidence interval.
The following are considered: average Aiken V index, confidence interval and proportion of items with satisfactory scores.
Source: Prepared by the authors of this study.

incorporated were designed to enhance the understanding and adaptation of the items to the local context of artisanal mining.

Following this quantitative and qualitative review, a group of four researchers reviewed the modified and final questionnaires. A new version of each was then generated with 100% agreement.

The resulting battery exhibits a structure more tailored to the labor realities of artisanal miners and is projected as a useful tool for participatory diagnosis and occupational health surveillance in contexts of high informality (Table 6).

In addition, it was proposed to adjust the time scales and categories of hearing protection use, differentiating between occasional and permanent use. The judges suggested

Table 5. Number of items modified, deleted, added and transferred from the initial questionnaires.

Questionnaire	Items used	% items modified	% ítems eliminated	% items added	% Items translated
General employment and working conditions	32	65.6% (n = 21)	12.5% (n = 4)	12.5% (n = 4)	31.3% (n =10a)
Exposure to UV radiation and heat	21	38.1% (n = 8)	4.8% (n = 1)	0	0
Silica exposure risk	17	58.8% (n = 10)	0	0	0
Noise exposure and hearing health	40	50% (n = 20)	2.5% (n = 1)	0	42.5% (n = 17[2])
Musculoskeletal Disorders Risk Conditions	21	57.1% (n = 12)	4.8% (n = 1)	4.8% (n = 1)	0
Exposure to diesel fuel	4	100% (n = 4)	0	0	100% (n = 4[3])
Exposure to biological agents	7	100% (n = 7)	71.4% (n = 5)	14.3% (n = 1)	42.9% (n = 3[3])
Exposure to chemical agents (pesticides)	13	100% (n = 13)	0	0	100% (n = 13[3])

UV, ultraviolet.
[a]These items were transferred to a health symptom questionnaire. [2] Seven of these items were transferred to the health symptoms questionnaire. The other 10 items were transferred to the pesticide questionnaire that will constitute the chemical risk exposure questionnaire. [3] These items form a new questionnaire called exposure to chemical risks together with the 10 items of the noise questionnaire.
Source: Prepared by the authors of this study.

Table 6. Final battery of questionnaires on exposure and occupational conditions in small scale mining.

Name of questionnaire	Construct evaluated	Observed dimensions	N° of final items
General employment and working conditions	Working conditions in contexts of informality	Employment, working, sanitary and environmental conditions; contact with vectors, animals and zoonotic risk.	22
UV radiation and heat	Perception of exposure to thermal conditions and radiation.	Occupational exposure to UV radiation and heat, use of PPE, and health associated with radiation and heat.	21
Silica exposure	Exposure to silica.	Occupational exposure to dust, control and prevention measures, use of PPE, access to silica monitoring and respiratory health.	16
Noise exposure and hearing health	Perception of respiratory risk associated with exposure to silica dust.	Occupational exposure to high-intensity, continuous, and impulsive noise, the use of PPE, and hearing health.	22
Musculoskeletal Disorders Risk Conditions	Perception of exposure to occupational noise and auditory effects.	Vibration, load handling, static postures, musculoskeletal pain and extreme temperatures.	21
Chemical exposure agents	Perception of exposure to occupational biomechanical factors	Occupational exposure to chemical agents (mercury, lead, arsenic, pesticides, diesel, among others), use of PPE and health associated with chemical agents.	21

A description of the construct and its dimensions is included.
Source: Prepared by the authors of this study.

unifying the language, avoiding redundancies and clarifying the distinction between surface and subway exposure. It was also proposed to eliminate items that overlapped with other modules, such as those related to auditory symptoms. Overall, the relevance of the instrument was assessed, stressing the need to adapt the language to the educational level of the target audience.

The qualitative analysis of the battery of questionnaires, aimed at small-scale mining workers, allowed us to identify relevant observations by expert judges regarding the clarity, relevance, contextual adequacy, item structure, and thematic representativeness of each instrument. The following is a summary of the findings for each module evaluated, integrating transversally the main adjustments proposed for improvement and application in the field.

