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Role of health locus of control in preventing occupational decompression sickness among deep-sea fisherman divers

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ABSTRACT

Background: Indigenous fisherman divers frequently experience decompression sickness (DCS). This study aimed to evaluate the associations between the level of knowledge of safe diving, beliefs in the health locus of control (HLC), and regular diving practices with DCS among the indigenous fisherman divers on Lipe island. The correlations among the level of beliefs in HLC, knowledge of safe diving and regular diving practices were evaluated also.

Method: We enrolled the fisherman divers on Lipe island and collected their demographics, health indices, levels of knowledge of safe diving, beliefs in external and internal HLC (EHLC and IHLC), and regular diving practices to evaluate the associations with the occurrence of DCS by logistic regression analysis. Pearson's correlation was used to test the correlations among the level of beliefs in IHLC and EHLC, knowledge of safe diving, and regular diving practices.

Results: Fifty-eight male fisherman divers whose mean age was 40.39 (±10.61) (range 21–57) years were enrolled. Twenty-six (44.8%) participants had experienced DCS. Body mass index (BMI), alcohol consumption, diving depth, duration of time in the sea/dive, level of beliefs in HLC and regular diving practices were significantly associated with DCS ($p < 0.05$). Level of belief in IHLC had a significantly strong reverse correlation with that in EHLC and a moderate correlation with level of knowledge of safe diving and regular diving practices. By contrast, level of belief in EHLC had a significantly moderate reverse correlation with level of knowledge of safe diving and regular diving practices ($p < 0.001$).

Conclusions: Encouraging the fisherman divers' belief in IHLC could be beneficial for their occupational safety.

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Introduction

Health concerns and adoption of preventive health advice depend markedly on an individual's beliefs or realization of perceived personal health risks. Several health behavioral

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and psychological concepts have been applied to motivate adoption of health advice. The Health Belief Model (HBM) is a well-known concept in this regard. Health beliefs are influenced by multidimensional interactions between one's internal and external influencers (Murray & McMillan, 1993; Nexøe et al., 1999; Rosenstock, 1974a, 1974b).

Apart from the HBM, empowerment of self-efficacy (SE) in monitoring one's health condition is encouraged to conjoin with the HBM to foster effective self-managed health care. SE is a personal belief in or perception of his own competence in managing personal health appropriately (Canbulat & Uzun, 2008). Furthermore, the social determinants of health (SDH), which are the circumstantial or environmental factors in which people live such as national policies or laws, occupation, socioeconomic differences (SEDs), education and social status, influence the ways people behave for health prevention (Reap et al., 2020). Besides the health models or concepts mentioned, the 'health locus of control' (HLC), which is a psychological concept, is considered as a significant moderator of desired health behaviors (Lindström & Rosvall, 2020; Marmot, 2017). Occupational behaviors, particularly safe occupational practices, are possibly based on the same health behavior concepts. We think that the health behavior concepts can be applied in occupational safety practices as well.

Health belief model (HBM)

The HBM is a psychological concept developed by US social psychologists in the 1950s and is widely used to explain an individual's intention to adhere to health advice, or seek health services or treatment (Rosenstock, 1966). It comprises the domains of perceived disease susceptibility, perceived disease severity, perceived benefits, perceived barriers, cues to action, and motivation, which influence how an individual decides whether to take advantage of health-promoting or health-prevention services or not. The concept emphasizes an individual's health beliefs as a predictor of intention to engage in health services such as influenza and COVID-19 vaccinations (Arceo et al., 2021; Mercadante & Law, 2021; Shmueli, 2021).

Self-efficacy (SE)

SE is an individual's perception or confidence in navigating own health behaviors to achieve the targeted healthy condition. SE was one of the domains in the theory of planned behavior proposed by Icek Ajzan (Ajzen & Fishbein, 1977), and was considered the most significant predictor of preventive health behavior adoption (Liao et al., 2011; McClenahan et al., 2007). Studies have shown that only providing theoretical knowledge is not powerful enough to motivate desired health behaviors; strengthening one's SE, either alone or in combination with HLC, was necessary (Elkind, 2007; Moradhaseli et al., 2021; Sheeran et al., 2016).

