Out of the
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Basic occupational safety and health for small-scale fishing workers in rural communities in Latin America using a community-based approach

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Occupational health, informal sector, rural health, fisheries, diving, decompression sickness, executive function, community-based participatory research, primary health care

Abstract

Background

Divers and fishermen in Chile's small-scale fishing communities lack basic occupational safety and health. We aimed to evaluate potential long-term effects on cognitive function among divers in southern Chile and to address occupational health problems at the community level. This approach was then part of a pilot training project on basic occupational health for rural communities of Latin America.

Methods

Quantitative and qualitative research methods were applied. Publication one refers to the participatory approach in diagnosing working conditions and health in the fishing community. The second contribution is a cross-sectional study on the evaluation of the executive function of shellfish divers and its relationship with the history of decompression illness. The last publication reports on the implementation and evaluation of the pilot training project which was applied in four rural communities of Latin America.

Results

Failures in executive function of divers were related to their history of decompression illness. A network built by the former paramedic of the rural post connecting fishermen, authorities and stakeholders was recognized by the community as the driving force to avoid fatalities due to the disease in the past. Having health personnel trained in handling and preventing the disease is a current community´s need. After implementing the pilot training project, the lack of occupational health knowledge among rural health workers, intersectorality in addressing multiple health-related factors in rural areas, and local public policies addressing occupational health in primary care were the major findings.

Conclusion

Community participation and involvement of primary health care are essential to provide basic occupational safety and health for workers in small-scale fisheries and other rural

communities. To make this feasible and sustained, an integrated vision of human health and the training of health professionals in such vision, along with public policy integrating workers' health into primary health care are needed in Latin America.

Table of Contents

i) List of Figures

ii) Abbreviations

ILO	International Labour Organization
OSH	Occupational Safety and Health
WHO	World Health Organization
PAHO	Pan American Health Organization
PHC	Primary Health Care
BOSH	Basic Occupational Safety and Health
WCST	Wisconsin Card Sorting Test
CIH^{LMU}	Center for International Health at the Hospital of the Ludwig Maximilian University

Introductory Summary

1. Introduction

1.1 Occupational health overview and small-scale fisheries

The latest estimates reported by the International Labour Organization (ILO) indicate that over 7,500 people die every day from work-related diseases and accidents worldwide, representing 5% of all annual fatalities.[1,2] Fishing is one of the most dangerous occupations,[3] but is also crucial to global food security.[4] More than 90% of the workers related to fishing belong to small-scale fisheries, which takes place mainly in remote coastal communities,[5] named “caletas” in Chile. The inhabitants of such communities participate in the activities of the fishing value chain, mainly as self-employed workers and under risky working conditions,[5] with the subsequent health outcomes.[6] Poverty, limited access to services such as health and education, and the effects of pollution and climate change on their source of employment are for the reality of fishermen’s work all over the globe.[5]

In Chile there are 467 caletas distributed throughout the country.[7] In 2018, about 90,000 people were registered in the National Artisanal Fisheries Register (which includes fishermen, shore collectors, divers among other occupations), with highest figures in Los Lagos Region[8] (figure 1a), one of the most productive regions contributing mainly species such as mollusks, crustaceans and echinoderms.[7] The harvesting of such products is done by basic shellfish divers, with the support of one or two dive assistants, who from the boats are in charge of the operation of the air compressor and hoses that supply air to the diver (Hookah system)[9,10] (figure 1 b-d). In 2018, there were 4,674 divers in the National Artisanal Fisheries Register in Los Lagos Region (27 women, 4,647 men), representing 44% of the divers nationwide.[8] Divers in artisanal fisheries have been a concern in the region because of the historical occurrence of fatal and serious accidents.[11] Due to the informality of their jobs, these divers lack access to social security[11,12] and therefore, to occupational health services.[13]

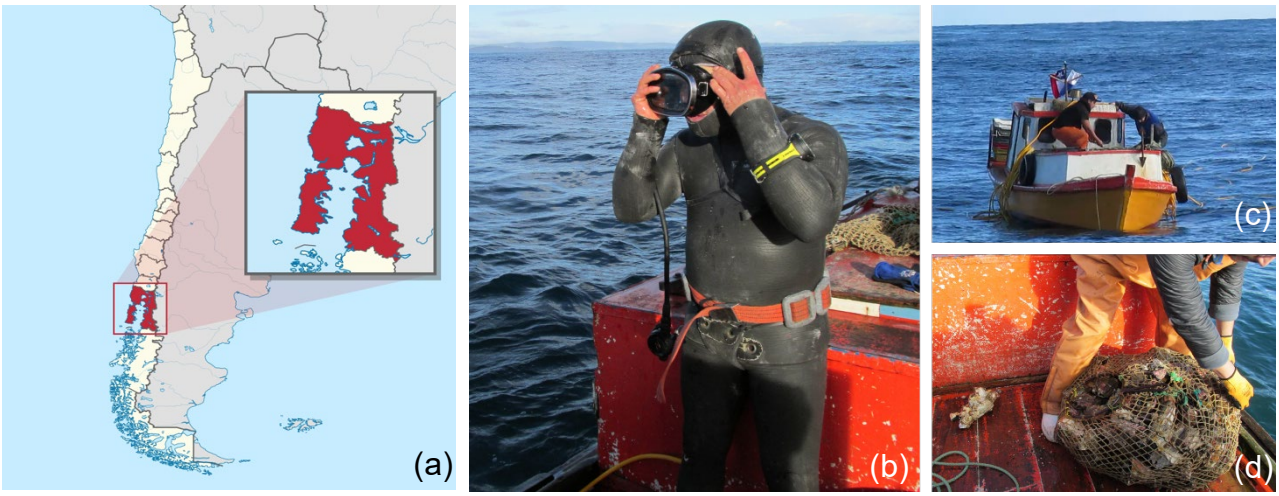

Figure 1: (a) Map of Chile. The Los Lagos Region is marked in red. Source: creative commons. (b) Shellfish diver preparing to dive. (c) Diving assistants working on the boat while the diver is harvesting on the seabed. (d) Products harvested by the diver. Source b-d: M.A. Garrido.

1.2 Sustainable development goals: decent work for all and basic occupational health services

Economic growth and decent work for all is one of the Sustainable Development Goals. Decent work implies, among other actions, access to "security in the workplace and social protection for families".[14] As stated by ILO, "safety and health at work can be key to the sustainable development and investment in OSH [Occupational Safety and Health] can help contribute to the achievement of the 2030 agenda for sustainable development".[2]

The World Health Organization (WHO) and the Pan American Health Organization (PAHO) have encouraged Primary Health Care (PHC) to provide basic occupational safety and health (BOSH) services.[15-17] Through BOSH, universal access of workers to health promotion and prevention of work-related accidents and diseases seems feasbile[18] as the different forms of primary care reach 70% of the world's population.[17] However, there is still a lack of concrete plans to reach the health of informal workers from rural areas of Latin America, such as artisanal fishermen in Chile.

1.3 (Occupational) health problems of artisanal divers in rural Chile

The frequent occurrence of fatal and non-fatal occupational accidents among shellfish divers in a southern Chilean community has brought our attention to this community. In

an earlier study in the community we were able to show that, like in other small-scale fishing communities, decompression illness has been one of the main work-related health problems.[19-22] Likewise, hearing loss[22] and impaired attention[23] were prevalent problems among divers with higher diving years and deeper dives respectively. The scarce use of decompression tables, deep and prolonged dives were common.[22] However, the long-term effects of working conditions on the health of shellfish divers remain poorly addressed in research and prevention strategies.

2. Rationale and Objectives

We were therefore interested in investigating long-term health effects among Chilean shellfish divers and to address occupational safety and health problems at the community level. For this, the southern Chilean community served as model community to pilot research and intervention studies and later on, implement the results in other Latin American rural communities.

The specific objectives were:

- To diagnose working conditions and health at the community level through a community-based approach.
- To evaluate possible long-term effects on the cognitive function – specifically the executive function - of shellfish divers in the community and its relationship with the history of decompression illness.
- To develop and evaluate the implementation of a pilot train-the-trainer program on basic occupational safety and health for health care workers related to primary healthcare in rural areas of Latin America.

3. Methods

We combined epidemiological and qualitative research methods, resulting in three manuscripts, two of which have already been published[24,25] while the third is currently under review.[26] The research was carried out between 2016 and 2019. The methods are described in detail in the publications and are summarized below.

3.1 Occupational safety and health in a community of shellfish divers: a community-based participatory approach.[24]

Two independent social dialogue workshops were held by the author of this thesis in the model community. The first workshop was focused on understanding the « status quo of diver's health and safety » in terms of actions already implemented and challenges for prevention of decompression illness. Participants included community representatives, authorities and stakeholders (N=25). The second workshop focused on identifying working and health conditions of workers in the value chain of seafood with community participation. Risk mapping was used as a tool to easily identify and analyze the hazards associated with seafood value chain activities in the community, and to seek resources to address them. Workers from the value chain and relatives of divers and fishermen participated in the workshop (N=10). Both workshops were conducted by applying the ecosystem approach to human health (ecohealth).[27] By this one-health approach, human health is addressed in connection with the environment and the socio-economic setting in the communities. The results of both workshops were analyzed through qualitative methods by the author of this thesis.

3.2 Executive function among Chilean shellfish divers: a cross-sectional study considering working and health conditions in artisanal fishing.[26]

This cross-sectional study was conducted in the model community and one other, closeby small-scale fishing community. Besides 104 divers, 58 fishermen were included. They served as unexposed controls. The inclusion of a second community was necessary in order to reach sufficient statistical power. A questionnaire on health and working conditions and a neuropsychological test for evaluation of executive function (Wisconsin Card

Sorting Test (WCST)) were applied through door-to-door sampling. The exposure variable was history of decompression illness, represented by a score assigned according to severity and frequency of symptoms. The percentages of perseverative responses and perseverative errors were used to measure executive function. Age, depressive symptoms and dangerous level of alcohol consumption were considered as potential confounders. Non-parametric tests were applied to compare WCST results between divers and non-divers and between the other study variables. Linear regression models were performed to assess the association between decompression illness score and executive function. The author of this thesis was responsible for all parts of the study from study design to statistical analyses of the results.

3.3 Courses on basic occupational safety and health: a train-the-trainer educational program for rural areas of Latin America.[25]

Using the results of the community-based participatory approach in the model community described in 3.1, a blended-learning program was developed in conjunction with Latin American teachers of the Center for International Health at the Hospital of the Ludwig Maximilian University (CIH^{LMU}) in order to develop and implement a basic Occupational Safety and Health approach in rural communities of Latin America. The participants (named ”trainers” herein) were four teams of lecturers and health workers related to primary health care in rural areas or to occupational health (N=15) from four Latin American universities (2 in Peru and 2 in Chile). Trainers were trained by the author of this thesis together with the CIH^{LMU} Latin American team in 1) the participatory diagnosis of occupational health in rural communities (based on the experience with the artisanal fishing community described in 3.1) and 2) teaching interventions. After training 1) and after training 2), the trainers replicated the methods in four rural communities to which their university was contact with (e.g. medical or nursing student internship sites of the university). Each team was supported by a tutor throughout the process. According to the main work-related problem identified with the community, the trainers developed their teaching interventions. Finally, the program was evaluated by the trainers through a questionnaire, and in a workshop. Quantitative and qualitative methods were used for data analysis. The author of this thesis was involved in the development of the methods, training, and evaluation of the results.

4. Results

4.1 Occupational safety and health in a community of shellfish divers: a community-based participatory approach.

The history of decompression illness and prevention actions in this community is more than 30 years old, when deaths and immediate sequels (such as paraplegia) from the disease were common and no knowledge or actions were available to address them. The paramedic (already retired) of the, at that time, rural post became the nexus of a network between fishermen, regional and local authorities (e.g. maritime authority) and other stakeholders (such as the hyperbaric specialist of a nearby hospital) and several actions were carried out over time. This collaboration was recognized by the first workshop attendees as the main contributing factor to prevent fatalities and serious consequences of decompression illness in the community over time. Improving technology and safety on boats and having staff from local health centers trained in the management of decompression illness and its prevention, as well as knowledge about other short- and long-term diving-related health problems, were identified as current challenges.

In the second workshop, the community representatives identified the work processes involved in seafood harvesting and post-harvest activities. In these processes, they identified hazards of the physical and psychosocial working environment. Conditions such as the informality of jobs, climate change, pollution and market demands were considered to influence the safety and health of all workers linked to the artisanal fishing value chain in the community. Availability of comprehensive health programs for fishermen, and training in basic occupational safety and health for primary health care workers in rural areas were identified as actions to be taken.

4.2 Executive function among Chilean shellfish divers: a cross sectional study considering working and health conditions in artisanal fishing.

Study participants were men, most of whom were ≥ 40 years old (68%) and had completed primary education (57%). Fishermen had a higher prevalence of depressive symptoms than divers (24% vs. 9% $p< 0.01$). Mild symptoms of decompression illness have been experienced by 75% of divers during their working life.

There were no differences between divers and fishermen in the Wisconsin Card Sorting Test results. Fishermen and divers with depressive symptoms, those who were older and those with lower educational level had a higher percentage of perseverative responses and perseverative errors; likewise, divers with higher decompression illness scores scored worse in the Wisconsin Card Sorting Test of executive function. The latter was confirmed after adjustment for potential confounders.

4.3 Courses on basic occupational safety and health: a train-the-trainer educational program for rural areas of Latin America.

The four teams of trainers successfully completed the train-the-trainer program and implemented it in a small-scale fishing community in Northern Peru and Central Southern Chile, in a community of Potato and Quinoa farmers in the Peruvian Highlands, and a community whose main activity was pottery in Central Chile. However, one of the teams was unable to implement its planned teaching intervention due to lack of time of the team of trainers and the community. The priority work-related health problems identified in the participatory diagnosis and then addressed in the teaching interventions were musculoskeletal disorders and distress. Although these problems, for example in the case of musculoskeletal disorders, were known to the community health centers and treatment was provided while prevention was not considered mainly due to knowledge deficits of the healthcare staff.

The train-the-trainer program was well evaluated by the trainers. According to the trainers, the implementation of actions with the community and the learning process for the trainers were facilitated by the flexibility of the methods, which promoted the participation of the community and other relevant actors, and respect and consideration for the knowledge and culture of the communities. The communities' remoteness and isolation along with the limited time of both the trainers and the communities' inhabitants added complexity to the implementation of the participatory diagnoses and teaching interventions. These factors also made it difficult to achieve the trainers' learning objectives. Teams of trainers with strong institutional support of both, the university and the primary care centers, were better able to overcome difficulties. This support was provided where the project was considered part of the academic and community care activities. Problems raised by the

teams of trainers included lack of occupational health knowledge of the rural health personnel, little awareness in local authorities about the importance of rural workers' health, and the lack of public health and primary care plans considering work as a determinant of the health of rural communities. Three of the universities continued post-project activities to address the working and health conditions in the communities.