The questionnaire on general employment and working conditions received observations regarding the use of technical language, which would make it difficult to understand among workers with a low level of education. It was recommended that terms such as "subcontracting" or "contractual relationship" be replaced by more understandable expressions such as "word of mouth" or "written contract". In addition, it was pointed out that some items contained more than one idea, which could generate ambiguity in the response. The judges also noted

that certain alternatives were not mutually exclusive, which made their application more challenging. In this sense, they proposed to allow multiple responses to questions on labor ties at the site and to offer open options. From the perspective of sufficiency, it was suggested to broaden the thematic coverage by incorporating aspects such as access to social benefits, social security, mode of payment and informal work organization. The instrument was considered relevant and necessary to understand the structural conditions of employment, highlighting the need for a simplified, contextualized and coherent wording.

In the questionnaire on exposure to ultraviolet radiation and heat, it was observed that several items included time formats with technical notation (for example, "AM" or "10:00 to 16:00"). In view of this, it was proposed to replace them with common expressions such as "from 10:00 a.m. to 4:00 p.m.". It was suggested to clarify technical concepts such as "ultraviolet radiation" or "dry air", incorporating examples from daily work experience, such as "sensation of dry throat" or "glare from metallic surfaces". It was appreciated that the instrument addressed key factors such as hydration, exposure times, availability of shade and use of sun protection. However, it was suggested that the response scales should be improved and that the option "not applicable" should be allowed when appropriate. The general consistency of the questionnaire was recognized, although it was recommended that a clear distinction be made between thermal perception and direct sun exposure. The importance of ensuring a clear linguistic structure appropriate to the profile of the workers was emphasized.

Regarding the questionnaire on exposure to crystalline silica, it was identified that terms such as "free silica", "forced ventilation" or "suspended dust" could make it difficult to understand. It was suggested that the items should be reworded using more accessible language or accompanied by practical examples such as "Does rock crushing raise a lot of dust? It was also recommended to break up long items and avoid double negative constructions. Questions on sources of exposure, mitigation measures and individual protection were positively valued. In terms of sufficiency, it was suggested to incorporate questions on respiratory symptoms, duration of exposure and frequency of preventive practices. The questionnaire was considered coherent and applicable to the context of labor informality, with emphasis on the need for training for its proper administration.

The questionnaire on noise exposure and hearing health was considered useful for identifying noise sources, although excessive use of technical terms such as "impulsive noise" or "continuous exposure" was detected. It was recommended to use more concrete expressions such as "tool noise" or "machine noise".

Regarding the questionnaire on musculoskeletal disorders, the judges noted that it adequately addressed the relevant ergonomic exposure conditions in small-scale mining. However, they noted that concepts such as "awkward postures", "vibration" or "repetitive movements" required more specificity through examples of common tasks such as shoveling, hammering or pushing wheelbarrows. It was identified that some questions included double choices (e.g., "pushing or pulling"), which could lead to confusion. It was proposed to reorganize the items by type of effort and to differentiate specific tasks. It was also recommended that conditions such as minimum load weight, duration of exposure and presence of breaks be specified. The questionnaire was considered relevant and sufficient, but in need of linguistic revision and empirical validation of the proposed scales.

The diesel exposure questionnaire was rated as addressing a low visible but relevant risk. The judges recommended replacing the term "diesel emissions" with expressions such as "engine smoke" or "exhaust gases", contextualizing their origin (compressors, backhoe loaders, trucks). The importance of distinguishing between direct and indirect exposure was emphasized, and the use of respiratory protection, perception of air quality and ventilation conditions should be investigated. Inconsistencies were observed between the statements and the response scales, which required structural adjustments. It was also proposed to include open-ended questions to capture unanticipated exposures. The instrument was considered relevant, with a need for linguistic adjustments and greater contextualization of the risk.

