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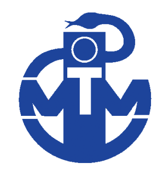

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Identification of DCS risk factors in recreational diving: multifactorial model based on the DAN DSL Database 2024

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ABSTRACT

Background: *Recreational diving creates risk for decompression sickness (DCS), which can occur in SCUBA diving even if current decompression algorithms are respected. The aim of this study was to identify the primary risk factors for decompression sickness in real-world regular recreational diving.*

Material and methods: *This study analyzed 127,957 dives from 5,907 divers in the DAN DSL database (version 07/2024) to identify independent risk factors for DCS in recreational diving.*

Results: *Decompression sickness was reported in 628 dives, yielding an incidence rate of 0.49%. The most critical predictor was the DAN Surface Supersaturation Gradient (DSSG), with significantly higher median values in DCS dives (0.866) compared to non-DCS dives (0.743, p < 0.001). Multivariate logistic regression identified 12 independent predictors of DCS, including DSSG (logarithmic effect on odds ratio [OR]), leading compartment, female gender (OR = 4.63), lower BMI classification (OR = 0.85), reduced number of repetitive dives (OR = 0.94 per dive), shorter surface intervals (OR = 0.96 per hour), greater gas count (OR = 2.87), exercise before diving (OR = 2.06), perceived thermal comfort (OR = 2.83), workload during dive (OR = 1.61), technical dive purpose (OR = 1.36), and pre-dive fatigue perception (protective, OR = 0.30). The model showed excellent discrimination with an area under the ROC curve of 0.910 and Somer's D = 0.8287. Notably, dives using more than one gas mixture and those performed by females carried substantially increased DCS risk.*

Conclusions: *The study confirms that both physiological and operational factors influence DCS risk and provides a basis for personalized risk prediction tools in recreational diving.*

(Int Marit Health 2026; 77, 1: 1–12)

Keywords: diving, modelling, risk factors, decompression sickness

INTRODUCTION

Recreational diving creates risk for decompression sickness (DCS). DCS can occur in SCUBA diving even if current decompression algorithms are respected. Since 1993, DAN Europe collects recreational diving data, including electronic dive profile recordings since 2010. In 2017, an originally developed database (DAN DB), including specific questionnaires for data collection, allowed for performing the statistical analysis of 39,099 electronically recorded open circuit dives made by 2,629 European divers (2,189 males, 83.3%; 440 females, 16.7%) over 5 years [1].

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The aim of this study was to identify the primary risk factors for decompression sickness in real-world regular recreational diving, based on the largest available database (DAN DSL database version 07/2024) representing the full range of diving habits and modalities.

MATERIAL AND METHODS

The query to the original database (DAN DB 07/2024), which included specific questionnaires for data collection and allowed for retrospective statistical analysis, returned 136,793 records. Manual analysis of outliers and unreliable entries resulted in the removal of 8,836 records (6.46%). In the final analysis, **127,957 dive records** were used.

Those records are referring to the population of **5,907 divers**, including 79.8% males and 20.2% females with a mean age of 39.9 ± 10.7 (standard deviation [SD]) years (range: 12–78 years).

The mean height was 175.0 ± 8.6 cm (SD) (range: 90–207 cm), the mean weight was 77.9 ± 14.8 kg (SD) (range: 35–160 kg), the mean body mass index (BMI) was 25.3 kg/m^2 ± 12.6 kg/m^2 (range: 18.0–50.0 kg/m^2). The divers with BMI < 16.0 kg/m^2 were classified as 'severely underweight' (12/101865 = 0.01%), 'moderately underweight' with BMI between 16.0 and 16.9 kg/m^2 (63/101865 = 0.06%), 'mildly underweight' as BMI between 17.0 and 18.4 kg/m^2 (877/101865 = = 0.86%), normal (healthy weight) with BMI between 18.5 and 24.9 kg/m^2 (41429/101865 = 40.67%), 'overweight' with BMI between 25.0 and 29.9 kg/m^2 (44888/101865 = = 44.07%), 'moderately obese (class I)' with BMI between 30.0 and 34.9 kg/m^2 (13588/101865 = 13.34%), 'severely obese (class II)' with BMI between 35.0 and 39.9 kg/m^2 (1125/101865 = 1.10%), and 'very severely or morbidly obese (class III)' with BMI ≥ 40.0 kg/m^2 (492/101865 = 0.48%) [2].

The divers included in the study reported from 1 to 1.432 dives (median: 3 dives per diver) to the maximum depth of 26.1 ± 12.0 m (range: 3–142.8 m) with the mean run-time of 47.2 ± 15.4 min (range: 3.3–605 min). The median number of dives per series was 2 (range: 1–15), with the median surface interval of 21 minutes (range: 10 min to 48 h); all dives conducted within 48 hours were considered 'repetitive' dives and counted consecutively.

Out of all the dives, 98.6% were conducted with open-circuit (OC) breathing apparatus (SCUBA) and 1.4% with closed-circuit rebreathers (CCR). Most of the dives conducted with OC (97.2%) used only a single breathing mixture (compressed air), while 2.8% used more than one breathing mixture up to 5 (median: 1.0).

Out of all the reported dives, 83.0% were conducted without any influence of alcohol, as declared by divers; 17.0% declared consuming alcohol before the dive, but no information about the strength or amount of alcohol was recorded.

For survey purposes, the following additional parameters with potential influence on DCS risk were defined: purpose of diving (PURPOSE), feeling before the dive (FEELING), thermal comfort (THERMAL), exercise before diving (EXERCISE), and workload during the dive (WORKLOAD).

— Purpose of diving (PURPOSE) was defined as recreational (82.5%), instructional (1.4%), guidance (1.2%), student (0.9%), technical (1.6%) and others (12.2%); 0.2% of entries were missing.
— Feeling before the dive (FEELING) was defined as rested (92.9%), tired (6.9%) or exhausted (0.2%); no information was missing (0.0%).
— Thermal comfort (THERMAL) was defined as comfortable (94.0%), cold (5.0%), very cold (0.5%) or hot 0.6%); no information was missing (0.0%).
— Exercise before diving (EXERCISE) was defined as none (62.8%), light (20.9%), moderate (5.9%) and heavy (0.4%); no information was missing (0.0%).
— Workload during the dive (WORKLOAD) was defined as none (63.7%), light (31.6%), moderate (4.1%), heavy (0.5%), and exhausting (0.1%); no information was missing (0.0%).

For each dive, the DAN Surface Supersaturation Gradient (DSSG) was calculated according to Bühlmann ZH-L16C model. Also, the leading compartment at the time of surfacing (DSSG_COMPRT) was identified — specifically, the one that exhibits the highest critical ratio when the diver reaches the surface. Explanation of the concept and details on calculations have been published previously [1].

The mean DSSG of our DAN DB was 0.71 ± 0.14 (range 0.25–1.40). The median compartment of DSSG (DSSG_ _COMPRT) was 6 (range 1 to 16).

All statistical analyses were conducted using Statistica software, version 14 (TIBCO Software Inc., Palo Alto, CA, USA). The Mann–Whitney U test was used to compare continuous variables between two independent groups when the data were not normally distributed. Categorical variables were analyzed using the chi-square (χ^2) test. To identify independent predictors of the clinical outcome, multivariable logistic regression with backward elimination was performed. A p-value of < 0.01 was considered statistically significant.

RESULTS

Decompression sickness (DCS) was observed in 628 dives (0.49% of all dives). The comparison of statistical results of uniparameter comparison between 'DCS' and 'no DCS' groups, as well as binary logistic regression calculating independent effects of each parameter on DCS occurrence conducted both in standard and backwards-rejection method, is collectively presented in Table 1.

Table 1. Comparison of the effects of divers' and diving parameters on decompression sickness (DCS)

Univariate analysis			**Multivariate analysis**				
Parameter	**Statistics***	**p**	**Parameter**	**Estimate (β)**	**SE**	**OR (eβ)**	**p**
			Intercept	−16.2976	0.664822	—	0.000000
DSSG	−31.1461	0.000	DSSG**	13.9063	0.734356	1097216	0.000000
DSSG_COMPRT	9.1812	0.000	DSSG_COMPRT	−0.2338	0.044961	0.7917	0.000000
GENDER	χ^2: 231.5554	0.000	GENDER_N	1.5330	0.110116	4.6335	0.000000
FEELING	χ^2: 9.984818	0.006	FEELING_N	−1.2014	0.263856	0.3005	0.000005
THERMAL	χ^2: 17.76335	0.000	THERMAL_N	1.0405	0.291368	2.8306	0.000355
GAS_COUNT	−7.0870	0.000	GAS_COUNT	1.0537	0.120053	2.8686	0.000000
EXERCISE	χ^2: 90.56316	0.000	EXERCISE_N	0.7254	0.107801	2.0656	0.000000
WORKLOAD	χ^2: 53.94492	0.000	WORKLOAD_N	0.4779	0.125233	1.6127	0.000136
PURPOSE	χ^2: 124.3065	0.000	PURPOSE_N	0.3065	0.148726	1.3586	0.039297
BMI_CLASS	χ^2: 68.90868	0.000	BMI_CLASS_N	−0.1591	0.070892	0.8530	0.024787
DIVE_NR	3.9128	0.000	DIVE_NR	−0.0638	0.013603	0.9382	0.000003
SURF_INTERVAL	9.0017	0.000	SURF_INTERVAL	−0.0404	0.003259	0.9604	0.000000
APPARATUS	χ^2:19.61122	0.000					
MAX_DEPTH	−19.7934	0.000					
RUNTIME	−9.8146	0.000					
ALCOHOL	χ^2: 6.003662	0.014					
Height	10.8365	0.000					
Weight	11.5587	0.000					
Age	−4.5393	0.000					
BMI	6.9075	0.000					
BMI_RANGE	χ^2: 67.54263	0.000					
MIN_TEMP	0.2079	0.835					
BOTTOM_FO2	1.4706	0.141					
ALTITUDE	−0.8640	0.387					

*Mann–Whitney test for quantitative parameter, χ^2 test for qualitative parameter

**High estimate of the parameter for DSSG (13.9) when compared to other parameters is related to the mathematical translation of DSSG calculated in small fractions (thousandths, e.g., from 0.695 to 0.700) to the binary effect of no DCS, which is zero vs. DCS, which is 1

OR — odds ratio, SE — standard error

Both groups, DCS and no DCS, differed significantly in the univariate analysis with the following recorded parameters: DSSG, DSSG_COMPRT, GENDER, FEELING, THERMAL, GAS_COUNT, EXERCISE, WORKLOAD, PURPOSE, BMI_CLASS, DIVE_NR, SURF_INTERVAL, APPARATUS, MAX_DEPTH, RUNTIME, ALCOHOL, Height, Weight, Age, BMI, and BMI_RANGE. This univariate analysis is included in the left side of the Table 1.

After conducting the multivariate analysis with logistic regression with backward elimination of non-significant parameters, the following parameters were shown to have independent influence on the probability of DCS occurrence

(DCS vs. no DCS): DSSG2, DSSG_COMPRT, GENDER_N, FEELING_N, THERMAL_N, GAS_COUNT, EXERCISE_N, WORKLOAD_N, PURPOSE_N, BMI_CLASS_N, DIVE_NR, SURF_INTERVAL. This is included in the right side of the Table 1.

The correlation matrix of estimates showed that there are medium to strong correlations (above 0.25) between the following parameters (Tab. 2): dive number (DIVE_NR) and surface interval (SURF_INTERVAL) — 0.328, DSSG_COMPRT and gas count (GAS_COUNT) — 0.251, purpose of diving (PURPOSE) and gas count (GAS_COUNT) — 0.356, feeling tired before the dive (FEELING) and exercise before the dive (EXERCISE) — 0.317, and gender (GENDER) and BMI class — 0.293 (Fig. 1).

To calculate the **probability of DCS** [P(DCS)] from our logistic regression model, one can use the **logistic function**:

$$P(DCS) = \frac{1}{1 + e^{-Z}}$$

where Z is the linear predictor, constructed from the coefficients:

$$\begin{aligned} Z = &-16.2976 \\ &+ 13.9063 \cdot DSSG2 \\ &- 0.2338 \cdot DSSG_COMPRT \\ &+ 1.5330 \cdot GENDER_N \\ &- 1.2014 \cdot FEELING_N \\ &+ 1.0405 \cdot THERMAL_N \\ &+ 1.0537 \cdot GAS_COUNT \\ &+ 0.7254 \cdot EXERCISE_N \\ &+ 0.4779 \cdot WORKLOAD_N \\ &+ 0.3065 \cdot PURPOSE_N \\ &- 0.1591 \cdot BMI_CLASS_N \\ &- 0.0638 \cdot DIVE_NR \\ &- 0.0404 \cdot SURF_INTERVAL \end{aligned}$$

So, the final probability formula:

$$P(DCS) = \frac{1}{1 + \exp(-Z)}$$

The predictive performance of the final model is classified as strong (Somer's D = 0.8287) and excellent discriminatory ability (KS statistic: 0.6832).

The receiver operating curve (ROC) is presented in Figure 2; the area under the curve is 0.910. Residual-based discrimination between DCS and no DCS is presented in Figure 3.

EXTENDED PRESENTATION OF RESULTS

The most reliable statistical analysis (binary logistics with backwards rejection) confirmed the following parameters **independently** influenced the probability of DCS occurrence: DSSG, DSSG_COMPRT, GENDER_N, FEELING_N, THERMAL_N, GAS_COUNT, EXERCISE_N, WORKLOAD_N, PURPOSE_N, BMI_CLASS_N, DIVE_NR, and SURF_INTERVAL.

The most critical parameter affecting the risk of DCS was DSSG. The median value of DSSG in divers with DCS — 0.866 (range 0.614–1.369) — was statistically significantly higher ($p < 0.001$) than in no DCS group, where it was 0.743 (range 0.252–1.381) (Fig. 4). There was a clear correlation of P(DCS) and DSSG in the univariate analysis (Tab. 3, Fig. 4, 5). DSSG also influences the probability of DCS in logistic regression analysis ($p < 0.001$). High estimate of the parameter for DSSG (13.9) when compared to other parameters was related to the mathematical translation of DSSG calculated in small fractions (thousandths, e.g., from 0.695 to 0.700) to the binary effect of no DCS, which was zero vs. DCS, which was 1.

In the univariate analysis, the DCS occurred 3.289 times more often in females (212/16703 = 1.25%) than in males (416/110494 = 0.38%) (χ^2 test, $p < 0.001$). Gender was also identified as an independent predictor of the DCS probability ($p < 0.001$). The estimate for the influence of 1.533 means that the odds ratio (OR) is $e^{1.5330} = 4.63$. This can imply that females have the odds of DCS increased independently from other parameters by a factor of 4.63 (or by 363%).

The probability of DCS, depending on BMI classification in the univariate analysis, showed a U-shape curve (Fig. 6). In the multivariate analysis, the OR is $e^{0.1591} = 0.85$, so the lower BMI class, especially below the normal range, was associated with a 15% increase in DCS odds.

The DCS rate in dives with workload reported was 0.67% (311 out of 46186 dives) and it was significantly higher than in those dives where no significant workload was reported by the diver — 0.39% (317 cases out of 81143 dives). The multivariate analysis reported this effect to be independent from other factors, with the increase of DCS odds by **61% with the workload ($e^{1.61}$)**.

The purpose of diving (PURPOSE) was significantly different between technical dives — 1.24% (25 out of 1989 dives), recreational dives — 0.57% (597 out of 104929) and other types of dives 0.02% (3 out of 18648). In the multiparameter analysis, diving for technical purposes increased DCS odds by **36%**.

In univariate analysis, it was shown that if divers were not exercising (EXERCISE) before the dive, DCS occurred in 0.38% cases (3306 out of 80062 dives), if exercise was described as light, DCS occurred in 0.78% (302 out of 39186 dives). In comparison, if the exercise was moderate or heavy, DCS occurred in 0.25% (20 out of 8081 dives). In the multivariate analysis, the exercise was the independent factor, **doubling the risk of DCS** ($e^{0.725} = 2.06$).

If divers reported being well-rested before the dive (FEELING), DCS occurred in 0.51% cases (602 out of 118256),

Table 2. Correlation matrix of estimates

Parameter	DIVE_NR	SURF_ _INTERVAL	DSSG	DSSG_ _COMPRT	PURPOSE_N	WORK- -LOAD_N	THERMAL_N	FEELING_N	EXERCISE_N	GAS_COUNT	GENDER_N	BMI_ _CLASS_N
Intercept	−0.112	0.002	−0.903	−0.378	−0.019	−0.029	0.008	0.066	−0.114	0.124	−0.127	−0.099
DIVE_NR	—	0.328	−0.022	0.018	−0.008	0.001	−0.020	−0.05082	0.037	0.062	−0.023	−0.001
SURF_INTERVAL		—	−0.115	0.087	−0.036	−0.029	−0.013	0.012	0.017	−0.137	0.034	0.019
DSSG			—	0.084	−0.106	0.002	−0.004	−0.061	0.080	−0.173	0.028	0.013
DSSG_COMPRT				—	−0.080	−0.017	−0.025	0.018	0.001	−0.251	−0.006	−0.002
PURPOSE_N					—	−0.033	−0.001	−0.016	0.106	−0.356	−0.019	−0.001
WORKLOAD_N						—	0.011	0.005	−0.584	0.001	0.001	0.055
THERMAL_N							—	0.076	0.014	0.036	0.041	−0.019
FEELING_N								—	−0.317	0.008	−0.022	−0.019
EXERCISE_N									—	−0.074	−0.007	0.006
GAS_COUNT										—	0.109	0.034
GENDER_N											—	0.293
BMI_CLASS_N												—

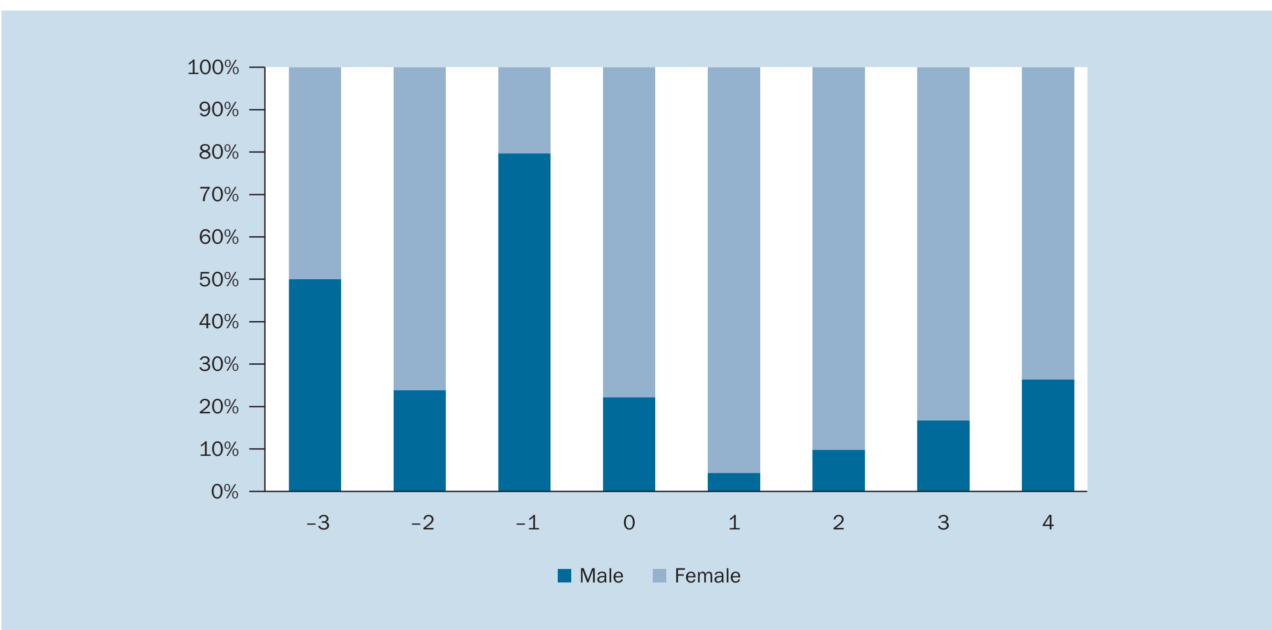

Figure 1. Gender ratio in body mass index (BMI) classes

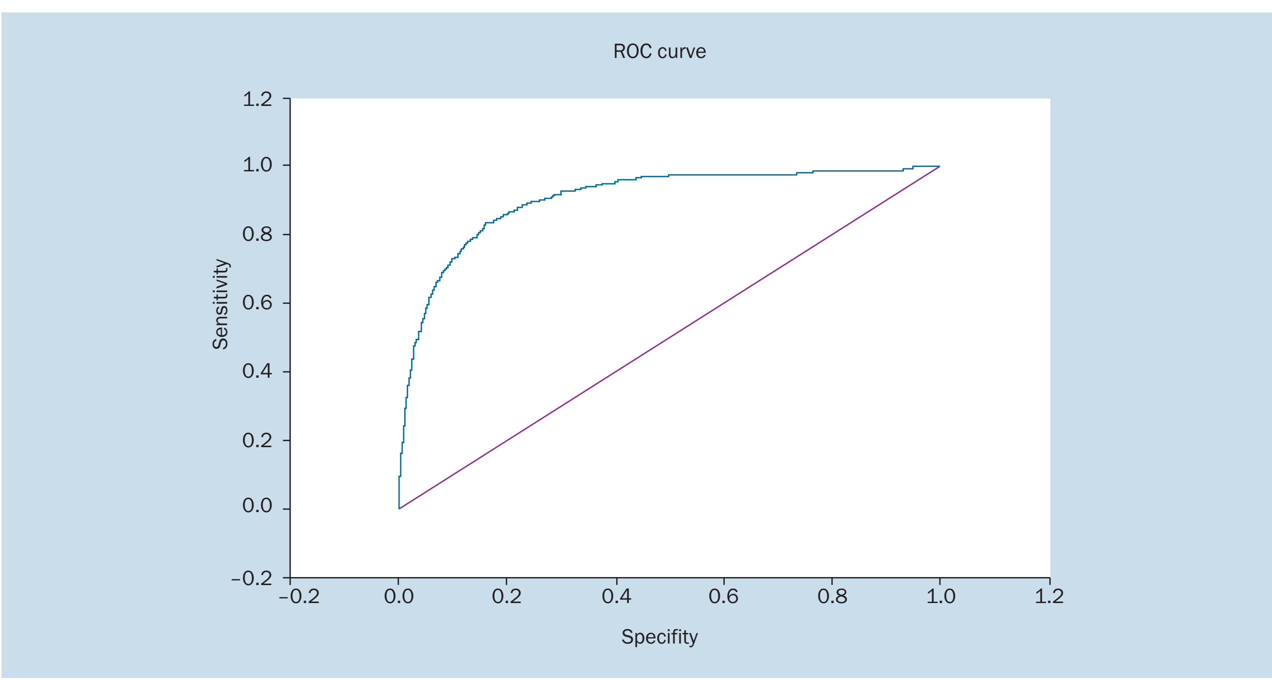

Figure 2. Receiver operating curve (ROC) for predicting decompression sickness (DCS)

and this was a higher rate than when divers reported being tired or exhausted, where DCS occurred in 0.29% of dives (26 out of 9073 dives). In multivariate analysis, a negative self-reported feeling before the dive reduced DCS odds by 70%.

In univariate analysis, surprisingly, the highest DCS rate was in dives where divers reported thermal comfort (THERMAL) — 0.51% (615 out of 119604 dives), and this was higher than when feeling either cold/very cold or hot — 0.16% (11 out of 7001 dives) and 0.28% dives (2 out of 724 dives), respectively. In multivariate analysis, the increase in thermal comfort, from cold to comfort and hot, was positively associated with DCS risk, with a factor of 2.8 ($e^{1.04}$).

