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RESEARCH NOTE

Occupational Health Hazards of Seaweed Farming in Sorsogon, the Philippines

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Seaweed farmers are important workers in the aquaculture industry who are vulnerable to diverse occupational health hazards. Concerns have however rarely been raised about these work-related health issues of these farmers in the Philippines. In this study, we employed a risk management approach that involved identifying health issues and considering strategies to reduce the impacts the risks may bring. We determined the physical health hazards faced by seaweed farmers in Sorsogon, an area in the eastern Philippines with active seaweed farms. Findings were presented focusing on descriptive and correlation analyses based on a risk matrix approach. Interview responses were collected using a five-step Likert scale to measure the frequency and severity of etic categories of health hazards. Most of the 29 identified health issues were experienced by the farmers during the repeated installation of farms. Headaches were most prevalent and severe, followed by skin and musculo-skeletal problems. Albeit only categorized as a minor risk, headache still ranks first in order and was correlated with age and sex. Based on physiological differences, women farmers were more vulnerable than men to experiencing headaches due to long-term exposure to heat. Shorter time of field exposure, financial rewards, and social scripting appeared to be key drivers for a consistently low

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appreciation by seaweed farmers to the frequency, severity, and potential risks of occupational health hazards. Our findings hold important implications for seeking appropriate interventions to include improving ergonomic conditions and the use of protective tools. The wider information campaign, provision of support services, and medical interventions targeting major health issues identified in this study can help address the actual health conditions affecting seaweed farmers in Sorsogon and thereby influence health policy and practice beneficial to this workforce throughout the Philippines.

Keywords: financial rewards, heat-related illnesses, headaches, musculoskeletal problems, occupational risk, social scripting

INTRODUCTION

Seaweed farming is one of the major components of global aquaculture activities. As a profitable source of income, it makes a significant contribution to the well-being of many marginalized communities, especially in developing countries such as the Philippines, Indonesia, and Tanzania (Valderrama *et al.* 2013; Hurtado *et al.* 2019). As the demand for seaweed products is projected to increase through the coming years (Chopin and Tacon 2021; Naylor *et al.* 2021), the seaweed industry is thus likely to attract more workers in the future.

The high return (financial gains and social impacts) of seaweed farming is not without cost. The entire work mechanism of seaweed farming chiefly requires extensive labor. Exposed to numerous health hazards in the sea and offshore working environment are the farmers who are prone to accidents, injuries, and diseases. Therefore, like any occupation, seaweed farming comes with its own set of hazards (Shimada *et al.* 1990; Fröcklin *et al.* 2012; Msuya 2012; Thamrin *et al.* 2020). Most seaweed farmers are poor (Valderrama et al. 2013) and most likely lack adequate health care. Understanding occupational health hazards is crucial to ensure the safety and well-being of these workers, as well as the sustainability of the industry itself. By identifying and assessing these risks, appropriate measures can be taken to reduce the occurrence of health problems related to work. The concerns about safety issues in seaweed farming remain grossly unaddressed (Myers 2010; Cavalli *et al.* 2019).

Sorsogon is a province in the Philippines lying at the tip of the southeastern Luzon Island. The region harbors one of the most diverse seaweed flora in the Philippines (Trono 1975; Kraft *et al.* 1999; Dumilag *et al.* 2020). A spate of research in the 1990s identified suitable sites for seaweed farming in the area (Trono 1992; Taw 1993), with these topics still receiving renewed attention in efforts to diversify and enhance seaweed-based livelihoods (Dumilag *et al.* 2023a, b). This study aims to identify the major health hazards as elements that describe occupational risks among seaweed farmers from Sorsogon.