Health locus of control (HLC)

The original description of the HLC concept by Rotter in 1966 classified HLC into internal HLC (IHLC) and external (EHLC) (Rotter, 1966). The classification was based on the source of reinforcement or empowerment, either from the internal drive of an

individual (IHLC) or from an external source (EHLC). The original HLC concept encouraged health care systems to strengthen an individual's IHLC for facilitation of the intention to adopt preventive health behaviors. Therefore, HLC was considered another key concept, apart from the HBM and SE, for encouraging a person to adopt appropriate health behaviors and monitor their own health conditions properly (Abredari et al., 2015; Afsahi & Kachooei, 2020; Bennett et al., 2017; Kudo et al., 2008; Náfrádi et al., 2017; Rizza et al., 2017; Tahmasebi & Noroozi, 2016). Studies on adopting recommended health behaviors highlighted the significance of the integration of these concepts, in which the HBM facilitated health screening concerns (Noroozi et al., 2011; Tastan et al., 2011), while HLC, and particularly when combined with SE, promoted effective preventive and constructive health behaviors. On the other hand, those who had low level of health beliefs, IHLC, and SE frequently had higher susceptibility to illness or mortality (Abredari et al., 2015; Bennett et al., 2017; Náfrádi et al., 2017; Tahmasebi & Noroozi, 2016). A prospective cohort, population-based study of mortality rates revealed a high mortality rate among people who had low IHLC scores after adjusting for all the influencing health behaviors (Lindström & Rosvall, 2020). The original conceptual HLC model was expanded by retaining IHLC and subdividing EHLC into powerful others HLC (PHLC), chance-attributed HLC (CHLC), God-attributed HLC (GHLC), and doctor-attributed HLC (DHLC) (Wallston et al., 1978, 1999). This model was called the 'multidimensional health locus of control (MHLC),' which described one's decision to adhere to health advice was influenced by personal and multiple environmental factors (Wallston, 2005; Wallston et al., 1978). Hence, MHLC model should be considered in designing health promotion programs expected for high adoption (Afsahi & Kachooei, 2020; Kudo et al., 2008; Náfrádi et al., 2017).

HLC studies on occupational health and knowledge gaps

Many studies on the implementation of the HLC model focus mainly on personal health rather than occupational health behaviors. One study from Japan found that workers with low IHLC but high CHLC scores had a low concern towards their annual health checkup results, even if the workers' annual health checkup and monitoring were mandatory according to the country's worker health laws (Kudo et al., 2008). We have found no studies evaluating the relationship between HLC and actual occupational practices in the regards of occupational safety, particularly the role of HLC on prevention of occupational decompression sickness syndrome (DCS) among artisanal fisherman divers as in the current study.

Diving practices of artisanal fisherman divers

In Thailand, a scattered group of sea nomads who do artisanal fishing live along the coast of the Andaman Sea from the southern coast of Myanmar to the northwestern coast of Malaysia. There are three culturally and linguistically different groups of sea nomads in Thailand, the Moken (MK), Moklen (MKl) and Urak Lawoi (UL) (Arunotai, 1997; Hinshiranan, 1996; Mayachicw, 1984). These sea nomads whose fishing techniques were passed on from generation to generation make their livings by harvesting sellable marine products at the sea bottom such as sea cucumbers, shell fish, sea fan coral, etc. While the MK and MKl commonly use a breath-holding diving technique in their fishing, the UL who live

Figure 1. Compressed air machine for generating plain air to the diver during fishing dive.

on Lipe island use plain air from a compressed air machine for their air supply when they dive (Figure 1). There are no oxygen tanks or emergency air supplement equipment prepared for these divers. The compressed air machine is carried on board a fishing boat floating on the sea surface at the diving site. The air is delivered to the fisherman diver through a 100–150-m-long rubber tube connecting the machine and locally-modified diving glasses (Figure 2). On the glasses, the rubber tube is connected to a short metal tube above the diver's right eye to deliver air into the glasses with an exhalation valve at the front (Figure 3). As they have neither a depth gage nor a watch for monitoring the depth of their dives and the ascent rate to the sea surface, the only way to save them from DCS is to follow an ancestral teaching of not ascending to the sea surface faster than the bubbles from the exhalation valve of the diving glasses. However, when any emergency or harmful event happens, this practical rule is often broken. A study of usual diving

Figure 2. Rubber tube connecting compressed air machine and diving glasses.