The number of gases used for diving was significantly correlated with DCS occurrence, both in univariate and

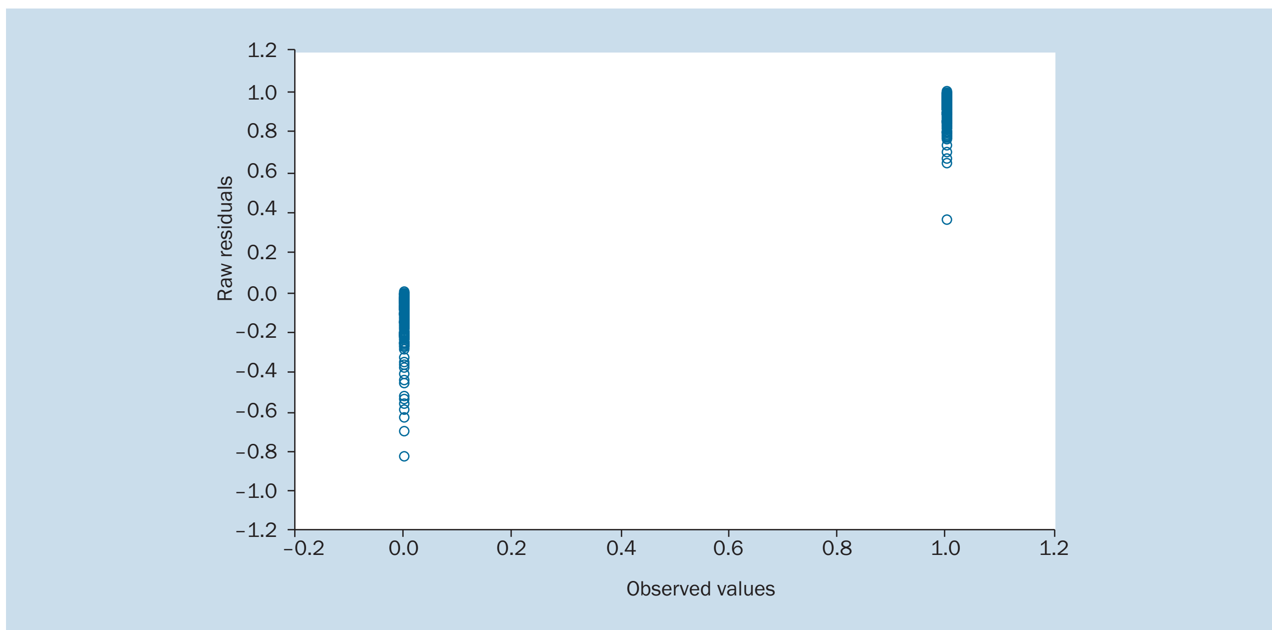

Figure 3. Residual-based discrimination between decompression sickness (DCS) and no DCS

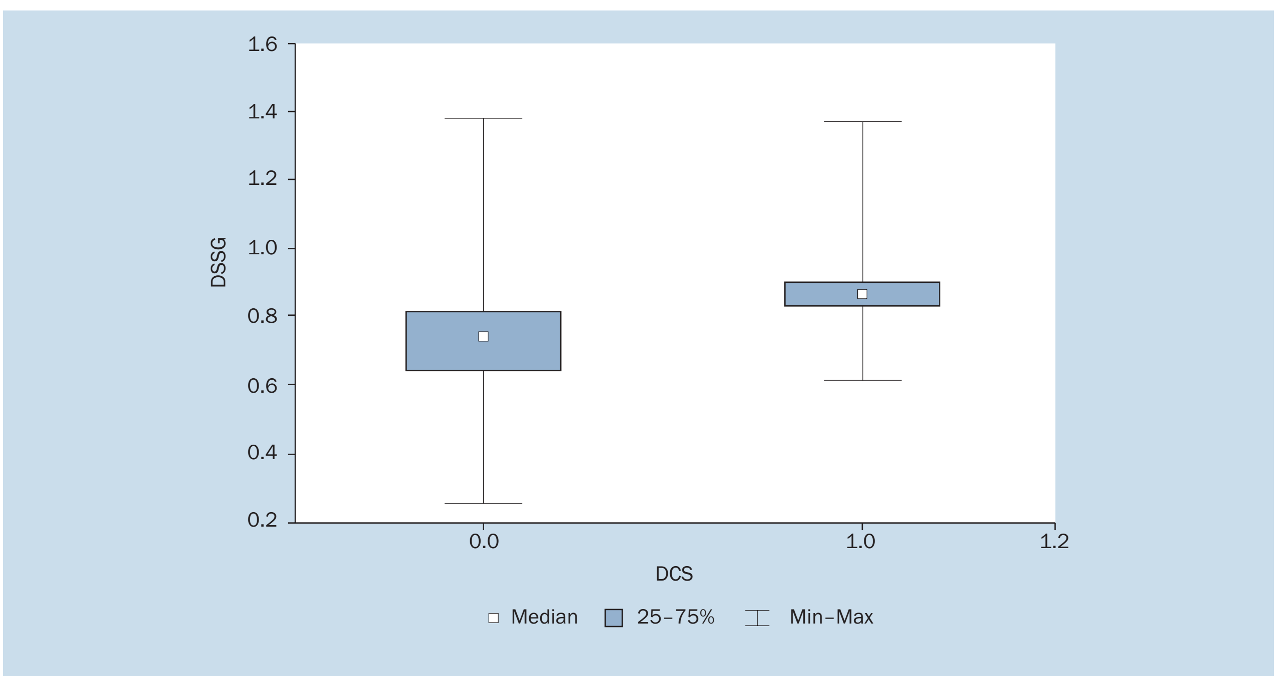

Figure 4. Probability of decompression sickness (DCS) as depending on DAN Surface Supersaturation Gradient (DSSG) in univariate analysis

multivariate analyses (Tab. 4, Fig. 7), where an increase in gas count increased DCS odds by 2.9 times ($e^{1.05}$ = 2.9).

The number of dives in series (DIVE_NR) and surface interval from the previous dive (SURF_INTERVAL) negatively correlated with the DCS odds, when each additional dive reduced DCS odds by approximately 6% ($e^{-0.06}$ = 0.94) and each hour at surface reduced DCS odds by 4% ($e^{-0.04}$ = 0.96).

DISCUSSION

The model, which employs the most reliable statistical analysis (binary logistics with backwards rejection) on a large set of records, exhibits 'strong predictive performance' and 'excellent discriminatory ability', as evidenced by the high values of both Somer's D = 0.8287 and KS statistic = = 0.6832. It means that the model is effectively distinguishing between the positive and negative outcomes

Table 3. Correlation of decompression sickness (DCS) rate from DAN Surface Supersaturation Gradient (DSSG) in univariate analysis

DSSG	No DCS dive	DCS dive	P(DCS)
0.3	4173	0	
0.4	6716	0	
0.5	8326	0	
0.6	19342	5	0.012%
0.7	34122	24	0.095%
0.8	46350	207	0.720%
0.9	16846	347	3.344%
≥ 1	918	45	37.532%
	136.793	628	

(e.g., predicting DCS with high accuracy). This is visually confirmed on the ROC curve and residual-based discrimination (Fig. 2, 3).

The most critical parameter affecting the risk for DCS is DSSG. The DSSG value is calculated by retracing the dive profile recorded by the dive computer, using the Bühlmann ZH-L16C algorithm, and identifying the moment the diver surfaces — that is, when the computer records a depth of 0 meters. However, this condition is not easily captured by most dive computers, as continuous tracking up to the surface depends not only on the sampling rate of the device but also on the position of the diver's arm wearing the computer, that may remain at a depth of around 50 to 70 cm for several minutes.

Currently, many dive computers use low sampling frequencies — in some cases, even 1 second — while others sample at intervals greater than 10 seconds. As a result, the recording often stops before the actual surface is reached. Consequently, the exported data files rarely include a final depth value of 0 meters, typically ending at depths between 0.5 and 1 meter.

Since it is not possible to obtain a consistent measure of supersaturation at zero depth from different dive computers, a correction algorithm has been defined to unambiguously determine the moment of surfacing as follows:

- if, in the final sampling intervals of a dive, the recorded depth is less than or equal to 0.5 meters,
- and if there is no subsequent descent to a depth equal to or greater than 1 meter,
- then these final values are to be replaced by a single data point of 0 meters depth, while maintaining the time interval defined by the sampling rate.

This approach makes it possible to standardize the moment of surfacing for DSSG calculation, ensuring consistency even across profiles generated by computers with varying sampling frequencies.

As is well known, the Bühlmann algorithm divides the human body into 16 tissue compartments, each characterized by different rates of inert gas uptake and release, as well as specific half-times for gas exchange.

The so-called 'leading compartment' is the one that, at a given time, first reaches the critical tension, thereby guiding the decompression calculation. In practice, the leading compartment is responsible for determining the decompression stops, if required.

The DSSG, calculated on the dive profile (time, depth, oxygen content, inert gases content), is fully controllable by the diver. So, in the future version of the probabilistic models of diving computers, this is the crucial parameter to be used

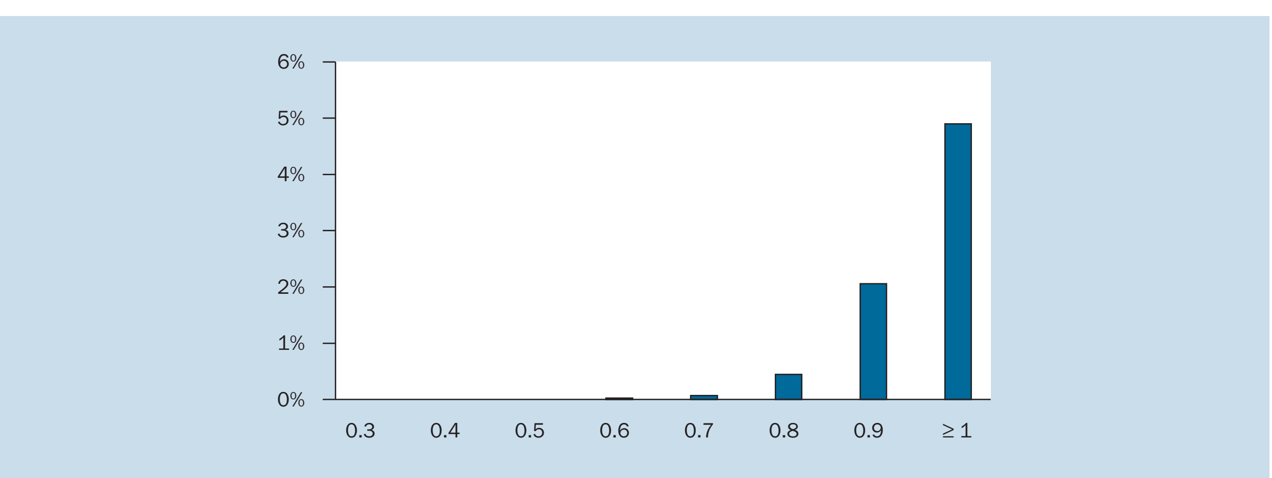

Figure 5. Rate of decompression sickness (DCS) as depending on DAN Surface Supersaturation Gradient (DSSG)

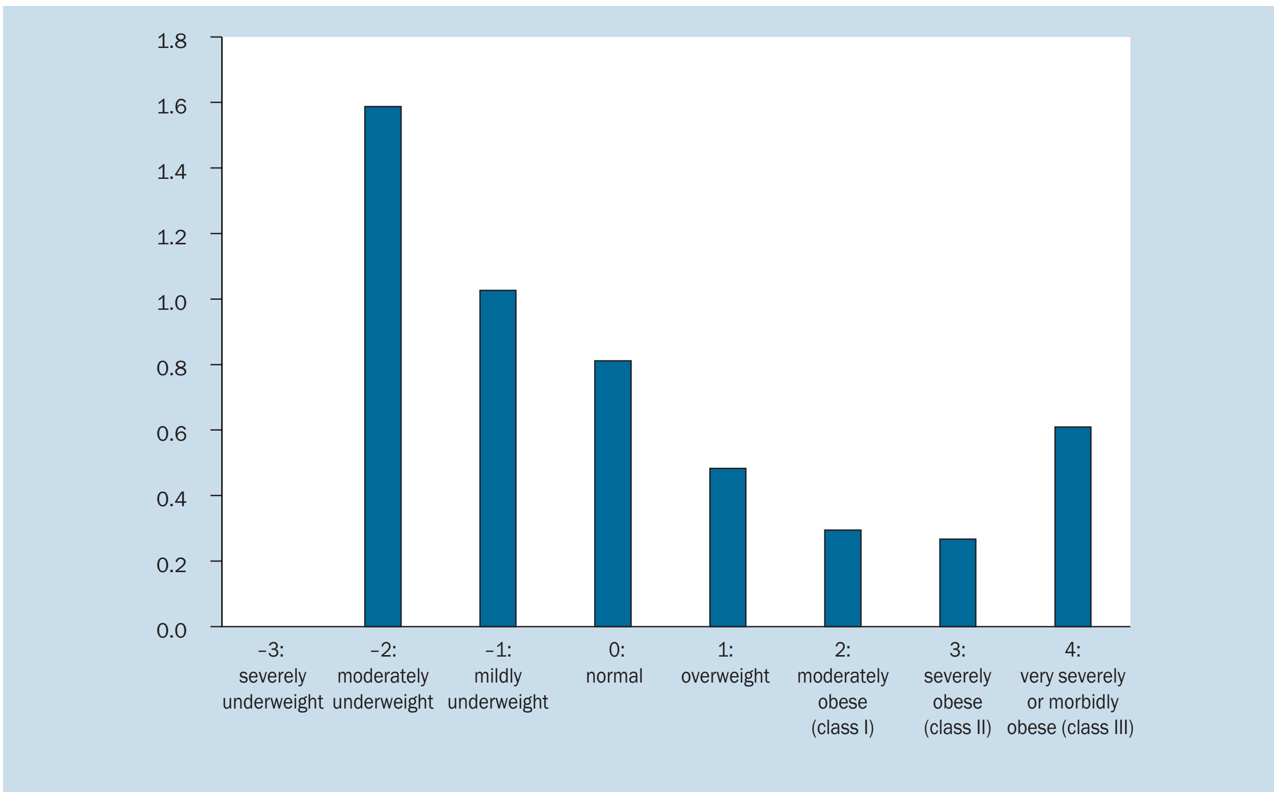

Figure 6. Probability of decompression sickness (DCS) depending on body mass index (BMI) classification (univariate analysis)

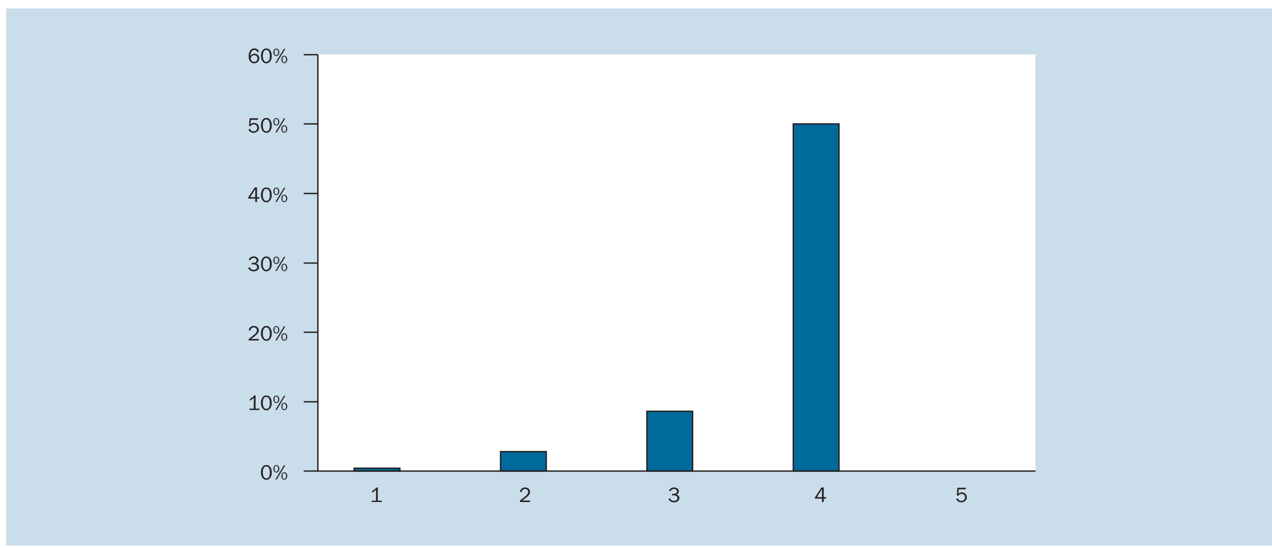

Figure 7. Rate of decompression sickness (DCS) depending on gas count

for the prediction of DCS risk. The second parameter that significantly influences the risk of DCS is the number of the conceptual compartment (DSSG_COMPRT) where the maximum DSSG occurs. This compartment is identified during the estimation of DSSG and also correlates with gas count (Tab. 4). While the detailed description of this parameter is beyond the scope of this report, it will be included in the personal estimation of DCS risk.

Table 4. Correlation of decompression sickness (DCS) rate from gas count in univariate analysis

DSSG	No DCS Dive	DCS Dive	P(DCS)
1	123897	498	0.40%
2	1287	67	2.81%
3	384	33	8.59%
4	18	9	50.00%
5	4	0	0.00%
MD	11203	21	
	136.793	628	

DSSG — DAN Surface Supersaturation Gradient

The physiological parameter which is independent of the diver is gender (GENDER). In the univariate analysis, the occurrence of DCS was 3.289 times higher in females than in males. This was also confirmed in multiparameter analysis, showing that the OR of DCS is 4.63 times greater for females than for males. In fact, some gender related differences in DCS occurrence or protection have been discussed in murine models [3]. The complex interplay between inflammation, endothelial function, and bubble production seems to be partially gender related [4]. In these studies, a principal components analysis showed that two principal components discriminate between DCS-resistant and nonresistant males, but not between DCS-resistant and nonresistant females. In conclusion, the mechanisms that drive the resistance to DCS appear to differ between males and females; lower coagulation tendency and enhanced inflammatory response to decompression stress might be key for resistance in males. Although still far from the diver, this opens a pathway to future adaptation of personalized decompression procedures for "DCS-prone" individuals.

The other parameter significantly influencing the risk of DCS is BMI (BMI_CLASS). Interestingly, the raw data show a U-shaped curve for DCS occurrence, with the lowest rate of DCS in obese divers and the highest rates of DCS in both moderately thin and very severely obese divers. However, multivariate analysis revealed that a lower BMI class is associated with a 15% increase in DCS OR. This finding by itself warrants future research.

Some risk factors are inherently linked to the purpose of diving, the type of diving equipment, specific configurations (i.e., gas count) and the way it is conducted.

The number of different gases (gas count) used in diving was the strongest non-physiological factor modifying the risk of DCS (after gender). Obviously, the gas count is not the hazard *per se*, but it reflects the other factors involved in so-called "technical diving" (e.g., CCR, greater depths, long runtimes, changes in thermal comfort, and dehydration, to name a few).

In this large version of our database, only some technical dives were involved, but their analysis is limited — for example, the parameter named 'gas count' cannot be easily extended to CCR dives, when the partial pressure of oxygen can be kept on a constant level with significant changes in the fractional amount of gases. Nevertheless, it appears that future planning for safe and effective decompression should not only rely on physiological parameters but also incorporate these data into the calculation of DCS risk.

Interestingly, from the current analysis, the number of dives in a series showed a somewhat protective effect against DCS risk (each 'repetitive' dive decreases DCS odds by 6%), but this can be related to the extension of the surface interval between dives to 48 hours for them to be treated as 'repetitive in series.'

The observation that each additional hour of surface interval decreases the odds of DCS by 4% confirms that recommendations for decreasing the risk of DCS should include adaptation and prolonging surface intervals.

This aligns with common knowledge, but the numbers behind the DCS risk calculations, which can be applied to future personal computers, are of great value.

The other physiological parameters that significantly influence the risk of DCS, which are somewhat controllable or at least identifiable by the diver, include workload and thermal comfort during the dive, exercise, and feeling tired before the dive.

The confirmation that an increased workload during diving increases the risk of DCS is already established in the literature [5, 6], as well as exhaustion or hyperventilation due to intense activity or work at the bottom [6] and feeling of cold at the bottom or during decompression [7].

Unfortunately, the current version of the database does not allow for quantifying the level of underwater workload. The same limitation applies to the subjective thermal comfort reported by divers, which is not confirmed in all cases.

In the DAN database, the thermal effect was identified as a significant and strong factor influencing DCS risk (OR = = 2.83), with a final effect comparable to that of the gas count (OR = 2.86). The effect of temperature on diving and decompression safety is multifactorial but controlled experiments have already shown that manipulating the underwater temperature can either decrease or increase the risk of DCS [8–11]. In future data collection, more extended version of monitoring both core (internal) and superficial (skin) temperatures should be used to allow quantifying the effects of body temperature on decompression effectiveness/safety.

Similarly, the effect of exercising before the dive is multifactorial and not easy to be included in single parameter

of subjective perception by a diver. In the multivariate analysis of the DAN DSL database, the exercise before dive was the independent risk factor, doubling the risk of DCS. However, we believe that this parameter must be interpreted with extreme caution, taking into account reliable data that prove controlled exercise in the form of specific "pre-conditioning" has been shown to be protective against DCS [12–17].

The scope of the questionnaire completed by divers submitting data to DAN Europe did not include information on whether the exercise was conducted as a part of preparation for diving or rather as a confounding negative activity.

At the same time, multivariate analysis shows that a self-reported negative feeling before the dive reduces DCS odds by 70%, suggesting that a feeling of "not doing well" may be a protective factor, as already proposed — it may push the diver to act more conservatively. It seems rational, that when feeling tired, the diver may act in a more safe or restricted way, and therefore increasing safety and decreasing the DCS risk. On the other hand, certain personal traits — regardless of the feeling of fatigue — may modulate risk taking behavior in diving, some of which may be related to the specific community the diver belongs to, such as technical, professional, or military [18–21].

In the observed dataset, there was a strong negative correlation between the exercise and the feeling of tiredness before the dive (–0.317), suggesting that one of the plausible explanations would be that at least in some dives 'feeling tired or exhausted before dive' was due to 'exercising before dive,' potentially confirming the 'pre-conditioning' effect. Unfortunately, the structure of DAN DSL database precludes drawing final and definitive conclusions on this topic. A revision of the questionnaire and ad-hoc field studies to further clarify these important issues are planned.

To summarize, the multifactorial analysis of the DAN DSL database created a statistical model with strong predictive performance and excellent discriminatory ability to predict the probability of DCS in recreational diving based on calculated DSSG, personal and operational factors.

While further analysis of specific subsets of collected data will serve to address specific research questions, such as gas bubble loads and types of DCS, the current model will serve as a basis for creating an individualized probabilistic diving computer.

The main strength of the study lies in the analysis of real data collected during actual diving, without any restrictions imposed by controlled experiments, so the conclusions are addressed to the general population of divers. The other strength lies in the number of records included in the final analysis. This is the largest dataset of dives, comprising divers' data and personal surveys collected worldwide. A large and reliable dataset, collected over the years, balances the unavoidable losses of some parameters in multivariate statistical analysis. The final model exhibits strong predictive performance and excellent discriminatory ability in predicting DCS.

On the other hand, the study also has several limitations. First is the longitude of the data collection, which limits the use of the most modern type of information (a detailed profile with dynamic recording of partial pressures of oxygen, nitrogen, and other inert gases, temperature, and gas bubbles). Such data have been collected in subsets dedicated to separate groups of divers (expeditions) to be included in the next analysis.

The second limitation is the absence of some important (patho)physiological parameters that clearly modify the risk of DCS, e.g., patent foramen ovale (PFO), personal predisposition to gas bubble formation, diet or dehydration, to name a few [22–26].

In the future, any dataset should include a larger number of collectable parameters.

CONCLUSIONS

The multivariate analysis of the largest available dataset of recreational dives identified the most important parameters influencing the risk of DCS, and it offers a "novel" evaluation of DCS risk factors in the real diving world based on factors unmodifiable by the diver, e.g., gender and BMI classification (the latter can be modified, but not in a short term), modifiable personal factors, including behavior before the dive, thermal control during the dive, exercise and workload while diving, controlling dive series and purpose of diving, as well as the most important modifiable operational parameter, which is the DSSG.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: Data is available on reasonable request.

Ethics statement: The Ethical Board of DAN Europe has approved the study.

Author contributions: Alessandro Marroni: concept, organization of research, data collection, manuscript preparation, manuscript verification; Jacek Kot: data analysis, manuscript preparation, manuscript verification; Massimo Pieri: data collection, data analysis, manuscript verification; Riccardo Pelliccia: data collection, data analysis, manuscript verification; Costantino Balestra: data analysis, manuscript preparation, manuscript verification.

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Conflict of interest: Authors declared no conflict of interest.

Supplementary material: None.

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ORIGINAL ARTICLE

A 4-year retrospective descriptive study on treatment outcomes of decompression illness patients in various hyperbaric chamber centers in Thailand

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ABSTRACT

Background: *Thailand is situated between two abundant bodies of water, the Andaman Sea and the Gulf of Thailand. Therefore, multiple industries are based around these waters. One of the largest economic incomes is from tourism, where recreational diving is a popular activity with multiple dive sites scattered across multiple provinces in Thailand. Moreover, there are types of diving such as military diving, occupational diving, and traditional (fishermen) diving.*

Material and methods: *A retrospective descriptive study reviewing medical records of 178 decompression illness (DCI) patients from various hyperbaric chamber centers in Thailand, between January 2020 to December 2023.*

Results: *Out of all the patients, 73.6% achieved complete resolution of symptoms, while 26.4% had residual symptoms. Traditional divers were at a higher risk of having residual symptoms after treatment (42%). Missing safety stops showed significant association with incomplete treatment outcomes (p = 0.008), univariate logistic regression confirmed significance (OR = 2.495, 95% CI: 1.263–4.926, p = 0.008); after multivariate logistic regression this factor lost its significance, but remained a strong predictor (adjusted OR = = 2.208, 95% CI: 0.962–5.069, p = 0.062). As for affected organs, spinal cord involvement was strongly related to incomplete outcomes (p = 0.001). First-aid high flow oxygen was given to only 18.5% of patients but had no significant associations with treatment outcomes.*

Conclusions: *This study was one of the first multi-center studies in Thailand, it raises multiple concerns for the diving industry in both the traditional and recreational sector. Both sectors can benefit from targeted education for divers, creating safety standards, and providing proper first-aid and treatment.*

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Keywords: decompression illness, decompression sickness, arterial gas embolism, hyperbaric oxygen therapy, Thailand

INTRODUCTION

Thailand's territorial maritime zone of 322,588.32 km^2 accounts for approximately 60% of the of the country's land mass. It connects the Indian and Pacific oceans into the Andaman Sea and the Gulf of Thailand, respectively [1]. The coastline of 3,148.23 kilometers covers 23 provinces of Thailand. There is an abundance of marine resources for commercial fishing, natural gas drilling, and tourism. Tourism is Thailand's major source of revenue, both domestically and internationally, showing a total revenue of 438 billion Thai baht ($12.3 billion US dollars) in the 3rd quarter of 2023 [2]. Scuba diving is one of Thailand's main

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attractions, as there are multiple dive sites with various profiles, from cave diving to wreck diving [3]. In addition to recreational diving, other diving activities in Thailand include: professional diving, scientific diving, military diving and traditional diving. These activities carry the risk of diving injuries and fatalities. The Divers Alert Network's (DAN) *Annual report 2020* noted a total of 189 diving fatality cases worldwide and reported 6–10 fatalities per year in Thailand [4]. The most significant diving injury is decompression illness (DCI), which includes two pathophysiological syndromes: arterial gas embolism (AGE) and decompression sickness (DCS). The two disorders can be clinically hard to differentiate but are different in pathogenesis. Arterial gas embolism is the presence of air or gas bubbles in the arterial circulation causing multifocal ischemia, where the bubbles may occur after pulmonary overinflation syndrome following the dive or may be iatrogenic with direct introduction of bubble into the circulation. The more common DCS is caused by nitrogen bubble formation after a state of supersaturation and a decrease of ambient pressure. These bubbles have mechanical, embolic, and biochemical effects leading to minor or fatal clinical symptoms [5, 6].

