ORIGINAL ARTICLE

Diving Related Injury and Illness among Scuba Divers in Malaysia and its Associated Factors

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ABSTRACT

Introduction: Recreational scuba diving, a popular adventure sport, inherent risks such as high-pressure environments, and physical/ challenges, potentially leading to injuries or illnesses. This study aimed to determine the prevalence of diving-related issues among recreational scuba divers in Malaysia and identify associated factors. The findings inform preventive measures for stakeholders, including dive operators, instructors, and regulatory bodies. **Materials and methods:** A cross-sectional study was conducted at diving centres located in the East Coast of Peninsular Malaysia, specifically in Perhentian and Tioman Islands. Data collection involved using a standardized proforma checklist, and the analysis was carried out using SPSS version 26. Descriptive analysis, as well as simple and multiple logistic regression, were employed to analyze the data. **Results:** Out of 407 scuba divers, 145 (36.1%) reported diving-related injuries or illnesses. The most common conditions were barotrauma (17.9%), muscle cramps (14.0%), and panic attacks (10.1%). Divers with injuries or illnesses were predominantly male, Malaysian, open water certification holder, used personal gear, and with mean age 31.13 (SD=6.23). Level of diving certificate was significantly associated with diving-related injury/illness according to multiple logistic regression, with adjusted odds ratio of 3.78 (95% CI: 1.68, 8.49; $p < 0.05$). **Conclusion:** This study underscores the imperative of enhancing diver safety and emphasizes the vital need to improve safety in Malaysian recreational scuba diving. The observed association between lower certifications and injuries underscores the importance of targeted preventive measures for stakeholders, contributing to overall advancements in diving safety protocols in Malaysia.
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Keywords: Diving-related injury/illness, Scuba divers, Associated factors, Prevalence, Recreational

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INTRODUCTION

The recreational scuba diving industry is rapidly expanding globally, including in Malaysia, with over 28 million diver certifications issued by the Professional Association of Dive Instructors (PADI) since 1967, and there are more than 128,000 PADI professional members around the globe (1).

Scuba diving constitutes a significant and economically valuable component of marine tourism, as evidenced by annual estimates exceeding USD4.5 billion in Southeast Asia (2). In Malaysia, the Semporna region contributes significantly, generating around USD55.3 million for local businesses This contribution accounts for approximately 0.02% of Malaysia's total Gross Domestic Product during the period spanning 2016 to 2018 (3).

Diving-related injuries and illnesses pose a significant concern, with the Divers Alert Network (DAN) reporting an incidence of 3.02 injuries per 100 dives in the USA. In 2014, DAN documented 2,046 diving-related injuries, predominantly otolaryngologic and otologic in origin. Moreover, other frequently reported injuries included decompression illness, near drowning, panic attacks, and other injuries such as wounds and musculoskeletal issues (4, 5).

DAN's 2019 report highlighted a troubling trend of increasing diving accidents in Southeast Asian countries, including Malaysia, Indonesia, and Thailand, observed from 2009 to 2011 (4). Specifically in Malaysia, the escalation in the percentage of diving accidents was directly linked to the increasing number of individuals

engaging in scuba diving activities, as reported by the Malaysia Scuba Diving Association (MSDA) in 2020. Lumut Armed Forces Hospital documented 175 diving-related cases over a decade (2000-2010), with 43% associated with recreational divers. The majority of these cases were treated for decompression sickness (6). Previously, it was reported an annual average of about 20 diving accidents, with 39% attributed to recreational diving. Decompression illness was notably prevalent, constituting 96.1% of all reported cases, particularly in commercial diving activities like underwater logging (7). However, determining the actual prevalence of these illnesses is challenging due to the unknown total number of scuba divers in Malaysia.

The factors contributing to diving-related injuries are categorised into environmental, diver-related, and dive activity-related categories. Importantly, these factors are not isolated; instead, they exhibit interdependencies and interconnectedness among them (8).

Diver-related factors play a crucial role in contributing to diving-related injuries and illnesses. These factors encompass the diver's health, behavior, and experience, all of which significantly influence their safety during a dive. Health issues, including underlying medical conditions such as cardiovascular disease and diabetes mellitus, have been identified as potential precursors to diving-related incidents (8-10).