5. Discussion

Although still there is a lack of local policies on workers' health in rural areas, the "natural" link to primary health care in rural communities reinforces the strategy of providing basic occupational health services through primary health care. This was the case with the history of decompression illness among divers in the artisanal fishing community in southern Chile, where the primary health care representative was the driving force behind connections to prevent fatalities in the past.

All three studies presented here indicate that training in occupational safety and health is a necessity for health workers in rural areas.[24-26] This is consistent with the finding that in countries where the policy of integrating basic occupational health services into primary health care has been adopted, the lack of trained personnel was an obstacle to overcome.[28,29] Training should be acquired in undergraduate education,[30] since in general, student internships to address health demands in rural areas of Latin American countries are carried out by undergraduates.[31] These trainings should include tools for community involvement.[31]

Participation and social dialogue are essential components of current global strategies for addressing workers' health and decent work.[14,32] Since the factors that influence the health of rural workers and their families are diverse - ranging from hazards directly present in the workplace to environmental and socio-economic factors -[20,24,25,33-35] participation and social dialogue must be transferred to rural areas.[36] Herein, intersectorality[37] and transdisciplinarity[27] play a fundamental role in problem analyses and the search for solutions, as has been the case in the model community in southern Chile.[24] Undergraduate inter-professional education focusing on the health[38,39] and development of rural communities should be considered. Thereby, one health strategies can be implemented integrating health of human beings, animals and the environment.[40-43]

Local initiatives under this integrative approach would contribute to sustainable development.[43] An example could be the shellfish divers who had worse results in the evaluation of the executive function associated with the history of decompression illness.[24,26] In general, the recommended measures for preventing decompression illness for artisanal shellfish divers during diving are to avoid deep and prolonged dives, and to use decompression tables to determine the necessary stops during ascent for gradual elimination of accumulated nitrogen.[44,45] The use of decompression tables is difficult among divers in artisanal fisheries, due to low levels of schooling,[22] but also due to environmental conditions. The effects attributable to climate change, pollution and overexploitation in the past, have led to less availability of the species they catch at shallow depths.[4,20] In addition, changes in tides, sea currents and cold-water temperature make it difficult to apply long decompression stops when necessary. Therefore, prevention of decompression illness requires collaborative interventions from different fields, with the participation of the divers themselves. Such a transdisciplinary approach should be used in addressing the challenges in small-scale fishing communities.[5,6]

Summarizing, local measures based on local needs raised with community participation and with a collaborative network trained in a comprehensive approach to people's health can contribute to the provision of basic occupational safety and health in rural communities. However, national/ local public policies on basic occupational safety and health services through primary health care in rural areas are needed to allocate resources and guidelines to the sector.[13,15-17,24,25] In this way the actions would be sustained over time. This need is reinforced by observing the experience of the teams of trainers who implemented actions in rural communities. They succeeded in identifying problems and seeking solutions, including post-project actions. Those teams that achieved this were those where primary health was integrated. However, limitations and difficulties in implementing the project were related to the lack of associated public policy. This lack of public policy can also be seen in the model fishing community in southern Chile. Currently, the community's primary care system does not actively address prevention of work-related health problems among divers and fishermen as it did in the past. This becomes a limitation for continuity of actions and partnership opportunities with stakeholders such as local universities. These local universities could help in solving problems and contribute to training professionals with a local understanding of the region's situation. Implementation of such

public policies would be favored if the primary care model adopted focused on promotion and primary prevention more than on a biomedical care model.[37]

Finally, I refer to the strengths and limitations of our study. Since community participation methodologies to address occupational health were only applied in rural communities in Chile and Peru, we cannot establish with certainty that the approach model can work in all Latin American countries. However, elements such as participation, occupational health in primary health care, and the one-health approach are in line with the current global sustainable development goals, becoming a strength. In relation to the evaluation of the executive function of divers in southern Chile, scarce available research on possible long-term problems in the divers' brains related to their working conditions was a limitation. Similarly, there was difficulty in finding simple tools for the assessment of cognitive function in the field in a population with low level of schooling. Allocating enough time to prepare the protocol and conduct pilot tests before data collection helped us to address these difficulties. During data collection, door-to-door sampling allowed us to reach the greatest number of divers and fishermen located in the communities, overcoming the lack of updated records. Therefore, we recommend it for further studies in rural communities. The constant bad weather conditions also made our field work difficult; extending the period for data collection allowed us to try to increase our number of participants.

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7. Publications

7.1 Occupational safety and health in a community of shellfish divers: a community-based participatory approach.[24]

Material from: Marie A. Garrido et al, Occupational Safety and Health in a Community of Shellfish Divers: A Community-Based Participatory Approach, [2019], [Springer Nature].

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ORIGINAL PAPER

Occupational Safety and Health in a Community of Shellfish Divers: A Community-Based Participatory Approach

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Abstract

In artisanal fishing communities in Chile, the access to occupational safety and health (OSH) is limited by factors such as the informality of employment. Our objective was to analyze the working and health conditions of workers in a coastal town in Southern Chile, under a community-based participatory approach. We carried out two independent social dialogue workshops within the community. The first one (N of participants = 25) was aimed to identify the strengths, weaknesses and challenges for preventing decompression sickness among divers. The second workshop (N of participants = 10) was set to identify the work processes and to map the occupational risks during seafood harvesting and processing in the community. Community members' training for handling and preventing decompression sickness among divers, and the collaboration between a local health representative, stakeholders and authorities, were identified as contributing factors in reducing fatalities and sequels among divers in the past. Technology and safety on board the vessels, training of healthcare personnel in OSH, and access to health programs, were identified as remaining challenges. Through risk mapping, the participants identified the relationship between working and health conditions in the community, reinforcing the necessity of improving access to health and social security. The community participation in identifying and analyzing working and health conditions could be the first step for a strategy to address OSH through primary health care in rural communities. Community empowerment and involvement in action plans, training on basic OSH for health care workers, and public policies are required.

Keywords Community-based participatory research · Diving · Decompression sickness · Informal sector · Occupational health

Introduction

About half of the working population worldwide works in the informal sector with highest figures in low and middle income countries [1–3]. Informal work can be defined as employment without legal status and institutional regulation [4]. It is characterized by unstable income, lack of social security coverage, unregulated working hours, poor working conditions and a lack of preventive measures [4–7]. A lack of workplace safety puts the worker at higher risk of occupational accidents and work-related diseases increasing the burden caused by non-communicable diseases of the community [8]. The prevalence and incidence of occupational accidents and work-related diseases in the informal sector is largely unknown, as no official statistics for this sector exist.

Informal work is especially common in rural areas of many countries around the world. The development of communities depends on exploitation, manufacturing and services around activities such as agricultural, mining and

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fishing [5]. Small-scale fishing communities are one example of rural economic activities where informal employment predominates and the communities mainly depend on one sector. About 58 million workers worldwide belong to the fishing sector [9]. The sector is considered one of the most dangerous around the world; however, concrete figures especially for small-scale fishermen (artisanal or subsistence fishing) are missing.

In Chile, fishing takes place both on industrial and on small-scale settings in rural coastal communities throughout the country. Artisanal fishing supplies both domestic consumption and raw materials for export products. Hookah diving is one of the fishing capture methods used to collect and harvest products such as shellfish, crustaceans and mollusks. The air that the diver breathes comes from an air compressor located on the surface of the boat.

The compressed air flows into the diver's mouth through a hose and a regulator. Divers face hard work conditions due to deep water, cold, tides and darkness, as well as hazards related to changes in atmospheric pressure on the human body [10] when collecting and harvesting such products.

In one of the towns of small-scale fishing in Southern Chile, serious health consequences of diving related accidents including paraplegia, tetraplegia and even death were the most visible health consequences of diving for the community. Such injuries, also called decompression sickness, are related to rapid ascend which may affect various parts of the body including the brain and the lung to different degrees [11]. However, as for other rural workers in low- and middle-income countries access to occupational health services is scarce [12–16]. Therefore, over 30 years the rural health paramedic of the town together with local maritime authorities, the specialist in underwater medicine from a regional hospital, health authorities and stakeholders implemented preventive measures. These preventive measures have been focused on education for prevention of decompression sickness, training for professionalization of diving activities, training for health care workers and research. The interest of the community's paramedic in occupational safety and health (OSH) gave us the opportunity to carry out a cross-sectional study on OSH of the divers. In this study, we could show that milder forms of decompression sickness were still common in the community. In addition, the prevalence of hearing loss and concentration problems was high among the professional shellfish divers [17, 18].

The provision of at least basic occupational health services through primary health care, as initiated since then in this community, is in line with current occupational health strategies for the informal sector in many countries and is promoted by ILO's decent work agenda [19–22]. One component of basic occupational health services is social dialogue [23]. Through social dialogue, tripartite or bipartite agreement can be reached between governments, employers and workers on necessary occupational health interventions. Given the fact that this town was one of the few examples of providing basic occupational health services in Chile, coupled with the community´s positive attitude towards OSH, as well as the finding in our epidemiological study showing that occupational health challenges remain, we decided to start social dialogues in the community. The aims of the social dialogues were to

(1) analyze strengths and challenges of the actions taken so far
(2) diagnose the communities' current working conditions and potential risks involved.

The results should serve as a starting point for a strategy to strengthen the local support network in the prevention of accidents and occupational diseases in the community. In addition, results might act as an example for other communities.

Methods

We conducted two independent workshops (Fig. 1) in the community. We applied the pillars of the ecosystem approach in human health (ecohealth) and participatory methods to synthesize information and obtain conclusions. Ecohealth addresses human health in its relationship with the environment, the economy and the community. It promotes the analysis and solution of health problems through (a) the participation of the community, using social dialogue to reach agreements; (b) a transdisciplinary approach, considering the knowledge of all community groups in the search for concrete and socially accepted solutions, and (c) a social and gender perspective, identifying how the roles of men and women, cultural and socioeconomic differences determine the health of the community [24].

The development of these workshops was revised and approved by Ekosanté, a Latin American, Caribbean and Canadian Collaboration in Ecohealth. Prior to the workshops, meetings were held with union and community leaders as well as health representatives, health and maritime authorities and other stakeholders in order to present the project and its objectives, and to invite them to participate. They expressed their support and acceptance to participate through confirmation letters. Afterwards, we invited community members with the support of the health representative of the community´s fishing terminal and community leaders. All participants provided oral consent after having obtained detailed verbal and written information about the project.

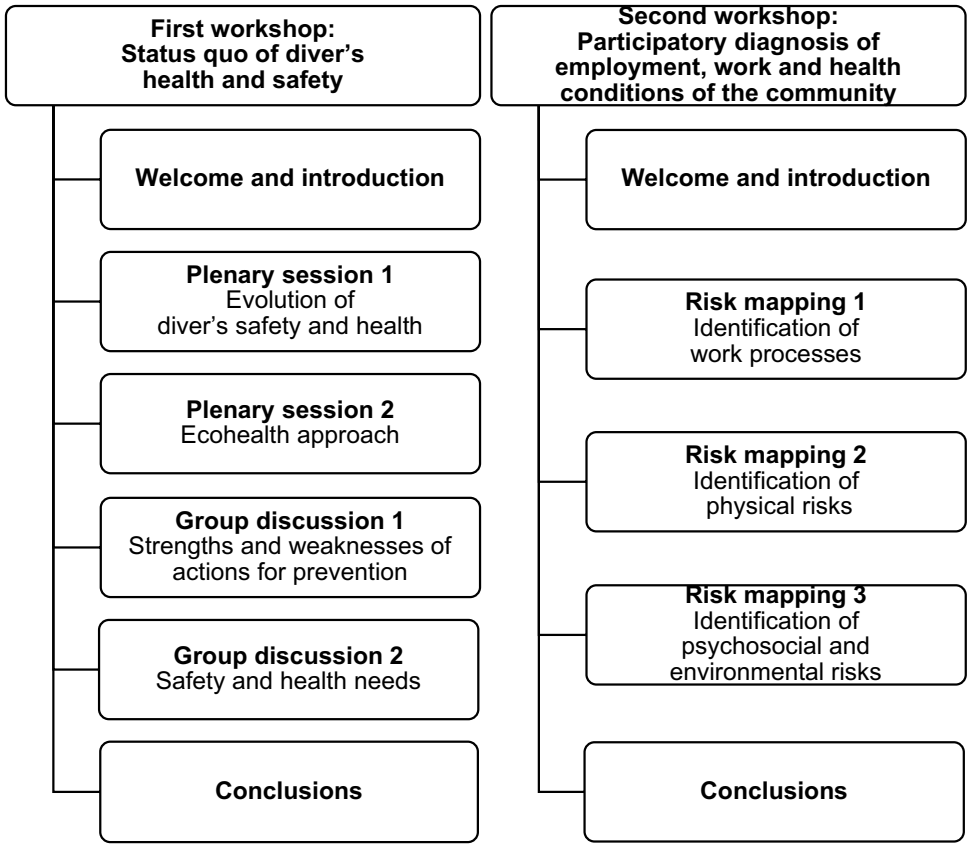

Fig. 1 Structure of the two occupational safety and health workshops carried out in the community of small-scale fishermen in the South of Chile

First Workshop: Status Quo of Divers' Health and Safety: An Analysis with Authorities, Stakeholders and the Community

The first workshop focused on the participative diagnosis of the status quo of divers' health and safety involving the community, authorities and stakeholders. Its objective was to analyze the actions already taken to address one of the main visible occupational health issues for the community: decompression sickness. Likewise, the strengths and weaknesses of the taken measures as well as safety and health aspects not yet covered should be identified.

Twenty-five community members (6 of them women) participated in the workshop. They represented different local and regional organizations such as fishermen's unions, community social organizations (sports clubs, neighborhood committees, women's groups), local primary health care center and hospital, and the regional health authority. Likewise, a professor of Phonoaudiology from a local university, the communities' medical specialist and the nurse of the hyperbaric medicine unit of a regional public hospital participated. The activities were led by three of the authors (MAG, MP, JD). The workshop took place in a room of the fishing terminal of the community in January 2016.

As shown in Fig. 1, two plenary presentations and two group discussion sessions (4–5 members per group) were carried out with an overall duration of 3.5 h. In the first plenary presentation (75 min), all collaborators synthesized history of actions already taken in order to improve OSH of divers and their family members. The second presentation (30 min), held by one of the authors (JM), explained the ecohealth approach to the participants. During the first group discussion session (20 min), participants identified the strengths and weaknesses perceived by the community in actions aimed at preventing health-related problems of diving. In the following second group discussion session (40 min), needs relating to health and safety at work of divers and artisanal fishermen which were not yet covered were identified. In both sessions, brainstorming was used as a strategy to identify points of interest and discuss them.