Figure 3. Diving glasses used by the Lipe fisherman divers. Top right view (Right), and front view (Left).

practices among the sea nomads in Thailand reported that one-fifth of them preferred to dive alone or stay far away from their buddy divers. Also, these fisherman divers usually do multiple dives a day with only a short break between dives to earn their livings because of the reduced marine product for harvesting. Taken together, these diving practices put the divers at a higher risk of DCS (Gold et al., 2000a, 2000b).

Since it takes average 4 hfrom Lipe island to the mainland where a physician and medical equipment are available for management of DCS, the local practices for DCS first aid are applied. These include local massage of the affected body parts, drinking or bathing in sacred water, and re-immersion to a comparable sea depth level to reset the compression conditions and then slowly ascend to the sea surface for decompression. The fishing dive-related DCS symptoms ranging from mild illness to disabling morbidity to death were reported in an earlier study (Gold et al., 2000a). Due to the difficult access to timely treatment and some risk occupational practices, these artisanal fisherman divers were susceptible to DCS-related injuries.

Proposed study hypothesis and aims

This study of artisanal fisherman divers of Lipe island aimed to (a) evaluate their levels of knowledge regarding safe diving, levels of beliefs in EHLC and IHLC, and their actual regular diving practices, and the association with DCS occurrence, and (b) assess the correlations among these factors in the context of occupational safety. In addition, we focused on whether HLC was a significant moderator of occupational safe diving practices among the Lipe fisherman divers.

Methods

Study population and location

Our study team in cooperation with the fisherman diver community leader and local health officers surveyed the study location and informed the study population of the

purposes and process of this study. We aimed to enroll all available fisherman divers who could understand the spoken Thai language as the study subjects. We obtained a list of all fisherman divers on the island from the fisherman leader for door-to-door contacts and interviews. Three local health officers who understood both the Thai official and local islanders' (Malayic) languages accompanied the interviews.

Lipe island is an island of the Adang-Rawi archipelago which is a part of Tarutao Marine Natural Park in the south Andaman Sea. The area is under the administrative governance of Satun province in southwestern Thailand. Although the island is a well-known tourist attraction in Thailand, the indigenous islanders are Malayic speaking sea nomads who earn their livings by artisanal deep-sea fishing diving. The island has an area of 4 km^2 and is located 85 km west of the Satun province.

Study questionnaire and tools

The questionnaire used in this study which was composed of 5 parts, underwent a content validity test by three experts in occupational health behaviors. The questionnaire was tested for reliability in 30 Bulon indigenous islanders who have the same ethnic origin, spoken language and earn their livings by artisanal fishing dive as the Lipe islanders.

The questionnaire used in this study included five parts as follow:

Part 1 General demographics, education, monthly income, and biomedical data.

Part 2 Diving experience including the age of beginning fisherman diving, number of dives per day, the depth of sea that they dived in, ascent time to sea surface, trainers of the diving techniques and experience of DCS.

Part 3 The 'Knowledge of safe diving' evaluation form. This form had 15 yes-no questions designed to evaluate the participant's knowledge regarding safe diving. This questionnaire was developed by combining the knowledge of recreational diving, the risks of DCS among the fisherman divers in Thailand reported in the earlier studies (Charapinyo, 2007; Gold, 2000; Tangjai, 2007) and the Lipe islanders' ancestral knowledge of safe diving. The 15 evaluation yes-no statements were:

- Fisherman divers should have buddy divers
- Fat people have a higher risk of DCS
- Drinking alcohol before diving increases the risk of DCS
- A man with hypertension should not dive
- Ascending to the sea surface faster than your exhaled bubbles is not dangerous
- Drinking at least 2 liters of fresh water/day is necessary for divers
- The occurrence of DCS does not depend on the rate of ascent
- Divers should make intermittent stops during ascent to the sea surface
- The chance of DCS occurrence is highest at a depth of 1–2 m before reaching the sea surface
- A man who has nasal congestion or a common cold should not dive
- The rubber tube connected to the compressed air machine should be secured
- Fisherman divers should have a sea depth gage during their dives
- Fisherman divers should have a watch during their dives
- Fisherman divers should have a compass during their dives
- The breath should be held during the ascent to the sea surface

The form had a total of 15 points (1 point for each correct answer), and the diver's knowledge was classified according to the points obtained as low (< 7.5 points) (≤ 50% of the total score), intermediate (7.5–12 points) (51–79% of the total score) and high (> 12 points,) (≥ 80% of the total score) based on the Bloom taxonomy of levels of knowledge tests (Bloom, 1971). The content validity of the evaluation form was 0.89. The reliability test using the KR-20 yielded a value of 0.76.