Environmental factors include underwater conditions that may pose risks to divers. These factors encompass water temperature, visibility, underwater currents, tides, aquatic life, and the characteristics of the underwater terrain, which can contribute to navigation problems, injuries, and medical complications (5, 11, 12).

Turning to dive activity-related factors, these encompass specific elements of a dive, including its nature, depth, duration, and the equipment employed. The type of dive (recreational, technical, or commercial) can introduce differing levels of risk and presents a distinct set of challenges, risks, and safety considerations (13). For example, deep dive usually associated with dysbaric osteonecrosis (DON) among recreational scuba divers and repetitive divers (14-16). Moreover, equipment malfunctions or improper usage can significantly contribute to diving incidents (17, 18).

Diving incidents rarely result from a single isolated factor. Instead, the interplay and convergence of various elements significantly impact the outcome of a dive. Identifying the root cause of an accident is crucial, going beyond focusing solely on the final act. Uncovering each root cause allows for early highlighting of prevention plans and actions, ultimately reducing the occurrence of incidents and injuries.

MATERIALS AND METHODS

Study design and materials

This cross-sectional study took place at 10 dive centres in Peninsular Malaysia. Data on scuba divers were collected using a proforma checklist distributed during the data collection period, covering demographic characteristics and diving profiles as independent variables. The study's outcome focused on the self-reported data regarding the experience of diving-related injury and illness.

Study location

This study was conducted at dive centres in Perhentian and Tioman Islands, which situated in the eastern coastal area of Peninsular Malaysia. These dive centres were selected using a purposive sampling method, with an emphasis on these two prominent islands due to their high tourist visitation and abundant dive centres. Ten dive centres, five each on Tioman and Perhentian Islands, were included in the study. For selection of respondents, universal sampling approach was applied, encompassing all scuba divers visiting these centres during the data collection period.

Study duration

The study spanned from March to November 2023, involving a one-month preparation phase, five months of data collection, and two months dedicated to data entry and analysis.

Study population

The reference population for this study comprised scuba divers in Malaysia. The sampling frame included certified scuba divers who were over 18 years old, engaged in recreational diving, proficient in English, participated in the study and attended the selected dive centres during the study period. In conclusion, a total of 407 recreational scuba divers were recruited for the study.

Statistical analysis

The statistical analysis was performed using IBM SPSS version 26, descriptive analysis for the prevalence of diving-related injury and illness, and simple and multiple logistic regression to study associated factors.

Initially, simple logistic regression was employed for variable selection in multiple logistic regression. The stepwise process, incorporating backward and forward selection procedures, was used in multiple logistic regression to investigate the collective impact of risk factors. Variables with p-value less than 0.25 in simple logistic regression or those previously found significant in other studies were included (19).

The p-value threshold for the best model in multiple

regression analysis was set at less than 0.05. Potential interactions between variables were explored, and the absence of multicollinearity was confirmed using correlation matrix and standard error. The model's goodness-of-fit was assessed with the Hosmer and Lemeshow test, with a p-value exceeding 0.05 indicating a good fit (20). Model fitness was further evaluated using the classification table, considering a good fit as demonstrating a high overall percentage of accuracy (>70%) (19).

Tables were generated to present crude odds ratios, adjusted odds ratios, 95% confidence intervals (CIs), and p-values. A two-tailed significance level of 0.05 was chosen for all statistical tests.

Ethical approval

Approval for the study was granted by the Human Research and Ethics Committee, Universiti Sains Malaysia, with the reference number USM/JEPeM/22070461.

RESULTS

Descriptive analysis

The study included 407 scuba divers, with mean age of 31.3 years (SD = 6.23). The majority were male (71%), and Malaysian citizens (89.7%). Nearly half identified as professionals (49.9%), and the majority held at least a bachelor's degree (64.6%). In terms of their diving profile, most participants had an open water certificate (49.4%), 4-5 years of diving experience (28.3%), and had completed at least 50 dives (54.3%) since obtaining their certification.