MATERIALS AND METHOD

Data Collection

A total of 49 seaweed farmers (Table 1) participated voluntarily in this study. Four sites in Sorsogon were surveyed – namely Carayat, Prieto Diaz (12°60' N, 124°9' E); San Rafael, Donsol (12°58' N, 123° 31' E); Calintaan, Matnog (12°32' N, 124°6' E); and Somal-ot, Casiguran (12°52' N, 124°1' E). The methods designed by Fröcklin *et al.* (2012) and Thamrin *et al.* (2020) were adapted with modifications to match the actual working conditions of seaweed farmers in the Philippines. Questions included the seaweed farmers' demographic profile, historical background about their occupation, and their identified health and safety hazards during farming (Table 2). An initial English survey form was translated and deployed in the local language. Twenty-nine (29) health indications (Table 2) were identified and distributed into eight etic categories: auditory, dermatological, environmental-exposure, musculo-skeletal, respiratory, urinary, visual, and others (headache, exhaustion, and hunger). In addition to those from previous literature, the selection of health indications used in this study involved input from healthcare professionals and clinical significance (commonly observed in populations under consideration). The respondents were asked based on questions by interview of closed type through a five-degree Likert scale to rank the frequency (1 = never, 2 = rarely, 3 = occasionally, 4 = frequently, and 5 = very frequently) and severity (1 = none, 2 = very mild, 3 = mild, 4 = moderate, and 5 = severe) of perceived experiences of each health indication per farming stage: [1] preparation of farming materials, [2] installation of the farm (Figure 1), [3] maintenance of the farm, [4] harvesting, and [5] drying of seaweeds.

Table 1. Socio-demographic characteristics of seaweed farmers examined in this study.

Variable	Frequency	Relative %
Sex		
Female	25	51
Male	24	49
Age group		
20–40	12	25
41–65	32	65
> 65	5	10
Civil status		
Single	6	12
Married	39	80
Others	4	8
Educational attainment		
Primary	25	51
Secondary	18	37
Tertiary	6	12
Years as seaweed farmer		
0.1–5	23	47
6–10	11	23
11–15	3	6
16–20	6	12
> 20	6	12

Data Analysis

Risk analysis was used following the recommendation from the United States (US) Occupational Safety and Health Administration (Michaels and Barab 2020). The descriptive statistics data were populated using Google Forms, organized in Microsoft® Excel, and analyzed in Wizard Pro version 1.9.49 (Evan Miller, Chicago, IL, USA). The identified risks were expressed as a product of frequency and severity. The risk level was quantitatively interpreted using the 5 x 5 L-type risk matrix approach (Donoghue 2001; Kadir *et al.* 2017). The order of risk propensity was determined based on the coefficient of variation – scores that are widely used as a measure of the relative degree or order of risks in the medical field (Wennberg and Wennberg 2000), as well as in other risk sciences (Weber *et al.* 2004). Spearman's rho was calculated using the STATA ver. 7 platform (Stata Corporation, College Station, TX, USA) to determine the correlation between risk level and key demographic variables.

Table 2. Survey questions used in this study. Note the initial questionnaire was developed in English but was translated to the local language when actually deployed during the interview of local seaweed farmers from Sorsogon, the Philippines.

Survey question
I. Demographics
A. Personal profile
1. Age
2. Sex (0 = male; 1 = female)
3. Civil status (0 = single; 1 = married)
4. Highest educational attainment (no proper education; elementary; high school; college graduate)
5. Years of residency
B. Reliance on seaweed farming as a source of income (yes; no; if no, list other income source)
C. Income from seaweed farming every cropping season (average income during peak *vs.* lean season)
D. Experience in seaweed farming (years in farming)
E. Ownership of seaweed farm (individual; cooperative ownership; others)
F. Hours and time spent on seaweed farming (preparing; installing; maintaining; harvesting; drying time)
II. Perceived health issues from seaweed farming as to frequency (1 = never; 2 = rarely; 3 = occasionally; 4 = frequently; 5 = very frequently)* and severity (1 = none; 2 = very mild; 3 = mild; 4 = moderate; 5 = severe)*
A. Dermatological (pruritic and erythematous rashes; tender and erythematous skin; dry; pruritic; desquamating skin; thick and hyper-pigmented skin; skin cancer (perceived); other skin infection)
B. Respiratory (difficulty of breathing; fever and cold; asthma; cough; sinusitis and rhinitis; pharyngitis)
C. Musculo-skeletal (back pain; muscle pain and stiffness; body pain; poor posture)
D. Environmental exposure (impalement injury; accident or trauma; wounds from sharp objects)
E. Urinary (dysuria; urinary tract infection)
F. Auditory (ear pain and discharge; hearing loss)
G. Visual (blurring of vision; pruritic and dry eyes; other eye diseases)
H. Others (headache; exhaustion; hunger)

*Rated on a five-point Likert scale per farming stage (preparation of farming materials, installation of the farm, maintenance of the farm, harvesting, and drying of seaweeds)

Figure 1. Some highlights of seaweed farming in Sorsogon, the Philippines. Ropes can be used repeatedly by removing nuisance seaweed attached to them (a). After tying the seedlings to cultivation lines (ropes), seaweed farmers spent about two to three hours tying the cultivation line to the support stakes (b, c), often under intense exposure to sunlight.