Second Workshop: Participatory Diagnosis of Employment, Work and Health Conditions of the Community

While the first workshop was focused on actions already taken to improve divers' health, the objective of the 2nd workshop was to identify work and health conditions together with the community. This should allow the community to identify risk factors at the workplace and identify preventive measures themselves. Ten community representatives (workers involved in fishing and seafood processing,

relatives of divers and fishermen and diver's assistant) participated in the workshop. One of them also took part in the first workshop. We had a low participation of fishermen (1 representative) and absence of divers because the workshop coincided with a day of good weather conditions after a long period of poor weather conditions so that they preferred to work over participation in the workshop.

The second workshop took place in the community's fishing terminal in March 2017. In two 2-h sessions carried out on different days, participants identified the work processes related to shellfish processing in their community through the construction of a risk map. Risk mapping promotes the participation of the workers and the community in learning and the identification of hazards at their workplace [25]. It allows social dialogue around the health of workers and sets the basis for the subsequent adoption of control measures. The risk map is used to identify risks as a first step to adopt control measures in the workplace. Its origins and application date back to the 1960s under the Italian workers' movement, in which workers and their unions played a leading role in improving working conditions [26, 27].

In the first part of the workshop, participants identified the work processes from preparation of the diving equipment to the processing of the product (seafood) at home. After that, the facilitators (MAG, MP) invited participants to identify work and environmental risk factors, and their possible health effects by using color cards and pictograms. Each color symbolized one type hazards, (e.g., red for chemical hazards and green for biological hazards. In order to facilitate the understanding and classification of hazards, we used familiar terms for the participants; ergonomic factors such as inadequate postures, load handling, etc.) were identified as "physical efforts", and those hazards of the physical work environment with potential risk of accidents were referred to as "safety factors". Pictograms were used to indicate environmental and psychosocial factors (e.g., a net for social support, an umbrella for social security).

Results

First Workshop: Status Quo of Divers' Health and Safety: An Analysis with Authorities, Stakeholders and the Community

In the first plenary session, participants stated that at least 30 years ago, neither the community nor the local health care givers were aware of measures to prevent decompression sickness. Due to severe diving accidents related to decompression sickness, several actions developed over time in a necessity driven approach (Table 1). Starting from capacity building by the local paramedic, a network was formed, and several research activities took place all of which contributed to the reduction of severe diving related accidents. In addition, participants felt that some legal measures were put into place, which improved the local situation.

In the group discussion, participants also identified challenges in the implementation of preventive actions. At the workplace level, inadequate maintenance of the technical equipment of the boats was considered a threat. Participants described situations where damaged compressors and hoses resulted in a contaminated or suddenly interrupted

Table 1 Evolvement of measures taken in the community for the prevention of decompression sickness over the last 30 years

Measure	Evolvement over time
1. Capacity building	The paramedic of the rural post – was trained and gained experience in underwater medicine – worked in the field with divers and fishermen to prevent decompression sickness and other accidents related to diving – received collaboration from the regional Navy and Health authorities and the specialist in hyperbaric and underwater medicine from the public hospital – encouraged divers to report symptoms of decompression sickness, and to accept diagnostic procedures and treatment of decompression sickness – became a link between fishermen' unions and stakeholders, forming a collaboration network
2. Development of a collaboration network: – Fishermen – Local health representative – Stakeholders	The collaboration network – became the main driving force for prevention – was the driving force to train young people in professional diving – organized preventive activities for fishermen, their families and health care workers
3. Legal aspects	Diving regulation – included training on reading of diving tables, speed control techniques for descent and ascent, etc. Territorial use rights in fisheries (TURFs) (since 1991) [52] – resulted in clearly defined distribution of diving areas.
4. Research	Various research activities – raised awareness – resulted in concrete measures (e.g., accident records kept by rural post's paramedic)

air supply. At the healthcare level, lack of trained healthcare professionals on diagnoses and treatment of decompression sickness outside the town were mentioned. With respect to training of the fishermen and divers, scheduling regular trainings was considered challenging as during the hours dedicated to training no income is generated. Along these lines, the low participation of more experienced workers in training activities was mentioned a challenge, as they could contribute to learning by their experience. Participants also stated that sociocultural factors need to be considered in training activities. In addition, it was mentioned that women in their role as caregiver within the family should be included in preventive actions.

Future Necessities for Community Health and Safety Identified in Workshop 1

Workshop participants identified the need to raise further awareness about safety risks in diving. In addition, they considered the implementation of technical safety measures on the boats like echo sounders to determine water depth, GPS and radio communication as crucial. However, in some cases the associated costs were considered an entry barrier. Likewise, improved preparedness to face emergencies emerged as a common point of interest for fishermen and health personnel.

Participants also felt that identification, diagnostic and surveillance of possible short and long-term effects of diving on health would be important. They also considered it necessary to promote research and facilitating access to health programs and to social security system.

Second Workshop: Participatory Diagnosis of Employment, Work and Health Conditions of the Community

During the risk mapping workshop, participants identified that the whole work process begins at the workers' homes when they prepare their equipment and themselves (in terms of food, clothing, etc.). The next step relates to the extraction of the product. Once back to town the product is distributed both locally and countrywide for: (1) processing in family businesses or homes in the community, (2) sale to the gastronomic sector or to consumers, and (3) industrial processing that provides both domestic consumption and export. The identified work processes gave a picture of the whole community's involvement in the economic activity (Fig. 2).

As a next step, participants categorized the hazards of each part of the process into physical, biological, chemical, ergonomics and psychosocial risk factors. After that, they named the potential health consequences of each hazard (Table 2). The final risk map gave an illustration of the broad range of occupational hazards present in the community's main economic activity aggravated by informality leading to lack of adequate safety equipment, manual work, unstable income and dependence on environmental factors (weather conditions, local and global supply chain, etc.). This reinforces the demand for, on the one hand, comprehensive health programs for divers, fishermen and the community, including occupational health issues and, on the other hand, facilitating access to them.

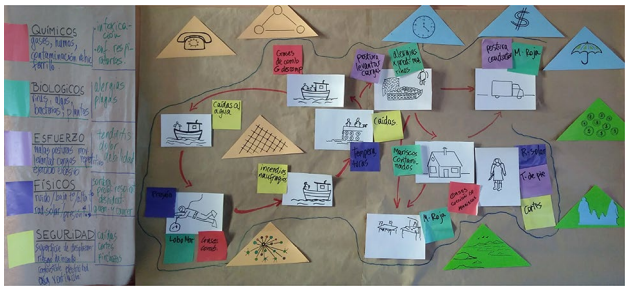

Fig. 2 Work processes identified by the participants

Discussion

The participatory diagnosis allowed community representatives, stakeholders and decision makers to analyze the OSH situation of workers in the community. The involvement of the community, the guided social dialogue, and the systematization of information triggered the identification of areas that need to be addressed both, from a public policy standpoint and at a local level, in order to promote safety and health for fishermen and their families: Training in OSH for professionals and technicians to address local work-related health problems, on-board safety technology, community-based participatory research and prevention activities, and health coverage for fishermen and divers.

As the boundary between the workplace and the community disappears in the fishermen's community, it becomes necessary to look at their health problems through a transdisciplinary lens. This requires an involvement of the community's actors, as it occurs with other public health problems. Such has been the experience in a rural community in Mexico, where the participation of the members from the community allowed them to identify health problems, prioritize them and commit themselves to solutions through the ecohealth approach [28]. Therefore, community participation becomes the cornerstone of health promotion in rural and remote areas.

In this community, this dynamic started as a response to injured divers in need of primary treatment. Driving force was the local paramedic who became interested in prevention and improved treatment of decompression sickness as she identified it as a serious health threat of the community

Table 2 Main work processes linked to seafood in the community and identified risks factors for workers' health

Process/place	Workers involved	Main tasks	Hazard	Risk factor	Effects	Technical term/expert assessment
1. Preparation/home	Divers Fishermen	Preparation of equipment Self-care (feeding, rest)		Alcohol consumption, inadequate feeding, inadequate rest	Diving accidents Health problems	Modifiable cardiovascular risk factors, [41] Decompression sickness [53]
2. Seafood collection/underwater and on board at open sea or in channels	Divers	Collect seafood	P	Hyperbaric environment	"Mal de presión"	Decompression sickness, arterial gas embolism, barotrauma, long-term effects, etc. [10, 54, 55]
			B	Marine fauna (sea lions)	Risk of cutting hoses that supply the diver with air	Drowning, Asphyxia, Decompression sickness, Arterial Gas Embolism (AGE) [56]
	Fishermen	Assist diver Move up net with seafood Classify and count seafood	P	Low temperature inside and outside the water	Hypothermia	Hypothermia [55]
			C	Smoke from engine combustion	Poisoning	Carbon monoxide poisoning [55]
			P	Physical work environment on board (confined spaces, wet surfaces, use of fuels, electricity)	Fires, shipwrecks, fall into the water.	Accidents [41, 42]
			E	Forced postures, manual handling of load	Pain, weakness, tendinitis	Musculoskeletal disorders [41, 42, 57]
3. Product delivery and sale/ Dock at fishing terminal	Divers Fishermen	Product unloading	P	Low temperature	Respiratory problems	Respiratory diseases [42]
	Sellers and buyers	Weighing and loading distribution vehicles	B	Allergens (seafood)	Contact allergy	Dermatitis, Asthma [46]
			P	Slippery surfaces	Tumble	Accidents
			E	Forced postures, load handling	Pain, weakness, tendinitis	Musculoskeletal disorders [42, 57]
4. Transport/Community, Region, Country	Drivers	Transport of products	E	Forced postures	Pain, weakness, tendinitis	Musculoskeletal disorders [58]
5. Home processing/Yard or basement of the house	Mainly women	Cleaning, shell removal, cooking, selling of product	P	Solar radiation	Burns and cancer	Skin diseases [59]
			P	Use of sharp objects	Wounds	Accidents [40]
			C	Seafood cooking	Respiratory diseases	Asthma, respiratory allergies [46, 47]
			E	Forced postures, repetitive movements	Pain, weakness, tendinitis	Musculoskeletal disorders [43, 60]

Table 2 (continued)

Process/place	Workers involved	Main tasks	Hazard	Risk factor	Effects	Technical term/expert assessment
All processes	Community		Ps + E	Informality of jobs	Lack of access to health, no income in case of sick leave	Lack of social protection [40]
				Non-fixed salaries	Uncertainty	
				Work schedules that depend on tides and climatic conditions	Impossibility to work	Working conditions and features of artisanal fisheries [40]
				Dependence on market demand	Overexertion to generate higher income	Accidents [40, 61]
				Environmental pollution and climate change	Vulnerability, crisis, loss of employment	Precariousness of employment, difficulty in adapting [62]

B biological hazard, *C* chemical hazard, *E* ergonomics (physical effort), *P* physical hazard (including "safety factors"), *Ps* psychosocial risk factors

she was taking care of. The experience shows that it is possible to address workers' health problems at a local level and through the local public health system, with collaborators' support. Key is a trustful environment between all key actors.

However, structural support is required to overcome the challenges of working in rural areas, [29–31] ensure access to occupational health [16] and decent work [32]. The core of the health attention in rural areas is a primary health care center or post, and it needs to be reinforced in three main areas: (1) Personnel professional training, where work needs to be considered as a health determinant in pre and post graduate programs; (2) Public policies that include basic occupational health services in primary health care; and (3) Strategies for the involvement of the community in promotion and prevention of health problems [19, 22, 33–40].

The risk map resulted to be a useful tool for the involvement of the community in identifying work processes and main associated risks. For the fishermen's community, these were primarily related to factors of the physical working environment, the psychosocial environment, the economy and the climate. This local picture, obtained with the knowledge of the community, matches the big picture of small-scale fishing at a world level, [40–42] validating the community as a qualified informant of the whole production process.

Furthermore, invisible groups of workers in the seafood productive chain have become known because of the community discussion, and they require further attention. This is the case of women processing seafood at home where several risks, mainly related to musculoskeletal disorders, were identified. In a study of artisanal fisherwomen in Brazil, a high prevalence of musculoskeletal disorders was found and product processing was identified as one of the most demanding activities [43]. The perception of the risks of women and children in rural areas has been visible through community participation strategies [44]. At the same time, it is possible to identify the need for research on health problems affecting the community and to consider gender relations that arise in the work of women in fishing [45]. One example is the mentioning of respiratory diseases by the women processing the products as no attention has been paid to this before in the community. However, it is known that seafood may cause allergies after airborne exposure [46, 47].

A possible limitation of this experience could be the absence of divers and low participation of fishermen representatives in the workshop 2, thus limiting the identification of risks in their work processes. However, this absence was not critical as community members were familiar with the work processes involved in the completely productive chain, from diving to seafood processing. In small communities that have developed around one main productive activity, it is expected that knowledge about the work be disseminated

inside families. In these terms, the family becomes a component of the support network for awareness and change of attitudes at the workplace that put the health of the community at risk [48–51]. Thus, this knowledge and support should be considered when working in the promotion and prevention of accidents and occupational diseases in the community.

The results of this experience are not generalizable to all the communities of artisanal fishermen; however, the methodology could be applied to address them, incorporating the prioritization phase of the problems, analysis of available resources and interventions.

Conclusion

Guided social dialogue, together with basic occupational health tools, allow to obtain a diagnostic of the health situation of workers in communities that lack access to occupational health. The next step is to analyze, prioritize, and implement an action plan. Likewise, research can be focused on topics of interest to the community and this way, increase participation and acceptance of the measures. However, structural support from decision makers, public health system (especially by the primary health care center) and stakeholders (universities, community organizations, etc.) is required to sustain the intervention in the long term. Based on this experience, our proposal is to train health care providers, working on the primary health system, on basic occupational health tools to address the rural health needs, and to promote the involvement of the community in education and action plans. We consider it crucial to incorporate training on occupational health in pre- and post-graduate programs.

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Compliance with Ethical Standards

Conflict of interest The authors declare no conflicts of interest. This article is part of the research conducted by MAG, as part of the requirements for the PhD degree in the Medical Research—International Health Program.