Regarding diving-related injuries and illnesses, 145 scuba divers (36.1%; 95%CI: 26.8%-36.4%) reported experiencing or being diagnosed with such conditions. These occurrences were more common among males (72.42%), Malaysians (89.8%), singles (51.0%), professionals (55.8%), and those with at least a bachelor's degree (55.8%). In terms of diving profile, the experience of diving-related injury and illness was common among those with Open Water Dive certificates and Advanced Open Water Dive certificates, with percentages of 30.6% respectively. Scuba divers who had been diving for four to five years (26.5%), dove less than 50 times since receiving their certificate (39.5%), used rental dive equipment (87.1%), preferred remembering their dive checklist (72.8%), dived more than 30 meters (38.1%), and used a dive log (63.3%) were more likely to experience diving-related injuries and illnesses in our study. Table I summarises the sociodemographic of the participants.

Table I: Characteristics of Scuba Divers in Malaysia in the Cross-Sectional Study, n=407.

Variables	Total, n (%)	Experience of diving-related injury/illness, n (%)	
		Yes	No
Sociodemographic characteristic			
Age (Years)*	31.13(6.23)		
Gender			
Male	289(71.0)	107(72.4)	182(70.0)
Female	118(29.1)	40(27.6)	78(30.0)
Nationalities			
Malaysians	365(89.7)	132(89.8)	233(89.6)
Non-Malaysians	42(10.3)	15(10.2)	27(10.4)
Marital status			
Single	244(60.0)	75(51.0)	169(65.0)
Married	148(36.4)	65(44.2)	83(31.9)
Divorced	15(3.7)	7(4.8)	8(3.1)
Occupation			
Professional	203(49.9)	82(55.8)	121(46.5)
Self-employed	88(21.6)	35(23.8)	53(20.4)
Student	101(24.8)	6(4.1)	9(3.5)
Unemployed	15(3.7)	24(16.3)	77(29.6)
Education level			
Postgraduate	34(8.4)	54(36.7)	56(21.5)
Degree	263(64.6)	82(55.8)	181(69.6)
Secondary school	110(27.0)	11(7.5)	23(8.8)
Primary school	0(0)	0(0)	0(0)
None	0(0)	0(0)	0(0)
Medical illness			
Yes	57(14.0)	27(18.4)	30(11.5)
No	350(86.0)	120(81.6)	230(88.5)
Smoking status			
Smoking	99(24.3)	44(29.9)	55(21.2)
Vaping	68(16.7)	21(14.3)	47(18.1)
Both	20(4.9)	10(6.8)	10(3.8)
None	220(54.1)	72(49.0)	148(56.9)
Alcohol consumption			
Yes	87(21.4)	31(21.1)	56(21.5)
No	320(78.6)	116(78.9)	204(78.5)
BMI[2]*	23.60(3.64)		
Diving Profile			
Level of certification			
Open Water	201(49.4)	45(30.6)	156(60.0)

CONTINUE

Table I: Characteristics of Scuba Divers in Malaysia in the Cross-Sectional Study, n=407. (CONT.)

Variables	Total, n (%)	Experience of diving-related injury/illness, n (%)	
		Yes	No
Diving Profile			
Level of certification			
Advance Open Water	116(28.5)	45(30.6)	71(27.3)
Rescue Dive	53(13.0)	31(21.1)	22(8.5)
Divemaster	37(9.1)	26(17.7)	11(4.2)
Duration of diving experience			
<1 year	110(27.0)	23(15.6)	87(33.5)
1-3 years	81(19.9)	26(17.7)	55(21.2)
4-5 years	115(28.3)	39(26.5)	76(29.2)
6-10 years	61(15.0)	30(20.4)	31(11.9)
>10 years	40(9.8)	29(19.7)	11(4.2)
Frequency of dive since certification granted			
<50 dives	221(54.3)	58(39.5)	163(62.7)
50-100 dives	99(24.3)	35(23.8)	64(24.6)
101-500 dives	51(12.5)	29(19.7)	22(8.5)
>500 dives	36(8.8)	25(17.0)	11(4.2)
Type of equipment used			
Owned	115(27.80)	51(34.7)	64(24.6)
Rental	179(44.0)	128(87.1)	51(19.6)
Mixed	113(27.8)	45(30.6)	68(26.2)
Type of checklist used			
Written	125(30.7)	40(27.2)	85(32.7)
Remembered	282(69.3)	107(72.8)	175(67.3)
Diving depth (meters)			
< 18 or less	159(39.1)	38(25.9)	121(46.5)
19-30	148(36.4)	53(36.1)	95(36.5)
>30	100(24.6)	56(38.1)	44(16.9)
Dive log			
Yes	261(64.1)	93(63.3)	168(64.6)
No	146(35.90	54(36.7)	92(35.4)
Dive Buddy			
Yes	400(98.3)	144(98.0)	256(98.5)
No	7(1.7)	3(2.0)	4(1.5)
TOTAL	**407(100)**	**147(36.1)**	**260(63.8)**