The incidence rate of DCS in recreational divers according to a DAN sample of 135,000 divers is 0.03% [7]. Previous studies in Thailand reported that 453 patients had received treatment for DCI from 2001–2005, and a more recent single center reported that 97 patients had received treatment for DCI between 2015 and 2021 [8, 9]. Conducting a review and analysis of medical records from multiple hyperbaric chamber facilities (public and private) will offer a better representation and understanding of the occurrence, characteristics, pre-hospital care, and outcomes of DCI patients in Thailand, as it would cover patients with diving injury from all major dive sites in Thailand and abroad.

The hyperbaric chamber facilities of interest are as follows: Somdech Phra Pinklao Hospital, Queen Sirikit Hospital, Arbhakornkiriwong Hospital, and Vachira Hospital. These hospitals were selected due to availability of both a multiplace and monoplace hyperbaric chambers with the capacity to be able to treat DCI adequately. Furthermore, these hospitals are in the public sector, capable of offering treatment to both insured and uninsured patients with DCI. Lastly, these hospitals are a true representation of DCI cases in Thailand, as they cover areas close to the dive sites and are located in the capital city, where cases are most often transferred to receive treatment with hyperbaric chamber. The information acquired from this study can be beneficial for improvement and standardization of future patient care and a reduction of incidence of DCI.

The objectives of this study are as follows: to study the presenting symptoms and their association with treatment outcomes, to study the importance of first aid oxygen and its impact on treatment outcomes, and to explore the time of onset and time to treatment of patients with DCI and whether it impacts treatment outcomes.

MATERIAL AND METHODS

This retrospective descriptive study was conducted between January 2020 to December 2023 at multiple hyperbaric chamber centers in Thailand. Medical records were searched using ICD-10 codes and reviewed according to the inclusion and exclusion criteria.

The inclusion criteria were as follows: patients diagnosed with DCI who received recompression treatments at multiple hyperbaric chamber facilities in Thailand. Patients who received treatments at multiple centers for the same DCI incident, patients who received a change of diagnosis after initial treatment, and patients with missing data (symptoms, outcome of treatment, treatment data, related diving profiles) in medical records were excluded.

Data were categorized into demographic data, diving data, and clinical data. Collection was done using a data collection form. Treatment outcomes were collected as 'complete resolution,' 'mild residual symptoms' (residual symptoms after treatment not affecting daily life), 'severe residual symptoms' (residual symptoms after treatment affecting daily life, such as weakness, urinary incontinence or paresthesia), and mortality. Treatment outcomes were later grouped into 'complete' and 'incomplete,' where the incomplete group included residual symptoms and mortality. Diving certification may vary a lot between different diving companies; therefore, in this study, the *Confédération Mondiale des Activités Subaquatiques* (CMAS) level was used to categorize diving level, as shown in Table 1.

STATISTICAL ANALYSIS

Data analysis was done using STATA/BE 18.0 Software. Continuous variables were presented as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. A chi-square test and Mann–Whitney U test were performed to check for the association between study variables among the participants. Then variables with significant associations were further analyzed using univariable and multivariable logistic regression adjusting for factors associated with diving and treatment outcomes. Odds ratios (OR), 95% confidence intervals (CI), and p-values were calculated to determine the strength of these associations, a p-value less than 0.05 was statistically significant (p-value > > 0.05).

RESULTS

The study includes 178 decompression illness patients that underwent treatment with hyperbaric chambers across Thailand during a 4-year period from January 2020 to

Table 1. *Confédération Mondiale des Activités Subaquatiques* (CMAS) equivalent level compared to Professional Association of Diving Instruc(PADI), Scuba Schools International (SSI), National Association of Underwater Instructors (NAUI)

CMAS equivalent	PADI	SSI	NAUI
Uncertified	Discover SCUBA diving	Try SCUBA	Try SCUBA
	Open water	Open water	SCUBA Diver
CMAS Level 1–2	Advanced Open Water	Advanced Adventurer	Advanced SCUBA Diver
	Rescue Diver	Diver Stress and Rescue	Rescue SCUBA Diver
CMAS Level 3	Dive Master	Dive Master	Dive Master

SCUBA — self-contained underwater breathing apparatus

December 2023. Patients were treated at Vachira Phuket Hospital (97), Somdech Phra Pinklao Hospital (65), Somdech Phra Nangchao Sirikit Hospital (15), and Abhakornkiartiwong Hospital (1).

Demographic data shows 57.9% of patients were male. All patients had a mean age of 37.46 ± 10.41 years, with an age range 16–64 years (Tab. 2); patients were predominantly Asian (89.3%), followed by European (7.3%), North American (2.2%), and a small number from Australasia/Oceania and the Middle East (0.6% each). Majority of patients had no underlying diseases (84.8%) and were not on any medications at the time of the study (92.7%). The most common purpose of diving was recreational diving (65.7%), followed by traditional diving (25.3%), occupational diving (8.4%), and military diving (0.6%). More than half of the divers (56.2%) held CMAS level 1–2 certification, 12.4% had CMAS level 3 certification, and 31.5% were uncertified. Notably, only 18.5% of patients received high-flow first aid oxygen prior to hyperbaric treatment (Tab. 3).

Presenting symptoms, varying from pain to paralysis, are shown in Figure 1. Some patients presented with one or more symptoms, the most common were pain, abnormal sensations, and constitutional symptoms, which accounted for 57% of all presenting symptoms. Figure 2 shows the affected organs determined by diagnosis of the diving

Table 2. Demographic data of patients

	n	%
Gender		
Male	103	57.9
Female	75	42.1
Ethnicity		
Asian	159	89.3
European	13	7.3
North American	4	2.2
Australasia/Oceania	1	0.6
Middle Eastern	1	0.6
Underlying condition		
No	151	84.8
Yes	27	15.2
Age		
Mean ± SD	37.46 ± 10.41	
Range	16–64	

Table 3. Diving-related demographic data

Diving purpose	n	%
Recreational	117	65.7
Occupational	15	8.4
Traditional	45	25.3
Military	1	0.6
Certification level		
CMAS 1–2	100	56.2
CMAS 3	22	12.4
Uncertified	56	31.5
High-flow first aid O_2		
No	141	81.5
Yes	32	18.5

CMAS — *Confédération Mondiale des Activités Subaquatiques*

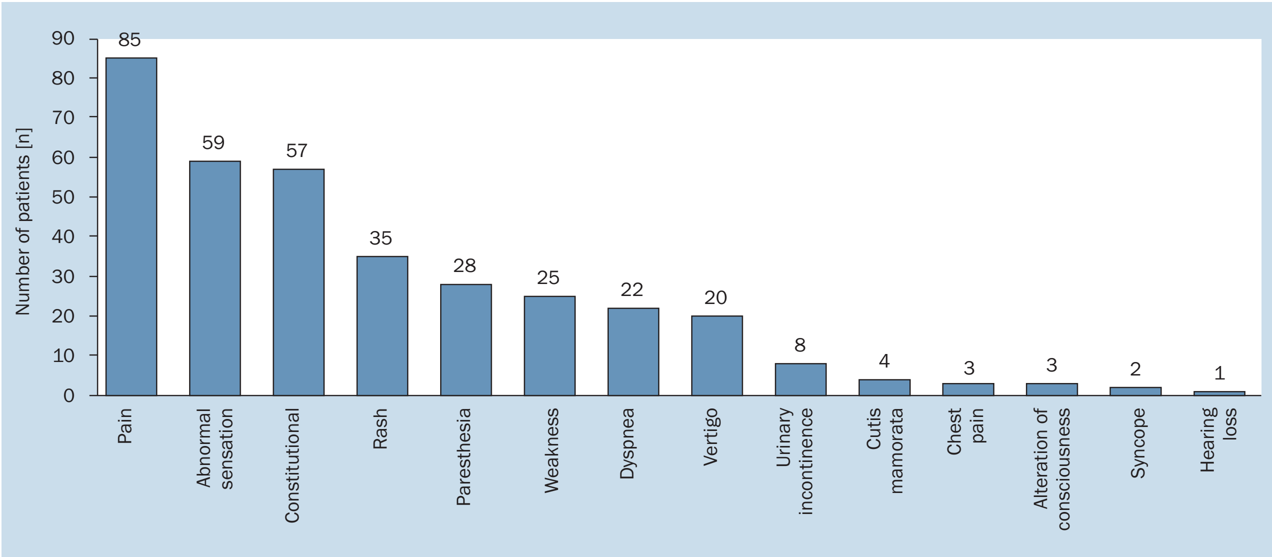

Figure 1. Bar chart represents the number of presenting symptoms of patients, some patients present with more than one symptom

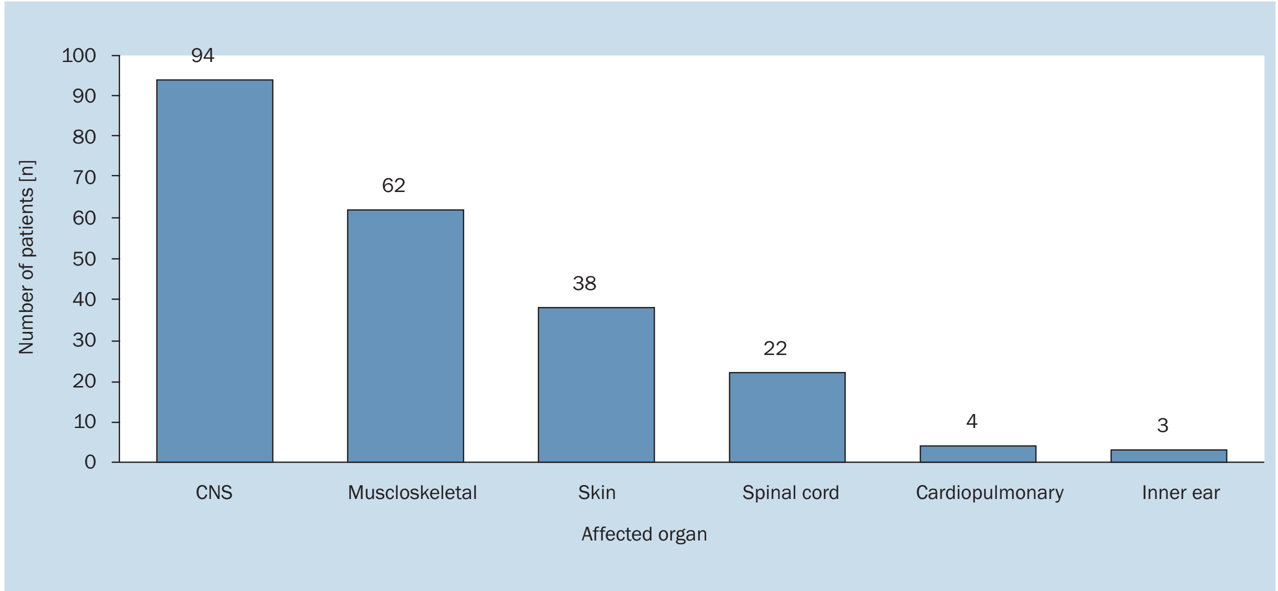

Figure 2. Bar chart represents the number of affected organs by diagnosis from medical records, some patients received more than one diagnosis

CNS — central nervous system

and hyperbaric physician, the most often diagnosed were central nervous system (CNS) symptoms followed by musculoskeletal symptoms, 42% and 28% respectively. Figures 3 and 4 show the time of onset and time to treatment, respectively.

The study observed treatment outcomes — 73.6% of patients achieved complete resolution of symptoms following treatment(s), while 19.1% had mild residual symptoms and 6.7% had severe residual symptoms (Fig. 5). These patients were grouped into complete and incomplete outcomes for further analysis.

Among the 178 patients with decompression illness included in the study, 131 (73.6%) achieved complete recovery, while 47 (26.4%) experienced incomplete recovery. Several variables were found to be significantly associated with treatment outcomes. The purpose of diving was a significant factor, with a higher proportion of incomplete recovery observed in traditional divers compared to recreational divers (42.2% vs. 22.2%, p = 0.036). Missing a safety stop was significantly associated with incomplete recovery (p = = 0.008), as 57.4% of patients in the incomplete group missed this procedure. Spinal cord involvement was strongly related to poor outcomes, occurring in 77.3% of patients with incomplete recovery compared to only 25.3%

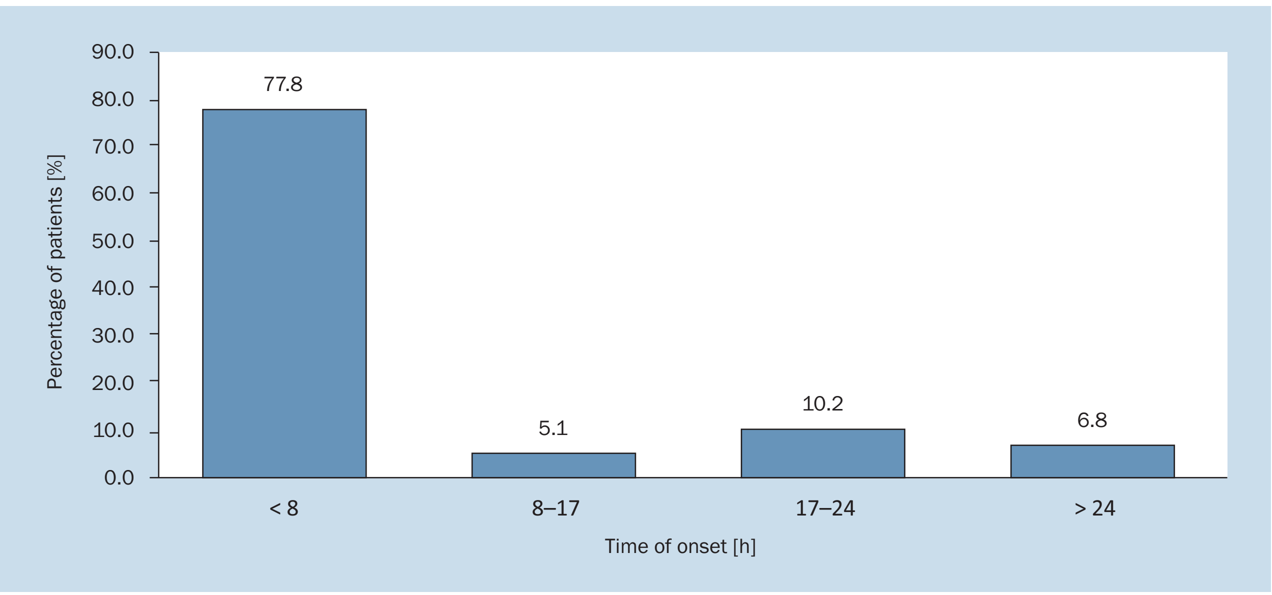

Figure 3. Bar chart represents the time of onset of symptoms after the last dive, data shown are the percentages of patients grouped in 8-hour intervals

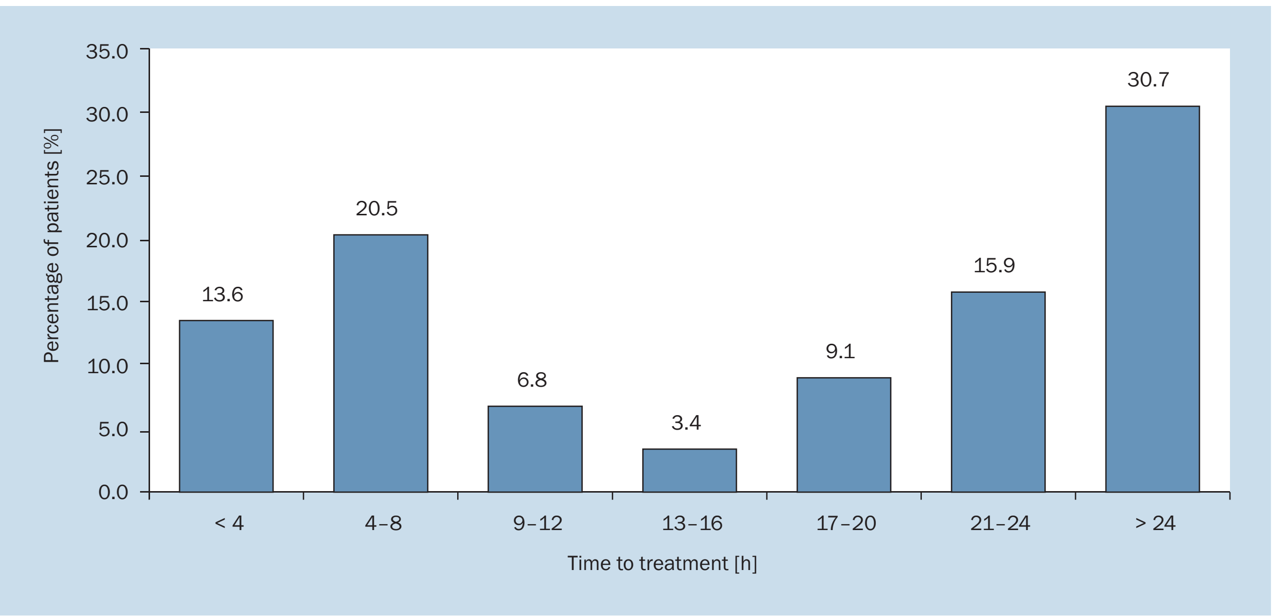

Figure 4. Bar chart represents the time of treatment after the onset of symptoms, data shown are the percentages of patients grouped in 4-hour intervals

in the complete recovery group (p < 0.001). Likewise, CNS symptoms were more frequent in the incomplete recovery group (33.3% vs. 19.3%, p = 0.035) (Tab. 4).

Univariable logistic regression identified several significant predictors of incomplete recovery. Patients who missed safety stops on dives were significantly more likely to have an incomplete recovery compared to those who did not (OR = = 2.495, 95% CI: 1.263–4.926, p = 0.008). Multivariable logistic regression analysis showed that missing a safety stop remained a borderline predictor of incomplete recovery when considering diving factors (adjusted OR = 2.208, 95% CI: 0.962–5.069, p = 0.062). Although not reaching statistical significance, traditional diving (fishermen) showed a trend towards increased risk (OR = 4.750, 95% CI: 0.957–23.572, p = 0.057). Other factors such as multilevel diving, high-flow first aid oxygen use, and rapid ascent were not significantly associated with incomplete recovery. Notably, symptom onset beyond 24 hours was significantly

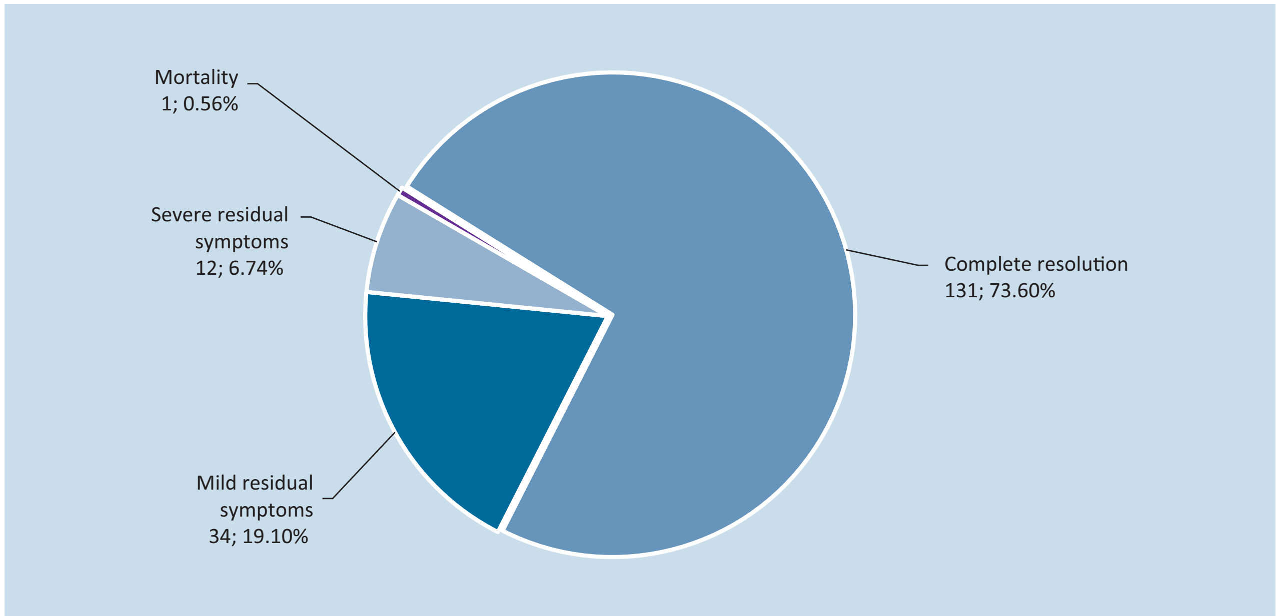

Figure 5. Pie chart represents the number and percentage [n; %] of treatment outcomes of decompression illness (DCI) patients

associated with incomplete recovery (OR = 6.563, 95% CI: 1.854–23.224, p = 0.004) in univariable analysis, but was not retained in the multivariable models due to limited sample size and wide confidence intervals (Tab. 5).

DISCUSSION

This 4-year retrospective study investigated factors associated with treatment outcomes of DCI patients who have received treatments at multiple government hyperbaric chamber centers in Thailand. The study period was between January 2020 to December 2023, during and after COVID-19, where the tourism industry in Thailand was put to a standstill. We observed a surge in traditional diving (fishermen), especially in the south of Thailand [10], during the pandemic, as fishermen went back to making a living by diving for seafood, but once tourism resumed these fishermen made earnings becoming tour guides, therefore, a decrease in traditional diving occured. The opposite was observed in the recreational diving sector due to pandemic lockdown.

The study shows no significant findings of associations between gender, age, ethnicity, body mass index, or pre-existing conditions when considering treatment outcomes. The time of onset of symptoms was consistent with literature reviews as the majority (72%) had onset of symptoms within 8 hours of the last dive, and within 24 hours of the last dive, 93% developed symptoms [5, 6, 11, 12]. More interestingly, an in-depth look revealed that patients in the group with an onset beyond the 24-hour mark had significant association with incomplete treatment outcome, (67% p = 0.007). There is little evidence supporting this finding, but it may be due to poor awareness of the symptoms of DCI leading to delayed treatments, causing residual symptoms and requiring more treatment as described in a study by Sokolowski et al. [13].

The symptoms observed in this study were consistent with those observed in literature, where the most common symptom was pain, followed by abnormal sensations and constitutional symptoms. On the other hand, when looking at affected organs determined by diagnosis, “CNS decompression sickness” was the most common. Upon review of medical records, this is most likely due to the fact that the Thai term ‘*Cha*’ can be ambiguous, as it may describe multiple symptoms, ranging from complete loss of sensation to pins-and-needles sensation — often a subjective felling without any objective findings. Therefore, an overdiagnosis of CNS decompression sickness might have occurred when it could just be cutaneous/skin decompression illness. However, as seen in the study, this had no adverse effect on the treatment outcomes and might have actually benefitted the patients, as they received treatments with a more extended treatment table. This finding may be considered a reason to use the term ‘decompression illness’ instead of ‘type I/II decompression sickness’ in clinical practice and to treat according to symptoms following the UHMS best practice guidelines to avoid under/overtreatment.