RESULTS AND DISCUSSION

Among the 29 identified hazards (Figure 2), health conditions were highest during the installation phase, with headaches being the most prevalent (65%) and most severe (51%). In terms of rank, headaches and tender and erythematous skin had the highest risk scores. These were followed by musculo-skeletal disorders (*i.e.* back pain, muscle pain, and stiffness) and wounds from sharp objects. All identified hazards ranged from insignificant to minor in terms of risk level (Figure 3).

Seaweed farming is an outdoor occupational activity that carries a substantial risk of sun exposure, regardless of the stage in which the activity is involved (Table 3). In the case of seaweed farmers in Sorsogon, long-term sun exposure may lead to headaches and skin problems, whereas often involvement in repeated tasks performed in the same posture would induce musculo-skeletal disorders (*e.g.* back pain and muscle pain and stiffness) and exhaustion.

Headaches during the installation stage were highly correlated with age and sex (see Figure 2 for other results of correlation analyses). Here, the prevalence of headaches among male and female seaweed farmers was 33.3 and 66.7%, respectively. The US National Institute for Occupational Safety and Health recognizes women as more vulnerable to heat exposure that may lead to headaches and exhaustion. Due to the greater body fat content combined with lower absolute muscle mass and hemoglobin concentration, a lower average maximal oxygen consumption, *i.e.* 70% VO_2 max of those for men, makes women more likely to experience a subjective complaint about heat-related problems (Jacklitsch *et al.* 2016).

In this study, values of frequency, severity, and risk were consistently low during the drying stage. A practical explanation may simply be that during the drying stage, the exposure of the farmers to direct sunlight is much less than during other phases of farming. The timing is much shorter (see Table 3). The farmers need not have to stay under the sun while the seaweeds are being dried and, hence, are exposed to less health hazard. Alternatively, perceived hazards appeared to be negligible during this final stage as farmers anticipated receiving rewards (in the form of income) after deployment. It is known that rewards exert a clear impact on reducing perceived hazards across types of workers (Karakhan and Gambatese 2018; Feng *et al.* 2023). Whereas conscious awareness about