*Mean (SD[1])
[1]SD= Standard Deviation; [2]BMI=Body Mass Index

Additionally, the most prevalent injury was barotrauma, affecting 17.9% of the respondents. Other reported injuries including muscle cramps (14%), panic attacks (10.1%), and wound injuries (8.6%). Allergic reactions, decompression injuries, and near-drowning incidents had a prevalence of less than 5%, as presented in Table II.

Table II: Summary of Diving-Related Injury/Illness, n=407

No	Type of diving related injury/illness	n (%)
1.	Barotrauma	73 (17.9)
2.	Muscle cramps	57 (14.0)
3.	Panic attack	41 (10.1)
4.	Wound injury	35 (8.6)
5.	Decompression injury/illness	10 (2.5)
5.	Near drowning	5 (1.2)
6.	Allergic reaction	4 (1.0)

Simple Logistic Regression

Univariate analysis was conducted on 18 variables of interest. Among these initial variables, 12 exhibited p-values of less than 0.25 and were subsequently included in the multivariate analysis to account for potential confounding factors. These variables encompassed age, occupation, marital status, education level, medical co-morbidities, smoking status, BMI, duration of diving experience, frequency of dive, type of equipment, type of checklist used, and diving depth. The outcomes of the simple logistic regression are summarised in Table III.

Table III: Factors Associated with Diving-related Injury and Illness among Scuba Divers in Malaysia by Simple Logistic Regression, n=407.

Variables	Crude Regression Coefficient (b)	Crude OR[1] (95%CI[2])	Wald Statistic	p-value
Age (Years)	0.072	1.08 (1.04,1.11)	17.92	<0.001
Marital status				
Single	1			
Married	-0.11	0.89 (0.31,2.60)	0.04	0.84
Divorced	-0.68	0.51 (0.18,1.450	1.61	0.21
Occupation				
Student	1			
Professional	-0.03	0.98 (0.59,1.62)	0.10	0.921
Self-employed	-0.78	0.46 (0.27,0.79)	8.03	0.005
Unemployed	-0.01	0.98 (0.34,2.87)	0.01	0.976
Education level				
Secondary school	1			
Degree	0.05	1.06 (0.49,2.27)	0.02	0.890
Postgraduate	0.76	2.13 (1.35,3.36)	10.55	0.001

CONTINUE

Table III: Factors Associated with Diving-related Injury and Illness among Scuba Divers in Malaysia by Simple Logistic Regression, n=407. (CONT.)

Variables	Crude Regression Coefficient (b)	Crude OR[1] (95%CI[2])	Wald Statistic	p-value
Medical illness				
No	1			
Yes	0.55	1.73 (0.98,3.04)	3.56	0.059
Smoking status				
None	1			
Smoking	-0.72	0.49 (0.19,1.22)	2.35	0.125
Vaping	-0.22	0.80 (0.31,2.10)	0.21	0.649
Both	-0.81	0.45 (0.16,1.24)	2.41	0.120
BMI	0.06	1.06 (1.00,1.12)	3.92	0.048
Level of certification				
Open water	1			
Advance open water	1.32	3.73 (1.68,8.28)	10.46	0.001
Rescue Dive	-0.79	0.46 (0.28,0.75)	9.54	0.002
Divemaster	0.80	2.22 (1.15,4.31)	5.60	0.018
Duration of diving experience				
<1 year	1			
1-3 years	-2.30	0.10 (0.04,0.23)	29.33	<0.001
4-5 years	-1.72	0.18 (0.08,0.41)	16.23	<0.001
6-10 years	-1.64	0.20 (0.09,0.43)	16.31	<0.001
>10 years	-1.00	0.37 (0.16,0.86)	5.26	0.022
Frequency of dive				
<50 dives	1			
50-100 dives	1.85	6.39 (2.96,13.79)	22.86	<0.001
101-500 dives	1.31	3.71 (1.97,6.96)	16.60	<0.001
>500 dives	0.43	1.53 (0.92,2.56)	2.73	0.098
Type of equipment used				
Owned	1			
Rental	0.19	1.20 (0,71,2.04)	0.48	0.489
Mixed	-0.51	0.60 (0.37,0.99)	4.00	0.045
Type of checklist				
Written	1			
Remembered	-0.26	0.77 (0.49,1.2)	1.32	0.250
Diving depth (meters)				
< 18 or less	1			
19-30	1.40	4.05 (2.37,6.94)	26.05	<0.001
>30	0.58	1.78 (1.08,2.92)	5.16	0.023