Regarding the biohazard questionnaire, the judges valued its inclusion given that this type of exposure is often underestimated. A suggestion was made to differentiate between direct and indirect contact with animals, as well as to categorize between domestic, community, feral and wild animals. It was recommended that terms such as "rodents" be clarified using local examples (e.g., mice, lizards, foxes). The relevance of certain items such as the consumption of wild animals or chagual was also questioned, proposing their reformulation or elimination if the health link was not clear. The importance of considering perceptions of the presence of vectors such as vinchucas or ticks was emphasized. In general, it was recommended to reinforce conceptual clarity and adapt the content to the socio-cultural environment of the workers.

Finally, the pesticide exposure questionnaire was perceived as a necessary innovation. However, difficulties in understanding were identified due to the use of technical terms ("active ingredients", "integrated management"). It was recommended to use more familiar expressions ("insecticides for flies", "fumigation against vinchucas") and to contextualize the real uses of pesticides in mining operations. It was suggested to include an initial filter item on the use of pesticides at the site and to allow "not applicable" responses when appropriate. It was also proposed to inquire about the use of personal protective equipment, understanding of labels and access to training. Although it was considered relevant, the need for significant adjustments and training support for its effective application was highlighted.

Overall, the qualitative observations reflect a clear pattern: the questionnaires are valued as relevant and necessary

instruments to assess occupational risks in small-scale mining, but require improvements in their wording, cultural adaptation and conceptual clarity. The judges insisted on the need to use accessible language, incorporate situated examples, adjust scales and ensure internal consistency to guarantee content validity and applicability in informal labor contexts.

DISCUSSION

The results of this research support the need for specific instruments to identify occupational hazards in artisanal and small-scale mining contexts in Chile [4–6]. The battery of questionnaires developed constitutes an unprecedented tool in the country, designed from a systematic process of documentary review [14–20], technical elaboration and validation by expert judgment. All this made it possible to adapt its contents to the specific conditions in which artisanal miners work.

From a methodological perspective, content validation by expert judgment made it possible not only to quantify the level of agreement with respect to the criteria of clarity, relevance, sufficiency and coherence, but also to qualitatively enrich the proposal with observations that contributed to the contextual and linguistic adjustment of the instruments. The decision to integrate both types of analysis was key to identifying items that were poorly formulated, redundant or inadequate to the socio-labor profile of the target population. Moreover, it reflects a carefully structured methodological strategy adapted to the particularities of the setting under study [24].

The results indicate that most of the instruments reached satisfactory levels of content validity, particularly highlighting the questionnaires on musculoskeletal disorders and exposure to chemical agents, which obtained high levels of consensus among experts. This result suggests that the risks associated with these areas are more clearly established in the occupational health literature, which facilitates their formulation into understandable and relevant items for the population being evaluated.

On the other hand, the questionnaire on general employment and working conditions showed greater difficulties, mainly associated with the clarity of the language, the use of complex categories or those poorly adapted to the everyday language of workers, and the need to expand the dimensions covered. This situation reflects the heterogeneity of artisanal mining work, characterized by contractual informality, family or neighborhood ties and unconventional organizational modalities. Thus, the instrument must not only adapt to material working conditions, but also to cultural and social forms of productive organization [8,9].

A relevant finding of this study was to show that, in Chile, certain risks that are not usually recognized in artisanal mining, such as exposure to pesticides or biological agents, are present and need to be addressed by means of specific assessment instruments [23]. The inclusion of these issues enabled the broadening of the view of occupational health in this sector and made visible sources of exposure that are typically overlooked by formal occupational surveillance systems.

The qualitative analysis contributed significantly to the adjustment of the questionnaires, especially in aspects related to wording, cultural appropriateness and comprehension by workers with different levels of schooling. The incorporation of contextualized examples, the revision of the response scales and the simplification of the technical language were key elements in improving their applicability. In this process, expert judgment not only allowed for a technical evaluation of the contents, but also facilitated the cultural adaptation of the instruments [25–27].

At the institutional level, this study poses an important challenge for public policies on occupational health: the need for differentiated tools for smaller-scale, informal or precarious productive contexts [12,13], traditionally excluded from technical and health regulation [28]. The battery of questionnaires developed may constitute a useful resource for guiding preventive actions, monitoring risk conditions and generating evidence to support policies that are more inclusive and adjusted to territorial realities.