Part 4 The 'Beliefs in IHLC and EHLC' evaluation form. This form was developed by the authors based on the concept of HLC and the fisherman divers' cultural beliefs. It comprised 20 questions that evaluated IHLC and EHLC. For EHLC, we included only the 'chance HLC' concept, which was interpreted as fate or fortune-attributed. This form evaluated how the divers thought or believed in each condition presented in the items. The answers were divided into three categorical levels of agreement, i.e. agree, uncertain or disagree. The score for each level of agreement was 1, 2, or 3, respectively. The agree/disagree statements of the form were:

- Muscle cramps which develop during dives are caused by the sacred spirits in the sea
- Disconnection of the rubber tube from the diving glasses is by chance
- Good and strong physical health prevents the occurrence of illnesses
- Worshiping the sea gods before diving will ensure safe dives
- Physicians at a hospital are the only persons who can treat your sickness
- You can do physical exercise regularly
- You learnt fishing diving from one who had no experience of DCS
- You trained yourself in diving
- Getting an illness depends on your fate
- DCS can occur even if you follow diving practice guidance
- Violation of sea ghosts causes DCS
- Only those who have bad luck will face a shark
- You have the confidence to do a technically-correct dive by yourself
- Diving with a group of buddies is safer
- A God or Goddess has already determined one's life line or sicknesses
- The speed of recovery from an illness depends on your health behaviors
- There is no difference among the various types of rubber tubes connecting the compressed air machine and the diving glasses
- The influencers of health take place by chance
- Good fortune always brings about good health
- Concern about your health condition decreases the chance of getting sick

The points obtained from this form was classified based on the calculation of subtracting the minimum from the maximum points, and the result was divided by the number of stratification levels (i.e. 3–1 divided by 3 = 0.67) (Best & Khan, 1998). Therefore, points of 1.00–1.67 were classified as low beliefs in HLC, 1.68–2.35 as intermediate, and 2.36–3.00 as high. The content validity of this evaluation form was 0.91. The reliability test using Cronbach's alpha was 0.81.

Part 5 The 'Regular diving practices' evaluation form. This 15-item form evaluated how frequently the divers performed each safety practice during their fishing dives. The answers were divided into three categorical levels of frequency of each practice as

always, occasionally or never. The points for the levels of frequency were 0, 1, or 2, respectively. The statements of this form were:

- The rubber tube security is checked before each dive
- You have a buddy diver or a group of them
- You check the oxygen tank before diving
- You do physical exercises regularly
- You have your blood pressure checked before each dive
- You drink 2 litres or more of fresh water/day
- You make stops during your ascent to the sea surface
- You hold your breath just before surfacing
- You ascend faster than your last exhaled bubbles
- You use a depth gage to report the depth during dives
- You use a compass during dives
- You have a watch with you when you dive
- You dive longer than 1 h/dive without rest
- You check the exhalation valve of your diving glasses before diving
- The use of an oxygen tank is good for diving

The point stratification in this form was the same as the beliefs in the HLC evaluation form, i.e. points from 0 to 0.67 were classified as poor practice, 0.68–1.35 as average practice, and 1.36–2.00 as good practice (Best & Khan, 1998). The content validity of the evaluation form was 0.88. Cronbach's alpha for the reliability test was 0.78.

Data collection and analysis

After the questionnaire was tested for validity and reliability, and the study location and translators for the interviews were well prepared, we started to collect the study data by door-to-door visits and face-to-face interviews after obtaining consent from the participants. Sound recorders were used to record the interviews for further review and validation if necessary. The data were stored in a computerized data base after validation. The data were analyzed using descriptive statistics, with frequencies, percentages, and means (SD). Multiple logistic regression analysis was used to identify the independent variables associated with the occurrence of DCS. Pearson's correlation was used to test the level and significance of paired correlations among level of knowledge of safe diving, levels of beliefs in IHLC and EHLC, and level of regular diving practices ($p < 0.001$).