[1]OR= Odds ratio; [2]CI= Confidence Interval

Multiple Logistic Regression

The preliminary main effect model was established at the multivariable level through a comparison of models using both backward and forward logistic regression. This model included only one significant variable: level of certification, as presented in Table IV.

Table IV: Factors Associated with Diving-related Injury and Illness among Scuba Divers in Malaysia by Multiple Logistic Regression, n=407.

Variables	Adjusted Regression Coefficient (b)	Adjusted OR[1] (95%CI[2])	Wald Statistic	p-value
Level of certification				
Open water	1			
Advance open water	1.33	3.78 (1.68,8.49)	0.41	**0.001**
Rescue Dive	-0.73	0.48 (0.29,0.81)	0.26	**0.006**
Divemaster	0.79	2.21 (1.34,4.30)	0.34	**0.020**

Backward LR multiple Logistic was applied.
Multicollinearity and interaction terms were checked and not found.
Model is fit with Hosmer-Lemeshow test p>0.05, Classification table=63.9%
No influential outliers were found.
[1]OR= Odds ratio; [2]CI= Confidence Interval

In our study, the level of certification also exhibited a significant association with diving-related injury and illness. Scuba divers with an advanced open water certificate had 3.78 times higher odds of experiencing diving-related injury and illness compared to those with an open water certificate, even after adjusting for variables (adjOR: 3.78; 95% CI: 1.68-8.49; p-value: 0.001). Divemaster faced 2.21 times higher odds of encountering diving-related injury and illness than other open water divers, considering other factors (adjOR: 2.21; 95% CI: 1.34-4.30; p-value: 0.02). Conversely, scuba divers holding a rescue dive certificate had a

48% reduced likelihood of experiencing diving-related injury and illness (adjOR: 0.48; 95% CI: 0.029-0.081; p= 0.006) than divers with an open water certificate.

DISCUSSION

Prevalence of diving related injury and illness

Discussing dive-related injury and illness prevalence is challenging due to varying methodologies in different studies. Literature employs diverse methods, such as incidence per dive, illness per hospital visit, or illness per 10,000 divers (21-24). Our study faced limitations in obtaining reliable records of hospital visits, total dives, and certified divers. Therefore, we calculated prevalence based on our sample size as a percentage, following methodologies in other studies (25, 26).

Among 407 scuba divers, 17.9% reported experiencing diving-related injuries or illnesses, which is lower than the 30% reported in a previous study (25). Both studies used self-reporting through surveys, and differences in intended populations and diving practices could influence variations in findings. Lucrezi et. al. (25) conducted their survey in Turkey, Germany, France, and Italy with 3766 scuba divers, included a diverse population with various diving practices, contributing to the higher reported prevalence of injuries and illnesses.

In another study, 65% of scuba divers in France reported experiencing at least one symptom related to diving injuries (26). However, the study's potential limitation lies in the nonspecific nature of the reported symptoms, such as fatigue, dizziness, ear pain, headaches, and more which could stem from various causes unrelated to diving, potentially leading to an overreported prevalence compared to other literature.

In our study, the most frequently reported injuries and illnesses among scuba divers included barotrauma (17.9%), muscle cramps (14%), panic attacks (10.1%), and wound injuries (8.6%). These findings align with the results reported by Monnot et. al. (26) and DAN (4). During diving, static pressure doubles within the initial 10m of descent, followed by a one-third pressure increase from 10m to 20m, exposing divers to the risk of barotrauma especially if ear pressure isn't equalized. Cumulative pressure exposure during repetitive dives may stress soft tissues, potentially causing damage to the tympanic membrane (27). Moreover, barotrauma symptoms tend to manifest earlier than other injuries, contributing to its higher frequency of reporting among divers (26).