Only 19% of all patients received proper high-flow first aid oxygen after the onset of symptoms, but contrary to common belief, this did not significantly affect treatment outcomes. A previous study by Guillen-Pino et al. [15]

Table 4. Cross-tabulation of multiple factors with treatment outcomes to find association between them, p-value of > 0.05 is considered to be of significance

	Complete resolution			Incomplete resolution			p-value
	Count	**Row N %**	**Column N %**	**Count**	**Row N %**	**Column N %**	
Demographic							
Gender							0.535
Male	74	71.8	56.5	29	28.2	61.7	
Female	57	76	43.5	18	24	38.3	
Diving purpose							**0.036***
Recreational	91	77.8	69.5	26	22.2	55.3	
Occupational	13	86.7	9.9	2	13.3	4.3	
Traditional	26	57.8	19.8	19	42.2	40.4	
Military	1	100	0.8	0	0	0	
Diving factors							
Multilevel diving							0.105
No	71	78.9	54.2	19	21.1	40.4	
Yes	60	68.2	45.8	28	31.8	59.6	
Missed safety stop							**0.008***
No	85	81	64.9	20	19	42.6	
Yes	46	63	35.1	27	37	57.4	
Rapid ascent							0.218
No	106	75.7	80.9	34	24.3	72.3	
Yes	25	65.8	19.1	13	34.2	27.7	
Affected organ							
Inner ear							0.784
No	129	73.7	98.5	46	26.3	97.9	
Yes	2	66.7	1.5	1	33.3	2.1	
Cardiopulmonary							0.949
No	128	73.6	97.7	46	26.4	97.9	
Yes	3	75	2.3	1	25	2.1	
Spinal cord							**< 0.001***
No	126	80.8	96.2	30	19.2	63.8	
Yes	5	22.7	3.8	17	77.3	36.2	
Skin							0.208
No	100	71.4	76.3	40	28.6	85.1	
Yes	31	81.6	23.7	7	18.4	14.9	
CNS							**0.035***
No	68	81	51.9	16	19	34	
Yes	63	67	48.1	31	33	66	
Musculoskeletal							0.066
No	80	69.6	61.1	35	30.4	76.1	
Yes	51	82.3	38.9	11	17.7	23.9	

Table 5. Represents factors associated with incomplete treatment outcome after logistic regression analysis

	Complete outcome		Incomplete outcome		p-value	Unadjusted odds ratio	95% CI	p-value	Adjusted odds ratio	95% CI
	Count	Row N %	Count	Row N %						
Diving purpose										
Recreational	91	77.8	26	22.2	0.434	1.857	0.394–8.760			
Occupational	13	86.7	2	13.3		1				
Traditional	26	57.8	19	42.2	0.057	4.750	0.957–23.572			
Military	1	100	0	0						
Time of onset										
< 8 hr	105	76.6	32	23.4	0.409	0.410	0.049–3.404			
8–19 hr	8	88.9	1	11.1		1				
17–24 hr	12	66.7	6	33.3	0.359	1.641	0.570–4.721			
> 24 hr	4	33.3	8	66.7	**0.004***	6.563	1.854–23.224			
Multilevel diving										
No	71	78.9	19	21.1		1			1	
Yes	60	68.2	28	31.8	0.107	1.744	0.887–3.430	0.621	1.215	0.561–2.634
Missed safety stop										
No	85	81	20	19		1			1	
Yes	46	63	27	37	**0.008***	2.495	1.263–4.926	0.062	2.208	0.962–5.069
Rapid ascent										
No	106	75.7	34	24.3		1			1	
Yes	25	65.8	13	34.2	0.221	1.621	0.748–3.514	0.819	1.105	0.469–2.606

CI — confidence interval

in the Canary Islands showed similar results, but further studies with a larger sample and consideration of symptoms severity should be conducted.

The study revealed almost one-third (27%) of patients had incomplete resolution of symptoms, especially seen in the traditional diving group, as 19 of 45 (42%) traditional divers had incomplete resolution of symptoms, and there was one case of mortality. The majority of residual symptoms observed in this group were bowel/bladder dysfunction and motor dysfunction. This is consistent with previous studies done in fishermen villages — in 2020, Blatteau et al. [16] published a study on factors influencing long-term sequelae of DCI in fishermen divers. Despite having been properly treated, residual symptoms were still apparent in both studies. Moreover, improper in-water recompressions were being practiced within fishermen diver populations. This study did not explore this aspect, but the previous study showed significant associations with poor outcomes [16, 17].

As for the recreational diving group, 9% of divers were uncertified — a common finding amongst studies done in tourist-destination countries with the try/explore SCUBA programs, as the number of total dives and diving profiles are relatively low risk. As for other levels of certifications, there was no statistically significant association with treatment outcomes. Out of the recreational divers, 22% had incomplete resolution of symptoms, all of which were mild residual symptoms. This was a consistent finding in recent studies looking into treatment outcomes of DCI patients done in Finland, Geneva, and Thailand [9, 18, 19].

Among the factors related to diving profiles, missing safety stops was found to be a significant factor associated with incomplete outcomes. Although after multivariable analysis this factor lost its significance, the adjusted odds ratio remained high (~2.2, p = 0.062). Other known risk factors [20] did not show significance, but this may be due to recall bias in retrospective data and the limited sample size.

In this study, the appropriate treatment protocols were used in accordance to the treatment guidelines of U.S. Navy diving manuals and the Undersea and Hyperbaric Medical Society (UHMS) [21, 22].

CONCLUSIONS

This study was the first multi-centered study looking into the associations of various factors and treatment outcomes. The findings have shown traditional divers to be at higher risk of having poor treatment outcomes. Traditional diving in Southeast Asia often involves prolonged deep dives with high repetition and little to no safety procedures or equipment. This group of divers can benefit from knowledge of available treatment and the proper diving procedures. As for the recreational group, this study only explores the tip of the iceberg, as a prior survey done before conducting this study revealed an extra 50–100 cases that have been treated for DCI in the private sector, where access to data can be limited.

This study has several limitations. The retrospective design introduces potential for selection and information bias. Some relevant variables, such as dive depth, duration, comorbidities, and precise treatment protocols, were not available. The small sample size in some subgroups may limit the statistical power to detect associations.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: The data are available on reasonable request.

Ethics statement: This research has been approved by the Institutional Review Board and Research Ethics Committee of Naval Medical Department, Project Code RP020/67.

Author contributions: Poonsak Jittanonta was responsible for study conceptualization, data collection, data analysis and wrote the manuscript.

Chanon Vongvanich was responsible for assisting in data collection and data analysis.

Hansa Premmaneesakul were responsible for data management, supervised the study and revised the manuscript.

All authors read and approved the final manuscript.

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Conflict of interest: Authors declared no conflict of interest.

Supplementary material: None.

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ORIGINAL ARTICLE

Occupational health and safety compliance in Turkish fishing vessels: a regulatory assessment

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ABSTRACT

Background: *Commercial fishing remains one of the most hazardous occupations globally, with small-scale fleets exhibiting persistent safety challenges. In Türkiye, fishing operations are characterized by low regulatory compliance, insufficient training, and fatigue-related risks.*

This study assessed occupational health and safety (OHS) compliance levels among Turkish fishing vessel crews and identified key predictors of safety outcomes across vessel size categories.

Material and methods: *A cross-sectional study was conducted (June–August 2018) across Türkiye's Aegean, Marmara, and Black Sea regions, involving 356 crew members from 180 vessels. Data collection included structured questionnaires, observational checklists, and interviews. Analyses employed descriptive statistics, χ^2 tests, independent t-tests, and multiple linear regression (SPSS v26).*

Results: *Of all participants, 38.8% reported at least one occupational accident in the past year. The most frequent injuries were cuts (12.9%), falls (9.3%), and equipment-related trauma (5.9%). The main contributing factors were the hasty work pace in the workplace (52.2%), inadequate training (28.9%), and fatigue due to long working hours (19.0%). PPE compliance was low at 18%, and only 27% of participants had received formal safety training. A significant association was found between vessel size and accident occurrence (χ^2 = 12.45, p = 0.002), with smaller vessels having a significantly higher accident risk than larger vessels. Workers involved in accidents reported longer working hours (M = 14.3, SD = 1.8) than their counterparts (M = 13.1, SD = 2.2, p < 0.001). Regression analysis identified formal training (β = 0.35, p < 0.001), education level (β = 0.21, p < 0.001), and vessel size (β = 0.14, p = 0.01) as significant predictors of OHS compliance (R^2 = 0.29).*

Conclusions: *Occupational health and safety compliance in Türkiye's fishing sector remains inadequate, particularly for small-scale vessels. Prioritizing training expansion, work-hour regulations, and targeted support for high-risk fleets is essential.*

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Keywords: occupational health and safety, fishing vessels, personal protective equipment, maritime regulations, work-related injuries, risk assessment

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INTRODUCTION

Fishing is globally recognized as one of the most hazardous occupations due to dynamic marine conditions, demanding physical labor, and high exposure to mechanical, environmental, and meteorological risks [1, 2]. Numerous studies from different geographies highlight that these risks are amplified in small-scale and developing fleet contexts by inadequate enforcement of regulations, low safety culture, and insufficient access to training and safety equipment [3–5].

Even in developed countries, commercial fishing remains extremely hazardous. In the United Kingdom (UK), between 1996 and 2005, the fatality rate in commercial fishing was 103 per 100,000 fishermen — about 115 times higher than for other jobs [1]. In Europe, a study found injury rates up to 103 per 1000 full-time fishermen, especially in offshore fleets [6]. Across Canada, between 2018 and 2020, the total number of commercial fishing fatalities reached 45 — marking the highest three-year death toll in two decades — while annual averages have held steady at around 11 deaths per 100,000 workers, underscoring that commercial fishing continues to be one of the deadliest occupations in the country [7]. These figures show that even with modern technology and regulations, commercial fishing is consistently one of the most dangerous jobs in developed nations.

International research continues to emphasize the importance of regulatory consistency and safety culture. Comparative analyses across countries show that fragmented or weakly enforced regulations correlate strongly with high incident rates.

For instance, it was found that the safety outcomes of fishers in six countries, including Canada and the UK, varied significantly depending on the coherence of national occupational health and safety (OHS) frameworks [8]. In Atlantic Canada, enforcement was hampered by limited inspection capacity and jurisdictional overlaps [9], whereas Norway, with more centralized governance and comprehensive data tracking, exhibited more effective OHS compliance [10].

Health-related concerns are also notable in fisheries. Significant gaps in physical and mental health services for fishers have been reported [11], while tailored safety training has been found to significantly reduce accident occurrence among commercial fishermen [12]. The Danish model offers a process-based injury classification that could support more targeted interventions globally [13].

In the Turkish context, especially in the Aegean region, local research has exposed both structural and cultural weaknesses in maritime safety management. One study analyzed large-scale fishing vessels and identified systematic deficiencies in personal protective equipment (PPE) provision, emergency preparedness, and compliance with inspection protocols [14]. These findings echo international critiques and demonstrate that safety lapses are not limited to small-scale fleets. Likewise, statistical data confirm recurring occupational injuries in the Turkish fisheries sector, with common issues including lack of training, outdated vessel conditions, and noncompliance with documentation standards [15].

Alignment with international instruments such as the International Safety Management (ISM) Code, Maritime Labor Convention (MLC), and Standards of Training, Certification, and Watchkeeping for Fishing Vessel Personnel (STCW-F) remains largely theoretical unless followed by practical enforcement and port-state controls. Additionally, national-level systemic weaknesses in accident reporting and record-keeping mechanisms emphasize the need for reliable data to inform risk mitigation strategies [16, 17].

To address ongoing gaps in maritime safety practices, this study presents a comprehensive field-based assessment of OHS conditions aboard Turkish fishing vessels along the Aegean, Marmara, and Black Sea coasts. Using a mixed-methods approach, data were collected from 180 vessels through structured questionnaires, semi-structured interviews, standardized onboard inspections, and direct observations. A 45-point checklist, aligned with Türkiye's 2013 national safety regulation and international standards, was applied across three vessel size classes (10–29 m, 30–49 m, and 50–99 m). By integrating quantitative compliance scores with qualitative insights, this research aims to support policy development and align national maritime safety with global best practices.

MATERIAL AND METHODS

This study employed a cross-sectional, field-based design to assess OHS practices in Turkish fishing and auxiliary maritime fleets. Data collection was conducted between June and August 2018, using a multi-method approach that included structured questionnaires, checklist-based inspections, and direct observations. This triangulated methodology ensured a comprehensive assessment of safety conditions and compliance with national and international standards.

STUDY AREA, SAMPLE AND VESSEL CLASSIFICATION

The research was carried out in 37 ports located across the Aegean, Marmara, and Black Sea regions (Fig. 1), representing key operational zones of Türkiye's fishing fleet. The target population consisted of 1200 registered fishing vessels operating across these regions.

To determine the minimum required sample size, Cochran's formula [18] was applied, assuming maximum variability ($p = 0.5$) and a 5% margin of error:

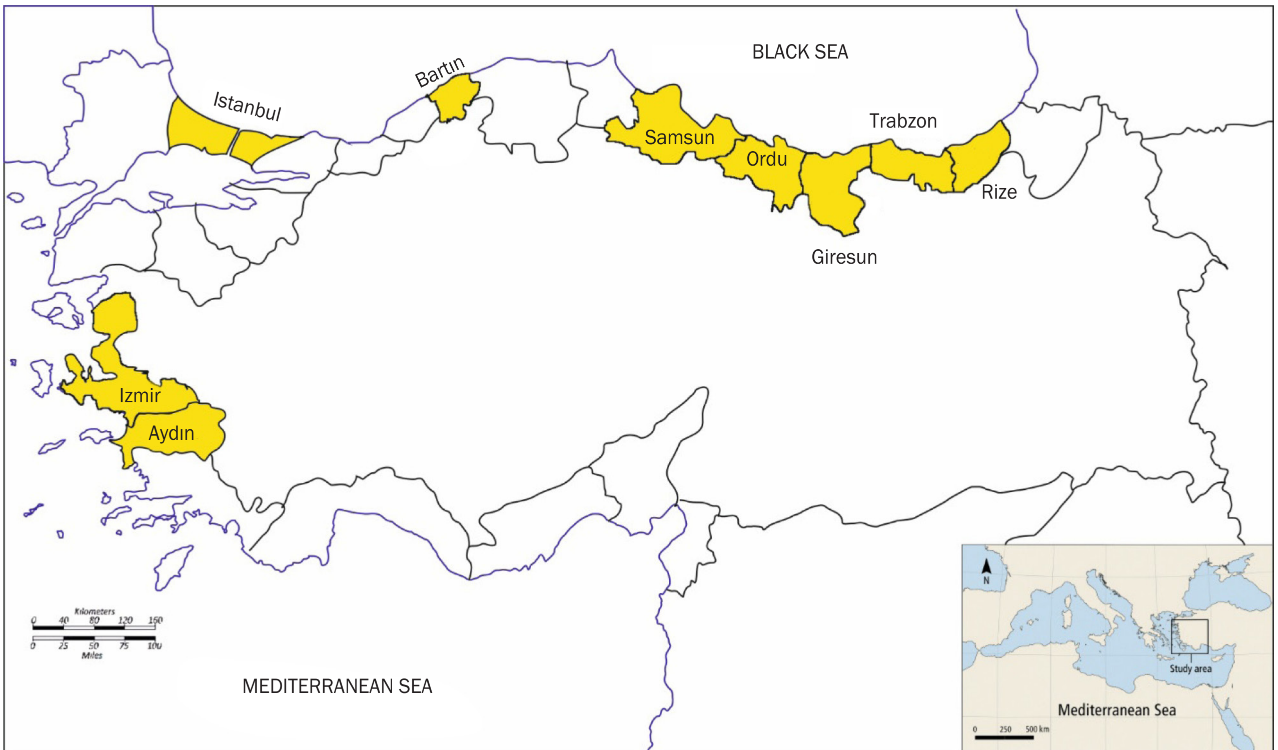

Figure 1. Geographic distribution of surveyed fishing shelters and port locations in Türkiye

$$n = (z)^2 p (1 - p) / e^2$$

where:
- Z = 1.96 (confidence level 95%),
- p = 0.5 (maximum variability),
- e = 0.05 (margin of error).

Given the finite nature of the population, the finite population correction (FPC) was applied, resulting in a minimum sample size of 294 participants [19]. Ultimately, 356 valid survey responses were collected from 180 vessels, exceeding the required sample size and ensuring statistical robustness.

The sampled vessels were categorized by overall length into three groups:
- small-scale vessels (10–29 m): 96 vessels,
- medium-scale vessels (30–49 m): 60 vessels,
- large-scale vessels (≥ 50 m): 24 vessels.

This classification enabled comparative analysis of OHS compliance and risk exposure across vessel sizes, contributing to a more nuanced understanding of safety dynamics within the fleet.

DATA COLLECTION TOOLS

Structured questionnaire

A structured questionnaire, consisting of 45 closed-ended questions, was developed to evaluate socio-demographic characteristics, occupational safety awareness, perceived risks, and compliance behaviors. It was piloted with 15 crew members, and revisions were made accordingly. The questionnaire was administered face-to-face by trained field researchers and took approximately 15–20 minutes per participant. The full set of questionnaire items is presented in Supplementary Materials A, B, C, and D. Specifically, Supplementary Material A includes full safety checklist items, Supplementary Material B includes socio-demographic variables, Supplementary Material C assesses safety knowledge, and Supplementary Material D focuses on self-reported safety practices and incident history.

Observational checklist

A 45-item observational checklist was developed in accordance with national maritime safety standards and internationally recognized frameworks such as the International Maritime Organization's (IMO's) Formal Safety Assessment (FSA) and the ISM Code [20, 21]. This tool was used to assess multiple safety components, including the proper use of PPE, the presence of safety signage, emergency preparedness, hygiene conditions, and ergonomic risks [22, 23]. Observations were conducted systematically during both onboard operations and scheduled inspections. Detailed checklist items and the associated safety domains (e.g., mechanical systems, lifesaving equipment, fire safety, noise exposure) are provided in Supplementary Material D.

Direct observations and interviews

In addition to the questionnaire and checklist assessments, field researchers conducted direct, non-intrusive observations of crew behavior and vessel conditions to capture real-time safety practices and deviations. Furthermore, semi-structured interviews were conducted with 20 key informants, including captains and experienced crew members. These interviews provided qualitative insights into operational routines, safety culture, perceived hazards, and barriers to compliance. This mixed-methods approach enriched the dataset and allowed for triangulation of quantitative results.

VARIABLES AND MEASUREMENT

The primary dependent variable in this study was the OHS Compliance Score, which was derived by aggregating the observed safety practices recorded through the checklist (Suppl. Mat. A) and self-reported behaviors obtained via the questionnaires (Suppl. Mat. D). This composite score reflects adherence to maritime safety regulations and operational best practices.

Independent variables encompassed a range of socio-demographic, occupational, and vessel-related factors collected through the structured questionnaire (Suppl. Mat. B and C).

DATA ANALYSIS

Descriptive statistics were computed using SPSS v26 [24]. Chi-square tests were used to assess associations between categorical variables, such as vessel size and accident occurrence [25]. Independent samples *t*-tests examined mean differences in daily working hours based on accident experience.

Multiple linear regression analysis was performed to identify significant predictors of the OHS Compliance Score, including age, education level, vessel size, and safety training status [26]. These variables were selected based on their relevance in prior studies examining safety behavior and compliance in maritime contexts [2, 12, 14].

Regression assumptions — linearity, normality of residuals, homoscedasticity, and multicollinearity — were tested and met, following procedures outlined by Field [25] and Tabachnick and Fidell [26].

The regression model identified formal safety training as the strongest predictor of OHS compliance. The model met all statistical assumptions and demonstrated acceptable explanatory power ($R^2 = 0.29$).

ETHICAL CONSIDERATIONS

The study adhered to international ethical research guidelines. Participation was voluntary, and all respondents provided informed consent. Data was anonymized and securely stored to ensure confidentiality.

RESULTS

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE CREW

A total of 356 crew members from 180 fishing vessels participated in this study. The mean age was 44.6 years (SD ± 9.93), with an average maritime work experience of 26.6 years (SD ± 10.7). 75% of participants were married, while 25% were single. Educational attainment was relatively low, with 58.3% having only primary education, 30% — middle school, 9.7% — high school, and 2% — university-level education (Tab. 1).

CERTIFICATION STATUS

Professional certification among crew members varied. 62.6% held a Deckhand Certificate (Fisherman Class), while 18.8% had a Master/Skipper Certificate, and 14.6% possessed Engine Department credentials. A small subset (3.9%) lacked any formal maritime certification. Certification distributions are summarized in Table 1.

OCCUPATIONAL ACCIDENTS AND SAFETY COMPLIANCE

Among all participants, 38.8% reported at least one occupational accident in the past year. The most common incidents were cuts (12.9%), falls (9.3%), equipment-related injuries (5.9%), and slips on wet surfaces (4.8%). Accident causes were primarily tight work schedules and hastiness (52.2%), lack of experience/training (28.9%), and fatigue due to extended work hours (19.0%).

A χ^2 test revealed a statistically significant association between vessel size and the occurrence of occupational accidents ($\chi^2 = 12.45$, df = 2, $p = 0.002$), indicating that smaller vessels were more likely to report accidents than larger ones (Tab. 2).

An independent samples *t*-test showed that crew members who experienced accidents worked significantly longer hours per day (M = 14.3, SD = 1.8) compared to those without accidents (M = 13.1, SD = 2.2), $t(354) = 5.94$, $p < 0.001$ (Tab. 2).

PREDICTORS OF OHS COMPLIANCE

A multiple regression model was constructed to assess predictors of the OHS compliance score. The model included age, education level, vessel size, and formal safety training as independent variables. Results indicated that the model significantly predicted compliance ($F(4, 351) = 19.23$, $p < 0.001$, $R^2 = 0.29$). Formal safety training was the strongest predictor ($\beta = 0.35$, $p < 0.001$), followed by education level ($\beta = 0.21$, $p < 0.001$) and vessel size ($\beta = 0.14$, $p = 0.01$) (Tab. 2).

Table 1. Sociodemographic characteristics and health-related behaviors of participants (n = 356)

Variable	Category/range	Frequency [%]
Age [mean ± SD]	44.6 ± 9.93 years	—
Experience [mean ± SD]	26.6 ± 10.7 years	—
Marital status	Married	75.0
	Single	25.0
Education level	Primary school	58.3
	Middle school	30.0
	High school	9.7
	Higher education	2.0
Inherited profession	Yes	53.6
	No	46.4
Position on vessel	Skipper	21.0
	Crew	79.0
Daily working hours	13.5 ± 2.1 hours	—
Income type	Wage-based	27.1
	Share-based	72.9
Certification type	Master certificate	18.8
	Fisherman-class deck crew cert.	62.6
	Deck-class seaman certificate	14.6
PPE usage	Gloves	96.1
	Hard hat	80.9
	Safety boots	84.5
	Life jacket/vest	60.9
Smoking	Yes	61.2
	No	37.6
Alcohol consumption	Yes	41.9
	No	52.9
Accident experience	Yes	38.8 (n = 138)
	No	61.2 (n = 218)

PPE — personal protective equipment, SD — standard deviation

Table 2. Safety compliance and deficiencies by vessel type and size

Category	Detail	Percentage [%]
Safety deficiencies	PPE compliance deficiency	72
	Fire safety non-compliance	41
	Crew lacking formal training	27
By vessel type	No PPE	75
	No emergency signage	85
	No fire equipment	40
By vessel size (10–29 m)	Compliance/non-compliance	81.86/14.15
By vessel size (30–49 m)	Compliance/non-compliance	82.63/13.55
By vessel size (≥ 50 m)	Compliance/non-compliance	86.05/10.88

PPE — personal protective equipment

HEALTH-RELATED BEHAVIORS

The health behavior profile of the crew members highlights notable lifestyle-related risk factors. As presented in Table 1, 61.2% of the respondents reported regular tobacco use, and 41.9% acknowledged alcohol consumption to varying degrees.

WORK-RELATED ACCIDENTS

Out of 356 crew members, 138 individuals (38.8%) reported having experienced at least one work-related accident in the past year. The distribution of accident types is shown in Table 3.

CIRCUMSTANCES AND CAUSES OF ACCIDENTS

The majority of accidents (65.9%) occurred during fishing operations, followed by incidents during navigation (18.8%) and port-related activities (15.3%). When asked about the primary causes of these accidents, 52.2% of the crew cited tight work schedules or hastiness, 28.9% attributed accidents to a lack of experience or training, and 19.0% to fatigue due to extended work hours (Tab. 3).

SAFETY COMPLIANCE AND PPE USAGE

Safety compliance across vessels showed significant gaps. Only 18% adhered to PPE regulations, while 72% had

Table 3. Types, circumstances, and causes of work-related accidents (n = 138)

Category	Detail	n (%)
Accident type	Cut injuries	46 (12.9)
	Fall injuries	33 (9.3)
	Struck by equipment	21 (5.9)
	Slipping on wet surfaces	17 (4.8)
	Hand/arm entrapment	9 (2.5)
	Burns (thermal/chemical)	6 (1.7)
	Eye injury from particles	4 (1.1)
	Falling overboard	2 (0.6)
	Other	1 (0.3)
Activity during accident	Fishing operations	65.9%
	Navigation	18.8%
	Port-related activities	15.3%
Cause of accident	Tight work schedule/hastiness	52.2%
	Lack of experience/training	28.9%
	Fatigue due to extended work	19.0%

deficiencies in protective equipment provision. Fire safety compliance was 41%, and only 27% of crew members had formal safety training (Tab. 2).

Usage rates of specific protective items varied. Gloves (96.1%), safety boots (84.5%), and hard hats (80.9%) were frequently used, whereas reflective vests and life jackets had lower adherence levels at 60.9% (Tab. 2).

COMPLIANCE BY VESSEL TYPE

Fishing vessels exhibited multiple safety deficiencies. Seventy-five percent lacked PPE, 85% had no emergency signage, and 65% failed to conduct emergency drills. Additionally, 40% had inadequate fire safety equipment (Tab. 2).

COMPLIANCE BY VESSEL SIZE

Occupational safety compliance varies by vessel length (Tab. 2). Larger vessels (≥ 50 m) had the highest compliance rate (86.05%), while smaller vessels (10–29 m) had the lowest (81.86%).