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7.2 Executive function among Chilean shellfish divers: a cross sectional study considering working and health conditions in artisanal fishing.[26]

Executive function among Chilean shellfish divers: a cross-sectional study considering working and health conditions in artisanal fishing

Executive function among Chilean artisanal divers

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M.A.G. contributed in the design of the study, acquisition, analysis and interpretation of data, and drafted the manuscript. L.M. contributed in data acquisition, revision and final approval of the manuscript. M.P. contributed in the design of the study, analysis and interpretation of data, revision and final approval of the manuscript. D.N. contributed in the analysis and interpretation of data, revision and final approval of the manuscript. K.R. contributed in the design of the study, analysis and interpretation of data, drafted the manuscript, revision and approval of the final version.

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Institution and Ethics approval and informed consent:

This study was conducted in two artisanal fishing communities in Southern Chile. The study was approved by the Scientific Ethics Committee of the Health Service of Los Ríos Region in Chile and by the Ethics Committee of the Medical Faculty of the Ludwig Maximilian University in Munich (Germany). Prior to data collection, participants signed an informed consent form. Those participants who could not read or write were assisted by a relative; in this case, the relative´s signature and fingerprint of the participant were recorded on the forms.

Disclosure (Authors): The authors declare no conflicts of interest. This study is part of the requirements for MAG to obtain a PhD degree at the CIH^{LMU}.

Disclaimer: None

Title: Executive function among Chilean shellfish divers: a cross-sectional study considering working and health conditions in artisanal fishing

Abstract

Background

Knowledge about professional diving-related risk factors for reduced executive function is still limited. Therefore, we evaluated the association between decompression illness and executive functioning among artisanal divers in southern Chile.

Methods

This cross-sectional study included divers and non-diving fishermen from two fishing communities. We applied a questionnaire on sociodemographics, depressive symptoms, alcohol consumption and history of decompression illness. Based on the latter history, a score was computed based on severity and frequency. The percentages of perseverative responses and perseverative errors from the Wisconsin Card Sorting Test were used to evaluate executive functioning. Potential predictors of failure in executive function were evaluated via linear regression modelling.

Results

Study participants were 104 divers and 58 fishermen. They were men, mostly ≥40 years old (68%). Seventy-five percent of divers had experienced at least mild decompression sickness. The percentages of perseverative responses and perseverative errors were higher in older compared to younger participants ($p<0.01$), participants with lower vs. higher educational level ($p<0.01$), participants with vs. without depressive symptoms ($p=0.05$), and divers with higher compared to lower decompression illness scores ($p<0.01$). After adjustment, divers with greater decompression illness scores had higher percentages of perseverative responses ($B_{Score\geq9}$= 16.20, 95%CI= 1.98–30.42) and perseverative errors ($B_{Score\geq9}$= 11.38,

95%CI 1.05–21.70) compared to divers with the lowest score. However, there were no differences between divers and fishermen.

Conclusion

Executive functioning seems to be reduced in artisanal divers with a more severe and frequent history of decompression illness. Therefore, intervention strategies should focus on prevention of decompression illness.

Keywords

Decompression sickness; Embolism, Air; Informal Sector; Wisconsin Card Sorting Test; Diving; Occupational Health

1 Introduction

Small-scale and artisanal fisheries are key for food security, poverty eradication, and sustainable development worldwide. Over 90% of the world's fishing-related workers are engaged in small-scale fisheries.[1] Despite their contribution, precarious working and employment conditions, environmental and socioeconomic factors and lack of access to social welfare services affect the development and health of the families and communities that directly depend on this sector.[1]

In Chile, artisanal fishing takes place mainly in rural coastal communities. Shellfish divers participate in artisanal fishing by harvesting and capturing marine species such as shellfish, crustaceans, mollusks and algae. They supply raw materials to the local market, to intermediaries or to processing companies that supply the international trade.[2] Nationally, 58% of the 38,440 divers registered at the Maritime Authority in 2017, were basic shellfish divers. However, there is an unknown number of unregistered divers.[3]

Under water, most basic shellfish divers in Chile breathe compressed air by the so-called Hookah technique.[3,4] The air is supplied from an air compressor located on the surface of the boat and passes into the diver's mouth through a hose and a regulator. While the diver is harvesting, one or two dive assistants maintain the Hookah breathing system and the boat in proper functioning.[3] The assistants also load into the boat, sort and count the products harvested by the diver.

Decompression sickness is one of the main occupational health problems for divers in artisanal fisheries worldwide.[5-9] It can occur when the inert gas (nitrogen) forms intra- or extra-vascular bubbles during ascent due to decreasing atmospheric pressure. These bubbles can obstruct blood flow, damage tissues, and promote the activation of the inflammatory response. Depending on the affected site, mild symptoms, such as joint pain and skin alterations, or more serious neurological and cardiovascular diseases, which are potentially fatal, may occur immediately or even hours after diving. Additionally, when bubbles reach the arterial bloodstream, a risk of arterial gas embolism exists, affecting mainly the brain. Decompression sickness as well as arterial gas embolism are known as "Decompression Illness".[10,11]

Decompression Illness may result in long-term effects on divers' brains [12] including changes in cognitive function.[13] Brain imaging of patients who suffered decompression illness, especially those with cerebral arterial gas embolism, showed changes in several brain regions, including the frontal and parietal lobes.[14,15] Bubble buoyancy into the bloodstream could explain the location of the lesions.[10,12,15,16] Executive function is one of the cognitive functions circumscribed to the frontal lobe, although a network connecting different brain areas is involved.[17,18] Executive functioning is understood as complex cognitive processes – such as cognitive flexibility, task-shifting, working memory, planning, and inhibition, among others – that are interrelated and allow adequate performance in goal-oriented tasks and functioning on a daily basis.[19] Cognitive flexibility is preponderant in adapting behavior to a changing context.[20] Deficits in cognitive flexibility result in perseverative behavior.[21]

Despite the importance of the executive function in divers' performance, limited evidence on the effects of decompression illness on executive functioning exists.[13,22] In the last decades, studies of cognitive function – including executive function – focused on assessing long-term effects of diving conditions on the central nervous system of divers with no history of decompression illness.[23] These studies – none of them carried out in artisanal fishing – showed poor performance on executive function tests by divers[24] compared to non-divers.[25,26] Deep dives and cold environments were factors involved in altering brain perfusion and cognitive performance of divers.[27] In concordance with these findings, we have previously shown a low level of attention in southern Chilean shellfish divers who frequently dived deeper than 30 meters.[28] A recent meta-analysis even showed that repetitive diving increased the risk of brain injury in divers with no history of decompression illness.[29]

However, since decompression illness is a major problem for divers in small-scale, artisanal fisheries, our objective was to assess frequency and severity of decompression illness as risk factor for reduced executive functioning among artisanal shellfish divers in Southern Chile.

2 Materials and Methods

2.1 Study design and participants

This cross-sectional study was carried out between September 2017 and October 2018 in two fishing communities from southern Chile. Seafood and algae harvesting are the main economic activities in these communities. We included male divers between the ages of 18 and 59 years, working in artisanal fishing or with a history of having worked as such in the past. We excluded women as no females are involved in artisanal diving in these communities. We established the age limit to avoid severe changes in cognitive function due to aging. In addition, we included a comparison group of never divers. They were fishermen from the same communities, chosen under the same inclusion criteria as the divers. A fisherman was everyone who worked from the surface of the boats during the harvesting of sea products (e.g. divers' assistants and crew members of the boats) without a history of diving.

2.2 Field work and study instruments

Recruitment

Prior to field work, we met with social leaders, both from artisanal fishing and from the communities (e.g. neighbourhood councils, fishermen´s unions, etc.). We introduced the study and its objectives, and we invited the community to participate. We also promoted the study through local radio stations, posters and flyers at strategic points in each community. For the recruitment of participants, we carried out a door-to-door sampling, supported by a local assistant. This helped us to avoid a healthy worker effect and to overcome the challenge that no official registry of artisanal divers exists. We visited each household up to three times in order to recruit potential participants. If an eligible household member agreed to participate, we made a maximum of three phone calls to (re-)schedule an appointment (i.e., if the fisherman or diver did not show up for his appointment).

Data collection and data collection instruments

Two of the authors (MAG; LM) interviewed the participants and applied an executive function assessment test. These were held in the participant´s home when conditions were appropriate (privacy, adequate lighting and no distractors). Otherwise, the evaluation was conducted in a room provided by one of the social community organizations.

The following data collection instruments were applied during the interview:

1) The Wisconsin Card Sorting Test (WCST) to evaluate executive function, mainly cognitive flexibility and task-shifting.[18,30] The examiner presents a set of 4 stimulus cards on a table. The cards contain figures that differ in shape, colour and quantity. The task of the examinee is to sort response cards with the appropriate stimulus card, according to classification criteria that he must find out without further instruction other than the examiner´s positive and negative feedback for correct and incorrect responses, respectively. The test ends when the examinee manages to solve the task by completing six correct classification categories or when all 128 responses cards (so-called trials) are finished.
2) An adapted questionnaire to assess work-related exposures and potential confounders such as depressive symptoms[31] and alcohol consumption,[32] using the following sources:
    - A questionnaire instrument developed during our previous work,[9,28] to assess sociodemographic data, working and health conditions, diving frequency and depths, and history of decompression illness.
    - The AUDIT-C questionnaire, corresponding to the first three questions on hazardous alcohol consumption from the WHO Alcohol Use Disorders Identification Test.[33]
    - The WHO STEPS Instrument for the surveillance of risk factors for chronic diseases [34] to assess smoking behaviour.
3) The PHQ-9 (Patient Health Questionnaire), the Chilean validation for the diagnosis of depression in primary health care.[35]

In addition, we used an exhaled carbon monoxide monitor (piCO™ Smokerlyzer®) to assess possible exposure to carbon monoxide (CO) from the boat engine and the air compressor on the boat as an additional potential occupational source of exposure that might affect brain function.[36,37] Although such potential exposure is outside the pathway between decompression illness and executive function, we evaluated it as a potential risk factor for the outcome. For this, we measured the participants' exhaled CO (in parts per million- ppm) on-site immediately before and up to 3-5 hours after the working day at sea, considering the CO elimination half-time.[38] Despite being a simple procedure, complexity of logistics permitted to apply this measurement only in a subsample of the study population.

Before data collection began, we conducted a pilot test including 10 fishermen and divers from one of the communities (who did not later participate in the study). The objective was to evaluate the understanding of the questionnaire as well as to verify the feasibility of applying all the procedures, considering the participant´s daily routine.

Variable definition

We used three WCST outcome variables to assess executive function:

1) Percentage of perseverative responses: corresponding to the proportion of perseverative responses in relation to the number of trials (or cards used) to complete the test. Perseverative responses mean persistence in a type of response that does not meet the new card sorting criterion, despite the negative feedback given by the examiner. These responses reflect a poor flexibility in adapting to change and finding the new sorting criterion.[18] Thus, the greater percentage of perseverative responses suggests less cognitive flexibility.

2) Percentage of perseverative errors: corresponding to the proportion of errors – which are also perseverations – in relation to the number of trials to complete the test. Perseverative errors in the WCST

are related to low cognitive flexibility,[18,39,40] and shifting ability[18] – „a lower-level form of cognitive flexibility“[20] –, which are preponderant abilities for performance in the WCST.

3) Percentage of non-perseverative errors: corresponding to the proportion of errors – which are not perseverations – in relation to the number of trials to complete the test.[39] Such errors should not depend on the cognitive flexibility and served thus as negative control.

We considered these three WCST variables as percentages instead of absolute values as they have not been validated in the Chilean population.

Our exposure variable was self-reported history of decompression illness. In absence of a validated measure to assess exposure severity, we assigned a score to the history of decompression illness taking frequency and severity into account. The score was one point if the symptoms occurred “once” in a lifetime, and two points if it occurred “several times” and three points if decompression illness was diagnosed at a health center. The score was multiplied by 1 if mild symptoms were reported, by 2 if it corresponded to neurological decompression sickness, and by 3 in case of cerebral arterial gas embolism. We then summed the total score and categorized it into four groups (0-1 points, 2 points, 3-8 points, and ≥ 9 points) in order to obtain equally sized groups. The score 0-1 corresponded to divers who did not have decompression illness or who only experienced mild symptoms of decompression sickness once in a lifetime; this group was our internal comparison group.

Due to (1) the variety of criteria in defining decompression illness,[41] (2) divers with neurological decompression sickness and primarily cerebral arterial gas embolism showed alterations in brain imaging,[14,15] and (3) our study was self-report based, requiring a “familiar” form of recognition for divers, the severity of decompression illness was linked to the possibility of brain involvement. Hence, mild symptoms refer to the specific symptoms of decompression sickness type 1 (in the former nomenclature) that is joint pain and skin alterations.[12] Neurological decompression sickness mainly refers to manifestations that could be more related to peripheral nerve and spinal cord involvement (regardless of

their severity).[12] Cerebral arterial gas embolism was considered when the diver had brain involvement after diving, with manifestations such as unconsciousness or seizures.[12]

We adjusted by age in three categories (18-39, 40-49 and 50-59 years), hazardous alcohol consumption, (Audit-C score ≥5),[42] and depressive symptoms (yes or no). We considered participants as suffering from depressive symptoms (based on the Chilean validation of the PHQ-9) as those reporting anhedonia or low mood "more than half the days" in the last two weeks, meeting or not the other criteria for "major depressive syndrome" or "other depressive syndrome".[35]

For descriptive analyses we also used the educational level in three categories (Incomplete primary, Complete primary & incomplete secondary, and Complete secondary & superior), community (called "A" and "B" herein), and the number of completed categories in the WCST, ranging from zero to six. During the WCST, the participant completes a category by correctly classifying 10 consecutive response cards with the established sorting criterion.[43] We used the number of completed categories as a measure of overall performance on the test.[39,40,44]

The variation in percentage of exhaled CO was calculated as the difference of the absolute values in ppm of exhaled CO after work and the exhaled CO before work (baseline) divided by the baseline value. A positive value thus indicates an increase in exhaled CO over the working day. As smoking largely affects CO levels, we also report the CO results restricted to non-smokers.

Statistical Analysis

We used the IBM SPSS® Statistics version 25. Double data entry was performed by two different persons in order to check and correct errors. Data from 13 participants were excluded from analysis due to history of stroke or diagnosis of current psychiatric illness (n=5), or failure /technical problems completing the WCST (n=8).

We performed Chi-square tests of categorical variables to test for independence between divers and fishermen. Then, we performed non-parametric tests (Kruskal-Wallis test and Independent-Samples Median test) to compare the executive function test results between both groups, as well as the other study variables. We used non-parametric tests due to the relatively small sample size and the skewed distribution of the data. Kruskal-Wallis test was used for those variables with ≥3 categories (age, educational level, and history of decompression illness score), while the Independent-Samples Median test was used for dichotomous variables (occupation, community, depressive symptoms and hazardous alcohol consumption). Finally, we performed a linear regression model for each of the three outcome variables, analysing the relationship between decompression illness score and executive function. The models were adjusted by age, hazardous alcohol consumption and depressive symptoms, for being possible confounders in the pathway between exposure and outcome. As decompression illness can only occur in divers, we restricted the linear regression models to the group of divers using divers with a decompression score of 0-1 as comparison group. In a sensitivity analysis we repeated the linear regression model adding fishermen to this comparison group.