Contrary to that, other studies highlighted decompression illness as the most frequently reported diving-related injury and illness (6, 7, 24, 25). The survey used by Lucrezi et. al. (25) had limitations as the focus on decompression illness might be influenced by the structure of multiple-choice questions, potentially neglecting other diving-related illnesses while, Jamharee et. al. (6) and Rozali et. al. (7) relied on hospital admission and hyperbaric chamber data, potentially biasing results toward decompression illness since most cases requiring hospitalization were related to decompression issues. Furthermore, Hubbard et. al. (24) suggested underreporting of barotrauma cases, as they may not be perceived as significant by divers or dive centres unless severe, and even if reported, these cases were less likely to be recorded.

Factors associated with diving-related injury and illness

Examining factors linked to injuries and illnesses related to diving seeks to pinpoint key elements contributing to these incidents. Grasping the underlying causes of injuries is essential for developing specific prevention strategies and improving current programmes and interventions (28). This method enables a more concentrated and pragmatic approach to reducing the risks associated with diving activities.

In our study, we found a significant association between the level of certification and diving-related injuries and illness. Scuba divers possessing an advanced open water certificate exhibited the highest odds of encountering diving-related injury and illness, with adjusted odds ratio of 3.78 when compared to divers with open water certificates. Furthermore, individuals holding a divemaster certificate had 2.21 times higher odds of experiencing diving-related injury and illness compared to those with open water certificates.

Our study was in line with the results reported by Ozdemir et. al. (29), which suggested that divers with higher certifications encountered diving-related health issues more frequently when compared to beginners and open-water divers. Indeed, individuals with greater diving experience often possessed the capability to explore greater depths, thereby exposing themselves to potential health risks associated with deep diving.

Additionally, divers with higher certifications tend to underestimate safety concerns during diving and violate fewer safety rules compared to those with lower certifications (30). Studies suggested that highly experienced divers, such as those with advanced open water and dive master certificates, may become complacent about safety measures. This complacency can result in lapses in attention, disregard for protocols, overconfidence in their abilities, leading to poor decision-making, and risky behavior (23, 31)

Interestingly, our study uncovered that scuba divers with a rescue dive certificate demonstrated a 48% reduced likelihood of encountering diving-related injury and illness. This observation can be attributed to the extensive training and heightened awareness that rescue divers receive. The rescue dive certification typically involves specialized training in emergency response and

rescue techniques, emphasizing a proactive approach to safety (32). This heightened preparedness and capacity to handle emergencies effectively may contribute to the lower occurrence of diving-related injuries and illnesses among individuals with a rescue dive certificate.

Divers without certification encountered injuries more frequently compared to their certified counterparts (23). This can be attributed to their limited knowledge of safety and inadequate safety practices, exposing them to a higher risk of injuries and accidents. It's worth noting that most dive centers do not allow uncertified divers to dive independently, except for discovery scuba dives, which are fully guided by a dive guide in proximity.

Other studies had also emphasized the association between the level of knowledge and practice and the occurrence of diving-related injury/illness (10, 21, 33). These studies revealed that insufficient knowledge and inadequate safety and emergency response practices among scuba divers contributed to diving-related injuries and mishaps. However, in our study, the three domains of interest, namely knowledge, awareness, and practice, were not significantly associated with diving-related injury and illness. This disparity suggested that other factors may have played a more prominent role in influencing the likelihood of such incidents in our study population.

Strengths and limitations

There is a notable gap in studies assessing the prevalence of diving-related injuries and illnesses in Malaysia, with limited published data on their current prevalence. Acquiring up-to-date information is crucial to inform stakeholders about the severity of the issue in terms of disease burden, facility availability, and the adequacy of our healthcare system.

The use of multivariate analyses to assess the factors associated with diving-related injuries and illnesses proved beneficial. This approach allowed us to control other confounding variables, providing more accurate odds ratios for predicting the desired dependent variables. To prevent injuries and illnesses, proactive measures can be taken through continuous training and a strong emphasis on safety awareness and practice. Planning prevention programs based on factors that significantly contribute to dive accidents is crucial for the success and effectiveness of these initiatives.

However, our study has a few limitations. It focused solely on diving centres in the East Coast of Malaysia, possibly not representing the entire diving community in the country. A more comprehensive approach would involve collaborating with dive agencies and associations to include participants from all over Malaysia. Nonetheless, since scuba divers often visit centres across different regions for their activities and come from diverse areas, we assumed that our participants could be considered representative of states throughout Malaysia.