Table 4. Risk classification and regulatory compliance

Category	Detail	Percentage [%]
Risk classification	High risk	38
	Medium risk	34
	Low risk	16
	Critical risk	12
Regulatory compliance	PPE compliance	18
	Emergency readiness	68
	Safety training	11
	Mechanical safety	42
	Ventilation	14
	Lighting & workspace	64

PPE — personal protective equipment

RISK CLASSIFICATION

Risk level classification based on safety hazard matrices showed that 12% of vessels presented critical hazards, 38% were at high risk, and only 16% met low-risk standards (Tab. 4).

REGULATORY COMPLIANCE WITH SAFETY STANDARDS

Compliance with key safety regulations was low, particularly in PPE usage (18%), formal safety training (11%), and ventilation (14%) (Tab. 4). Outdated technology and inconsistent enforcement contribute to these deficiencies.

DISCUSSION

This study offers a detailed assessment of OHS compliance in Turkish fishing vessels, drawing from both Ege and Van region studies [14, 27], and contextualizing results within international standards such as the MLC, STCW-F (1995), and ISM Code (1998) [28–30].

Statistical findings reinforce earlier studies showing vessel size and crew fatigue as key accident predictors [3, 5]. Smaller vessels face higher risks due to limited infrastructure and oversight, consistent with findings by Jin and Thunberg and Thomas et al. Fatigue-related risks linked to long hours align with models by the National Institute for Occupational Safety and Health (NIOSH) and the Food and Agriculture Organization of the United Nations (FAO), which advocate regulated rest periods [31, 32].

Regression analysis confirmed that formal safety training significantly predicts OHS compliance, echoing previous research [12, 13]. The positive link between vessel size and compliance highlights structural disparities between fleet types, underscoring the need for tailored policy interventions. These insights can inform strategies to improve safety in Türkiye's small-scale fisheries.

Sociodemographic factors also play a critical role. The aging workforce (mean age 44.6 years, 26.6 years' experience) may be more susceptible to fatigue-related incidents [11]. Low educational attainment — only 2% with higher education — limits safety awareness and correlates with underreporting and risky behavior [1, 33].

Certification and training deficiencies are evident: only 27% of crew have received formal safety training, and 3.9% lack any credentials. Most (62.6%) hold basic Fisherman-Class Deckhand status. Türkiye's fragmented implementation of STCW-F hampers consistency, and enhanced training in vessel stability and emergency response is critical [10, 13, 34].

Accident prevalence remains high, with 38.8% of crew reporting incidents in the past year. Leading causes include hastiness, carelessness, and fatigue [17]. Tight schedules and long hours account for over half of cases. Global evidence highlights the need for structured training and fatigue management [8, 10, 33–35].

Personal protective equipment usage is insufficient: although gloves and boots are common, full compliance is only 18%, and 72% of vessels lack adequate provisions. Economic barriers and weak enforcement contribute to this gap. Subsidized PPE access and regular inspections are essential [1, 9].

Vessel conditions vary significantly. Larger vessels (≥ 50 m) showed higher compliance (86.05%) than smaller ones (10–29 m, 81.86%) [14, 27]. Enforcement of ISM Code standards in Türkiye is inconsistent compared to successful models in Norway and Denmark [10].

Risk classification revealed that 12% of vessels operate under critical conditions, and 38% are high-risk, primarily due to electrical hazards, poor emergency readiness, and inadequate training. Norway's centralized risk system offers a proven model for reducing maritime incidents [10].

Finally, behavioral health factors such as smoking (61.2%) and alcohol use (41.9%) undermine safety performance. Effective OHS programs must address both occupational and behavioral health risks [1, 11].

POLICY RECOMMENDATIONS FOR IMPROVING OHS COMPLIANCE

1. Expand Safety Training: Broaden access to certified programs aligned with STCW-F, with region-specific content tailored to vessel types [14, 27, 34].
2. Strengthen PPE Enforcement: Implement routine inspections, stricter penalties, and subsidized PPE programs to boost compliance [9, 31].
3. Upgrade Vessel Safety Systems: Mandate installation of fire systems and hazard markers in line with ISM Code; standardize maintenance protocols [34].
4. Financial Support for Small Fleets: Provide grants and low-interest loans to support vessel upgrades and safety compliance [27, 36].
5. Create a Centralized Risk Monitoring System: Establish a national database for risk profiling, inspections, and data-driven interventions [13, 35].

CONCLUSIONS

This study reveals that OHS compliance in Turkish fishing vessels remains significantly below international standards. Critical deficiencies were identified in crew training, PPE usage, vessel infrastructure, and regulatory enforcement. These gaps are further compounded by low education levels, insufficient certification, and limited oversight — particularly among small-scale operators.

To address these issues, systemic reforms aligned with global frameworks such as STCW-F and the ISM Code are needed. Improvements in training access, safety inspections, infrastructure upgrades, and national-level risk monitoring are essential. Targeted interventions, supported by robust national data infrastructure and informed by international best practices, will be key to enhancing safety, reducing occupational risks, and promoting sustainability in Türkiye's maritime sector.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to privacy and ethical restrictions concerning human subjects and workplace safety assessments, the datasets are not publicly available. Aggregated or anonymized data may be provided upon request for academic and research purposes, subject to institutional approval.

Ethics statement: All participants were informed about the purpose of the research and participated voluntarily. Informed consent was obtained from all individuals involved in the study. No personal identifiers were collected, and all data were anonymized to protect participants' confidentiality.

Author contributions: Veli Cem Peker: conceptualization, writing — original draft, visualization; Yaşar Özvarol: supervision, methodology, investigation, data curation, formal analysis, validation, writing — review and editing, project

administration. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this article.

Supplementary material: The full sets of questionnaire item used in this study are provided as separate Supplementary Materials (A–D) submitted alongside the manuscript. These materials offer additional detail supporting the analysis and findings presented in the main text.

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ORIGINAL ARTICLE

Musculoskeletal disorders and associated factors among fishermen in Vietnam — a cross-sectional study

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ABSTRACT

Background: *Fishing is a physically demanding occupation that exposes workers to harsh environmental conditions, awkward working postures and vibrations. These factors contribute to the development of musculoskeletal disorders (MSDs). This study aimed to determine the prevalence of MSDs as well as their associated factors among fishermen.*

Material and methods: *This cross-sectional descriptive study was conducted among 576 male fishermen aged 20 to 58 years. Data were collected through clinical examinations and face-to-face interviews using the standardized Nordic Musculoskeletal Questionnaire.*

Results: *The 7-day prevalence of MSDs among fishermen was 85.2%. The most affected anatomical sites were the lower back (79.5%), wrists/hands (71.0%), and shoulders (56.6%). Associated factors identified included age 40 and above, work experience of 10 years or more, being overweight/obese, alcohol abuse, and engine crew or fisherman vs. fishing boat captain.*

Conclusions: *Musculoskeletal disorders are a highly prevalent occupational health issue among fishermen. Preventive measures should focus on improving working conditions, promoting health education, conducting regular screenings, and strengthening occupational health services to reduce the risks and impacts of MSDs in this workforce.*

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Keywords: musculoskeletal disorders (MSDs), fishermen, associated factors, Vietnam

INTRODUCTION

Musculoskeletal disorders (MSDs) refer to injuries or pain affecting the musculoskeletal system of the body, including joints, ligaments, muscles, nerves, tendons, and surrounding structures [1]. Musculoskeletal disorders are among the most common occupational health problems, significantly impacting physical health, mental well-being, quality of life, and work productivity [2]. According to the World Health Organization, approximately 1.7 billion people worldwide suffer from musculoskeletal conditions, making them the leading cause of disability in 160 countries. These disorders contribute to reduced or lost work capacity and increased healthcare expenditures for nations [3]. The prevalence of MSDs tends to be higher in occupations that involve high-intensity labor, manual work, or repetitive tasks [4].

The prevalence of MSDs varies across different occupations and the nature of the work. It has been reported to be 71.0% among seafood processing workers [5], 56.3% in aquaculture workers [6], 55.7% in teachers [7] and 45.6% in shoemakers [8].

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Fishing is considered a physically demanding occupation, in which workers are often required to spend extended periods at sea under harsh conditions, including strong winds, high waves, and constant vessel motion. In addition, fishermen typically work outdoors in humid environments and are frequently engaged in repetitive manual tasks such as hauling nets, lifting heavy loads, and performing physically strenuous activities. These occupational characteristics represent significant risk factors for developing work-related injuries and MSDs [9–11]. A study conducted by Laraqui et al. [12] among fishermen in northern Morocco reported prevalence of MSDs was 61.9%, with the most commonly affected body regions being the lower back (40.5%), wrist/hand joints (40.4%), neck (34.6%), and shoulders (31.7%) [12]. A meta-analysis of 16 studies published in PubMed/MEDLINE, EMBASE, and CINAHL found that the prevalence of MSDs among fishermen ranged widely, from 15% to 93% [10].

Vietnam is a nation with 28 coastal provinces and 12 island districts, where fishing remains a primary source of livelihood for many communities in coastal and island regions. However, occupational risk factors and the health burden associated with MSDs among fishermen have not been comprehensively investigated. To date, research on MSDs in this occupational group remains limited, particularly studies that provide both prevalence data and associated risk factors. Therefore, this study was conducted to determine the prevalence and associated factors of MDSs among fishermen. The findings aim to contribute to the evidence base necessary for developing appropriate intervention strategies to improve occupational health and protect the well-being of the fishing workforce.

MATERIAL AND METHODS

Participants: A total of 576 fishermen, aged 20 to 58 years, from the coastal provinces of Ha Tinh, Thanh Hoa, Nam Dinh, Quang Ninh, and Hai Phong, who engaged in offshore fishing activities in the Gulf of Tonkin, Vietnam, between May and December 2024, were included in the study.

The participants were categorized into three occupational groups:

- fishing boat captain: responsible for navigating the vessel, identifying fishing grounds, and coordinating fishing operations;
- engineers: in charge of maintaining and operating the vessel's mechanical and electrical systems, including the main engine, electrical circuits, and lighting systems;
- fishermen: directly involved in fishing activities, including casting and hauling nets, harvesting seafood, processing, and preserving the catch.

Inclusion criteria: fishermen with at least two years of work experience who voluntarily agreed to participate in the study.

Sample size: The sample size was calculated based on the formula for estimating the sample size for a proportion:

$$n = Z^2_{1-\frac{\infty}{2}} \frac{p(1-p)}{(d)^2};$$

in which Z: the confidence level of 95%, Z = 1.96; p: is the estimated prevalence of MSDs from a previous study. Currently, there is no data on the prevalence of MSDs among fishermen in Vietnam, thus we chose p = 0.5; d: the margin of error (d = 0.05); n (minimum sample size) = 384 participants. To increase reliability, the minimum sample was multiplied by 1.5, resulting in the final sample size of n = 576.

Sampling method: A simple random sampling method was employed. A list of all fishing vessels in the Gulf of Tonkin was made. A simple random number table to randomly select 60 fishing vessels was used. All fishermen working on 60 vessels were selected — 576 people in total. Out of this number, 71 fishermen were absent at the time of data collection or did not agree to participate in the study.

Data collection: Participants underwent a clinical examination to assess musculoskeletal status. Height and weight were measured, and body mass index (BMI) was calculated.

All participants were interviewed directly to collect information on the following variables: sex, age, work experience, educational level, job position on the vessel, smoking status, and alcohol abuse.

Fishermen were asked to self-report the presence or absence of pain or movement limitation in nine anatomical regions of the body over the period of seven days prior to the examination. These regions included the neck, shoulders, upper back, elbows, lower back, wrists/hands, hips/thighs, knees, and ankles/feet.

Definitions: diagnosis of musculoskeletal disorders — MSDs were assessed using the Nordic Musculoskeletal Questionnaire (NMQ), a standardized instrument developed by Kuorinka et al. [13]. The questionnaire demonstrates high internal consistency with a Cronbach's alpha > 0.945 and excellent inter-rater reliability, with a Cohen's Kappa ranging from 0.88 to 1.00 [13]. The NMQ has been validated and widely used in Vietnam [14]. The instrument consists of 40 forced-choice questions targeting musculoskeletal symptoms in various anatomical regions, supported by a body map illustrating nine specific areas: neck, shoulders, upper back, elbows, lower back, wrists/hands, hips/thighs, knees, and ankles/feet. Respondents were asked whether they had experienced musculoskeletal symptoms in the 7 days prior to the examination and whether these symptoms interfered with their normal daily activities. MSDs were defined as pain, discomfort, or limited movement in at least one of the nine anatomical locations.

The assessment of overweight and obesity was based on BMI, calculated using the formula weight [kg]/height^2 [m^2]

according to WHO standards for Asian adults [15]. Underweight is defined as BMI < 18.5 kg/m^2, normal weight as BMI 18.50–22.9 kg/m^2, overweight as BMI 23.00–24.9 kg/m^2, and obesity as BMI ≥ 25 kg/m^2.

Alcohol abuse criteria: Seafarers were interviewed about their alcohol consumption over the 7 days prior to the examination. Alcohol abuse is defined according to the standards of the World Health Organization: males consuming more than 3 units of alcohol per day or 21 units per week; females consuming more than 2 units per day or 14 units per week. One unit of alcohol is equivalent to 10 grams of pure alcohol contained in a beverage. One standard drink is equivalent to one 330 mL can of beer with 5% alcohol, one 125 mL glass of wine with 11% alcohol, one 75 mL glass of fortified wine with 20% alcohol, or one 30 mL shot of spirits with 30% alcohol [16].

STATISTICAL ANALYSIS

The study data were analyzed using biomedical statistical methods with SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were represented by frequency and percentage (%), while continuous variables were represented by mean and standard deviation (SD). The χ^2 test was used to compare two proportions. Multivariable logistic regression analysis was employed to calculate odds ratios (ORs) along with 95% confidence intervals (CIs) to assess the relationship between risk factors and musculoskeletal disorders among fishermen. Statistical significance was determined with $p < 0.05$. Risk factors were identified through multivariable logistic regression analysis, using binary dependent variables representing musculoskeletal disorders. The variables included in the model as potential risk factors comprised: working experience, education level, BMI, smoking, alcohol abuse, position on the ship.

ETHICAL APPROVAL

This study has been approved by the Ethics Committee in Biomedical Research of the Maritime Medical Institute under decision 09/2024/QD-YHB. Participation in the study was entirely voluntary for all fishermen.

RESULTS

A study was conducted among 576 offshore fishermen operating in the Gulf of Tonkin, Vietnam, to assess the prevalence of MSDs and associated factors. The following results were obtained:

Study results (Tab. 1) showed that: 100% of the study participants were male, with ages ranging from 20 to 58 years. The mean age was 38.5 ± 8.6 years. Participants aged 20–29 accounted for 18.9%, those aged 30–39 accounted for 38.2%, 40–49 years made up 31.6%, and those aged 50 years or older represented 11.3%. The mean work experience seniority was 14.8 ± 6.4 years, with a minimum of 2 years and a maximum of 37 years. Participants with less than 10 years of work experience comprised 28.0%, those with 10–19 years made up 45.8%, and those with 20 years or more accounted for 26.2%. The educational level of the participants was relatively low: the majority had completed lower secondary school (44.8%), followed by elementary (36.8%), and high school or higher (13.7%). Notably, 27 participants were illiterate. In terms of position on the ship, the majority were fisherman (78.3%), followed by fishing boat captain (12.3%) and engineers (9.4%).

Table 1. General characteristics of the study participants (n = 576)

Variable		No. (%)
Gender	Male	576 (100.0)
	Female	0 (0.0)
Age [years]	20–29	109 (18.9)
	30–39	220 (38.2)
	40–49	182 (31.6)
	≥ 50	65 (11.3)
	Mean (SD); min — max	38.5 ± 8.6, 20–58
Work experience [years]	< 10	161 (28.0)
	10–19	264 (45.8)
	≥ 20	151 (26.2)
	Mean (SD); min — max	14.8 ± 6.4, 2–37
Education level	Illiteracy	27 (4.7)
	Elementary	212 (36.8)
	Secondary school	258 (44.8)
	High school or higher	79 (13.7)
Position on the ship	Fishing boat captain	71 (12.3)
	Engineers	54 (9.4)
	Fishermen	451 (78.3)

SD — standard deviation, No. — number

The study results (Fig. 1) showed that the prevalence of musculoskeletal disorders among fishermen was 85.2%.

Regarding the distribution of musculoskeletal disorders by anatomical location, the results (Tab. 2) showed that musculoskeletal disorders were most common in the lower back (79.5%), followed by the wrist/hand (71.0%), shoulder (56.6%), upper back (48.6%), neck (45.8%), knees (41.5), elbow (34.2%), ankles/feet (32.1), hip/thigh (28.3%).

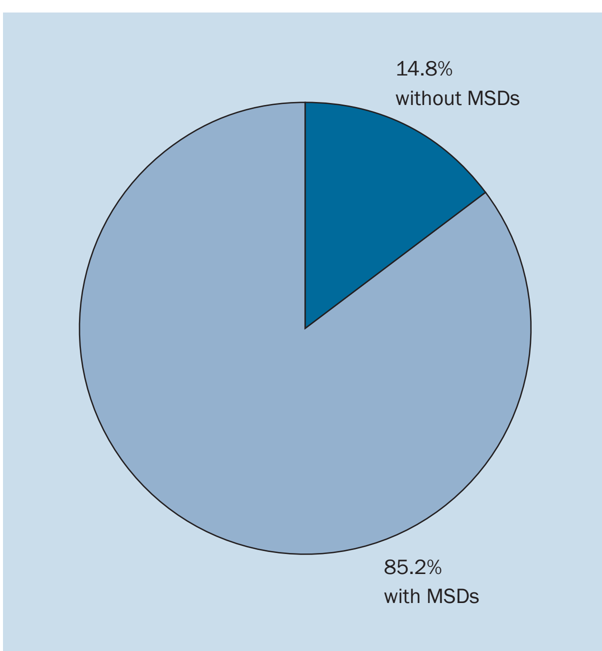

Figure 1. Prevalence of musculoskeletal disorders (MSDs) in study participants (n = 576)

Table 2. Distribution of musculoskeletal disorders in the study participants by anatomical location (n = 576)

Location	No. (%)
Neck	264 (45.8)
Shoulder	326 (56.6)
Upper back	280 (48.6)
Elbow	197 (34.2)
Wrist/hand	409 (71.0)
Lower back	458 (79.5)
Hips/thighs	163 (28.3)
Knees	239 (41.5)
Ankles/feet	185 (32.1)

Multivariable logistic regression analysis of factors associated to MSDs among fishermen revealed several identified factors (Tab. 3), including: age 40–49 years (OR = 2.32, 95% CI: 1.20–4.49, p = 0.01) and ≥ 50 years (OR = 5.47, 95% CI: 1.56–17.62, p < 0.001), compared to the 20–29 age; work experience of 10–19 years (OR = 1.93, 95% CI: 1.16–3.21, p = 0.011) and ≥ 20 years (OR = 2.94, 95% CI: 1.52–5.69, p < 0.001), compared to < 10 years; being overweight or obese (OR = 2.77, 95% CI: 1.25–6.18, p = 0.01); alcohol abuse (OR = 1.71, 95% CI: 1.03–2.81, p = 0.035); engine group (OR = 2.70, 95% CI: 1.05–6.87, p = 0.035) or fishermen (OR = 2.91, 95% CI: 1.63–5.20, p < 0.001) compared to fishing boat captain.

DISCUSSION

The results presented in Figure 1 indicate that the prevalence of MSDs among fishermen is remarkably high, reaching 85.2%. This finding highlights a serious occupational health issue in this workforce. The prevalence observed in this study is significantly higher than that reported in other occupational groups. Specifically, prevalence of MSDs was 37.9% among office workers [17], 53.1% in automobile factory workers [18], 56.3% in aquaculture workers [6], and 76.9% in farmers [19]. Several studies have attributed this elevated rate among fishermen to the physically demanding nature of their work. Fishing involves prolonged working hours under harsh weather conditions, repetitive and constrained movements, frequent heavy lifting, net hauling, and operating in a constantly wet environment. These factors are recognized as major risk contributors to occupation-specific illnesses and injuries, including MSDs [11, 20].

The prevalence of MSDs in this study is similar to some studies on fishermen in different countries. In a study by Müller et al. [21] on Brazilian fishermen, the prevalence of MSDs was 93.5%. The prevalence of MSDs in Korean fishermen was 84.0% [22], and in Danish fishermen 80.0% [20].

Regarding the distribution of MSDs by anatomical location, the study results show that the lower back was the most commonly affected anatomical site (79.5%), followed by the wrist/hand (71.0%), shoulder (56.6%) and upper back (48.6%). These findings are consistent with previous studies. Müller et al. [21] reported that the most prevalent site of MSDs among fishermen was the lower back (86.4%), followed by the wrist/hand (73.5%) and upper back (66.8%). Similarly, de Lima et al. [23] found that the lower back was the most frequently affected area (80.0%), followed by the upper back (43.5%) and knees (40.9%). The predominance of lower back disorders in fishermen may be attributed to the fact that this region bears the majority of mechanical load during lifting, pulling, pushing, and balancing movements that are routinely performed during fishing activities. Moreover, tasks such as hauling nets, handling winch ropes, or moving on unstable boat decks place significant stress on the lumbar spine, especially when executed in a bent posture or with improper technique [24].

The next most common MSDs sites identified in this study were the wrist/hand (71.0%) and shoulder (56.6%). These regions are frequently involved in repetitive movements during fishing activities such as casting nets, tying anchors, and hauling gear. High-intensity repetitive actions can lead to peripheral nerve entrapment syndromes or tendinitis. The neck, upper back, and knees were also reported as

Table 3. Multivariate logistic regression analyses of associated factors with musculoskeletal disorders (MSDs) among fishermen

Variable	n	With MSDs n (%)	Without MSDs n (%)	AOR (95%CI)	p-value
Age [years]					
20–29	109	86 (78.9)	23 (21.1)	1	
30–39	220	180 (81.8)	40 (18.2)	1.21 (0.68–2.15)	0.514
40–49	182	163 (89.6)	19 (10.4)	2.32 (1.20–4.49)	0.01
≥ 50	65	62 (95.4)	3 (4.6)	5.47 (1.56–17.62)	< 0.001
Work experience [years]					
< 10	161	124 (77.0)	37 (23.0)	1	1
10–19	264	230 (87.1)	34 (12.9)	1.93 (1.16–3.21)	0.011
≥ 20	151	137 (90.7)	14 (9.3)	2.94 (1.52–5.69)	< 0.001
Education level					
High school or higher	79	65 (82.3)	14 (17.7)	1	1
Secondary school	258	220 (85.3)	38 (14.7)	1.24 (0.63–2.42)	0.537
Elementary, illiteracy	239	206 (86.2)	33 (13.8)	1.36 (0.68–2.69)	0.380
BMI					
< 23	471	394 (83.7)	77 (16.3)	2.77 (1.25–6.18)	0.010
≥ 23	105	97 (92.4)	8 (7.6)		
Smoking					
No	149	123 (82.6)	26 (17.4)	1.23 (0.74–2.05)	0.419
Yes	427	368 (86.2)	59 (13.8)		
Alcohol abuse					
No	347	286 (82.4)	61 (17.6)	1.71 (1.03–2.81)	0.035
Yes	229	205 (89.5)	24 (10.5)		
Position on the ship					
Fishing boat captain	71	50 (70.4)	21 (29.6)	1	
Engineers	54	47 (87.0)	7 (13.0)	2.70 (1.05–6.87)	0.035
Fishermen	451	394 (87.4)	57 (12.6)	2.91 (1.63–5.20)	< 0.001

AOR — adjusted odds ratio, BMI — body mass index, CI — confidence interval

significant sites of MSDs, reflecting the association between improper working postures and chronic musculoskeletal disorders among fishermen [10, 22].

Multivariate logistic regression analysis was conducted to identify factors associated with MSDs among fishermen. The results (Tab. 3) indicated that age was significantly associated with MSDs. Fishermen aged 40–49 years had a 2.32-fold higher risk of developing MSDs, while those aged 50 years and above had a 5.47-fold increased risk compared to the 20–29 age group. This finding aligns with the physiological aging process, during which musculoskeletal structures progressively decline in function, increasing

susceptibility to injuries. A study by Remmen et al. [10] also reported a higher prevalence of MSDs among older fishermen, particularly in the lower back and shoulders.

Working experience was also identified as a significant associated factor. Fishermen with 10–19 years of work experience had a 1.93-fold higher risk of developing MSDs, while those with 20 or more years of work experience had a 2.94-fold increased risk compared to those with less than 10 years of experience. The study by Okezue et al. [25] also reported that several factors were associated with MSDs among workers, including prolonged working hours ($p = 0.003$) and occupational tenure ($p = 0.014$). Another study conducted among Danish fishermen also confirmed the association between occupational tenure and the prevalence of MSDs in this population [26]. These findings suggest that longer occupational tenure entails prolonged exposure to biomechanical stressors and adverse environmental and working conditions, thereby increasing the risk of MSDs.

The study results (Tab. 3) also indicated that overweight and obesity may increase the risk of MSDs ($p = 0.01$). This finding is consistent with previous studies [17, 27], which suggest that overweight and obesity not only affect cardiovascular health but also impair musculoskeletal function. Excess body weight increases mechanical load on joints, particularly the knees and hips, leading to degradation of synovial fluid properties and joint pain.