Ethics statement

This study protocol was approved by the Ethic Committee of Faculty of Medicine, Prince of Songkla University (EC approval No. 54-050-09-222). Personal information of all study participants was completely anonymized. We strictly followed the regulations of the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants. We analyzed the data in aggregation to protect the participants' identities.

Results

A total of 58 out of 65 fisherman divers on Lipe island were enrollable for statistical analysis. As with the other sea nomad groups who did artisanal fishing in the Andaman coastal area, they were all males. Among them, 26 participants (44.8%) had experienced DCS at least once during their diving experience. Six (10.3%) divers experienced severe DCS symptoms necessitating emergency medical treatment such as cardiopulmonary or neurological illness, i.e. stroke or spinal cord disorders, while 20 (34.5%) divers had mild symptoms. The majority of mild DCS cases involved joint pain, muscle ache, paresthesia of the body and/or limbs without paralysis. Generally, these mild DCS illnesses were short, lasting only for a few days, except the divers with repeated DCS had permanent physical injuries, especially joint destruction. However, one disabling paraplegia and one death two years before starting this study were reported. Diving to earn their livings was reported by most participants (75.9%), followed by diving as a tourist guide (21.1%) and other reasons (3%). On the medical evaluation, 48 (82.8%) of the divers had a high body mass index (BMI) categorized as overweight or obese (BMI > 23 for Asians) and 51 (87.9%) divers were current smokers. The study participants were trained for fishing dive by their male seniors such as fathers, grandfathers, elder brothers or cousins who were experienced in this type of traditional diving. Their knowledge of safe diving was transferred from generation to generation, for example that they should be accompanied by buddy divers, avoid smoking or drinking alcoholic beverages before diving, stop periodically during the ascent to the sea surface, especially when approaching the surface, and ascend from the sea bottom slower than their last exhaled air bubbles, etc. The personal diving equipment was a set of locally-modified diving glasses connected to a compressed plain air machine by a long rubber tube line without an oxygen tank for underwater oxygen supplementation (Figures 1–3). While 53.9% of the divers had a moderate level of knowledge of safe diving and beliefs in IHLC and EHLC, 75.9% of them had an average level of regular diving practices (Table 1).

There was a significantly strong reverse correlation between the level of beliefs in IHLC and EHLC. Also, the level of belief in IHLC had a significant intermediate correlation with the level of knowledge of safe diving and regular diving practices, whereas the level of belief in EHLC had an intermediate reverse correlation with both the levels of knowledge of safe diving and regular diving practices as assessed by Pearson's correlation ($p < 0.001$) (Table 2).

By multivariable analysis, we found that BMI, alcohol consumption, diving depth, and duration of time in the sea/dive were significantly associated with the occurrence of DCS among the study participants (Table 3). Considering the levels of belief in HLC, knowledge of safe diving and regular diving practices, we found that the levels of belief in both EHLC and IHLC, and regular diving practices were significantly associated with the occurrence of DCS (Table 4).

Discussion

Our study found that the fisherman divers of Lipe island started their fishing dives at very young ages and dived without oxygen supplement. Younger age when beginning diving

Table 1. General demographics, underlying the diseases, diving practices, level of knowledge of safe diving, levels of beliefs in internal and external HLC and level of regular diving practices in 58 Lipe island fisherman divers.