Our study relies on self-reported accounts of diving-related injuries, illnesses, and mishaps, which introduces the possibility of recall bias (34). Scuba divers may not accurately recall their experiences, given factors like memory lapses, emotional influences, or intervening events. To mitigate this, the research team took measures during data collection, providing clear instructions and definitions in the survey to assist participants in accurately recalling and reporting experiences.

CONCLUSION

In our study, diving-related injuries and illnesses were mainly attributed to barotrauma, muscle cramps, panic attacks, and wound injuries, with a notably low prevalence of decompression sickness. Certification level was significantly associated with these incidents, emphasizing the need to analyze factors for scuba diving safety. This insight allows for specific interventions, preventive measures, and educational programs to enhance safety standards within the scuba diving community. The study's findings offer valuable recommendations for stakeholders, dive agencies, and associations to improve global diving industry safety, covering areas such as risk mitigation, safety protocol enhancement, education, industry regulation, and injury prevention.

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REFERENCES

1. PADI. 2021 Worldwide Corporate Statistics, Data for 2015-2020. PADI; 2021 January 2021.
2. De Brauwer M, Harvey ES, McIlwain JL, Hobbs JP, Jompa J, Burton M. The economic contribution of the muck dive industry to tourism in Southeast Asia. Marine Policy. 2017;83:92-9.
3. Zimmerhackel JS, Kragt M, Meekan MG. The past, present and future benefits of the shark-diving industry in Semporna Malaysia. Australian Institute of Marine Science: Australian Institute of Marine Science; 2018 June 2018.
4. DAN. DAN Annual Diving Report 2019 Edition - A report on 2017 diving fatalities, injuries, and incidents.: Divers Alert Network; 2019.
5. Mallen JR, Roberts DS. SCUBA Medicine for otolaryngologists: Part I. Diving into SCUBA physiology and injury prevention. Laryngoscope. 2020;130(1):52-8.
6. Jamharee F, Noh AY, Kamauzaman TH, Abdullah AA, Nor J. A Descriptive Study of Decompression