Alcohol abuse has emerged as an increasingly recognized risk factor for MSDs, particularly among individuals engaged in heavy manual labor such as fishermen. The findings of this study revealed that alcohol abuse significantly increased the risk of MSDs ($p = 0.035$). Biologically, alcohol negatively affects bone and muscle metabolism. Chronic alcohol consumption suppresses osteoblast activity while promoting bone resorption by stimulating osteoclasts, thereby weakening bone structure and increasing the risk of joint and spinal injuries [28]. A 2021 study conducted in Taiwan also reported a significant association between alcohol abuse and MSDs [29].

This study also revealed a significantly higher risk of MSDs among fishermen in the engine crew group (OR = 2.70, 95% CI: 1.05–6.87) and fisherman group (OR = 2.91, 95% CI: 1.63–5.20) compared to the fishing boat captain group. This difference reflects the nature of task distribution in fishing operations, where engine crew and fisherman group are responsible for physically demanding work involving high mechanical loads, repetitive tasks, constrained postures, and high pressure. Engine crew members primarily operate mechanical equipment such as winches, ship engines, and haul systems, and are frequently exposed to noise, vibration, and hot and humid environments, all of which contribute to an increased risk of MSDs. A study by Lings et al. [30] found that prolonged exposure to whole-body vibration significantly increased the risk of lower back pain and other MSDs. Meanwhile, fishermen serve as the primary workforce for direct fishing operations, including net deployment and retrieval, fish collection, anchoring, sorting, and preservation of seafood. These tasks involve repetitive movements, forceful exertions, and frequently require working in awkward postures such as bending or twisting, especially under adverse weather conditions and on slippery boat decks. Repetitive motions and poor working postures have been identified as major risk factors for tendinitis, carpal tunnel syndrome, and degenerative joint diseases affecting the shoulders, spine, and knees [31].

CONCLUSIONS

Musculoskeletal disorders are common occupational health problems among fishermen, with a high prevalence of 85.2%, primarily affecting the lower back (79.5%), wrist/hand (71.0%), and shoulder (56.6%). Several factors were found to be significantly associated with MSDs, including age ≥ 40 years, work experience ≥ 10 years, overweight/obesity, alcohol abuse, and employment as engine crew or fisherman. These findings provide evidence to support the development of risk-based intervention programs aimed at the prevention and management of MSDs among fishermen. Improving working conditions, providing targeted health education, implementing routine screenings, and strengthening occupational health services are essential strategies to protect and promote musculoskeletal health in this workforce.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: The authors confirm that all data in this study were collected, analyzed, and reported honestly and objectively. The datasets generated and/or analyzed are available from the corresponding author upon reasonable request, in accordance with ethical standards and institutional regulations.

Ethics statement: This study has been approved by the Ethics Committee in Biomedical Research of the Maritime Medical Institute under decision 09/2024/QD-YHB. Participation in the study was entirely voluntary for all fishermen.

Author contributions: Nam Bao Nguyen — manuscript writing and revision, literature review, and interpretation of results. Tam Nguyen Van — conceptualization, methodology, and data analysis; manuscript writing and revision. Ha Nguyen Thi Hai — application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data. Chi Tran Thi Quynh — supervision and project coordination. Son Nguyen Truong — literature review and background research; data acquisition.

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Supplementary material: None.

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REVIEW ARTICLE

Oral and perioral disease prevalence among fishermen — systematic review and meta-analysis

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ABSTRACT

Background: *Fishermen face challenges that increase their vulnerability to oral and perioral diseases due to demanding working conditions, excessive environmental exposure and limited access to health care. This systematic review aims to map and synthesize the available evidence on the prevalence of oral and perioral diseases among fishermen.*

Material and methods: *An extensive literature search was conducted in September 2024, including electronic databases, grey literature, and manual searches, without date or language restrictions, to identify observational studies evaluating the prevalence of oral and perioral diseases among fishermen. The risk of bias was assessed using the JBI critical appraisal checklist for studies reporting prevalence data. Meta-analyses were conducted to combine prevalence data from the included studies. The GRADE approach assessed the certainty of the evidence.*

Results: *Thirteen analytical cross-sectional studies, involving 4,546 fishermen, of moderate methodological quality were found. The meta-analysis showed that the overall prevalence of oral and perioral diseases was around 49% (95% CI: 27–72%; 4,546 participants; low-quality evidence). Considering the most common diseases reported, the pooled prevalence of dental caries was 84%, leukoplakia 26%, and actinic cheilitis 35%. The most frequent risk factors identified as associated were smoking habits, alcohol consumption, and poor oral hygiene.*

Conclusions: *These findings should be recognized as a public health concern and addressed through preventive and informational policies in fishing communities and related organizations. Further studies using more reliable methods, larger sample sizes, and adequate management of confounding factors are necessary to confirm these findings.*

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Keywords: fishermen, occupational diseases, oral health, systematic review, meta-analysis, prevalence

INTRODUCTION

Oral health is a critical yet often overlooked aspect of overall well-being, particularly in populations exposed to high-risk occupational environments. Fishermen face significant health challenges that extend beyond the physical demands of their work. The demanding nature of their profession encompasses long and irregular working hours, strenuous manual labor, prolonged sun exposure — often without adequate protection, social isolation at sea, poor dietary habits, and high prevalence of harmful behaviors

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such as tobacco and alcohol use — factors strongly associated with adverse oral and perioral health outcomes [1–3].

In particular, chronic exposure to ultraviolet radiation and harsh weather conditions elevates the risk of actinic cheilitis and lip or oral cavity cancers [4, 5]. Squamous cell carcinoma, often preceded by conditions such as leukoplakia and erythroplakia, is of particular concern in populations exposed to risk factors, highlighting the need for monitoring and prevention [1, 5]. Actinic cheilitis, prevalent among individuals exposed to chronic ultraviolet radiation, is characterized by symptoms such as dryness, scaling, and ulceration and can progress to invasive cancer if not diagnosed and treated promptly [4].

These occupational hazards are compounded by structural barriers, including limited access to preventive dental care and low health literacy, which contribute to a higher prevalence of dental caries, periodontal disease, and mucosal lesions in fishing communities [4–6]. The multifactorial nature of these risks overlaps significantly with the health profiles of artisanal fishing populations, where occupational exposure, socioeconomic vulnerabilities, and behavioral patterns converge [4, 5].

Furthermore, the specific work environment of fishermen can exacerbate health issues and hinder access to oral care [1]. In response, a growing number of scientific evidence has been published seeking to identify the frequency and undertake a detailed examination of the oral health challenges experienced by fishermen, emphasizing the interconnections between occupational exposure and the development of lesions and diseases. Thus, this systematic review aimed to map and synthesize the available evidence on the prevalence of oral and perioral diseases among fishermen. By reviewing the current literature, this study aims to understand the natural history of oral and perioral diseases among fishermen, identify associated risk factors, and identify the need for preventive strategies, public health interventions, and further research.

MATERIAL AND METHODS

This systematic review and meta-analysis followed the methodological recommendations of the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis [7] and the Cochrane Handbook for Systematic Reviews of Intervention [8], with the necessary adaptations for prevalence data studies. To ensure the quality of the report and in the absence of a specific tool for prevalence systematic reviews, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guideline [9] was followed, with appropriate adaptations. The protocol for this systematic review was registered on the PROSPERO platform. PRISMA checklist is available in the Supplementary Table 1.

ELIGIBILITY CRITERIA

The eligibility criteria were defined according to the research question structured by the acronym CoCoPop (Condition, Context, and Population).

- Condition: oral and perioral diseases, referring to any diseases or conditions affecting the mouth, lips, gums, tongue, and surrounding areas. Examples include dental caries, periodontal diseases, perioral diseases, and oral cavity cancer.
- Context: occupational and environmental exposure. This involves the work environment and environmental factors that could influence the prevalence of oral and perioral diseases, such as solar exposure and poor oral hygiene.
- Population: fishermen (aged above 18 years) diagnosed with any oral and/or perioral diseases.

We considered including observational longitudinal studies with prevalence data (cohort or case-control), cross-sectional studies (prevalence, population-based survey, or analytical cross-sectional), and case series. Studies that did not report sufficient information on data prevalence and case reports were not considered.

OUTCOMES OF INTEREST

The primary outcome of interest was the prevalence of oral and perioral diseases among adult fishermen, with diagnoses based on the definitions provided by each study. Secondary outcomes included the identification of potential risk factors associated with these diseases.

DATA SOURCES AND SEARCH STRATEGY

A comprehensive search was conducted on September 12, 2024, to identify studies that meet the eligibility criteria. The following databases were used: MEDLINE (via PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Embase (via Elsevier); Latin American and Caribbean Health Sciences Literature (LILACS, via Biblioteca Virtual em Saúde, including Bibliografia Brasileira de Odontologia [BBO]) and Web of Science. The Data Archiving and Networked Services (DANS) were used to search for grey literature, which can provide valuable unpublished data (https://easy.dans.knaw.nl/ui/datasets/id/easy-dataset:200362/tab/2). Additionally, the reference lists of the included studies were manually scanned for all relevant sources. No restrictions were placed on publication date, language, or status (abstract or full text). Supplementary Table 2 provides detailed search strategies.

STUDY SELECTION AND DATA EXTRACTION

Two independent reviewers conducted the study selection process, with a third reviewer available to resolve any disagreements. This process was carried out in two phases. In the first phase, the titles and abstracts of references identified through the search strategy were assessed using the Rayyan platform (https://rayyan.qcri.org) [10], resulting in the pre-selection of potentially eligible studies. In the second phase, the full texts of these pre-selected studies were evaluated to confirm their eligibility. Two independent reviewers extracted the included studies' data, and a third reviewer solved any divergences. A data extraction form was used, comprising the following information: author and publication year, country, settings, population characteristics, prevalence outcomes (values, measurement tools, time points), methodological aspects, and funding sources. Authors of the included studies could be contacted for any additional information if needed.

METHODOLOGICAL QUALITY ASSESSMENT

Two reviewers independently assessed the risk of bias for each study, with a third reviewer resolving any discrepancies. The methodological quality assessment was conducted using the JBI critical appraisal Checklist for Analytical Cross-Sectional Studies [11], which comprises eight questions involving sample, setting, inclusion criteria, exposure and condition measures, identification of confounding factors, and appropriate statistical analysis. The studies were classified as having high methodological quality when all assessed domains were deemed adequate.

STRATEGIES FOR DATA SYNTHESIS

When possible (homogeneous studies with available prevalence data), the included studies were pooled into meta-analyses using STATA software version 17.0, employing a random effect model. A 95% confidence interval (95% CI) was used for the analyses. Statistical heterogeneity between studies was assessed using Cochrane's Q test and I^2 statistics, with I^2 values greater than 50% indicating significant heterogeneity. Potential causes of substantial cross-study heterogeneity ($I^2 > 50\%$) were also investigated [8]. When meta-analysis was not feasible, results were presented as a qualitative synthesis (descriptive presentation). If data were available, subgroup analysis was planned to examine the frequency of oral and perioral diseases based on working time and age.

CERTAINTY OF THE EVIDENCE

Due to the absence of current guidance for assessing the certainty of evidence in systematic reviews of prevalence, we employed the GRADE approach (Grading of Recommendations Assessment, Development, and Evaluation) [12], developed originally for prognostic estimates, with relevant adaptations. The certainty of the evidence assessment was conducted for the primary outcome: overall prevalence rate of oral and perioral diseases.

RESULTS

SEARCH RESULTS

The search strategies yielded 622 references. After eliminating 27 duplicates, 595 references were screened based on titles and abstracts. Eighteen studies were chosen for full-text review. Three of these studies were excluded because they did not provide separate data for fishermen participants or did not present prevalence data for oral or perioral lesions [13–15]. Two studies were categorized as "awaiting classification" due to the unavailability of the full text [16, 17]. Ultimately, 13 [6, 18–29] studies were included in this systematic review (Fig. 1).

CHARACTERISTICS OF THE INCLUDED STUDIES

Table 1 presents the main characteristics of the included studies. All 13 studies were observational analytical cross-sectional designs conducted in fishing communities across five countries and published between 1989 and 2022. The total sample included 4,546 fishermen, predominantly men aged 15 to 54, with an average of 20 years of occupational sun exposure. Most studies did not report on the use of sun protection strategies.

METHODOLOGICAL QUALITY ASSESSMENT (JOANNA BRIGGS INSTITUTE APPRAISAL TOOL)

Table 2 summarizes the methodological quality assessment of the included studies. The risk of bias was assessed using the JBI appraisal tool for analytical cross-sectional studies. Most studies showed a reasonable methodological quality, since 92.3% (12/13) achieved more than five criteria adequately. Items 5 and 6 of the JBI tool, regarding strategies to identify and deal with possible confounding factors related to the causal association between fishermen's activities and oral and perioral lesions, were considered inadequate for most of the included studies. One study [21] was classified as 'uncertain' for most assessed items, as only the abstract was available, and the methodological details were missing.

PREVALENCE ESTIMATE OF ORAL AND PERIORAL LESIONS AMONG FISHERMEN

Table 3 details the estimated prevalence of oral and perioral diseases among fishermen reported in the individual studies, followed by the associated risk factors assessed. The summary of findings table presents the certainty

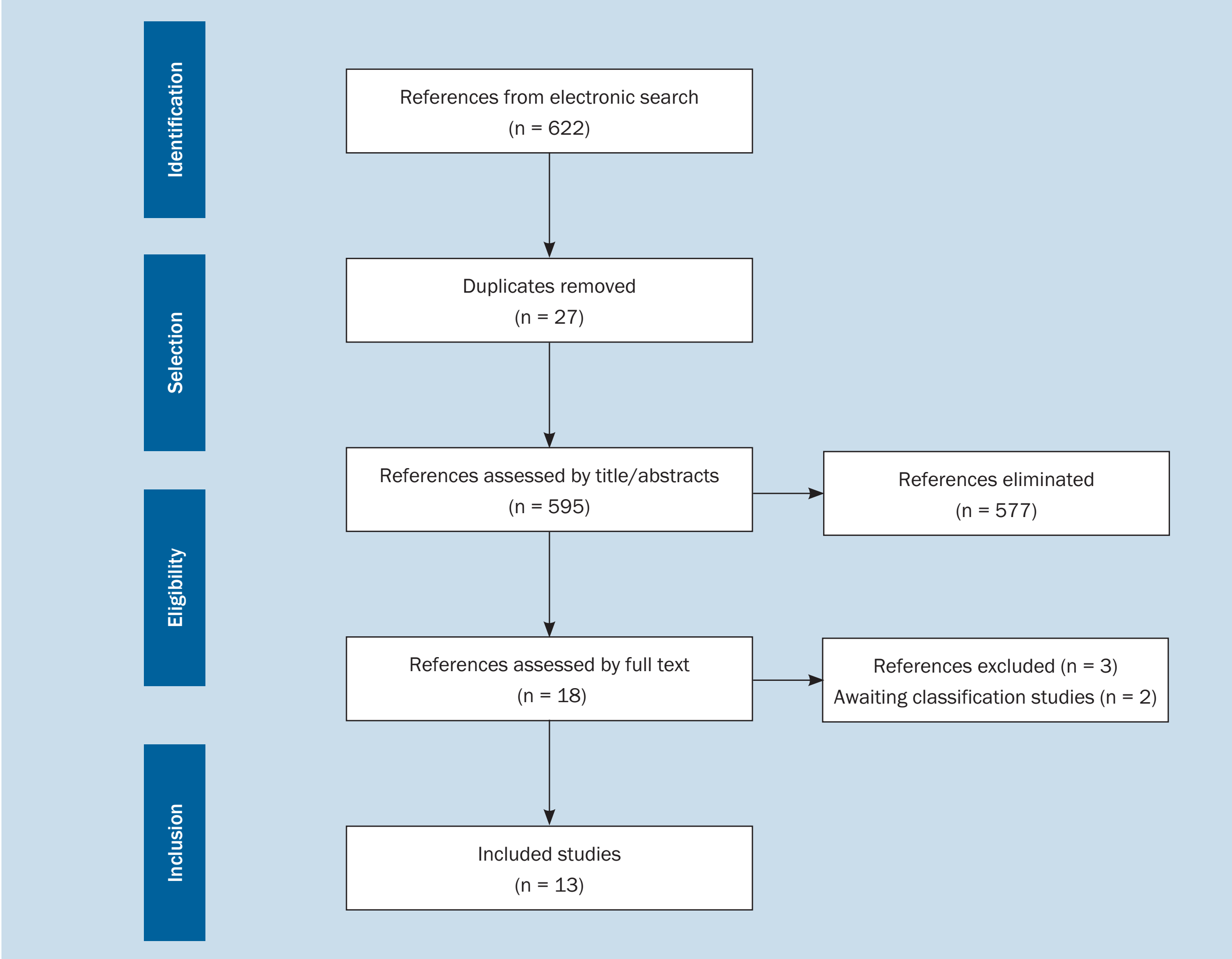

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram of the study selection process

of the evidence (Tab. 4). The meta-analysis showed that the overall pooled prevalence of diseases was 49% (95% CI: 27 to 72, I^2 = 99.9%, 4,546 participants, 13 studies, low quality of evidence) (Fig. 2).

Considering the most common lesions reported in the included studies, the pooled prevalence of dental caries was 84% (95% CI: 80 to 88, I^2 = 54.1%, 3 studies); for leukoplakia, the estimated prevalence was 26% (95% CI: 13 to 39, I^2 = 99.2%, 6 studies), and actinic cheilitis, 35% (95% CI: 9 to 61, I^2 = 97.8%, 3 studies) (Figs. 3–5).

The most frequent risk factors identified as the probable association between fishermen activities and oral and perioral lesions were smoking habit (18 to 83%), alcohol consumption (7.4 to 62%), poor oral hygiene (57 to 75%), and chewing sticks for cleaning their teeth (32 to 98%). One study [28] reported that fishermen younger than 50 had a four times higher probability of good oral health. Another study [24] showed that a higher prevalence of actinic cheilitis was observed in fishermen and women with fair skin, those over 50 years old, with more than 30 years of cumulative solar radiation exposure, daily exposure exceeding 4 hours, and those who did not use sunscreen ($p < 0.05$).

DISCUSSION

This systematic review aims to review the current literature to understand the natural history of oral and perioral diseases among fishermen, identify associated risk factors, and highlight the need for preventive strategies, public health interventions, and further research. Thirteen analytical cross-sectional studies of moderate methodological quality were found, involving samples between 71 to 1,100 fishermen, predominantly male and of working age, from communities in five countries. Based on low certainty evidence, the pooled results showed that the overall prevalence of oral and perioral diseases could be around 49%. Considering the most reported diseases, the pooled prevalence of dental caries was 84%, leukoplakia 26%, and actinic cheilitis 35%. Among the associated risk factors, smoking and alcohol consumption were particularly

Table 1. Main characteristics of the studies included in the review

Study	Study design	Location	Participants					Data collection period	Financial sources
			Number of fishermen	Male sex	Age [years, mean ± SD]	Cumulative exposure to work [years]	Type of sun protection reported		
Anzil [18]	Cross-sectional	Mahe, India	362	73.4%	15 to 54	NR	NR	NR	NR
Asawa [19]	Cross-sectional	Gujarat, India	1.100	61.3%	33.5 ± 13.4	NR	NR	January to June 2013	NR
Chandroth [20]	Cross-sectional	Kutch, Gujarat, India	979	57.4%	48 to 57	NR	NR	January to March 2014	Deanship of Scientific Research at King Saud University
Nicolini [21] (abstract)	Cross-sectional	Valparaíso, Chile	566	NR	16 to 45	NR	NR	NR	NR
Nithya [22]	Cross-sectional	North Chennai, India	71	78.9%	38.8 ± 9.2	NR	NR	NR	NR
Piñera-Marques [23]	Cross-sectional	Santa Catarina, Brazil	125	96.8%	50.5 ± 12.7	32.14 (± 12.47)	NR	NR	NR
Ribeiro [24]	Cross-sectional	Sergipe, Brazil	210	54.2%	> 50	< 30 yrs (n = 154) ≥ 30 yrs (n = 56)	Sunblock (15%) Hat (45%)	September 2010 to April 2011	NR
Ríos [25]	Cross-sectional	Valdivia, Chile	180	98.3%	45	0 to 9 (n = 33) 10 to 19 (n = 50) > 20 (n = 97)	Sunblock (22%) Hat (7.7%) Both (6%)	November 2014 to April 2015	*Escuela de Odontología Universidad Austral de Chile*
Sekizhar [26]	Cross-sectional	Pondicherry, India	262	100%	42.4 ± 15.3	115/262 (49.3%) > 20 years	NR	January 2020 to June 2021	No funding
Silva [27]	Cross-sectional	Florianópolis, Brazil	111	NR	47.7 ± 15.2	27.45 (±15.81)	Sunblock (19%) Hat (33%) Both (4%)	August 2002 to March 2003	NR
Singh [28]	Cross-sectional	Teluk Bahang, Penang, Malaysia	242	100%	≥ 50-yrs = 175 (72.3%)	NR	NR	January 2017	No funding
Tormeti [29]	Cross-sectional	Accra, Gana	138	NR	31 to 40	NR	NR	NR	NR
Varkey [6]	Cross-sectional	South Goa, India	200	72%	28.5 ± 8.9	NR	NR	November 2019 to January 2020	NR

NR — not reported, SD — standard deviation

Table 2. Methodological quality of the included cross-sectional studies assessed using the Joanna Briggs Institute (JBI) critical appraisal checklist

Included studies	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured validly and reliably?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured validly and reliably?	8. Was appropriate statistical analysis used?	Total
Anzil [18]	N	Y	Y	Y	N	N	Y	Y	5/8 62.5%
Asawa [19]	Y	Y	N	Y	Y	N	Y	Y	6/8 75%
Chandroth [20]	Y	Y	Y	Y	N	N	Y	Y	6/8 75%
Nicolini [21] (abstract)	Y	U	Y	U	U	U	U	U	2/8 25%
Nithya [22]	Y	Y	Y	Y	N	N	Y	Y	6/8 75%
Piñera-Marques [23]	Y	Y	Y	Y	N	N	Y	Y	6/8 75%
Ribeiro [24]	N	Y	Y	Y	N	N	Y	Y	5/8 62.5%
Rios [25]	Y	N	Y	Y	N	N	Y	Y	5/8 62.5%
Sekizhar [26]	Y	Y	N	Y	N	N	Y	Y	5/8 62.5%
Silva [27]	Y	Y	Y	Y	N	N	Y	Y	5/8 62.5%
Singh [28]	Y	Y	Y	Y	N	N	Y	Y	5/8 62.5%
Tormeti [29]	Y	Y	N	Y	Y	N	Y	Y	5/8 62.5%
Varkey [6]	N	Y	Y	Y	N	N	Y	Y	5/8 62.5%

N — no, U — unclear, Y — yes

Table 3. Prevalence, types, and associated risk factors of oral and perioral lesions among fishermen in the included studies

Study, year	Overall prevalence rate of oral and perioral lesions (n/N, %)	Types of oral and perioral lesions (n/N, %)	Risk factors that impacted oral health (n/N, %)
Anzil [18]	53/362 (14.9%)	• Ulcerations 18/362 (4.9%) • Leukoplakia 5/362 (1.3%) • Abscesses 5/362 (1.3%)	• Smoking habit 88/362 (24.3%) • Chew sticks for cleaning their teeth 116/362 (32.4%) • Consume alcohol 177/362 (48.8%) No statistically significant association was found between age groups and oral mucosal lesions.
Asawa [19]	968/1.100 (88%)	• Dental caries 908/1.100 (82.6%) • Mild fluorosis 275/1.100 (25%) • Severe fluorosis 251/1.100 (22.8%) • Calculus and shallow pockets (4–5 mm) 275/1.100 (25%) • Loss of attachment (9–11 mm) 283/1.100 (25.8%)	• Use of toothpaste/tooth powder (24%) • Chew sticks for cleaning their teeth (43.1%) Males (50.5%) reported a significantly higher prevalence of adverse oral habits than females (49.2%). Significant augmentation in dental fluorosis was seen up to 64 years of age ($p = 0.001$).
Chandroth [20]	293/979 (30%)	• Leukoplakia 135/979 (13.8%) • Ulceration 70/979 (7.2%) • Oral submucous fibrosis and cheilitis 47/979 (4.8%)	• Consume alcohol and tobacco 863/979 (42.9%) • Chew sticks for cleaning their teeth 419/979 (32.4%) • No oral hygiene practices 734/979 (75%) Using toothbrushes and toothpaste decreased with age ($p = 0.043$). A higher proportion of females (38.6%) used toothbrushes and toothpaste than males (57.4%) ($p = 0.002$).
Nicolini [21] (abstract)	243/566 (43%)	• NR	• NR
Nithya [22]	50/71 (67.6%)	• Dental caries 64/71 (90.9%) • Leukoplakia 48/71 (67.6%) • Ulceration 17/71 (23.9%) • Submucous fibrosis 10/71 (14.1%)	• Smoking habit 19/71 (26.8%) • Consume alcohol 24/71 (33.8%) • Chew sticks for cleaning their teeth 70/71 (98.6%) • No oral hygiene practices 1/71 (1.4%)
Piñera--Marques [23]	4 /125 (3.2%)	• Lip squamous cell carcinoma 4/125 (3.2%)	• Smoking habit 40/125 (32%) • Consume alcohol 48/125 (38.4%)
Ribeiro [24]	24/210 (11.4%)	• Actinic cheilitis 24/210 (11.4%)	• Cumulative exposure to sunlight > 30 years 74/210 (11.4%) • Smoking habit 39/210 (18.2%) A higher prevalence of actinic cheilitis was observed in fishermen and women with fair skin, those over 50 years old, with more than 30 years of cumulative solar radiation exposure, daily exposure exceeding 4 hours, and those who did not use sunscreen ($p < 0.05$).
Ríos [25]	70/180 (38.8%)	• Actinic cheilitis 70/180 (38.8%)	• Smoking habit 113/180 (62.7%) • Consume alcohol 37/180 (20.5%) • Cumulative exposure to sunlight > 20 years 51/180 (52.5%)
Sekizhar [26]	43/262 (16.7%)	• Leukoplakia 22/262 (8.4%) • Pre-leukoplakia 8/262 (3.4%) • Oral submucous fibrosis 2/262 (1.1%)	• Smoking habit 65/262 (24.8%) • Consume alcohol 63/262 (24%) • Cumulative exposure to sunlight > 20 years 115/262 (49.3%)

Table 3 cont. Prevalence, types, and associated risk factors of oral and perioral lesions among fishermen in the included studies

Study, year	Overall prevalence rate of oral and perioral lesions (n/N, %)	Types of oral and perioral lesions (n/N, %)	Risk factors that impacted oral health (n/N, %)
Silva [27]	61/111 (60%)	• Actinic cheilitis 48/111 (43.24%) • Acute actinic cheilitis 2/111 (1.8%) • Leucoplakia 3/111 (2.7%) • Hyperkeratosis 4/111 (3.6%) • Squamous cell carcinoma 4/111 (3.6%)	• Smoking habit 37/111 (33.3%) • Consume alcohol 67/111 (62.1%)
Singh [28]	217/242 (90%)	• Oral health problems 217/242 (90%)	• Smoking habit 201/242 (83.1%) • Consume alcohol 18/242 (7.4%) Fishermen aged 50 or younger had approximately four times higher odds of having good oral health than those aged 50 or older.
Tormeti [29]	138/138 (100%)	• Plaque Index 138/138 (100%)	Do not provide separate data on risk factors for fishermen
Varkey [6]	164/200 (82%)	• Dental caries 164/200 (82%)	• No oral hygiene practices 114/200 (57%) Fishermen who used a toothbrush were 4.5 times less susceptible to caries.