Among the limitations of the study, it should be mentioned that the validation focused only on the validity of the content. Therefore, it is necessary to move forward in subsequent stages, which include reliability analysis, pilot field tests, and validation of constructs. Also, although we had a diverse panel of specialists, the number of judges per questionnaire varied, which could have affected the stability of the V coefficients obtained.

It is important to point out that, although this stage represents a significant methodological advance, it does not in itself constitute a complete validation of the instruments. The content evaluation by means of expert judgment should be understood as a preliminary phase within a broader validation process, which should continue with additional studies on reliability, construct validity and field application.

CONCLUSIONS

This study represents a first relevant step for the development of instruments that respond to the specific conditions of small-scale mining workers, historically marginalized from formal monitoring systems. Its future implementation should consider participatory processes with workers, state representatives, regional and central health services, as well as accident and occupational disease management agencies (such as those contemplated in Law 16 744), among other key actors. This is to ensure continuous evaluation and preserve the usefulness, relevance, and technical quality of the instruments.

Contributor roles NLM, MTMQ and VI: participated in the conceptualization of the study. NLM, MTMQ, VI and RV: developed the methodology. NL, VI and MTMQ: were in charge of data curation. NLM, VI, MTMQ, KY, RV, CJ, RVD, DC, GF, BC and FA: performed the formal analysis. NLM and MTMQ: performed the writing of the original draft.

NLM, VI, MTMQ, KY RV, CJ, RVD, DC, GF, BC and FA: were in charge of the critical review and editing. VI and MTMQ: were responsible for the overall supervision of the study. NLM and MTMQ: developed the visualization. NLM: was in charge of funding. All authors reviewed and approved the final version of the manuscript.

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Adaptación y validez de contenido de una batería de cuestionarios para identificar las condiciones ocupacionales de los mineros artesanales y de pequeña escala chilenos

RESUMEN

INTRODUCCIÓN La pequeña minería y minería artesanal son actividades históricas en Chile, con fuerte arraigo territorial y relevancia económica. Sin embargo, sus trabajadores enfrentan altos niveles de exposición a riesgos laborales en condiciones de informalidad, sin contar con herramientas adaptadas para su vigilancia en salud ocupacional. Los instrumentos disponibles están diseñados para empresas formales y no consideran el contexto operativo de dichos trabajadores.
OBJETIVO Adaptar y validar el contenido de una batería de cuestionarios diseñada para identificar condiciones laborales que afectan a trabajadores de la minería artesanal y de pequeña escala en Chile.
MÉTODOS Estudio instrumental desarrollado en cuatro fases: revisión documental de protocolos nacionales e internacionales; identificación participativa de riesgos con dirigentes sindicales; elaboración de cuestionarios temáticos; y validación de contenido mediante juicio de 25 expertos en salud ocupacional, minería, psicometría y estadística. Se evaluaron 155 ítems bajo criterios de claridad, relevancia, suficiencia y coherencia, usando el coeficiente V de Aiken (umbral igual o mayor a 0,80).
RESULTADOS El 87% de los ítems alcanzó el umbral en los cuatro criterios. Los valores de Aiken oscilaron entre 0,77 y 0,98. El módulo de exposición a diésel obtuvo los puntajes más altos, mientras que el de condiciones laborales mostró menor claridad (0,77), justificando la modificación o eliminación del 41% de sus ítems. Se creó un nuevo cuestionario sobre exposición a agentes químicos mediante la integración de módulos. Como resultado del proceso de ajuste, la batería final quedó conformada por seis cuestionarios temáticos.
CONCLUSIONES Esta es la primera batería de cuestionarios con validez de contenido favorable para evaluar condiciones laborales en la minería artesanal chilena, marcada por alta informalidad. Este trabajo, representa un primer paso en su validación. Se requieren estudios posteriores que analicen confiabilidad, validez de constructo y aplicabilidad en terreno.