2.3 Ethics

The study was approved by the Scientific Ethics Committee of the Health Service of Los Ríos Region in Chile and by the Ethics Committee of the Medical Faculty of the Ludwig Maximilian University in Munich (Germany). Prior to data collection, participants signed an informed consent form. Those participants who could not read or write were assisted by a relative; in this case, the relative´s signature and fingerprint of the participant were recorded on the forms. The study was voluntary and anonymous. To the questionnaires and other records an ID was randomly assigned which was not linked to the identifying information of the participants. This number was handed out to each participant, in case they later decided to withdraw from the study.

3 Results

One hundred sixty-two workers (104 divers and 58 fishermen) participated in our study. The overall response was 62% (64% for divers and 58% for fishermen; Figure 1). Sixty-eight percent of the participants were ≥ 40 years of age, and 57% had only primary education (Table I). The overall prevalence of depressive symptoms was 14%, being higher among fishermen (24%) than among divers (9%, pChi2 <0.01).

Sixty participants (20 fishermen and 40 divers) completed exhaled CO measurements before and after the working day. After excluding smokers (11 fishermen and 13 divers), no statistically significant differences were observed in the variation of exhaled CO between fishermen (median 0%; range 0% to 150%) and divers (67%; -67% to 400%; Data including smokers are shown in table I). Divers reported a median of 150 dives in the last year (min.= 0, max.= 300), of which 83% went to a depth of less than 30 meters, and 16% between 30 and 50 meters.

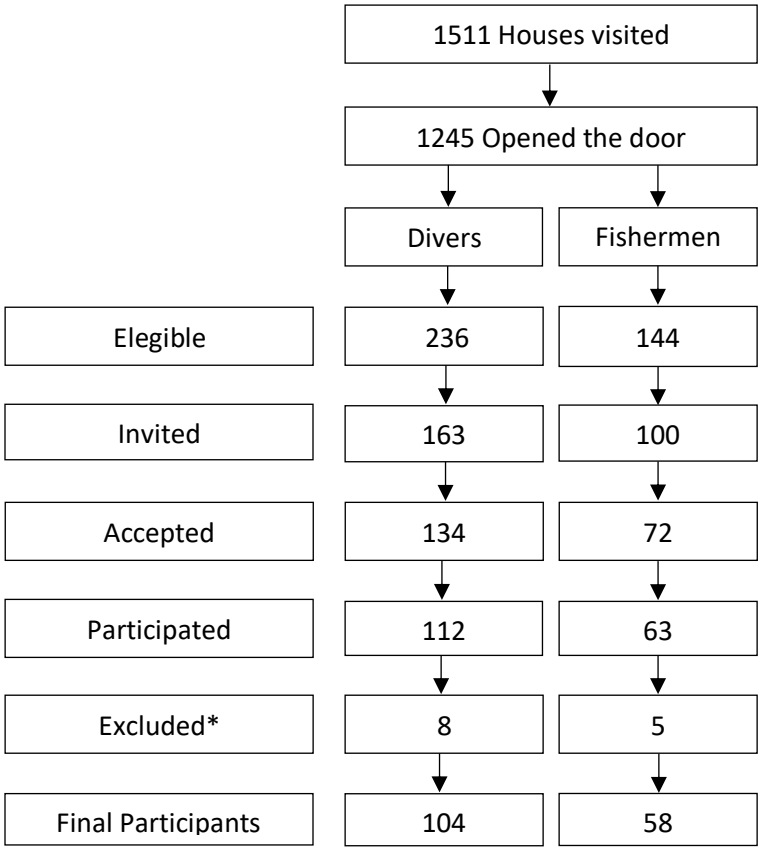
The divers' self-report of the life-time history of decompression sickness was 75% for mild symptoms, and 37% for episodes with neurological symptoms. Twenty divers also reported having had cerebral air gas embolism. Regarding the decompression illness score, 37 of the 47 divers who scored ≥ 3 reported neurological symptoms of decompression sickness and embolism; the remaining 10 were diagnosed with mild decompression sickness.

With respect to the executive functioning, divers and fishermen achieved a median of 2.5 completed categories in the WCST. The median (and ranges) for percentages of perseverative responses, perseverative errors and non-perseverative errors were 22.0 (2 – 98), 20.0 (2 – 74) and 21.0 (2 – 66) respectively.

There were no statistically significant differences in WCST results between divers and fishermen (Table II). The percentages of perseverative responses and perseverative errors were higher with increasing age, lower educational level, and if depressive symptoms were present.

Among divers, the percentages of perseverative responses and perseverative errors were higher in those with history of more severe and frequent decompression illness, but not the percentage of non-perseverative errors (Table II). After adjusting for age, depressive symptoms and hazardous alcohol consumption, we observed a dose-response association between decompression illness score and the percentages of perseverative responses and perseverative errors in the WCST (Table III). This association was statistically significant among divers with decompression illness score ≥3 for percentage of perseverative errors ($B_{Score3\text{-}8}$= 10, 95%CI= 0.2 – 21; $B_{Score\geq9}$= 11.38, 95%CI 1 – 22), and among divers with decompression illness score ≥9 for the percentage of perseverative responses (B= 16, 95%CI= 2 – 30). Results were basically confirmed when including fishermen, albeit not reaching statistical significance for percentage of perseverative responses (Table SI).

Figure 1: Participants and recruitment process in both communities.



* Excluded for 1) having had a stroke or a diagnosis of current psychiatric illness, and 2) failure to complete WCST or records thereof could not be evaluated.

Table I: Comparison of socio-demographics, potential confounders, variation in percentage of exhaled CO, decompression sickness score and Wisconsin Card Sorting Test between fishermen and divers.

	Total N= 162	**Fishermen** [a] N= 58	**Divers** [b] N= 104	**pChi²** (Divers vs. fishermen)
	n (%)	n (%)	n (%)	
Age (years)				0.05
18 – 39	51 (31.5)	25 (43.1)	26 (25.0)	
40 – 49	57 (35.2)	18 (31.0)	39 (37.5)	
50 -59	54 (33.3)	15 (25.9)	39 (37.5)	
Education				0.61
Incomplete primary	32 (19.8)	10 (17.2)	22 (21.2)	
Complete primary & incomplete secondary	70 (43.2)	28 (48.3)	42 (40.4)	
Complete secondary & superior	60 (37.0)	20 (34.5)	40 (38.5)	
Community				0.49
A	133 (82.1)	46 (79.3)	87 (83.7)	
B	29 (17.9)	12 (20.7)	17 (16.3)	
Depressive symptoms [c]	23 (14.2)	14 (24.1)	9 (8.7)	<0.01
Hazardous alcohol consumption [d]	61 (37.7)	26 (44.8)	35 (33.7)	0.16

	Total N= 162	**Fishermen** [a] N= 58	**Divers** [b] N= 104	**pChi²** (Divers vs. fishermen)
History of decompression illness [e]				N/A
Score 0 -1	n/a	n/a	33 (32.0)	
Score 2	n/a	n/a	23 (22.3)	
Score 3 – 8	n/a	n/a	22 (21.4)	
Score ≥9	n/a	n/a	25 (24.3)	
	N; Median (Min – Max)	**N; Median (Min -- Max)**		**p (Median test)**
% change in exhaled CO [f]	60; 0.00 (-80.00 – 400.00)	20; 0.00 (-40.00 – 150.00)	40; 33.33 (-80.00 – 400.00)	0.02
WCST categories completed [g]	162; 2.50 (0 – 6)	58; 2.00 (0 – 6)	104; 3.00 (0 – 6)	0.41

a. Former fishermen included in the study n= 6. Reasons why they were no longer fishermen: economic (3), change of occupation (1), missing (2).

b. Former divers included in the study n= 13. Reasons why they were no longer divers: diving accidents (7), other diseases (2), economic (1), missing (2).

c. Anhedonia or low mood “more than half the days” in the last two weeks

d. AUDIT C questionnaire score ≥5

e. Score of self-reported history of decompression illness according to severity and frequency of symptoms. Missing n= 1.

f. Percentage of variation in exhaled carbon monoxide level ((after-before)/before). Smokers are included. Missing n total= 102 (64 divers and 38 fishermen).

g. Number of WCST completed categories where 0 is the worst and 6 is the maximum.

Table II: Comparison of medians between independent, confounding and Wisconsin Card Sorting Test outcomes by Kruskal-Wallis- and Independent-Samples Median test (fishermen and divers; N=162).

	% Perseverative responses		**% Perseverative errors**		**% Non-perseverative errors**	
	Median (Min - Max)	**p**	**Median (Min - Max)**	**p**	**Median (Min - Max)**	**p**
Age (years)		**<0.01#**		**<0.01#**		0.94#
18 – 39	17.0 (2.00 – 80.00)		16.0 (2.00 – 63.00)		20.0 (4.00 – 53.00)	
40 – 49	22.0 (3.00 – 98.00)		20.0 (3.00 – 74.00)		22.0 (2.00 – 54.00)	
50 – 59	28.0 (5.00 – 98.00)		24.0 (5.00 – 73.00)		22.0 (2.00 – 66.00)	
Education		<0.01#		<0.01#		0.13#
Incomplete primary	32.5 (8.00 – 98.00)		28.0 (7.00 – 73.00)		15.0 (2.00 – 59.00)	

	% Perseverative responses		% Perseverative errors		% Non-perseverative errors	
	Median (Min - Max)	**p**	**Median (Min - Max)**	**p**	**Median (Min - Max)**	**p**
Complete primary & incomplete secondary	22.0 (3.00 – 97.00)		20.0 (3.00 – 73.00)		22.5 (2.00 – 66.00)	
Complete secondary & superior	19.0 (2.00 – 98.00)		16.5 (2.00 – 74.00)		20.5 (2.00 – 53.00)	
Occupation		0.29~		0.24~		0.30~
Fisherman	25.0 (2.00 - 98.00)		22.0 (2.00 - 74.00)		20.0 (2.00 – 54.00)	
Diver	21.0 (3.00 - 98.00)		19.0 (3.00 – 73.00)		22.5 (2.00 – 66.00)	
Community		0.79~		0.85~		0.25~
B	21.0 (5.00 – 98.00)		20.0 (5.00 – 73.00)		19.0 (2.00 – 54.00)	

	% Perseverative responses		% Perseverative errors		% Non-perseverative errors	
	Median (Min - Max)	**p**	**Median (Min - Max)**	**p**	**Median (Min - Max)**	**p**
A	22.0 (2.00 – 98.00)		20.0 (2.00 – 74.00)		22.0 (2.00 – 66.00)	
Depressive Symptoms [a]		**0.05**~		**0.05**~		0.20~
No	21.0 (3.00 – 98.00)		19.0 (3.00 – 74.00)		22.0 (2.00 – 66.00)	
Yes	34.0 (2.00 – 97.00)		29.0 (2.00 – 73.00)		18.0 (2.00 – 54.00)	
Hazardous alcohol consumption [b]		0.22~		0.31~		0.60~
No	20.0 (3.00 – 98.00)		19.0 (3.00 – 74.00)		22.0 (2.00 – 66.00)	
Yes	26.0 (2.00 – 98.00)		22.0 (2.00 – 73.00)		20.0 (2.00 – 52.00)	

	% Perseverative responses		% Perseverative errors		% Non-perseverative errors	
	Median (Min - Max)	**p**	**Median (Min - Max)**	**p**	**Median (Min - Max)**	**p**
History of decompression illness score [c]		**<0.01#**		**<0.01#**		0.18#
0 -1	18.0 (3.00 – 88.00)		16.0 (3.00 – 66.00)		26.0 (4.00 – 66.00)	
2	20.0 (12.00 – 98.00)		18.0 (12.00 – 73.00)		25 (2.00 – 38.00)	
3 – 8	29.5 (8.00 – 98.00)		26.5 (7.00 – 73.00)		18.4 (2.00 – 59.00)	
≥9	32.0 (8.00 – 98.00)		26.0 (8.00 – 73.00)		20.0 (2.00 – 58.00)	

#Kruskal-Wallis test, ~ Independent-Samples Median test

a. Anhedonia or low mood “more than half the days” in the last two weeks

b. AUDIT C questionnaire score ≥5

c. Score of self-reported history of decompression illness according to severity and frequency of symptoms. Missing n= 1.

Table III: Linear regression models to assess the severity and frequency of decompression illness as a risk factor for reduced executive functioning. The models are adjusted by age, depressive symptoms and hazardous alcohol consumption; N=103.

	% Perseverative responses		**% Perseverative errors**		**% Non-perseverative errors**	
	B	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Age (years)						
<40	0		0		0	
40-49	13.85	-0.13 – 27.83	10.68	0.53 – 20.83	0.95	-6.44 – 8.33
50-59	13.64	-0.53 – 27.81	10.11	-0.18 – 20.40	4.89	-2.60 – 12.38
Depressive symptoms [a] yes vs. no	11.51	-5.59 – 28.60	7.88	-4.54 – 20.30	-7.04	-16.07– 2.00
Hazardous alcohol consumption [b] yes vs. no	4.67	-5.59 – 14.93	3.31	-4.14 – 10.76	-0.08	-5.50 – 5.34
History of decompression illness score [c]						
0-1						
2	-2.05	-16.66 – 12.57	-1.58	-12.19 – 9.04	-2.73	-10.46 – 4.99
3 – 8	13.96	-0.34 – 28.26	10.53	0.15 – 20.92	-6.21	-13.77 – 1.35
≥9	16.20	1.98 – 30.42	11.38	1.05 – 21.70	-6.82	-14.34 – 0.70

a. Anhedonia or low mood “more than half the days” in the last two weeks

b. AUDIT C questionnaire score ≥5

c. Score of self-reported history of decompression illness according to severity and frequency of symptoms. Missing n= 1.

4 Discussion

While the average executive function in our study population of artisanal divers was not worse than among an unexposed comparison group of fishermen, the dose-dependent decrease in executive function with type and frequency of decompression illness suggests that decompression illness is crucial in long-term effects of diving on the brain.

To our knowledge, there are no studies available assessing WCST perseverations as a measure of executive function in divers with history of decompression illness. In a prospective study, results on a memory test – where executive control might be involved – were worse in divers with decompression illness compared to those whitout it.[13] Studies on long-term effects on cognitive functioning of divers without a history of decompression illness support the argument for negative effects on the central nervous system related to diving history and diving conditions.[23-27] However, in those studies where the WCST was applied, no difference was found between divers and control groups in the percentage of perseverative responses[23,26] and perseverative errors.[24] This was confirmed in our study as no differences in mental flexibility were seen between divers without or with just a mild history of decompression sickness and fishermen.