Variable	*n* (%)
Age, yrs, mean (SD), (range)	40.93 (10.61), (21.00–57.00)
Marital status	
Single	6 (10.3)
Married	50 (86.2)
Divorced	2 (3.4)
Educational level	
Illiterate	9 (15.5)
Primary school	48 (82.8)
Initial Secondary school	1 (1.7)
Diving purpose	
Deep-sea fishing	44 (75.9)
Tourism	14 (24.1)
Income/month, Baht, mean (SD), (range)	(20,000–50,000),(3,764.22)13,379.31
Weight, Kgs, mean (SD), (range)	79.66 (7.46), (62.00–92.00)
Height, cms, mean (SD), (range)	167.21 (8.16), (157.00–178.00)
Systolic blood pressure, mmHg, mean (SD), (range)	134.72 (8.16), (121.00–154.00)
Diastolic blood pressure, mmHg, mean (SD), (range)	82.79 (5.88), (73.00–93.00)
Body mass index	
Normal (18.5–23.0)	10 (17.2)
Overweight-obese (> 23.0)	48 (82.8)
History of smoking	
Non-smoker	1 (1.7)
Ex-smoker	6 (10.3)
Current smoker	51 (87.9)
Number of cigarettes smoked/day, mean (SD), (range)	7.36 (5.80), (0–20)
None	7 (12.1)
2–5	26 (44.8)
6–10	14 (24.1)
11–15	6 (10.3)
16–20	5 (8.6)
Alcohol consumption	
Non-drinker	9 (15.5)
Ex-drinker	12 (20.7)
Current drinker	37 (63.8)
Annual health checkup	
No	15 (25.9)
Yes	43 (74.1)
Previous medical illness	
None	38 (65.5)
Essential hypertension (≥ 130 and/or 85 mmHg.)	11 (19.0)
Diabetes mellitus (FBS ≥ 126 mg/dL)	5 (8.6)
Rhinitis or asthma	4 (6.9)
Age at the beginning a diver, yrs, mean (SD), (range)	13.90 (1.80), (11.00–18.00)
11–13	27 (46.6)
14–16	26 (44.8)
17–18	5 (8.6)
Duration of time in the sea/dive hrs., mean (SD), (range)	2.56 (0.82), (1.00–4.00)
Average number of dives/day, mean (SD), (range)	3.00 (0.99), (1.00–5.00)
Dive depth, m, mean (SD), (range)	27.69 (7.77), (15.00–50.00)
Estimated time of ascending to sea surface, min., mean (SD), (range)	4.93 (1.28), (3.00–8.00)
Estimated rest time between dives, min, mean (SD), (range)	3.60 (1.05), (2.00–6.00)
Decompression sickness (DCS) experience	
No	32 (55.2)
Yes	26 (44.8)
– Severe DCS	(10.3) 6
– Mild DCS	(34.5) 20
Diving trainer	
Father	45 (77.6)

(*Continued*)

Table 1. Continued.

Variable	*n* (%)
Elder brother	9 (15.5)
Other relatives	4 (6.9)
Level of knowledge of safe diving	
Low	24 (41.4)
Intermediate	31 (53.4)
High	3 (5.2)
Level of belief in IHLC	
Low	23 (39.7)
Intermediate	31 (53.4)
High	4 (6.9)
Level of belief in EHLC	
Low	2 (3.4)
Intermediate	31 (53.4)
High	25 (43.1)
Level of regular diving practices	
Poor	10 (17.2)
Average	44 (75.9)
Good	4 (6.9)

NB: The data are shown in numbers (%), except where indicated otherwise.
Abbreviations: yrs, years; cms, centimeters; min, minute; m, meters; hrs, hours; EHLC, external health locus of control; IHLC, internal health locus of control.

was not significantly associated with the occurrence of DCS as previously reported (Dunford et al., 2002; Schellart et al., 2013). A diving depth of 20 ft or more was reported to be a risk factor for DCS in recreational diving (Francis & Mitchell, 2003). However, the recreational diving with full equipment support and instructions for diving safety was different from the artisanal fishing diving in this study. The results of this study indicated that high BMI, alcohol consumption, diving depth, and duration of time in the sea/dive were independent factors associated with the occurrence of DCS (Table 3). Though alcohol consumption seemed to be a protective factor, we believed that this could be an effect of the small sample size of this study. Also, we did not collect data on the amount of alcohol consumed or the time interval between alcohol drinking and diving. Because the marine ecology had been changed and the establishment of Tarutao Marine National Park in 1974, the fishermen harvested much fewer marine products. Hence, they had to spend longer times and dive deeper in the sea to make their livings. Data from face-to-face interviews with the diver leader and divers on the island reported that most of the divers had experienced mild and transient DCS symptoms as reported previously (Table 1) (Gold et al., 2000b; Kirby, 2019). Only one

Table 2. Pearson's correlation among level of knowledge of safe diving, levels of belief in EHLC and IHLC, and level of regular diving practices in 58 Lipe island fisherman divers.