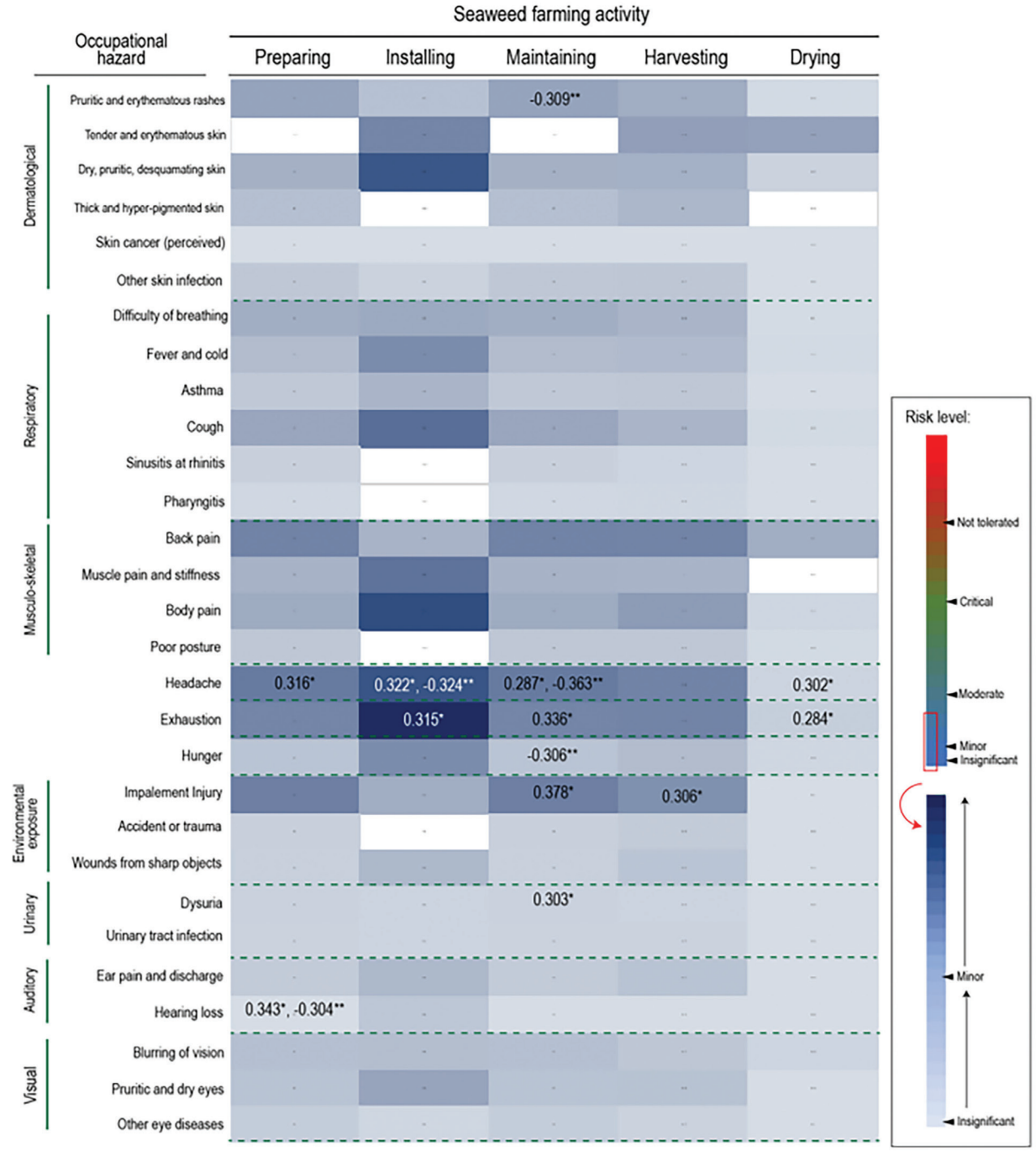

Figure 2. Risk level heat map of occupational hazards in seaweed farming in Sorsogon, the Philippines, per major farming stage, including r_s value of significantly correlated key demographic factors (*age and **sex) with $p < 0.05$.

health hazards among seaweed farmers is perception-based, the level of risks may not be merely independent of their willingness to tolerate those hazards. The farmers' judgment of hazards (frequency or severity) may also be influenced by their values or a consensus of opinions that reflect a range of hazard characteristics (risk) as perceived by other workers in a specific occupational setting. This social phenomenon, called scripting, is said to be requisite to becoming a "good" farmer. A "good" farmer has a set of characters following a relational and collective affirmation of the common social ethos of the community where he or she lives (Silvasti 2003; Herman 2015). Work-related health problems among seaweed farmers may also be exacerbated by other factors affecting production such as disease attacks, weather, and market fluctuations, which should also be taken into account.