Illness among Scuba Divers Treated with Hyperbaric Oxygen Therapy at a Military Hospital-Based Recompression Facility in Peninsular Malaysia. Malaysian Journal of Emergency Medicine. 2016;1(1):11-23.
7. Rozali A, Khairuddin H, Sherina MS, Halim MA, Zin BM, Sulaiman A. Diving Accidents Treated at a Military Hospital-Based Recompression Chamber Facility in Peninsular Malaysia. Med J Malaysia. 2008;63(2):91-5.
8. Buzzacott P. Determinants of Risk Factors for Recreational Diving Morbidity and Mortality in Western Australia. 2010.
9. Koufakis T, Karras SN, Mustafa OG, Karangelis D, Zebekakis P, Kotsa K. Into the Deep Blue Sea: A Review of the Safety of Recreational Diving in People With Diabetes Mellitus. European Journal of Sport Science. 2019.
10. Denoble PJ, Caruso JL, Dear Gde L, Pieper CF, Vann RD. Common causes of open-circuit recreational diving fatalities. Undersea & hyperbaric medicine : journal of the Undersea and Hyperbaric Medical Society, Inc. 2008;35(6):393-406.
11. Pendergast DR, Moon RE, Krasney JJ, Held HE, Zamparo P. Human Physiology in an Aquatic Environment. Comprehensive Physiology. 2015;5(4):1705-50.
12. Mitchell S, Doolette D. Recreational technical diving part 1: An introduction to technical diving methods and activities. Diving and hyperbaric medicine : the journal of the South Pacific Underwater Medicine Society. 2013;43:86-93.
13. Cialoni D, Pieri M, Balestra C, Marroni A. Dive Risk Factors, Gas Bubble Formation, and Decompression Illness in Recreational SCUBA Diving: Analysis of DAN Europe DSL Data Base. Frontiers in Psychology. 2017.
14. Patrician A, Dujić Ž, Spajić B, Drviš I, Ainslie PN. Breath-Hold Diving – The Physiology of Diving Deep and Returning. Frontiers in Physiology. 2021.
15. Coleman B, Davis FM. Dysbaric Osteonecrosis in Technical Divers: The New 'At-Risk' Group? Diving and Hyperbaric Medicine Journal. 2020.
16. Zec M, Antičević V, Kalcina LL, Valić Z, Božić J. Psychophysiological Stress Response in SCUBA Divers: The Contribution of Negative Automatic Thoughts and Negative Emotions. Current Psychology. 2022.
17. Baldassarre R, Bonifazi M, Zamparo P, Piacentini MF. Characteristics and Challenges of Open-Water Swimming Performance: A Review. International Journal of Sports Physiology and Performance. 2017;12:1-35.
18. Merinar TR, Dick W. Career Part-Time Fire Fighter Dies After Being Struck by Pressurized SCUBA Cylinder - Ohio. Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH Morgantown, West Virginia; 2019.
19. Hosmer DW, Lemeshow S. Applied Logistic Regression. Applied Logistic Regression. Third Edition: John Wiley & Sons, Inc., Hoboken, New Jersey; 2013. p. i-xvi.
20. Fagerland MW, Hosmer DW, Bofin AM. Multinomial goodness-of-fit tests for logistic regression models. Statistics in medicine. 2008;27(21):4238-53.
21. Buzzacott P, Schiller D, Crain J, Denoble PJ. Epidemiology of morbidity and mortality in US and Canadian recreational scuba diving. Public Health. 2018;155:62-8.
22. Ranapurwala SI, Nicholas Bird, Vaithiyanathan P, Denoble PJ. Scuba diving injuries among Divers Alert Network members 2010–2011. Diving and Hyperbaric Medicine. 2014;44(2):79-85.
23. Buzzacott PL. The Epidemiology of Injury in Scuba Diving. Med Sport Sci Basel, Karger. 2012;58:57-79.
24. Hubbard M, Davis FM, Malcolm K, Mitchell SJ. Decompression illness and other injuries in a recreational dive charter operation. Diving Hyperb Med. 2018;48(4):218-23.
25. Lucrezi S, Egi SM, Pieri M, Burman F, Ozyigit T, Cialoni D, et al. Safety Priorities and Underestimations in Recreational Scuba Diving Operations: A European Study Supporting the Implementation of New Risk Management Programmes. Frontiers in Psychology. 2018;9(383):1-13.
26. Monnot D, Michot T, Dugrenot E, Guerrero F, Lafиre P. A survey of scuba diving-related injuries and outcomes among French recreational divers. Diving and Hyperbaric Medicine Journal. 2019;49(2):96-106.
27. Jansen S, Meyer MF, Boor M, Felsch M, Kluenter H-D, Pracht ED, et al. Prevalence of Barotrauma in Recreational Scuba Divers After Repetitive Saltwater Dives. Otology & Neurotology. 2016;37(9).
28. Abdullah TNZT, Amirah NA. A Review of Equipment Contribution among Recreational Scuba Divers. The Journal of Management Theory and Practice (JMTP). 2020;1(3):98-104.
29. Ozdemir L, Duru-Asiret G, Bayrak-Kahraman B, Devrez N, Akbayir A. Health-related adverse events and associated factors in recreational divers with different certification levels. J Travel Med. 2013;20(5):289-95.
30. Buzzacott P, Denoble PJ, Simon O, Dunford R, Vann RD. Dive problems and risk factors for diving morbidity. Diving Hyperb Med. 2009;39(4):205-9.
31. Davis A. Technical Diving Traits: Understanding Personality Factors and Dive Safety Scubatechphillipine.com: Scubatechphillipine.com; 2023 [cited 2023 30th August 2023]. Available from: https://scubatechphilippines.com/scuba_blog/technical-diver-traits-personality-factors-and-dive-safety.
32. Evans C. What's the Difference Between Technical

Diving and Recreational Diving? https://blog.padi.com: PADI; 2023 [cited 2023 12th November 2023]. Available from: https://blog.padi.com/whats-difference-technical-diving-recreational-diving/.
33. Dreyer S, Schneppendahl J, Moeller F, Koch A, Muth T, Schipke JD. An Updated Narrative Review on Ergometric Systems Applied to Date in Assessing Divers' Fitness. Healthcare. 2021.
34. Coughlin SS. Recall Bias in Epidemiologic Studies. Journal of Clinical Epidemiology. 1990.