	Level of Knowledge of safety diving	Level of belief in EHLC	Level of belief in IHLC	Level of regular diving practices
Level of Knowledge of safe diving	–	−0.490**	0.553**	0.464**
Level of belief in EHLC		–	−0.846**	−0.490**
Level of belief in IHLC			–	0.478**
Level of regular diving practices				–

**$p < 0.001$.
Abbreviations: EHLC, external health locus of control; IHLC, internal health locus of control.

Table 3. Associations between body mass index, health behaviors, diving practice factors and decompression sickness among Lipe island fisherman divers by multivariable analysis.

Factor	DCS		β	S.E.	OR (95% CI)	p-Value
	Yes (26)	No (32)				
Body mass index (BMI)			2.281	1.093	9.783 (1.148–83.329)	0.037*
Normal	1	9				
Overweight-obese	25	23				
Smoking			1.753	1.116	5.769 (0.648–51.397)	0.116
Non- or Ex-smoker	1	6				
Current smoker	25	26				
Alcohol consumption			1.776	0.602	0.169 (0.051–0.551)	0.003*
No	15	6				
Yes	11	26				
Depth of diving			2.493	0.664	12.10 (3.293–44.462)	<.001**
< 30 m	4	22				
≥ 30 m	22	10				
Duration of time in the sea/dive			3.912	0.866	50.00 (9.158–272.981)	<.001**
< 3 hrs	6	30				
≥ 3 hrs	20	2				

*$p < 0.05$.
**$p < .001$.
Abbreviation: m, meters; hrs, hours; DCS, decompression sickness.

death related to diving DCS was reported in this study. In cases of serious DCS requiring emergency hyperbaric chamber treatment, the patients had to be transferred to Phuket provincial hospital which required first a 4–5 h of boat trip from the island to the mainland plus another 5 h by ambulance.

Occupational health behavior conceptual framework

A. Relation between HLC concepts and occupational safety practices

Our study results showed a larger proportion of the divers had a high level of belief in EHLC (43.1%) than those who had a high level of belief in IHLC (6.9%). In addition,

Table 4. Associations between level of knowledge of safe diving, level of regular diving practices, levels of beliefs in EHLC and IHLC, and decompression sickness in Lipe island fisherman divers by multivariable analysis.

Factor	DCS		β	S.E.	OR (95% CI)	p-Value
	Yes (26)	No (32)				
Level of Knowledge of safe diving			0.357	0.537	1.429 (0.499–4.091)	0.506
High-intermediate	14	20				
Low	12	12				
Level of regular diving practices			1.897	0.845	6.667 (1.273–34.923)	0.025*
Good	18	30				
Poor-Average	8	2				
Level of belief in EHLC			1.408	0.563	4.089 (1.356–12.329)	0.012*
High	16	9				
Low-intermediate	10	23				
Level of belief in IHLC			2.944	0.694	19.000 (4.878–73.998)	<.001**
High	7	28				
Low-intermediate	19	4				

*$p < 0.05$.
**$p < .001$.
Abbreviations: DCS, decompression sickness; EHLC, external health locus of control; IHLC, internal health locus of control.

the level of belief in EHLC showed a significant and strong reverse correlation with the level of belief in IHLC, and an intermediate reverse correlation with the level of knowledge of safe diving and regular diving practices (Table 2). This finding implies that the fisherman divers of Lipe island think that the occurrence of DCS is out of their control. However, they have perceived the diving-related DCS risks so that they should follow their ancestral diving instructions as shown by the high percentage of divers who follow average to good diving practices (Table 1).

Based on the concepts of HBM and HLC in moderating health behaviors in current health care, various studies have reported that MHLC influenced health beliefs and thoughts on the value of healthy practices and preventive health behaviors (Lai et al., 2006; Nexøe et al., 1999; Shope et al., 1993; Tahmasebi & Noroozi, 2016; van den Akker et al., 2001). Many studies have reported that people with higher beliefs in IHLC formed their self-confidence and SE in monitoring their own health and sought health advice from available information sources, i.e. websites or applications (Abredari et al., 2015; Afsahi & Kachooei, 2020; Armistead-Jehle et al., 2020; Bennett et al., 2017; Náfrádi et al., 2017). Among the fisherman divers in this study, the beliefs in both EHLC and IHLC and the levels of regular diving practices were significant factors associated with the occurrence of DCS in multivariable analysis. We believed that the interaction between HBM and beliefs in HLC possibly moderated the level of regular diving practices among them.