Although further cognitive effects have not been evaluated, brain abnormalities in divers who suffered neurological decompression sickness and cerebral arterial gas embolism were shown.[14,15] Failures in the air supply from the surface, resulting in sudden ascent, triggered cerebral arterial gas embolism in abalone divers who had multiple brain injuries mainly in the frontal and parietal lobes.[15] Failures in Hookah system are common in small-scale fisheries[5,7] so that our results fits well to these findings. This result is of special importance considering that only 37% of the divers who had mild decompression illness and 69% of those who had neurologycal symptoms received some form of medical care (data not shown). Diagnosis (including assessment of neurological status), early treatment, and follow-up (even in patients with mild symptoms) are crucial for avoiding consequences of decompression illness.[10,11,45] In small-scale fishing

communities, access to early diagnosis and treatment is hampered by barriers such as distance to a hyperbaric center,[7] funding for treatment, unawareness of proper treatment, and unsafe use of "in-water recompression using air".[8] In addition, local health care providers frequently lack training in basic handling of divers with decompression illness before referral to a hyperbaric center.[5,45]

The overall prevalence of depressive symptoms among divers and fishermen was above the estimated prevalence of suspected depression for Chilean men (14% out of 10%).[46] Depression and mental health problems are a common issue among farmers[47,48] and fishermen[49-51] in rural communities worldwide. "Contextual community factors" such as employment,[48,49] environmental factors (e.g. climate), and poor access to mental health services are involved.[48] Although we cannot establish a causal relationship, this study was carried out just one year after episodes of harmful algae bloom in the study region. This environmental situation affected the work and income of fishermen and their families.[52] In addition, during data collection, the frequent bad weather conditions were unfavorable to recover from the crisis. Therefore, depressive symptoms might be a consequence of these events, since low income has been described as a predictor for depression among fishermen.[49] Re-employment opportunities into the salmon industry to cope with the crisis[53] - mostly for divers due to the industry's historical demand for qualified divers[52] - might explain the differences in the prevalence of depressive symptoms between fishermen and divers in our study.

Our study has certain limitations and strengths. Despite the small number of participants in the study, our results could be representative for artisanal diving in Chilean small-scale fisheries, but not for other countries where diving techniques, depths and diving environment are different. Only few samples of carbon monoxide could be taken; therefore, further analysis of potential chronic exposure and its relationship to the executive function of divers and fishermen is pending.

Through door-to-door sampling in the communities we were able to invite as many fishermen and divers as possible who were in the communities during data collection period. Thus, we could address potential selection bias as well as the healthy worker effect. Healthy worker effect was also addressed by including former workers from the same sector but not exposed to diving or to more severe forms of decompression illness.

To our knowledge, this is the first study in Chilean artisanal divers indicating an association between decompression illness and increased percentages of perseverative responses and perseverative errors. Such work-related factors should be addressed to prevent cognitive impairment over time. Similarly, protective factors from the "cognitive reserve" (e.g. high educational level) that allows the individual to cope with brain deterioration by decreasing the risk of functional impairment (e.g. in dementia) should be considered in prevention and rehabilitation.[54,55] Further studies should consider the validation of simple batteries for the assessment of cognitive function at the community level in the working population, as well as prevention (at all levels) of decompression illness in a local context.

In conclusion, the dose-response effect between the severity and frequency of decompression illness and the percentages of perseverative responses and errors indicate that decompression illness could be a risk factor for decreased executive functioning of artisanal divers. Prevention of decompression illness, along with early diagnosis and treatment, remains crucial to avoid further damage and should be reinforced in small-scale Chilean fishing communities. Training plans and collaborative networking between health services and social partners are necessary interventions to achieve a better quality of life for workers in artisanal fishing communities.

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Competing Interests

The authors declare no conflict of interest. This study is part of the requirements for MAG to obtain a PhD degree at the CIH[LMU].

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Table SI: Sensitivity analysis to assess the severity and frequency of decompression illness (DI) as a risk factor for reduced executive functioning of divers, including the fishermen in the comparison group scoring 0-1 in the history of DI. The linear regression model is adjusted for age, depressive symptoms and hazardous alcohol consumption; N= 161.

	% Perseverative responses		**% Perseverative errors**		**% Non-perseverative errors**	
	B	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Age (years)						
<40	0		0		0	
40-49	13.68	3.81 – 23.54	10.50	3.29 – 17.71	-0.001	-5.16 – 5.16
50-59	13.79	3.67 – 23.91	10.37	2.98 – 17.77	2.38	-2.92 – 7.67
Depressive symptoms [a] yes vs. no	15.19	4.32 – 26.06	10.92	2.97 – 18.86	-5.11	-10.79 – 0.58
Hazardous alcohol consumption [b] yes vs. no	7.45	-0.34 – 15.23	5.47	-0.22 – 11.16	-1.92	-5.99 – 2.15

History of decompression illness score [c]						
0-1	0		0		0	
2	-6.04	-17.75 – 5.68	-4.73	-13.29 – 3.83	0.78	-5.35 – 6.91
3 – 8	9.88	-1.76 – 21.52	7.26	-1.25 – 15.76	-2.83	-8.92 – 3.26
≥9	12.05	0.75 – 23.35	8.05	-0.21 – 16.30	-3.18	-9.10 – 2.73

a. Anhedonia or low mood “more than half the days” in the last two weeks

b. AUDIT C questionnaire score ≥5

c. Score of self-reported history of decompression illness according to severity and frequency of symptoms. Missing n= 1.

7.3 Courses on basic occupational safety and health: a train-the-trainer educational program for rural areas of Latin America.[25]

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Courses on Basic Occupational Safety and Health: A Train-the-Trainer Educational Program for Rural Areas of Latin America

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Abstract: Integrating basic occupational health services into primary care is encouraged by the Pan American Health Organization. However, concrete initiatives are still scarce. We aimed to develop a training program focusing on prevention of occupational risks for primary healthcare professionals. This train-the-trainer program was piloted at four universities in Chile and Peru. Occupational health or primary healthcare lecturers formed a team with representative(s) of one rural primary healthcare center connected to their university ($N_{participants}$ = 15). Training started with a workshop on participatory diagnosis of working conditions. Once teams had conducted the participatory diagnosis in the rural communities, they designed in a second course an active teaching intervention. The intervention was targeted at the main occupational health problem of the community. After implementation of the intervention, teams evaluated the program. Evaluation results were very positive with an overall score of 9.7 out of 10. Teams reported that the methodology enabled them to visualize hazardous working conditions. They also stated that the training improved their abilities for problem analysis and preventive actions. Aspects like time constraints and difficult geographical access were mentioned as challenges. In summary, addressing occupational health in primary care through targeted training modules is feasible, but long-term health outcomes need to be evaluated.

Keywords: informal sector; community-based participatory research; primary health care; occupational health services; capacity building; social determinants of health; workplace

1. Introduction

Globally, work activities in rural areas are mostly linked to the use of natural resources. Examples of such work activities include small-scale mining, fishing, livestock, and agriculture [1]. In agriculture, exposure to hazardous substances, machinery, contact with animals, plants, and vectors is common all over the world [2]. Globally, this results in high morbidity and mortality rates caused by work-related accidents and diseases in rural areas [2]. However, concrete numbers are hardly available partly due

to underreporting [2]. Contributing to the poor occupational health outcome, informal employment, temporary employment, unpaid family work, child labor, and the employment of migrants under precarious conditions are common [1–7].

In addition to these work-related characteristics, poverty, cultural aspects (such as knowledge about and conception of health and illness, language barriers), geographical features, and limited access to health services and to formal education are challenges for rural populations' health [2,4,8,9]. Within this scenario, a close relationship is established between the absence of social security, poverty, rurality, and lack of access to decent work [1,2]. Furthermore, pollution generated by economic activities can indirectly affect rural populations' health [10–12].

In the framework of the sustainable development goals (SDGs), decent work and good health and well-being are two of the 17 goals. These 17 objectives are closely related and improving one will also have positive effects on the others [13]. Decent work involves "opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men." [14]. Through this, decent work promotes rural economic growth [2]. Addressing occupational health in rural areas is therefore a necessity [15]. However, only 15% of workers worldwide (and even less in rural areas) have access to at least basic occupational safety and health services (BOSH) [16].

Since its Global Plan of Action on Workers Health for 2008 to 2017, the World Health Organization (WHO) considers the integration of BOSH into primary health care (PHC) as a strategy to universally address workers' health [1,16–20]. This strategy is supported by the Pan American Health Organization in its Plan of Action on Workers Health 2015–2025 [21]. To the best of our knowledge, concrete actions have only been taken in a few Latin American countries. One example is Brazil, where occupational health was implemented into primary healthcare in the 1980s [22]. However, outcome is still poor, especially in rural areas of Brazil. For example, for one case of pesticide poisoning notified, 50 are not reported [23]. The absence of infrastructure, adequate public policies, accessibility, and trained primary healthcare professionals in occupational health is a prevailing barrier not only in Brazil [1,19,20,24,25].

In many Latin American countries, providing health care services in rural areas is an obligatory part of internships for health care students [26]. However, training on occupational health, prevention, social health determinants, and working with multidisciplinary teams are still scarce for interns [26]. Considering this together with the fact that (1) health promotion and prevention tend to be effective when the community is involved at all stages [27–29], (2) community participation is a promising strategy to address work-related health problems [30–34], and (3) implementation of training on occupational safety and health aspects in primary healthcare is encouraged to achieve good health and decent work for rural communities of Latin America [21], we aimed to develop a train-the-trainer program on prevention of occupational risks to be implemented in health-related training at Latin American universities. This article reports on the concept and the evaluation results of the pilot program.

The rest of the paper is divided as follows: We first describe the methodology of the training program. After that, the evaluation strategy is explained. In Section 3 we start by presenting the results of the pilot implementation at four Latin American universities and continue with the evaluation results. In the discussion, we highlight strengths and limitations of the approach in light of the international literature and close with a general outlook and conclusions.

2. Materials and Methods

The train-the-trainer program was developed and implemented between January to December 2018. It is based on a blended-learning concept (here: online and onsite training) with a theoretical and practical component. The program was piloted at four universities collaborating with the Center for International Health (CIH). The CIH is a training network on health-related aspects coordinated by the Ludwig-Maximilians-Universität in Munich, Germany. It is funded by the German Federal Ministry

for Economic Cooperation and Development [35] "Higher Education Excellence in Development Cooperation" (exceed) initiative. This initiative, coordinated by the German Academic Exchange Service [36], supports the development of competence centers at German universities with their partners in low- and middle-income countries (LMICs), which contribute to the realization of the Sustainable Development Goals (SDGs). In Latin America, the CIH focuses on training in occupational safety and health [37].

From 2015 to 2019, the CIH annually offered parts of its funds as competitive research and training funds for the seven partner universities, associated teachers, and alumni from LMICs. The call was open for any research or training project relevant to the SDGs and in the scope of the CIH's vision "we empower health professionals". The project had to be completed within a maximum of 12 months. In 2017, the authors of this paper, together with the four collaborating universities, successfully applied for these funds (number of projects received: 25 of which 6 received funding). The authors of this paper are all lecturers within the CIH training programs in Latin America who jointly designed and carried out the program. In addition, four of them accompanied the participating universities throughout the training program as "tutors".

The collaborating universities were one CIH partner university and three universities at which CIH alumni are teaching. At all of them, medical or nursing interns provide health services to rural communities. At this stage, we restricted participating universities to two universities located in two geographical regions of Chile (center and central south) and two universities in Peru, one located in the coastal region, the other in the Andean region. This was done in order to limit the travel expenses of the workshops and at the same time, pilot the program in different cultural settings. The universities were informed about the initiative and invited to take part in the training program. All invited universities agreed to participate. Each university was encouraged to participate with a team of lecturers in occupational health and/or PHC and with at least one PHC representative of a rural community (named "team of trainers" herein). The community was selected by each university from those in which the universities' interns are involved in primary healthcare. The selection was based on the preference of the universities.

2.1. Description of the Training Program

The program was taught in two phases (Table 1) and can be downloaded from the Supplementary Materials S1:

Phase I: Participatory diagnosis of health status and working conditions in rural communities. The objective of this first phase was to provide the teams of trainers with the necessary skills to carry out participatory diagnoses of work-related hazards (i.e., something that may cause damage) and risks (i.e., the likelihood that a hazard causes damage) related to the main production chain in each community following the EcoHealth approach. Nowadays, community participation in healthcare is recommended to customize solutions to local needs [38]. It encourages the community to solve its own problems [39] (p. 177). The EcoHealth approach considers health within its close relationship with environmental and socio-economic factors; therefore, health problems are addressed under its principles of participation, transdisciplinary work, and social, ethnic, and gender equity [40] (pp. 103–147). The methodology was successfully piloted previously by two of the authors (M.A.G., M.P.) in a community of artisanal fishermen in Southern Chile [41]. Using a flipped classroom format, teams were first introduced to the theoretical framework in an online case study (CASUS® [42]). Access to the case study was provided through a Moodle™ platform which was also used as a communication tool (forum, news) and for sharing information and training materials/guides. After this introductory problem-based online training, the four teams met in a three-day face-to-face workshop. In this workshop they learned how to—jointly with the community—use a risk map to visualize the work processes, the related risks/hazards, and the potentially exposed population. In addition, they learned how to jointly search for solutions and resources to address the identified problems [43]. After that, each team, supervised by a tutor, worked on the planning of the participatory diagnosis in the rural

communities. After completion of the workshop, all trainers were invited to implement the planned participatory diagnosis in their respective rural communities. During the implementation step they were also accompanied by their tutor.

Phase II: Teaching interventions to address work-related health challenges in the rural communities. Phase II again started with an online introduction followed by a second three-day face-to-face workshop. In this workshop, the teams of trainers got to know active learning methods to prevent work-related health problems and applied them to the problems identified in the community during phase I. "Active learning" means that learning sessions include active application of learning content for all learners in order to raise motivation and improve learning outcome [44]. In order to structure the sessions in such an active way, the ARIPE (adjust, reactivate, inform, process, evaluation) model for competence-based learning was used [45]. According to this model, each training session is divided into five phases and starts with drawing the attention of the learner to the content (e.g., by relating it to an everyday situation (adjust)). After that, the trainer reactivates learners' previous knowledge on the topic (reactivate). Based on that, the teacher provides the group with new information on the topic (inform), which the learners then process and apply (process). Finally, participants provide the trainer with feedback on their learning experience (evaluate).