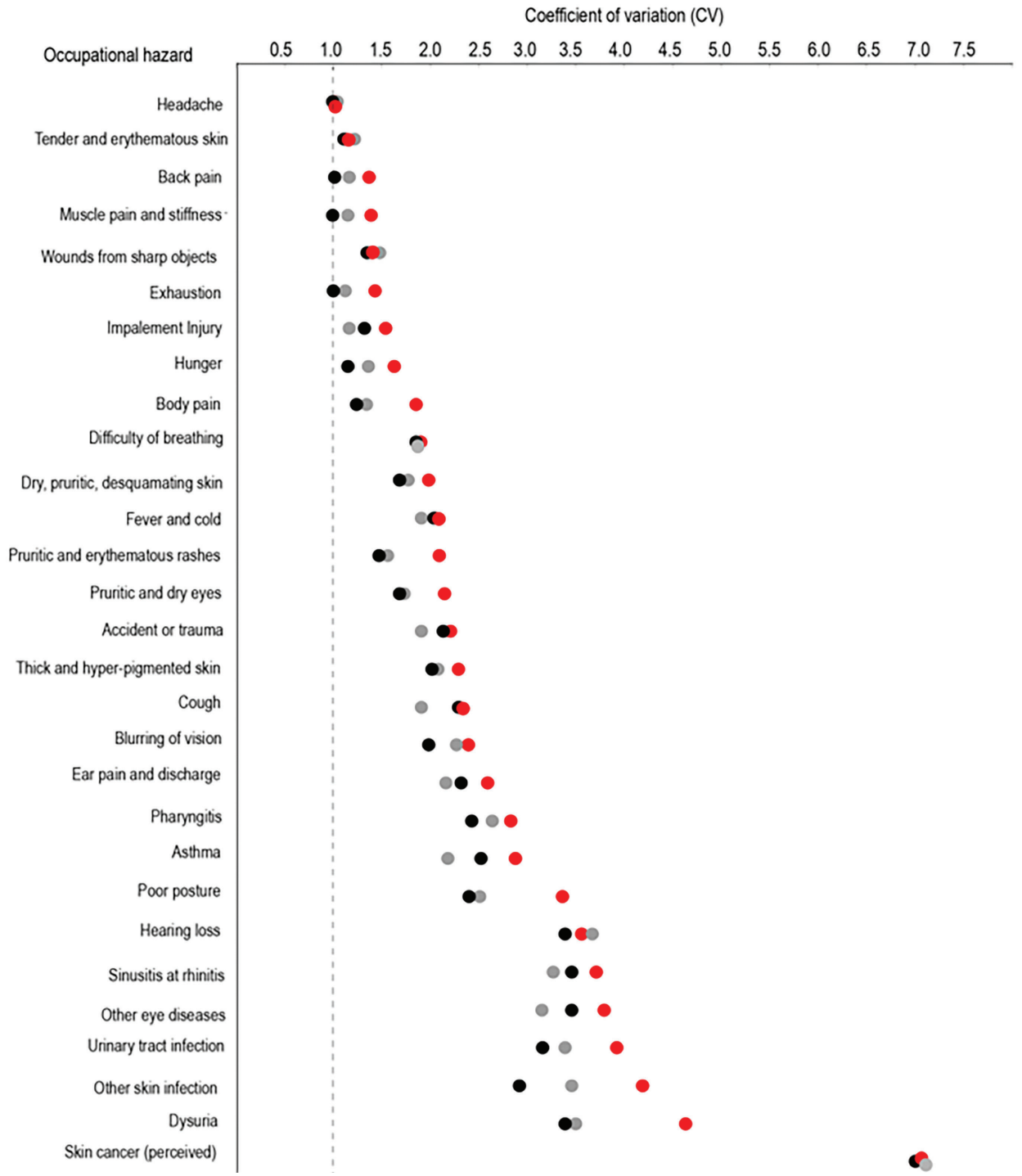

Figure 3. Coefficient of variation (CV) of frequency (gray circle), severity (black circle), and risk (red circle) of occupational hazards experienced by seaweed farmers during the installation of seaweed farms in Sorsogon, the Philippines. The vertical dash line traverses the lowest threshold CV values (highest rank).

Studies conducted in Indonesia and Tanzania have found that general fatigue leading to musculo-skeletal pain was the major health concern faced by seaweed farmers (Fröcklin *et al.* 2012; Msuya 2012; Thamrin *et al.* 2020). The results of our study corroborate these previous findings (Table 4). The strengths of the present study include the actual measure of risk level derived from frequency and severity scores, addressing a lack of these considerations found in other studies. Due to the limitation of the design of our survey, possible causes

Table 3. Stages in seaweed farming, including a description of the activities involved and the amount of time needed to carry them out.

Stage	Description	Average hour spent per day (range in h)*	Average day covered (range in d)*
Preparing	Area selection, clearing of obstructions (rocks, seagrass, other macroalgae, sea urchin), preparation of support structures including ropes, buoys, rock weights for mooring	9 (4–12)†	1.5 (1–2)
Installing	Tying seedlings on ropes and placement in farming area	6 (4–8) †	8.5 (7–10)
Monitoring	Regular observation including cutting of portions or removal of unhealthy or epiphyte-infected crops, transfer of crops to deeper area	3 (2–4) ‡	Daily
Harvesting	Manual collection of crops for sale or processing	6 (3–10) †	2 (1–3)
Post-harvesting	Sun drying, packaging for transport, physical examination of crops as to adequate moisture content (color, texture)	5 (3–8) †	3 (dry season), up to 7 (wet season)

*Per 10 lines of 100 m, morning until afternoon †
†Intermittent
‡Continuously

Table 4. Comparison of occupational hazards examined across seaweed farming sites, including causes and recommendations to address these health issues.