95% CI — 95% confidence interval, NA — not assessed

Table 4. Summary of findings table: overall prevalence of oral and perioral diseases among fishermen using the GRADE approach

Number of participants (studies)	Certainty assessment						Summary of findings	Certainty
	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		
4,546 participants (13 studies)	Cross-sectional	Not serious	Serious[a]	Not serious	Not serious	None	The prevalence of oral and perioral diseases among fishermen was 49% (95% CI: 27 to 72%)	⊕⊕◯◯ Low

[a]Heterogeneity (I^2 = 99.9%) (downgraded two levels)

prevalent among fishermen. A significant issue identified was the population's lack of guidance on oral hygiene.

The findings of this systematic review highlighted the occupational fragility within this professional category. Fishermen are frequently exposed to ultraviolet radiation and diverse climatic conditions and often do not use adequate protective measures. Four of the 13 studies included in this review evaluated this variable and revealed a low frequency of preventive strategies, such as wearing hats and skin or lip protectors. Consequently, the prevalence rate of actinic cheilitis appears to be directly associated with this prolonged and cumulative exposure without protection. In addition, leukoplakia was another notably prevalent condition which, in addition to being related to constant sun exposure, may be caused by other common risk factors reported by the analyzed fishermen, such as the habit of smoking.

Additionally, the data regarding the incidence of perioral and oral cavity cancers, including those affecting the lip, tongue, and oral oropharyngeal regions, is particularly concerning among fishermen.

The included studies were assessed as having a reasonable methodological quality based on the JBI tool, achieving an average score of 6 or higher. However, according to the GRADE approach, the estimated prevalence was classified as low certainty of evidence. This classification is justified by methodological limitations and high heterogeneity, which indicates that further studies should be necessary to support these findings. The substantial heterogeneity

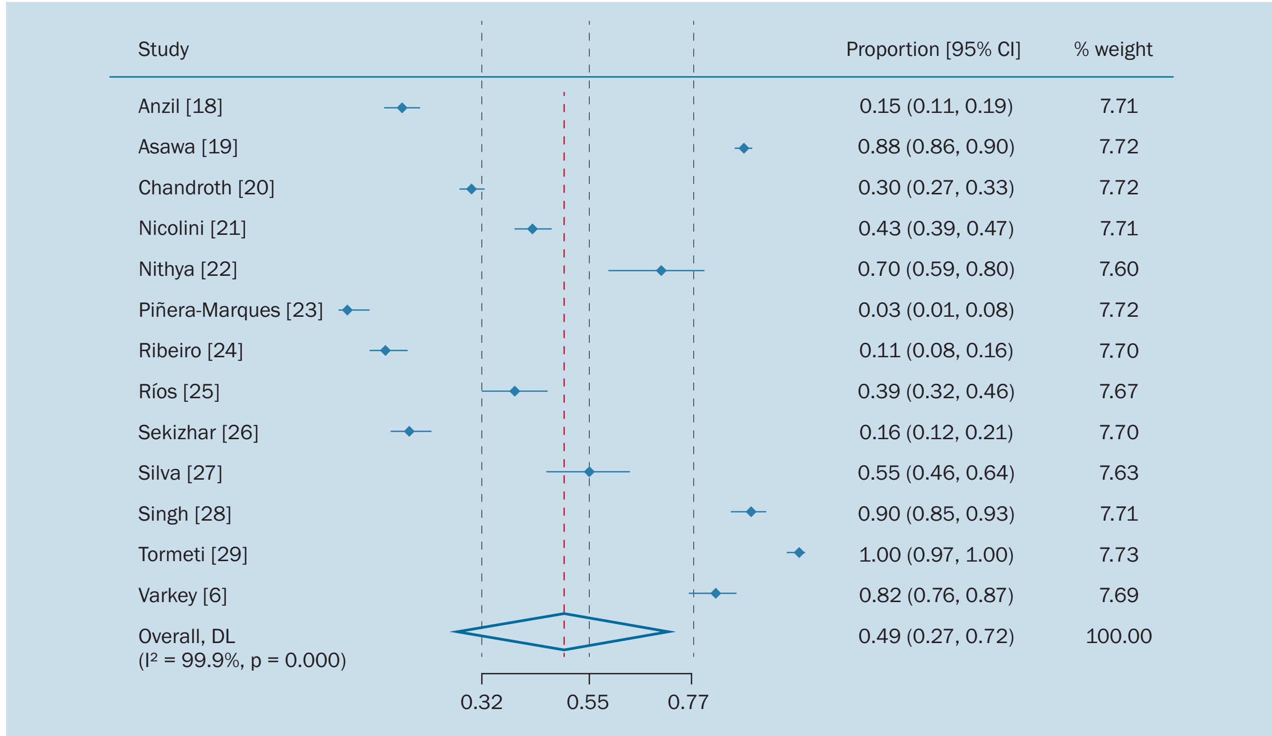

Figure 2. Meta-analysis of the pooled prevalence of oral and perioral lesions among fishermen

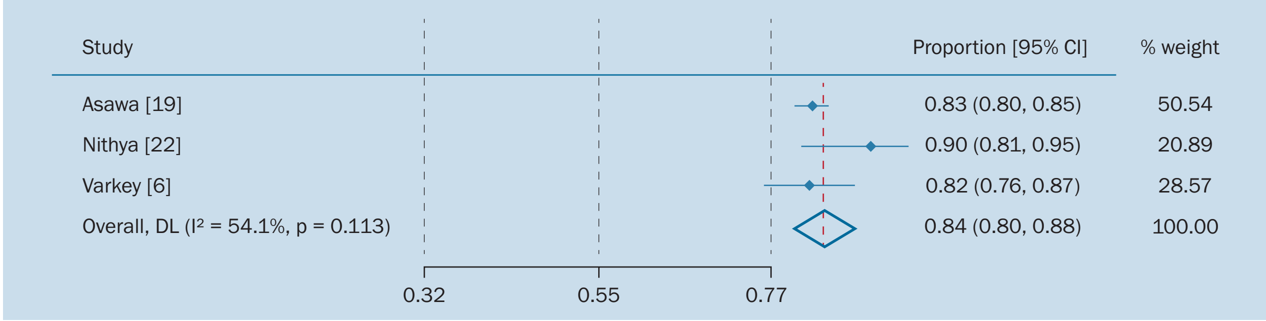

Figure 3. Meta-analysis of the pooled prevalence of dental caries among fishermen

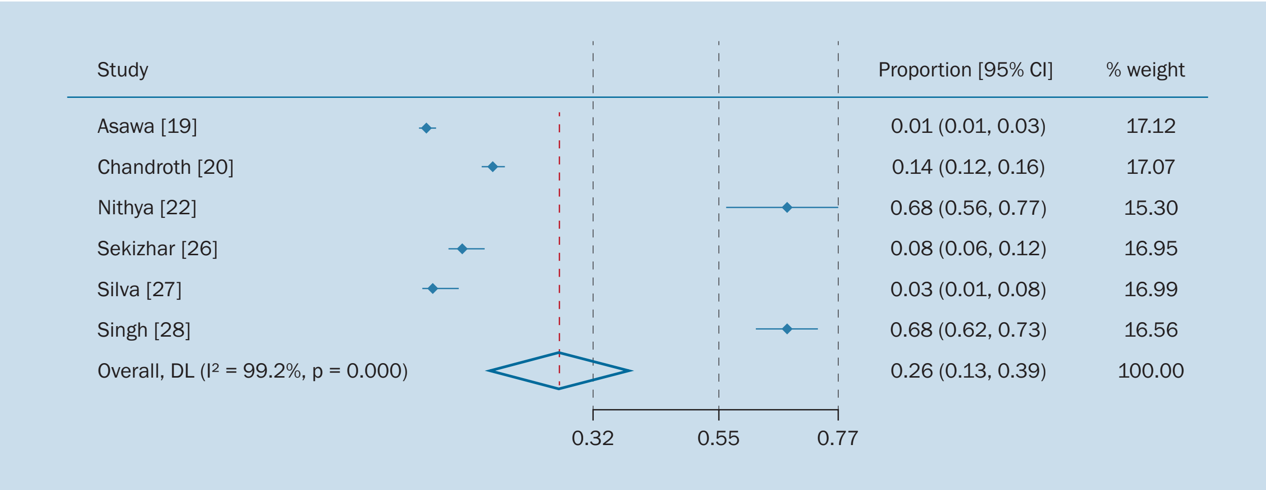

Figure 4. Meta-analysis of the pooled prevalence of leukoplakia lesions among fishermen

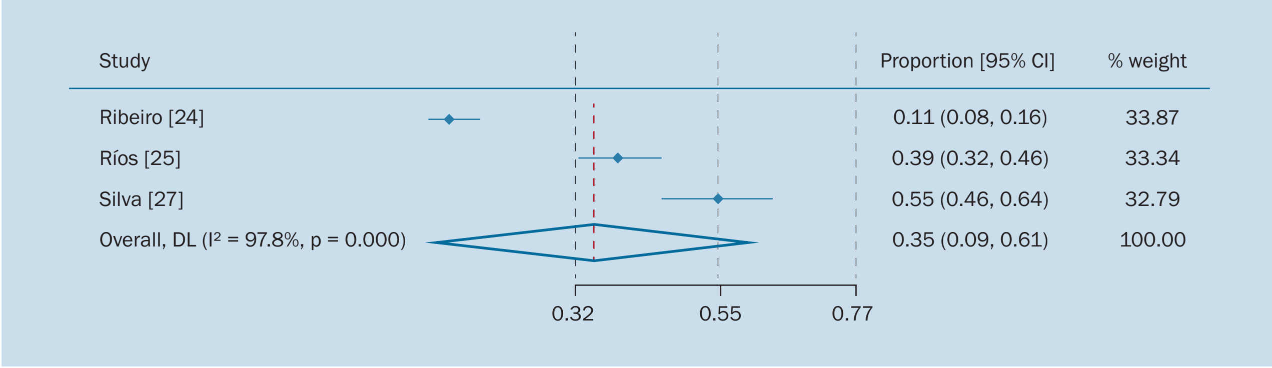

Figure 5. Meta-analysis of the pooled prevalence of actinic cheilitis among fishermen

can be attributed to the differences between the reality of the fishing communities analyzed in the different geographical locations, the previous health conditions of these populations, the level of guidance on oral and perioral health and protective measures, and the time of exposure to risk factors, not assessed by the included studies.

No similar systematic review was explicitly identified assessing the prevalence of fishing community and oral and perioral diseases. A review published in 2023 evaluated the prevalence of these diseases in maritime settings and revealed that seafarers are at a higher risk of developing lip, tongue, and oral cavity cancer [5]. We found only one study [24] assessing lip squamous cell carcinoma, showing a prevalence of 3.2% among fishermen.

The present systematic review rigorously followed the JBI and Cochrane methodological recommendations for prevalence reviews, using a sensitive search strategy across multiple databases to minimize the likelihood of missing relevant studies. However, the included studies have limitations mainly related to the nature of the cross-sectional study design. Given the lack of a temporal longitudinal observation, inferring a correlation between the risk factor exposure and the disease is complex.

Furthermore, these studies are susceptible to measurement and confounding biases, which could have influenced prevalence outcomes. Additionally, there was a lack of information regarding the duration of occupation and exposure time among participants.

Estimating prevalence of oral and perioral diseases is essential for informing occupational health policies and guiding the implementation of culturally appropriate preventive and educational interventions among fishermen. These concerning findings should prompt the development of public policies targeting coastal regions and fishing communities, focusing on accessible oral health prevention measures. Several preventive measures were reported in the included studies, such as the use of physical sun protection (e.g., hats, sunscreen), community-based education on oral hygiene and tobacco cessation, and occupational health surveillance programs focused on the early detection of oral lesions. However, adherence to these measures was frequently limited, underscoring the need for more structured, accessible, and culturally tailored interventions for fishermen. Additional preventive actions, such as external health promotion campaigns, regular dental screenings, and the distribution of low-cost protective equipment, were also identified as essential for mitigating risks and promoting timely health practices within this vulnerable occupational group.

CONCLUSION

Based on low-certainty evidence, oral and perioral diseases seem prevalent among fishermen, mainly dental caries, actinic cheilitis, and leukoplakia. The most frequent risk factors identified as associated were smoking habits, alcohol consumption, and poor oral hygiene. These findings should be recognized as a public health concern and addressed through preventive and informational policies in fishing communities and related organizations. Further studies using more reliable methods, larger sample sizes, and adequate management of confounding factors are necessary to confirm these findings.

ARTICLE INFORMATION AND DECLARATIONS

Author contributions: All authors contributed to the study's conception and design. MMM, ALCM, ABSL, MAAMM, GMS, MLLG, and GCML performed material preparation, data collection, and analysis. MMM, ALCM, ABSL, SKB, MLLG and EMS wrote the first draft of the manuscript, and all authors commented on previous versions. All authors read and approved the final manuscript.

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Supplementary material: Supplementary Tables 1 and 2.

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ORIGINAL ARTICLE

Characteristics of Polish travellers admitted at the University Centre of Maritime and Tropical Medicine in Poland, 2024–2025

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ABSTRACT

Background: *Poland, a Central European country with the population of 37.5 million and a steadily improving economic situation, has experienced a continuous increase in the number of international travels, exceeding 15 million annually. The aim of this article was to profile Polish travellers seeking pre-departure advice between 2024 and 2025 at the largest diagnostic and treatment center for tropical and travel medicine in Poland.*

Material and methods: *This retrospective study was based on the analysis of medical records of patients seeking pre-travel consultations at the University Centre of Maritime and Tropical Medicine in Gdynia, Poland. The dataset included 2,197 visits recorded in 2024 and 3,073 visits in 2025. The analysis focused on the following variables: age, sex, and travel-related characteristics, including purpose of travel, duration of stay, month of departure, and planned destinations by continent and country. The scope of preventive measures recommended or administered during consultations, including immunoprophylaxis and chemoprophylaxis, was also evaluated. Additionally, the health status of patients presenting to the travel medicine centre was assessed.*

Results: *Patients seeking pre-travel advice were predominantly aged 18–35 years (49.5%) in 2024 vs. 46–65 years (50.5%) in 2025. Most of the examined patients travelled for tourism purposes, typically for up to 4 weeks, with departures most frequently planned for November, January, and February. The majority of travellers intended to visit Asia and Africa, most commonly Thailand (22.3% in 2024, 21.0% in 2025), Vietnam, Kenya, Indonesia, Tanzania, and India. The most frequently administered immunoprophylaxis included vaccinations against typhoid fever, hepatitis A, tetanus/diphtheria/pertussis/poliomyelitis and rabies. Other commonly recommended preventive measures included insect repellents, sunscreen, antidiarrheal medications, antimalarial drugs, and antithrombotic agents. Analysis of patient interviews showed that 41.4% of travellers admitted at the UCMTM in 2024 had underlying medical conditions. In contrast, among patients presenting for pre-travel consultations in 2025, as many as 62.0% reported various health problems. The most commonly reported medical conditions included allergies, thyroid disorders, cardiovascular diseases, psychiatric disorders, and gastrointestinal diseases.*

Conclusions: *A substantial proportion of Polish travellers visit destinations associated with an increased risk of infectious diseases. At the same time, due to the ageing of the Polish population, individuals aged 46–65 travel more frequently, including patients with chronic diseases or disorders. Providing professional medical advice during pre-travel consultations plays a crucial role in reducing the risk of travel-related health problems and improving overall travel safety.*

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Keywords: Polish travellers, international travel, risk assessment, prophylaxis

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INTRODUCTION

Following the pandemic-related restrictions of 2020–2023, there was a sharp increase in international tourist arrivals, exceeding 1.52 billion worldwide in the first 12 months of 2025 (representing an increase of 60 million compared with 2024). Europe remained the world's largest destination region, recording 793 million international tourists in 2025, 6% more than in 2019 (i.e., before the COVID-19 pandemic). Western Europe and Southern Mediterranean Europe (France, Spain, Italy) recorded the highest number of visitors [1]. Poland, a Central European country with a population of 37.5 million and a steadily improving economic situation, has experienced a continuous increase in the number of international travels, exceeding 15 million annually. Turkey, Greece, and Egypt are among the most popular destinations for Polish travellers; however, recent years have also seen a substantial increase in the number of travels to tropical and subtropical regions of Asia, Africa, and Central and South America. The proportion of Poles who travelled abroad at least once in 2025 reached 44%, compared with 40% in 2024. The proportion of individuals travelling abroad for leisure several times per year also increased from 18% to 21% [2]. Hundreds of thousands of Polish tourists of all ages and health statuses seek medical advice from travel medicine centres in order to prepare adequately for travel to countries with different climatic and sanitary conditions. The aim of this article was to profile Polish travellers seeking pre-travel advice between 2024 and 2025 at the largest diagnostic and treatment centre for tropical and travel medicine in Poland.

MATERIAL AND METHODS

STUDY POPULATION

All patients who sought pre-travel consultations at the Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine (UCMTM) in 2024 (n = 2,147) and in 2025 (n = 3,073) were included in this study. Patient demographics (age and sex), travel-related information (purpose of travel, duration of stay, month of departure, and destinations), and preventive measures undertaken (pre-travel vaccinations, chemoprophylaxis, and other interventions) were recorded and analysed. In addition, the health status of patients attending the travel medicine clinic was assessed based on the information obtained during structured interviews.

DATA COLLECTION

Prior to consultations, patients were asked to complete a pre-travel questionnaire containing personal data, travel details, planned activities, and past and present medical history, including any chronic conditions and medications. During the visit, the consulting physician completed the remaining sections of the questionnaire, including current health status, vaccinations received prior to the visit or recommended during the consultation, and any additional preventive measures advised.

ETHICAL CONSIDERATIONS

As this was a non-interventional, cross-sectional study based on the retrospective analysis of anonymised medical records, approval from a Bioethics Committee was not required under applicable regulations.

RESULTS

TRAVELLER AND TRAVEL CHARACTERISTICS

In 2024, 52.3% of the total number of 2,197 patients were women, and 47.7% were men. Patients who sought pre-travel advice were predominantly aged 16–35 years old (48.1%). The majority travelled for tourism purposes (82.1%), for up to 4 weeks (85.6%), with departures most frequently planned for February and November (25.7% of travellers combined).

In 2025, 50.7% of the total number of 3,073 patients were women, and 49.3% were men. Patients who sought pre-travel advice were predominantly aged 36–65 years old (50.5%). The majority travelled for tourism purposes (85.4%), for up to 4 weeks (86.9%), with departures most frequently planned for January and November (26.2% of travellers combined).

The Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine in Gdynia does not provide medical consultations for individuals under 18 years of age (Tab. 1).

MEDICAL HISTORY

The analysis of patient interviews conducted in 2024 (n = 2147) showed that 58.6% of travellers had no pre-existing medical conditions, whereas 41.4% reported underlying diseases requiring the use of chronic medications. The most commonly reported conditions included thyroid disorders (13.9%), allergies (13.8%), cardiovascular diseases (10.2%), psychiatric disorders (5.6%), and gastrointestinal diseases (5.6%). In contrast, among patients presenting for pre-travel consultations in 2025 (n = 3073), only 38.0% reported no health-related conditions, whereas 42.2% of travellers required chronic use of medications, most frequently for allergies (14.7%), thyroid disorders (14.3%), cardiovascular diseases (11.2%), psychiatric disorders (6.5%), and gastrointestinal diseases (5.9%) (Tab. 2).

Table 1. Characteristics of Polish travellers consulted at the Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine in 2024 (n = 2147) *vs.* 2025 (n = 3073)

Travellers and travel characteristics	Number of travellers in 2024; n (%)	Number of travellers in 2025; n (%)
Sex		
Male	1049 (47.7)	1514 (49.3)
Female	1148 (52.3)	1559 (50.7)
Age [years]		
< 18	0 (0.0)	0 (0.0)
18–35	1057 (48.1)	1361 (44.3)
36–65	1013 (46.1)	1553 (50.5)
> 65	127 (5.8)	159 (5.2)
Travel purpose		
Tourism	1803 (82.1)	2624 (85.4)
Business	326 (14.8)	419 (13.6)
Others	68 (3.1)	30 (1.0)
Travel duration		
< 4 weeks	1880 (85.6)	2672 (86.9)
> 4 weeks	317 (14.4)	401 (13.1)

Table 2. Medical history of Polish travellers consulted at the Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine in 2024 (n = 2147) *vs.* 2025 (n = 3073)

Patients' medical history	Number of travellers in 2024; n (%)	Number of travellers in 2025; n (%)
No pre-existing conditions	1288 (58.6)	1168 (38.0)
Patients taking chronic medications	909 (41.4)	1297 (42.2)
Allergies	304 (13.8)	451 (14.7)
Thyroid disorders	305 (13.9)	440 (14.3)
Cardiovascular diseases	223 (10.2)	345 (11.2)
Psychiatric disorders	123 (5.6)	200 (6.5)
Gastrointestinal diseases	123 (5.6)	181 (5.9)
Respiratory illnesses	70 (3.2)	90 (2.9)
Urogenital diseases	66 (3.0)	77 (2.5)
Diabetes mellitus	66 (3.0)	76 (2.5)
Skin diseases	58 (2.6)	80 (2.6)
Neoplasms	40 (1.8)	55 (1.8)
Neurological diseases	45 (2.0)	49 (1.6)
Pregnancy	6 (0.3)	30 (1.0)

TRAVEL DESTINATIONS

The study data indicated that Asia and Africa were the most popular travel destinations among Polish travellers included in the study in both 2024 and 2025. The most frequently visited countries in 2024 included Thailand (22.3%), Vietnam (8.1%), India (7.9%), Indonesia (7.2%), Kenya (7.1%), and Tanzania (6.8%). In 2025, Thailand remained the most popular destination (21.0%), followed by Vietnam (9.7%), Kenya (9.5%), Indonesia (6.8%), Tanzania (6.7%) and India (6.0%) (Tab. 3).

VACCINES AND RECOMMENDED CHEMOPROPHYLAXIS

The most frequently administered vaccines included typhoid fever vaccine (single dose), hepatitis A vaccine (two-dose schedule), tetanus/diphtheria/pertussis/poliomyelitis (single dose), and rabies (two or three-dose schedule). Other commonly recommended or prescribed preventive measures included insect repellents, sunscreen, antimalarial drugs, antithrombotic prophylaxis, and antidiarrheal medications (Tab. 4).