Following the workshop, teams of trainers were asked to implement the planned educational intervention in the community. Once more, they were accompanied by their tutor. At the end of the implementation, each team completed a report including feedback from the community members. No (health) outcome evaluation in the communities was done.

Table 1. Activities, topics, content, and schedule of the training program on occupational risk prevention in rural communities.

Phase	Activity	Topic	Content/Activities for the Trainers	Time Period
Participatory diagnosis	1-h problem-based e-learning for trainers	Work-related hazards and risks in rural areas	Basic information on: • Common work-related hazards in rural areas with potentially adverse effects on workers' and families' health • Community actors who should be involved in risk control • Preventive measures	March–April 2018
	Three-day face-to-face workshop for trainers	Participatory diagnosis of working conditions and health	• Intercultural communication • Approaching the community through the work–health relationship • Introduction to participatory diagnosis • Risk mapping as a tool of participatory diagnosis • Identification of work processes in the community • Hazards identification • Prioritization and analysis of one problem using the following questions based on the EcoHealth approach [40]: 1. What is the problematic situation? 2. What is the potential damage to health? 3. How does the problem affect different community members? 4. Who knows about the problem? 5. Who should be involved in addressing the problem? 6. Which is the possible source of the problem?	April 2018
	One-day workshop for community members offered by trainers	Implementation of the participatory diagnosis of working conditions and health	• Organization of the workshop and invitation of community members • Diagnosis of working conditions and health in the community • Selection of the most relevant work-related health problem to be addressed in the teaching intervention	May–July 2018

Table 1. *Cont.*

Phase	Activity	Topic	Content/Activities for the Trainers	Time Period
Teaching intervention	2-h problem-based e-learning for trainers	Introduction to teaching interventions	• Problem tree analysis • Scientific literature search	July–August 2018
	Three-day face-to-face workshop for trainers	Teaching interventions to address work-related health challenges in rural communities	• Introduction to teaching interventions • Drafting the concept of the teaching intervention • Background • Context (framework conditions) • Learning objectives • Active learning based on the ARIPE Model (adjust, reactivate, inform, process, evaluate) [45] • Planning the teaching intervention • Practice and feedback • Evaluation	August 2018
	Half-day workshop for community members offered by trainers	Implementation of the teaching interventions	• Organization of the workshop and invitation of community members • Teaching intervention workshop to prevent the most relevant work-related health problem identified with the community	September–November 2018
Evaluation	Online questionnaire for trainers			November 2018
	Evaluation workshop for trainers			September 2019

2.2. Program Evaluation

After implementation of the second project phase in the communities, the trainers completed an online evaluation form (Supplementary Materials S2). It consisted of 10 questions (Likert scale/close-ended and open-ended questions). Questions aimed at evaluating the five "Attributes of Innovations" that influence their adoption rate as described by Rogers [46] (pp. 10–16):

1. relative advantage, as "the degree to which an innovation is perceived as being better than the idea it supersedes";
2. compatibility, as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters";
3. complexity, as "the degree to which an innovation is perceived as relatively difficult to understand and use";
4. trialability, as "the degree to which an innovation may be experimented with on a limited basis";
5. observability, as "the degree to which the results of an innovation are visible to others".

Additionally, a program evaluation workshop was carried out 10 months after the second onsite training due to additional funds received from the Center for International Health. In this workshop, we discussed with the teams:

1. How and to what extent were the program objectives achieved?
2. What facilitated the achievement?
3. Which obstacles were identified in the achievement of the objectives?

Qualitative data of the online survey and the program evaluation workshop were analyzed by two of the authors (V.E., M.A.G.) through the framework analysis methodology. This qualitative research method is suitable to analyze what is happening in a specific setting [47]. Applying this method, the researcher synthesizes the information and obtains common topics; in our case regarding, (1) the attributes of innovation and (2) the quality of the training program.

2.3. Ethical Considerations

The universities of the teams of trainers expressed their approval to participate in the course through a letter of commitment. The questionnaire completed by the trainers was anonymous and voluntary. According to the ethical board of the Medical Faculty of the Ludwig–Maximilians-Universität (Munich, Germany) anonymous and voluntary evaluations of training programs do not require ethical approval.

3. Results

3.1. Participants and Implementation Experiences

At all four universities, occupational health experts (n = 5) or PHC lecturers (n = 4) underwent the program. Additionally, one vice rector of one of the universities participated. Three universities managed to include at least one PHC representative (total n = 5) of the rural community in which they were implementing the project. The rural communities were two fishing villages, one located in the north of Peru, the other located in the central south of Chile; one village dedicated to pottery in the central part of Chile, and finally an agricultural village in the high Andes of Peru. The first workshop was successfully completed by all participating teams of trainers. In the three months following the workshop, all four teams were able to conduct the participatory diagnosis in the communities. The number of community participants in this implementation step varied from five in the Chilean fishing community to 20 in the Peruvian agricultural community (Table 2). The main work-related problems identified were related to musculoskeletal disorders (Chilean pottery and fishing community, Peruvian agricultural community) and mental distress (Peruvian fishing community).

Table 2. Findings from the participatory diagnosis, topics of the teaching interventions, and related activities carried out by the teams of trainers.

Trainers' Teams	Communities/ Country	Phase I: Participatory Diagnosis		Phase II: Teaching Intervention		Further Activities
		Community Participants	Work-Related Risks and Resulting Health Problems Identified	Community Participants	Content	
1 [1]	Artisanal fishermen/Peru	N = 6 (3 women) Representatives of • Health care workers (*n* = 2) • Fishermen (*n* = 2) • Community health promotors (*n* = 1) • Municipality (*n* = 1)	• Psychosocial risks (work demands and interpersonal relationship) • Ergonomics risks (overstrain) • Environmental pollution (transport)	N = 11 men (0 women)Representatives of: • Fishermen (*n* = 11)	Self-control of mental distress in artisanal fishermen	• Planning a study on working conditions of artisanal fishermen
2 [2]	Potato and quinoa farmers/Peru	N = 20 (6 women) Representatives of: • Community members (*n* = 10) • Primary health care workers (*n* = 3) • Primary school teacher (*n* = 3) • Community leaders (*n* = 3) • Local authorities (*n* = 1)	• Ergonomic risks (load handling, repetitive movements) resulting in lower back pain	N = 26 (13 women)Representatives of: • Community members (*n* = 17) • Social health insurance (*n* = 1) • University (*n* = 1) • Regional health officer (*n* = 2) • Primary school teachers (*n* = 5)	Prevention of lower back musculoskeletal disorders	• Participatory round table to present the project results and to raise awareness among decision makers about health of rural workers
3 [3]	Pottery makers/Chile	N = 17 (14 women)Representatives of: • Pottery makers (*n* = 12) • Medical students in their internship (*n* = 2) • Primary healthcare authorities (*n* = 2) • University administrator (*n* = 1)	• Ergonomic risks (repetitive movements, inadequate posture, load handling) resulting in musculoskeletal problems • Psychosocial risks (presentism, double burden, work schedule) resulting in mental distress	Session 1: N = 16 (14 women)Representatives of: • Female pottery makers (*n* = 14) • Medical students in their internship (*n* = 1) • University administrator (*n* = 1) Session 2: N = 52 female pottery makers	Prevention of musculoskeletal disorders	Since 2018, best practices in health projects including: • Training of community health promotors to prevent musculoskeletal disorders • Training of primary health care center staff • Interventions to improve working conditions for pottery makers • Intersectoral coordination
4 [4]	Artisanal fishermen/Chile	N = 5 (2 women) Representatives of: • Fishermen/shore collectors and relatives (*n* = 5)	• Ergonomic risks (poor posture, load handling) resulting in lower back pain • Biological risks resulting in infectious diseases • Physical risks resulting in decompression illness	Not implemented due to time constraints of the team of trainers and community members	Prevention of musculoskeletal disorders	None

[1] Team composed of one university occupational safety and health (OSH) expert and three community primary health care (PHC) representatives, all of them men in the age range 40 to 44 yrs. Tutor was a female OSH expert from Chile. [2] Team composed of two university OSH experts (one man, one woman) and one male university representative; age range 20 to 69 yrs. Tutor was a female OSH expert from Argentina. [3] Team composed of two university PHC lecturers and two primary health care representatives, two men, two women in the age range of 30 to 59 yrs. Tutor was a female OSH expert from Bolivia. [4] Team composed of two university OSH experts and two PHC lecturers, three men, one woman in the age range 30 to 44 yrs. Tutor was a female OSH expert from Chile.

Therefore, teaching interventions developed in phase II focused on prevention of musculoskeletal symptoms (n = 3) and work-related stress (n = 1). The interventions were successfully carried out in three communities with 11 (Peruvian fishing community) to 68 participants (Chilean pottery community). In the Chilean fishing community, the intervention could not be implemented due to time constraints of the team of trainers and community members.

The verbal feedback trainers received from the communities was positive. Community participants were very satisfied with the participatory and collaborative method, as well as the trustful environment during the activities. They appreciated having the opportunity to learn about risks and hazards and how to take care of their health. They were also motivated to continue these actions involving more members of their communities. Participating community members considered local authorities, educational institutions (i.e., primary school), and PHC workers as important actors for rural workers' safety and health.

After the end of the project, the three teams which could carry out the interventions continued to work on occupational health aspects with the communities' PHC centers. In Peru, the type of activities varied from a research project on working conditions of artisanal fishermen to a participatory round table presenting the results and raising awareness among local stakeholders. In Chile, the team started various activities including OSH training of some of the pottery makers so that they would become health promotors and help prevent musculoskeletal problems, OSH training for PHC center staff, as well as coordination of intersectoral activities to raise awareness of occupational safety and health problems in the community. In addition, the PHC professors started implementing parts of the program in the regular training of medical interns before their rural internship.

3.2. Quantitative Evaluation Results

Ten of the fifteen trainers completed the evaluation form. The overall evaluation of the training program was 9.7 out of 10. Although trainers suggested to deepen the training, all would recommend this program to their colleagues. According to them, both phases of the program were beneficial to the community compared to traditional, passive ways of learning. Finally, all attributes of innovation, except complexity, showed high mean scores (4+ out of 5) (Figure 1).

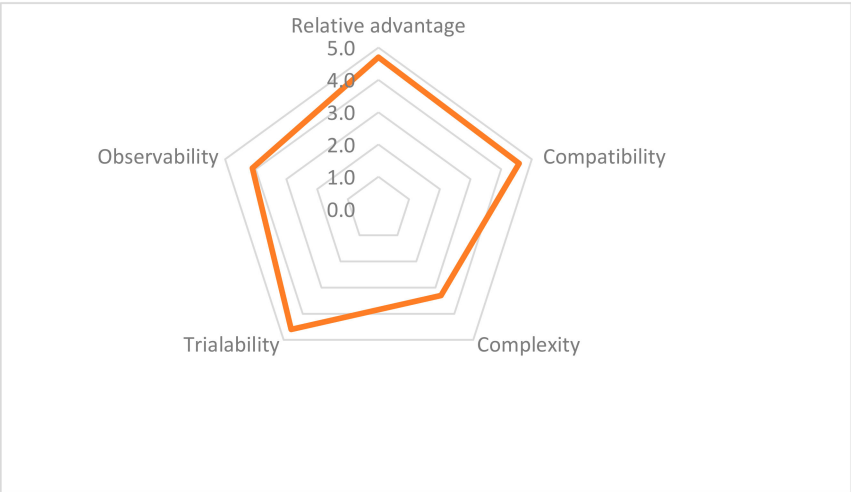

Figure 1. Score for each attribute, based on the mean of five Likert questions rated from 1 to 5.

3.3. Qualitative Evaluation Results

3.3.1. Evaluation Form

1. Relative advantage

The trainers highlighted that the collaborative work between them and the community showed positive results and facilitated achieving objectives. The simple and participatory methodology provided a respectful environment for approaching the community, overcoming the classic "top-down" knowledge transfer model, as expressed by a trainer:

> "I think that with this, local knowledge is respected, validating the work of the people involved, which is complemented by technical knowledge."
>
> (Translated from local language)

Trainers stated that continuity of actions and further interventions are needed to strengthen changes. Impact assessment was also mentioned as being necessary.

2. Compatibility

According to the trainers, the methodology respected the community's identity, socio-cultural, local political, and gender aspects. A trainer stated:

> "Community beliefs and values were not altered with the implementation of the different stages of the project; the community vision of health-disease process is based on the Andean worldview where mother earth (Pachamama) intervenes as a source of life, gods such as Apus (tutelary hills) that influence the health-disease process … In this Andean society, the woman plays an important role in the family and at the same time, maintains a certain level of dependence on the male … "
>
> (Translated from local language)

When implementing the project, sociodemographic characteristics, community knowledge, as well as the participants' work organization were considered. A trainer said:

> " … Considering their work schedules, availability of time and with the participation of assistants of different ages … the educational session was designed (physical exercises) according to health conditions and age … that contribute to improve their ailments without altering their daily work activity."
>
> (Translated from local language)

It became evident that workers' health problems were related to factors beyond the workplace, which should be considered in the search for solutions. A challenge was seen in how to advance in the process of community participation, in order to increase the level of community empowerment and the collaborative relationship with institutional partners in addressing their issues.

3. Complexity

Complexity experienced by the trainers throughout the project's implementation was determined by:

- The isolation and difficult access to the communities due to the geographical remoteness and dispersion of the population within the territory.
- The political-institutional current situation in Latin America, which made it more difficult to carry out the interventions since in some cases, the local authority approved the intervention and when changed, approval had to be sought again from the successor.

- Time demand and management for adjusting interventions according to community characteristics, as pointed out by two trainers:

  "It took time to define and prepare educational and audio-visual material because of the schooling and age of the participants."

  (Translated from local language)

  "The organization and assistance by fishermen were complex, 100% was not reached due to work activities of the participants."

  (Translated from local language)

- Lack of policies in primary healthcare and lack of intersectoral action addressing workers' health issues. Trainers stated:

  "My view of being complex is based on the fact that it requires intense coordination of actions which are not always easy. Primary care does not have a work plan in the area [of occupational health]. Therefore, these efforts imply additional commitments, especially if a greater impact to be achieved".

  (Translated from local language)

  "I think skills for this kind of work could be strengthened in the healthcare team."

  (Translated from local language)

  " ... I think it is necessary to incorporate follow-up and to develop other instances of intervention, like networking and intersectoral work."

  (Translated from local language)

- Lack of financial support for teaching interventions (e.g., staff time, travel, and material costs).

Some teams partly overcame the shortcomings as a result of the positive relationship with the community, management, and commitment of some local authorities. A trainer said:

"We had constant support from the university ... this allowed us to have sufficient teaching hours, finance travel costs, coffee breaks, materials ... Local primary healthcare center contemplated the necessary professional hours, as well as time for coordination of actions with social and institutional organizations."