Site	Japan[1]	Indonesia[2]	Tanzania	Philippines (Sorsogon)
Type of farming	Nori farming	Eucheumatoid farming	Eucheumatoid farming	Eucheumatoid farming
Major health problems	Low back pain	Pain (sore), strain, sprain, fever, numb	General fatigue, other pains (hips, leg, neck, waist), hunger, back pain, respiratory problems	Headache, tender and erymatous skin, back pain, muscle pain and stiffness, wounds from sharp objects
Major possible causes	Deep forward bending during net retrieval and repair	Poor working position exacerbated by long sun exposure	Extensive labor under harsh conditions	Extensive labor under harsh conditions
Recommendation	Improve ergonomic conditions, change of mindsets toward pain alleviation	Redesign the equipment or tools, as well as work processes	Promotion of social–ecological resilience, further research for comprehensive medical studies	Improve ergonomic condition, use of protective tools (using hat, balaclava), information campaign, provision of support services and medical interventions targeting major health issues identified in this study
Reference	Shimada *et al.* (1990)	Thamrin *et al.* (2020)	Fröcklin *et al.* (2012); Msuya (2012)	This study

[1]An epidemiological study on low back pain
[2]Emphasis on ergonomics and musculo-skeletal disorders

of identified health hazards are only suggestive, and any causal inferences should only be drawn with great caution. The limitations of this small-scale study are also acknowledged. We hypothesized that seaweed farmers with severe work-related health problems were more likely to quit or change jobs and, hence, may have been excluded from the study population. Moreover, to complicate the matter, seaweed farmers may not afford to take time off from farming and, thus, may frequently have to endure their health problems to keep their jobs.

The provision of medicines is the most common intervention in health services in the Philippines (Phillips 1986). Prioritizing evidence-based policy and practices in selecting medicines for public distribution is crucial for targeted intervention decisions. With the identification of major health hazards among seaweed farmers, we can specifically determine the appropriate medications for them. Seaweed farmers in Sorsogon, being at high risk of back pain and headaches apparently without warning signs (*e.g.* neurologic deficits, presence of mass, physical trauma, fracture, systemic constitutional signs and symptoms), should benefit from taking non-steroidal anti-inflammatory drugs. A regular preventive medical examination, as well as exercises that promote appropriate body posture and ergonomics, should also be considered (Al-Otaibi 2015; di Prinzio *et al.* 2022). Campaign

plans of support groups from the government or private agencies may also advance and improve the accessibility of safety hazard determination and prevention community resources (*e.g.* protective tools, information, or support services) for the farmers.

Although this study covered only the seaweed farmers in Sorsogon, the findings obtained should have wider relevance to farmers in other seaweed-producing areas in the Philippines. The lack of data from outside Sorsogon made comparison of results limiting and generation of a nation wide perspective of the problems difficult. It is hoped that this report will motivate other researchers to employ similar studies to address work-related health problems in each unique population of seaweed farmers. Besides traditional crop production, seaweed farmers may have other important responsibilities *e.g.* maintaining the quality of their dried harvests and augmenting their income, especially during lean seasons (Fröcklin *et al.* 2012). These elements may put them under psychosocial stress and, hence, should also be considered in future studies.

CONCLUSION

Providing health support for seaweed farmers requires identifying their distinct concerns and customizing interventions accordingly. Our study has identified the most common health risks experienced among seaweed farmers in Sorsogon. Although these risks were of relatively minor concern, they may otherwise indicate serious implications for the future well-being of seaweed farmers, especially as the demand for seaweed production increases and the drive for higher crop yields intensifies. To meet these challenges, farmers may need to adopt more intensive farming practices. For example, the possible use of fertilizers to increase production would require additional physical labor or higher exposure to hazards (Tahiluddin *et al.* 2022). Our study contributes to improving the understanding of specific health issues and their possible drivers of health risks of seaweed farming in the Philippines. Ultimately, our study raises the profile of occupational hazards for the advancement of policies that improve health support among seaweed farmers in the Philippines.

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