B. Implications of HLC and health behavior concepts in occupational health

A previous study confirmed that people who had a strong belief in EHLC, either CHLC or PHLC, adopted passive or dependent health behaviors. They frequently showed noncompliance with the health advice or treatment provided (Demir & Yıldırım, 2019). Similarly, the Lipe fisherman divers in this study had a high level of belief in EHLC which reversely correlated with their levels of regular diving practices and knowledge of safe diving.

We thought that the existing health behavior concepts could be employed in the context of occupational health. The realization of susceptibility, severity of occupational harms, benefits of and barriers to following constructive occupational health advice were formed on the same basis of HBM. When this concept was conjoined with other psychological concepts such as HLC or SE, self-management for occupational safety could occur. On the other hand, one's higher belief in the EHLC concept could lead to misperception of sickness (or occupational harms) as a result of external rather than internal influencers (Galanos et al., 1994; Kuwahara et al., 2004). Based on the mentioned health concepts, we would like to propose the actions which we believed that they would lead to adoption of an advice of safe occupational practices among the study participants and others in a similar condition.

a) Safe diving instructions should be provided. Integrated knowledge of modern recreational and artisanal diving should be provided to the fisherman divers. Sharing DCS direct experiences and solutions among them should be supported.
b) Empowerment of IHLC and SE programs should be encouraged to match the divers' culture and beliefs.

c) Follow-up evaluation for feedback on the outcomes and further strengthening of individual's IHLC and SE.

Some studies emphasized that promotion of not only IHLC but also empowering SE as a behavioral facilitator, would enhance the adherence to health advice (Náfrádi et al., 2017; Wallston, 1991, 2005).

C. Effects of social determinants of health on occupational safety practices

Social determinants of health (SDH) is an external contributor that influence an individual's health behaviors. SDH comprises structural mechanisms (i.e. policies and laws), socio-economic status, educational status, livelihood and occupational conditions (WHO, 2010). We believe that interactions among SDH, personal health beliefs or circumstantial factors influence one's decision in adoption of preventive general as well as occupational health advice. The marine ecology changes and application of marine conservation laws were the significant social determinants affecting the divers' practices for earning their livings. A study of SDH in UL people in two communities on Lanta Island and one on Lipe Island found that livelihood and education were the significant SDH among these indigenous populations (Reap et al., 2020).

Strength, limitations and future studies

Our study highlighted safety practices in an artisanal occupation. We found that the risks of occupational hazards in our study participants were influenced by multiple factors, including personal health status, health beliefs, health psychology, and socio-economic status, ecological change, and environmental conditions. We applied various current health psychological concepts in general health behaviors on artisanal occupational practices.

There were some limitations in this study. First, it was a cross-sectional study with a small sample size. Second, each interview statement listed in the evaluation forms were unweighted according to the levels of DCS risk. Future studies to differentiate the levels of DCS risk among the interview statements are pending. Third, applying a recreational dive regulation to evaluate diving safety practices among the artisanal fisherman divers in this study may be invalid. However, we thought that some basic principles for diving safety were similar such as monitoring the ascent time from the sea bottom and the depth of dives. Nevertheless, we think that our study can serve as a starting point for future prospective cohort studies regarding risks of DCS occurrence among artisanal fisherman divers.

Conclusions

BMI, alcohol consumption, diving depth and duration of time in the sea/dive, levels of belief in IHLC and EHLC, and level of regular diving practices were significant independent factors associated with DCS in our study. Our findings suggested that occupational practices like health behaviors were products of an individual's physical health and health psychology interactions. Artisanal fisherman diving techniques are based on experiential-

based teaching which may put the divers at risk of DCS. Further studies regarding safe diving among the artisanal fisherman divers based on the integration of modern and ancestral knowledge of diving are required.

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Data availability statement

All the data and methods of statistical analysis were included in the manuscript.

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