(Translated from local language)

4. Trialability

Based on their experience, trainers considered applying this methodology to address different health problems and rural communities as feasible. An initial approach to recognizing community health problems and prioritizing more effective measures would be facilitated. Nevertheless, due to the diversity of factors involved in the problems, interventions beyond education should be considered. A trainer mentioned:

"Since the disease model in general has changed, it is important to consider social factors in interventions. Participatory diagnosis and educational intervention models in communities are useful for the development of respectful strategies in which the community is involved."

(Translated from local language)

5. Observability

The local communities' situation and the internal dynamics of the formed work teams became visible. Through this experience, both the teams of trainers and communities were able to recognize the health problems of the community's workers, possible solutions, and the obstacles to overcome. Likewise, institutional support facilitated the work of the teams:

"I think we should work with local authorities on a results basis to achieve greater impact."

" . . . for the community, the problems arising from the current legislation are more complex . . . "

(Translated from local language)

3.3.2. Program Evaluation Workshop

Ten trainers (representing all four teams) participated in the final evaluation workshop. All declared that the objective of the training program was fulfilled although one of the teams could not complete the teaching intervention. Reasons for this were mainly the geographical distance from the community and difficulties of the team to carry out meetings (time and distance). A trainer mentioned:

"In general, the objectives were achieved, it was possible to make diagnosis of the community's health problems and their occupational risks. No intervention was carried out."

(Translated from local language)

Factors mentioned to facilitate the achievement of the program's objectives were related to the motivation of all involved parties as well as the learning methodology. Hindering aspects were time, geography, limited knowledge, and lack of awareness of occupational safety and health, as well as little institutional support (Table 3).

Table 3. Factors identified by the trainers as facilitators and hinderers for achieving the objectives of the program.

Facilitating Factors	Situations to Which These Factors Applied
• Commitment and involvement: trainer teams, communities, local authorities, and universities	• Prior to the participatory diagnosis and teaching intervention sessions, the teams met with local authorities, workers' associations, and other community actors, achieving commitment and support for the activities. As an example, in two of the communities the participatory diagnosis and teaching intervention took place in the primary school. Likewise, teachers collaborated in convening the workers, as most of them were parents of school children. • Some universities, local authorities, and healthcare centers provided financial support for transportation, teaching materials, and catering.
• Working closely with the community	• The pre-existing formal relationship between universities, healthcare centers, and communities contributed to the inclusion and sustainability of the activities during the training program. • Respect, trust, and empathy facilitated finding common ground in participatory diagnosis and searching for solutions.
• Participatory methodology	• The role of facilitators assumed by the trainers along with involvement of diverse community actors promoted the identification of work-related health problems in the community. • Knowledge from community members and trainers was mutually recognized and shared (e.g., community workers and schoolteachers were key in building the risk map). Teachers were knowledgeable about the work of the community but unaware of the risks involved. They were also helpful in adapting teaching materials to the local language. Some trainers were aware of funding sources for the sustainability of actions with the community.
• Flexibility of the methodology	• Although the participatory diagnosis and teaching intervention phases were pre-structured, the teams could adapt the methods to meet their own and the communities' needs. Examples of these adaptations included: ◦ Flexible duration of the sessions. ◦ Learning methods and materials adapted to age, educational level, and language of the community. ◦ Before carrying out the participatory diagnosis, some teams conducted field trips to learn about the main work activities in the community.
• Position of the trainer teams at the university	• Being a full-time professor and having a good relationship to university management facilitated the involvement of lecturers in the program.
• Availability of time for the activity	• Some universities assigned hours of the teaching staff for the program. This enhanced commitment of the trainers and smoothed adjustment to community participants' schedules.

Table 3. *Cont.*

Facilitating Factors	Situations to Which These Factors Applied
• Coordinated teamwork	• Respect, communication, and commitment favored teamwork, especially when trainer teams were composed of lecturers from different departments.
Hindering factors	Situations to which these factors applied and potential solutions.
• Lack of knowledge on occupational health issues	• Trainers and community participants involved in primary health care expressed the need to deepen occupational health knowledge. • The lack of knowledge was overcome thanks to the active learning methods, mentorship, and teamwork with occupational safety and health experts.
• Low level of schooling of the community participants	• Low level of schooling required adaptation of the learning material. • Active learning methods helped to master this challenge.
• Lack of time for the activity	• In some cases, the trainers' workload together with the irregular work schedule of community members made it difficult to organize activities. • Including the program as part of institutional activities allowed trainers to allocate time for the program.
• Geographical distance and accessibility of the communities	• Some communities were hard to reach due to their geographical isolation resulting in long commuting times for the teams of trainers. • Careful arrangement of schedules and sufficient time allocated to the activities are necessary for the successful implementation of the program.
• Limited economic resources	• Funding was needed to implement the participatory diagnosis and teaching intervention in the community (e.g., transport, catering, teaching materials). • The teams managed to receive financial support from the universities and stakeholders (e.g., in one case the regional health office provided the catering).
• "Hiddenness" of work-related illnesses	• Lack of awareness about the association between work and health lowered the priority given to occupational safety and health activities. • Health care workers realized that work-related health problems were not visible in the primary healthcare centers prior to the activity. • For some workers of the communities it was the first time they understood the relationship between hazardous working conditions and their health problems. • Beliefs such as "the man in the countryside can tolerate more effort than the man in the city", as stated by one team of trainers, influenced the conception of occupational health. • Implementing the program in the communities changed their perspectives.

Table 3. *Cont.*

Facilitating Factors	Situations to Which These Factors Applied
• Lack of institutional support	• One trainer perceived a lack of institutional support from the university as one factor hindering the achievement of the program's objectives. • Institutional support and rewards for engagement in the program need to be considered from the beginning.
• Lack of local authorities' awareness about the relation between work and health	• Lack of awareness about the importance of work for health required additional efforts to involve local authorities. • Careful prior information provided in for example, regional round tables for local authorities, raises awareness and helps receive support.
• Local political situation	• The planning and implementation of activities were affected in two communities by a change of regional authorities, requiring seeking approval twice, and a strike of the workers of their target group. • Unforeseen circumstances need to be considered when planning the activities.

4. Discussions

Based on the Pan American Health Organization's (PAHO) strategy to integrate occupational health services into primary healthcare, we developed and pilot-tested a train-the-trainer program to address occupational risk prevention in rural communities of Latin America. The program was conducted as a combination of online training, face-to-face learning, and implementation practice carried out in two phases: risk assessment and intervention. Community participation was considered at all stages. Overall, evaluation results were positive and implementation was successful in three out of four communities. Three of four teams continued occupational safety and health activities in the communities after the end of the project. One university implemented the program into regular training of medical interns.

As a result of the participatory diagnosis, knowledge was generated regarding the health of workers in rural areas, both for the trainers and for the communities. Musculoskeletal disorders and mental distress were identified as the main work-related health problems and thus, the major rural work-related problems worldwide were targeted [48–50]. The teams realized that the relationship between work and community health problems was unknown to the communities' health care staff. This so-called "blind spot" in occupational health [51,52] of health care providers is well known globally [24,25,41,49,51–54]. Likewise, local authorities were unaware of the association between work and health. This might indicate that the inclusion of occupational health into PHC as suggested by PAHO still needs to be translated into local policies [21,24].

Joint efforts between communities and teams resulted in teaching interventions based on community needs. Socio-demographic characteristics (e.g., level of schooling, type of work), the use of local languages (i.e., Aymara, Quechua), and the low educational level of many community members were challenging. However, for the successful implementation of the program it was important to consider them as it is known that innovations become more widely adapted when they are socio-culturally accepted [46] (p. 15), and trust exists between community members and health care providers [55].

Our program raised awareness about the association between work and health and the prevention of occupational risks in the community. Previous studies suggest that the community-based approach taken contributed to the success of the program [29,31,33,56]. PHC should be involved given its close relationship with the communities [57] and in order to ensure the sustainability of further actions. In our case, the trainers' teams worked on subsequent interventions, enabling progress in improving working conditions and providing tools for community empowerment. At one of the universities, the program could already be implemented into the regular preparation of medical students for their rural internship. Such a regular implementation would be the long-term goal of the program once its effectiveness on community health was shown. It is interesting to note that at this especially successful university the institutional support was high. In addition, the team was rewarded by the university for their successful work with the community through a travel grant (personal communication). On the contrary, in one community the planned intervention could not be implemented. Reported reasons were related to the difficulty in adapting the trainers' times to those of the community members. This involved the geographical conditions of the community which required long commuting times. It is interesting to note that in this community no community member could be involved in the team of trainers. In addition, occupational health lecturers at this university were not full-time professors and no extra hours were assigned by universities' management for the program. This highlights the importance of community involvement from the beginning as well as the importance of institutional support in programs like this [58].

Lack of public policies, missing involvement of authorities, and lack of intersectoral action became the main factors of complexity. According to the International Labour Organization (ILO), low social security coverage is a major shortcoming in terms of access to decent work in rural areas; cross-ministerial policies encompassing the scope of occupational safety and health in rural development are needed [1]. Some countries [49,59] have already implemented in their public policies

the provision of occupational health services in primary care; however, the lack of trained health care providers in occupational health is a global challenge [60]. This need was also perceived by the trainers in our project and therefore, our training program was well received. Teams even suggested to deepen the training; however, longer workshops would have been difficult to carry out due to time constraints especially for the rural health care professionals. One has to bear in mind, that frequently only one health care professional works together with an internal in a rural community and thus, leaving the community for longer periods of time is hard to compensate [25]. Therefore, we offered parts of the program online. While those who completed the virtual part indicated the benefits of it, only 6 out of the 15 participants completed all online parts of the program (data not shown). However, as we had to rely on compliance of our participants, this figure indicates their high interest in the program. In comparison, less than 1% of medical students completed e-learning components of the medical curriculum when no external motivation was provided [61].

As a limitation, the methodologies and strategies used might not be suitable in all parts of rural Latin America. However, the multi-national team of authors of the program (Chile, Bolivia, Guatemala, Argentina), the involvement of trainers' teams from northern Peru to the central south of Chile, as well as the flexibility of the used methods are promising for its implementation in other contexts. The project duration was also a limitation, especially for trainers' teams as they had to organize the workshops in the communities. Likewise, the duration of the project, limited financial resources, and lack of experience with research of most of the participating teams did not allow evaluation of the impact of the actions on communities' health. In addition, no control group was included. Furthermore, not all trainers completed the evaluation form or took part in the final workshop. Although all participants were invited, participation was voluntary, respecting the personal decisions of the trainers and their availability of time. While we cannot know to which degree the written evaluation was representative, members of all four teams took part in the final evaluation workshop. Therefore, we expect selection bias to be small. Reporting bias might have played a role especially in the final workshop; however, as there was an atmosphere of trust and respect built over the training program, we do believe that this had only a minor impact on the results.

5. Conclusions

We have successfully developed a train-the-trainer program on occupational risk prevention and have shown the feasibility of its implementation in rural areas of Latin America. The cornerstones are its participatory community-based approach and active learning methodology combining classroom teaching with guided practice. In the next step, we need to test its medium- and long-term impact on communities' health. After successful evaluation, it can be used as a tool to implement occupational safety and health in rural areas. For this, we consider cooperation with relevant intersectoral stakeholders and institutional support to be crucial.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/6/1842/s1, Training program S1: Training workshops programs for occupational health in rural areas of Latin America, Evaluation form S2: Evaluation of the work with the community.

Author Contributions: All the authors participated in the design of the course, acquisition, analysis, and interpretation of data. V.E., M.A.G., M.T.S.-S., and K.R. drafted the manuscript. M.F.B., C.M., and M.P. substantively revised the manuscript. All authors read and approved the final version of the manuscript.

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8. Conclusion

We could show that failure in executive function of artisanal shellfish divers in southern Chile was related to decompression illness. Therefore, prevention of decompression illness and first handling should be considered in small-scale fisheries to prevent long-term damage. The involvement of primary health care in rural communities together with community participation constitute the cornerstone for implementing preventive strategies based on local needs. To make this feasible, skilled primary health care personnel is required. Integrating work as a determinant of people's heath and a vision of « one health » into the curriculum at the undergraduate level would help in the development of skills in basic occupational safety and health and transdisciplinary work. In our experience, connecting universities, health care centers and communities around work allowed for learning by all parties.

Finally, adoption and implementation of public policies at national or regional level to facilitate the integration of basic occupational safety and health services into primary care in Latin America are required. To this purpose, a vision focused on health promotion and prevention, together with joint efforts from other sectors and partners, is essential for sustained action.

9. Annex

List of Publications

1. Garrido MA, Encina V, Solis-Soto MT, et al. Courses on Basic Occupational Safety and Health: A Train-the-Trainer Educational Program for Rural Areas of Latin America. *Int J Environ Res Public Health.* 2020;17(6)

2. Garrido MA, Parra M, Diaz J, Medel J, Nowak D, Radon K. Occupational Safety and Health in a Community of Shellfish Divers: A Community-Based Participatory Approach [published online ahead of print November 14, 2019]. *J Community Health.*

3. Garrido MA, Mark L, Parra M, Nowak D, Radon K. Executive function among Chilean shellfish divers: a cross-sectional study considering working and health conditions in artisanal fishing. [Submitted].

4. Garrido Campos MA, Hindelang BA, De Carvalho DS, Urzúa Finke I, Herrera R, Radon K. Prevalence and risk factors for hearing loss in Chilean shellfish divers. *Ann Glob Health.* 2018;84(3):442-449.

Statement on Pre-release and Contribution

The manuscripts included in this thesis correspond to original research carried out in the course of the PhD studies. Information on previous publication and my contribution in each of the articles included is as follows:

- Occupational Safety and Health in a Community of Shellfish Divers: A Community-Based Participatory Approach was published online first in November 2019 in the Journal of Community Health. I contributed to the design, application for funding grants, data collection and analysis, and writing of the manuscript.
- Courses on Basic Occupational Safety and Health: A Train-the-Trainer Educational Program for Rural Areas of Latin America was published in March 2020 in the International Journal of Environmental Research and Public Health. I contributed in the project design and application for funding, as a tutor in the project execution, in data collection and analysis, and in writing the article.

- Executive function among Chilean shellfish divers: a cross sectional study considering working and health conditions in artisanal fishing was submited to the American Journal of Industrial Medicine on April 21, 2020. This manuscript is the result of the project on Assessment of neurocognitive function and its relation with occupational risk factors among shellfish divers from southern Chile. My contribution was in the study design, search for funding, data collection and analysis, and writing of the article.

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