DISCUSSION

Travellers planning to visit countries with challenging environmental conditions (e.g., high temperatures, high humidity, low sanitary standards) should take appropriate precautions to minimise the risk of infections. Recommended preventive measures include completion of all required and recommended vaccinations, as well as counseling on self-medication (e.g., antimalarial chemoprophylaxis, prevention and treatment of travellers' diarrhoea, etc.) [3]. Travellers with cardiovascular diseases or associated risk factors (e.g., obesity, hypertension, hypercholesterolaemia) are advised to undergo a resting electrocardiogram (ECG) prior to international travel [4]. A dental examination is recommended for all international travellers. Women may benefit from a gynaecological consultation, and individuals with visual impairment should consider an ophthalmological

Table 3. The most visited destinations by Polish travellers consulted at the Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine in 2024 (n = 2147) *vs.* 2025 (n = 3073)

Destinations	Number of travellers in 2024; n (%)	Number of travellers in 2025; n (%)
Continents		
Asia	1289 (58.7)	1723 (56.1)
Africa	625 (28.4)	948 (30.8)
South America	149 (6.8)	233 (7.6)
North & Central America	83 (3.8)	109 (3.5)
Australia & Oceania	30 (1.4)	31 (1.0)
Europe	16 (0.7)	18 (0.6)
Several continents	4 (0.2)	11 (0.4)
Countries		
Thailand	489 (22.3)	644 (21.0)
Vietnam	177 (8.1)	298 (9.7)
Kenya	157 (7.1)	291 (9.5)
Indonesia/Bali	158 (7.2)	209 (6.8)
Tanzania/Zanzibar	149 (6.8)	207 (6.7)
India	174 (7.9)	185 (6.0)
Sri Lanka	136 (6.2)	170 (5.5)
Cambodia	75 (3.4)	106 (3.4)
Philippines	66 (3.0)	94 (3.1)
Malaysia	70 (3.2)	86 (2.8)

Table 4. The list of selected vaccines and chemoprophylactic agents prescribed/recommended to Polish travellers consulted at the Outpatient Clinic of Travel Medicine, Tropical Diseases and Occupational Medicine at the University Centre of Maritime and Tropical Medicine in 2024 (n = 2147) *vs.* 2025 (n = 3073)

Vaccines	Number of doses in 2024	Number of doses in 2025
Typhoid fever (1 dose)	2122	2592
Hepatitis A (2 doses)	1945	2269
Tetanus, diphtheria, pertussis or tetanus, diphtheria, pertussis, poliomyelitis (1 dose)	1620	1947
Rabies (2 or 3 doses)	1477	1860
Hepatitis A+B (3 doses)	829	922
Yellow fever (1 dose)	558	745
Cholera (1 or 2 doses)	284	306
Meningococcal infections A,C,W-135,Y (1 dose)	231	269
Japanese encephalitis (2 doses)	180	339
Chemoprophylaxis	**Number of travellers in 2024; n (%)**	**Number of travellers in 2025; n (%)**
Repellents	1568 (71.4)	2346 (76.3)
Antidiarrheal medications	1126 (51.2)	2349 (76.4)
Sun protection	1398 (63.6)	2128 (69.2)
Antimalarial medications	887 (40.4)	1285 (41.8)
Antithrombotic medications	857 (39.0)	1057 (34.4)
Altitude sickness medications	43 (2.0)	40 (1.3)

examination before departure [5, 6]. Each traveller should prepare and carry an appropriately equipped travel medical kit tailored to the destination, duration of travel, and individual health risks. The kit should include essential medications (including adequate quantities of chronic medications and contraceptives), wound-care supplies, insect repellents containing DEET (N,N-diethyl-meta-toluamide) or picaridin, probiotics, analgesics, antipyretics, antihistamines, medications for respiratory or urinary tract infections, topical disinfectants, eye drops, sunscreen, UV-protective sunglasses and hand disinfectants. Travellers with severe allergies (e.g., to *Hymenoptera* venom) should carry a pre-filled adrenaline auto-injector. Spare eyeglasses or contact lenses should also be included when necessary [3, 6].

Travellers should familiarize themselves with disease-prevention strategies relevant to their destination. These include gradual acclimatization to climate, altitude, and time-zone changes; adherence to food and water hygiene precautions; maintenance of personal and accommodation hygiene; and prevention of insect bites through the use

of repellents, mosquito nets and wearing protective clothing. Contact with animals (both domestic and wild) should be avoided at all times. In the event of an animal bite or scratch, the wound should be washed thoroughly with soap and water, and immediate medical attention should be sought for rabies post-exposure prophylaxis. Previously vaccinated individuals require booster doses, whereas unvaccinated individuals require full post-exposure vaccination regimens, including the administration of human rabies immunoglobulin (HRIG) when indicated [7]. Additional safety recommendations include protection against excessive sun exposure, avoidance of non-sterile needles or procedures (to prevent HIV, HBV, and HCV transmission), consistent condom use to prevent sexually transmitted infections [8], and avoidance of walking barefoot in potentially contaminated areas to reduce the risk of transmission of parasitic infections such as cutaneous larva migrans [9]. Both travellers and healthcare professionals providing pre-travel consultations should be familiar with the fundamental principles of travel medicine to ensure effective prevention of travel-associated health risks.

Pre-travel health interventions can prevent the acquisition of communicable diseases and reduce the risk of transmission during or after international travel. Travel medicine centres should collect data to expand the evidence base regarding the risks of exposure, and costs associated with pre-travel interventions. This evidence base can inform recommendations for specific groups of travellers and the formulation of population-specific health policies [10].

CONCLUSIONS

Polish travellers frequently visit destinations associated with an increased risk of infectious diseases. Concurrently, due to the aging of Polish population, individuals aged 46–65 travel more frequently, including those with chronic medical conditions. Providing patients with professional medical advice during pre-travel consultations plays a crucial role in reducing the risk of travel-related health problems and improving overall travel safety.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: The data used in the article are available from the author's resources.

Ethics statement: As this was a non-interventional, cross-sectional study based on the retrospective analysis of anonymised medical records, approval from a Bioethics Committee was not required under applicable regulations.

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Characteristics of disease patterns in tuna fishermen

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Dear Editor,

the publication on *Characteristics of disease patterns in tuna fishermen in Pelita Jaya hamlet, West Seram regency in 2024* [1] is interesting. The study aimed to investigate the characteristics of diseases among tuna fisherman in Pelita Jaya Village, West Seram Province, which is an important topic, particularly among marine workers who are commonly overlooked in terms of health. However, the chosen method has significant limitations that may reduce the findings' reliability and generalizability. For example, using "accidental sampling" or convenience sampling may result in sample bias, which may not accurately represent the area's fishing population. Furthermore, the sample size of 68 participants is considered small, which may result in incorrect or insufficient statistical significance.

In terms of statistics, the majority of the reported results are still descriptive statistics, such as frequency distribution, rather than inferential statistics, which are used to test the relationship between health behaviors, such as smoking or drinking alcohol, and disease characteristics, such as gastritis or back pain. Inferential statistics would make it easier to detect risk variables. Furthermore, the classification of "moderate" activities, such as moderate alcohol intake, lacks a precise definition, thus complicating the interpretation of the data.

Important points that should be brought up for broader consideration in the discussion of the results include the following: Does the work environment effect health? How responsive and accessible is the local healthcare system to fishermen's needs? To what extent do fisherman know about and how do they feel about healthcare? And should certain illnesses that are associated with fishing be classified as occupational diseases? More focused preventative and health promotion initiatives may result from these inquiries.

When the results are re-analyzed in the context of informal workers' health, a new perspective may be found: the characteristics of various diseases found may be the cumulative result of structural inequalities, such as lack of health welfare, limited access to medical services, and lack of state health insurance. The fact that the main diseases, such as gastritis, respiratory tract infections, and back pain, reflect chronic stress, hard work in challenging environments, and imbalanced nutrition. Future research should include social and psychological dimensions to gain a more comprehensive understanding and translate the results into more effective policy applications.

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Special Edition – Medical Repatriation and TMAS

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Editorial

by James A. Denham

Dear Readers,

Welcome to this Special Edition of the IMH Magazine, dedicated to the complex and sometimes unnoticed topic of medical repatriation and maritime Telemedical Assistance Services (TMAS).

As you will learn in the pages that follow, in maritime medicine, the decision to send a seafarer home is rarely a simple logistical matter. It is frequently a medical judgment that has been shaped by limited onboard resources, operational realities of the vessel while at sea, and the physician's responsibility to maintain a balance between clinical care and the safety and wellbeing of the individual seafarer. Additionally, the regulatory framework provided by the Maritime Labour Convention (MLC 2006) emphasizes the importance of ensuring appropriate medical care and repatriation when illness or injury occurs far from shore.

This issue of the Magazine brings together several perspectives from experienced TMAS practitioners who share insights drawn from their daily clinical work supporting ships around the world. Their contributions highlight the complexity of medical decision-making in maritime environments and the collaborative nature of telemedical assistance.

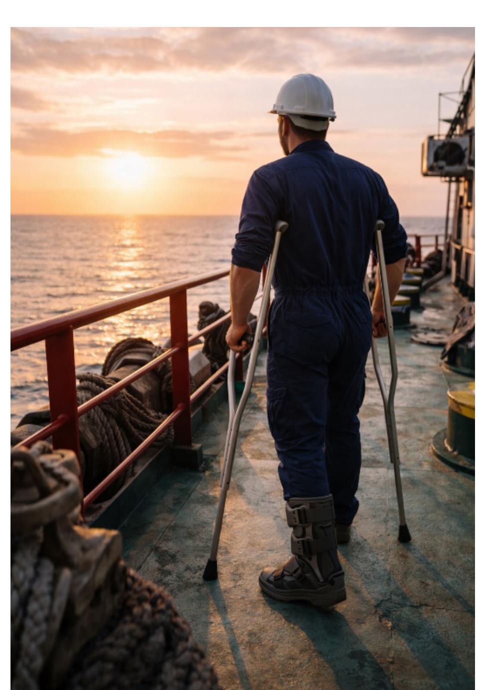
We hope that this special edition will not only be an engaging read but can also serve as a useful reference for maritime health professionals who may one day face the difficult question of when going home becomes, above all, a medical decision.

On behalf of the editorial team, thank you for joining us in exploring this important aspect of maritime medicine.

Warm regards,
James A. Denham, MD
Editor, IMH Magazine

WHEN GOING HOME BECOMES A MEDICAL DECISION: REPATRIATION, RESPONSIBILITY, AND THE AMENDED MLC

by James A. Denham



Conceptual illustration of seafarer repatriation generated using artificial intelligence

Summary: Repatriation of seafarers is often treated as an administrative endpoint, yet it represents a complex medical, legal, and social transition. The 2024 amendments to the Maritime Labour Convention (MLC) emphasise timely repatriation and highlight the risks of delay. This editorial examines the role of maritime clinicians and TMAS in assessing fitness to travel and argues that repatriation is a clinical decision with significant human consequences.

Keywords: maritime medicine; repatriation; Maritime Labour Convention; TMAS; fitness to travel; seafarers; medical decision-making

Repatriation is frequently regarded as the last administrative step to take after a seafarer had experienced an illness or an injury while working at sea. Administratively, a ticket is booked, a handover document is prepared, and the case is considered closed. However, for the seafarer, repatriation is rarely a conclusion of the process. It represents a medically and socially significant transition, one that can affect their recovery, financial stability, and overall long-term health.

The recent amendments to the Maritime Labour Convention (MLC), which became effective in late 2024, invites us to view this moment not merely as a logistical detail, but as shared responsibility extending over medical, legal, and operational areas. For maritime clinicians, this shift matters.

The MLC has long recognised that seafarers have the right to be repatriated at no cost when illness or injury renders them unfit for duty. The amended Convention highlights something that practitioners have known intuitively but seldom expressed: any delays during the repatriation process can also be harmful. Extended stays in foreign ports, while waiting for a decision, documentation, or financial guarantees, can expose seafarers to interrupted care, psychological stress, and uncertainty during a moment when they are most vulnerable. Therefore, the Convention's renewed amendments focused on prompt repatriation and enforceable financial security are not just a labour safeguard, they are also a health protection measure.

But where does medicine meet liability? Medical disembarkation starts a chain of decisions that is not controlled by a single actor. Shipowners, agents, insurers, flag States, and port authorities all have a defined and important role. Yet in practice, it is often the medical assessment, particularly determining their "fitness to travel," that becomes a pivoting point of repatriation. This places maritime physicians and TMAS providers in a quiet yet substantially influential position. Clinical caution is essential, yes, but so is to recognise when a prolonged overseas tour will serve no medical purpose.

The amended MLC does not dictate clinical judgement, but it sharpens the consequences of indecision. The uncomfortable question that follows now is, once a decision has been taken, are we aware of the impact that our recommendations causes downstream?

The amended MLC reinforces that once a seafarer is medically deemed unfit to continue their service, repatriation is no longer discretionary. For clinicians, being clear about documentation and explicit on the statements regarding "fitness for duty" and "fitness to travel" are no longer administrative niceties, but essential for protecting the patient.

Is there a human cost behind this process? Yes, repatriation may sometimes coincide with contract termination, loss of income, and uncertainty about future employability. In many labour-supplying countries, access to follow-up care and social protection is limited. Decisions made during the repatriation phase can therefore echo long after the seafarer steps off the aircraft at home. To maintain the holistic view of health, the process cannot stop at hospital discharge. It requires us to consider the whole picture.

A Call to Clinical Responsibility

The amended MLC strengthens legal clarity, but it cannot replace professional judgment. Maritime clinicians and TMAS providers occupy a critical intersection between law and care. Their assessments influence not only medical outcomes, but dignity, fairness, and recovery.

As this issue explores repatriation from multiple perspectives, one message deserves emphasis at the outset: **sending a seafarer home is never a purely administrative act.** It is a medical decision with legal weight and human consequences — and it deserves to be treated as such.

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News

contributed by Nebojša Nikolić

FROM WHO

WORLD HAND HYGIENE DAY 2026

Each year since 2009, the SAVE LIVES: Clean Your Hands campaign has aimed to maintain global awareness of the importance of hand hygiene and infection prevention and control (IPC) in health care. The initiative also brings people together worldwide to support improvements in safe healthcare practices.

A large proportion of avoidable infections acquired during healthcare delivery can still be prevented through proper hand hygiene and effective infection prevention and control measures performed at the right times. These practices provide a high return on investment for health systems and countries by reducing the burden of healthcare-associated infections. In 2026, these actions — including proper hand hygiene — are more critical than ever.

Hand hygiene is not a luxury. Through global campaigning, the World Health Organization (WHO) reaches a worldwide audience to highlight that infection prevention and control — including hand hygiene — is fundamental to safe and effective healthcare systems. This includes health services dedicated to seafarers and maritime environments.

Hand hygiene is relevant to all healthcare workers, including providers on board ships and their patients, at every healthcare encounter.

Since 2009, WHO has developed tools, resources, and guidance each year to support healthcare settings in improving hand hygiene practices. For 5 May — World Hand Hygiene Day, WHO provides an Advocacy Toolkit designed for healthcare workers and organizations planning campaign activities on or around this date.

The toolkit can also be used by shipping companies and organizations promoting health on board vessels. It offers a framework for advocacy and guidance on developing campaign materials at the local level.

Annual 5 May Advocacy Toolkit: https://www.who.int/publications/m/item/annual-5-may-advocacy-toolkit.

FROM ILO

HOW MIGHT GENERATIVE AI IMPACT DIFFERENT OCCUPATIONS?

Much of the interest in artificial intelligence (AI) in connection to work concerns its possible effects on job loss — will jobs be replaced by AI or will they be transformed? While it is not possible to predict the future — particularly as the technology is still evolving — International Labour Organisation (ILO) researchers first developed a methodology in 2023, and later refined it in 2025, to estimate the potential effects of generative AI on existing occupations, and then in a second step, on employment. And that includes, of course, seafarers.

In the ILO "Jobs' level of exposure to artificial intelligence/Generative AI" index, occupations are grouped into four exposure gradients based on how much of their tasks could potentially be done by AI.

ILO exposure groups (simplified):

1. Gradient 1 — Low exposure (very little AI impact);
2. Gradient 2 — Some exposure/augmentation;
3. Gradient 3 — High exposure;
4. Gradient 4 — Highest exposure/strong automation potential.

Typical maritime crew occupations such as: deck ratings/able seafarers, engine room ratings/motormen/oilers, marine engineers and deck officers (partly) belong to manual, operational, and mechanical occupations that involve physical maintenance, equipment operation, navigation watchkeeping, mechanical troubleshooting, safety and emergency response. These tasks are not primarily text-, data-, or computer-based, which are the activities most exposed to generative AI.

Therefore, seafarers (engine and deck ratings) are generally classified in Gradient 1 — Low exposure to AI (sometimes described as "minimal GenAI exposure").

Artificial intelligence currently performs best at cognitive digital tasks such as writing, coding, document processing, and data analysis. Occupations with physical, environmental, and mechanical work — like maritime operations — are much harder to automate with AI alone. For seafarers, AI is more likely to assist rather than replace, for example: predictive maintenance systems, voyage optimization software, automated engine monitoring and decision-support for navigation, but the core work on board still requires human presence, manual work, and safety responsibilities.

You can check ILO's Jobs' level of exposure to artificial intelligence at: https://www.ilo.org/resource/article/how-might-generative-ai-impact-different-occupations.

FROM IMO

DEADLY ATTACK ON VESSEL IN STRAIT OF HORMUZ PROMPTS CONCERN FROM IMO CHIEF

The Secretary-General of the International Maritime Organization (IMO), Arsenio Dominguez, has expressed deep concern following a deadly attack on a vessel in the Strait of Hormuz that reportedly left at least four seafarers dead and three others severely injured.

In a statement issued after the incident, Dominguez said he was "alarmed and deeply saddened" by the attack and extended condolences to those affected.

"*My thoughts are with the families and loved ones of those affected, as well as the global maritime community mourning these losses*," he said.

The incident has also highlighted the precarious situation faced by thousands of maritime workers in the region. According to the IMO Secretary-General, approximately 20,000 seafarers remain stranded aboard ships in the Persian Gulf amid escalating risks and mounting psychological pressure.

"Around 20,000 seafarers remain stranded in the Persian Gulf, on board ships under heightened risk and considerable mental strain," Dominguez stated.

He described the situation as "unacceptable and unsustainable," urging all involved parties to take immediate action to safeguard maritime personnel and ensure safe passage through critical shipping routes.

Dominguez stressed that governments, maritime stakeholders, and other parties must fulfil their responsibilities under international law to protect seafarers and maintain freedom of navigation.

"*All parties and stakeholders have an obligation to take necessary measures to ensure the protection of seafarers, including their rights and well-being, and the freedom of navigation, in accordance with international law*," he said.

The Strait of Hormuz remains one of the world's most strategically important maritime chokepoints, carrying a significant portion of global oil shipments and commercial shipping traffic. Recent security incidents in the area have raised growing concerns about the safety of vessels and crews navigating the region.

IMO provides an indicative list of shipboard incidents in the vicinity of the Strait of Hormuz (incidents confirmed by the flag State of the relevant ship) as well as links to other resources here: Information related to shipping and seafarers — Strait of Hormuz and the Middle East: https://www.imo.org/en/mediacentre/hottopics/pages/middle-east-strait-of-hormuz.aspx.

FROM ITF

JOINT ITF–JNG STATEMENT: DESIGNATION OF WARLIKE OPERATIONS AREA IN THE STRAIT OF HORMUZ

On the 5th of March, the International Transport Workers' Federation (ITF) and the Joint Negotiating Group (JNG), issued following statement:

"*The International Transport Workers' Federation (ITF) and the Joint Negotiating Group (JNG), as the social partners of the International Bargaining Forum (IBF), agree to designate the Strait of Hormuz, Gulf of Oman and Persian Gulf as a Warlike Operations Area (WOA) following a review today by the IBF Warlike Operations Area Committee (WOAC).*"

The designation upgrades the High-Risk Area designation applied to the Strait of Hormuz, Gulf of Oman and Persian Gulf on 2 March and reflects the continuing and heightened threat to seafarers and vessels operating in the region. Hundreds of vessels are stranded in the Gulf following the halt of vessel movements through the Strait of Hormuz, highlighting the scale of disruption and risk facing civilian crews in the region.

The WOA designation ensures that seafarers on IBF-covered vessels receive enhanced protection and compensation if they are stranded or operating in the area. Seafarers already within the designated area are entitled to additional compensation

and to request repatriation, noting the current, significant operational difficulties, while those instructed to enter it have the right to refuse to sail and request repatriation at the company's expense.

Under the terms agreed by the IBF parties, seafarers serving on vessels within or entering the designated WOA will be entitled to the following protections:

- A bonus equal to 100% of basic wage, payable for a minimum of five days, and for each additional day a vessel remains in the area.
- Doubled compensation for death and disability arising from incidents in the area.
- The right for seafarers to refuse to sail into the area, with repatriation at the company's cost and compensation equal to two months' basic wage.
- A recommendation for ship operators to implement enhanced security arrangements equivalent to ISPS Level 3.

These provisions reflect the standard protections applied to seafarers transiting Warlike Operations Areas under IBF agreements.

The ITF and JNG emphasise that the safety and welfare of seafarers must remain paramount. The safest way to protect seafarers is through de-escalation and a return to diplomacy. At present, the closure of international airspace across the majority of the region is also severely constraining repatriation options for seafarers seeking to leave vessels, further underlining the urgent need for stability and safe passage.

Seafarers operating in or near the designated area should remain vigilant and seek guidance from their companies or unions regarding their rights and options — while recognising that repatriation will be difficult due to restrictions and limitations on air travel and the rapidly evolving security situation. Shipowners and operators will make every effort to facilitate repatriation and take all available measures to safeguard crews.

The Strait of Hormuz is one of the most strategically important maritime routes in the world, through which a significant share of global energy and commodity trade passes, making peace and stability in the region critical for both seafarer safety and global trade.

The Warlike Operations Area designation will remain under weekly review by the WOAC.

FROM THE SEAFARERS' CHARITY

STRENGTHENING SKILLS FOR A SAFER SOUTH AFRICAN FISHING FLEET

The Seafarers' Charity is supporting a project which aims to increase the number of maritime professionals in South Africa qualified to support vital vessel stability inspection and certification processes.

The partnership project aims to address a critical shortage of naval architects across that region in a bid to address the safety challenges of the local fishing industry. The shortage puts pressure on vessel inspection and certification processes, creating a bottleneck and putting fisher safety at risk.

The two-year project "Upskilling maritime professionals in South Africa towards a safer fishing fleet" brings together the University of Southampton's Wolfson Unit with The Seafarers' Charity and the Northeast Centre for Occupational Health and Safety (NEC). It has been funded by Lloyd's Register Foundation as part of its "Engineering a Safer World" funding opportunity.

Its delivery will be supported by the Cape Town-based SSTG Maritime Training Academy which specialises in compliance audit services for the South African commercial fishing fleet. They will host the pilot course.

Work will be carried out to design and pilot a new, accredited course for developing expertise for local maritime professionals through abbreviated naval architecture training. Classroom-based activities, simulations and mock inspections will enable the trainees to undertake basic stability appraisals of fishing vessels, thus supporting fishing vessel inspection and certification processes.

While the initial project specifically targets South Africa, a feasibility study will investigate whether it could be expanded to more countries in the southern Africa sub-region.

Journal Club

WHEN HELP IS A CONTINENT AWAY: REFLECTIONS FROM A TMAS PHYSICIAN

by Katherine Sinclaire

Summary: This reflective article explores the realities of providing telemedical care to seafarers working far from shore. Drawing on personal experience, it highlights the operational, environmental, and human challenges that shape medical decision-making at sea, where access to definitive care may be days away.
Keywords: maritime medicine; TMAS; telemedicine; remote care; seafarers; decision-making; access to care; maritime environment

A patient is experiencing chest pain. The nearest hospital is two days away... A situation like this is not uncommon in telemedical assistance for ships at sea.

When I first took over management of a commercial maritime Telemedical Assistance Service (TMAS) program about eleven years ago, I was no stranger to providing remote medical advice. For many years, I had provided top-side support to medics working on remote sites and offshore vessels. I thought I understood the challenges of practicing medicine at a distance. *How different could it be*? I asked myself. But as it turned out, very.

Maritime medicine brings its own unique complexities. Early on, I had to learn an entirely new language of maritime terminology and abbreviations. I still remember the first time a vessel's master wrote "AGW WP" next to the ship's next port of call. I had to look it up and even got a few varied responses from Google. *All Going Well, Weather Permitting*, it turned out.

Very quickly, it became clear that providing medical advice to ships at sea requires far more than clinical knowledge. It demands an understanding of the maritime environment itself.

Sending someone ashore for medical care is rarely a straightforward process. Unlike a patient on land, a seafarer cannot simply walk out the door to a waiting taxi and head to the nearest hospital. The vessel may be days from the nearest port or committed to a tight commercial schedule. Even when a ship is approaching land, there is no guarantee that appropriate medical care will be available.

This means that every recommendation must be made with careful consideration of the vessel's location, its voyage plan, and the logistics involved in arranging care ashore. I remember telling a client once, "*Almost no decision to deviate a vessel is an easy one*." A medical evacuation or diversion can carry major operational and financial consequences, so the risks and benefits must be weighed very carefully.

One of the most valuable resources in this work is having access to reliable information about medical facilities around the world. Sometimes, the instinct may be to get a patient ashore as quickly as possible; however, if the local care available is limited, that may not be the best option. In some cases, it may actually be safer for the vessel to continue to another port where more appropriate medical services are available.

Although ships carry medical supplies and equipment in accordance with maritime regulations, the onboard medical locker will never replace the expertise of a hospital, doctor, or dentist. Accessing care ashore can be surprisingly difficult, even when a vessel is in port. Try finding a dentist on a Saturday evening when the ship is alongside for only twelve hours.

Despite these challenges, working in TMAS can be incredibly rewarding. Seeing a seafarer recover from illness or injury with the help of your guidance — and the dedication of their fellow crew members — is deeply satisfying. The seafaring community is among the most grateful and humble groups of people I have ever encountered.

At the same time, the work can be heartbreaking. There are moments when captains and crews do everything they possibly can to save the life of a colleague. Watching their determination and teamwork in the face of crisis is deeply humbling. And sometimes, despite everyone's best efforts, their friend and shipmate is lost.

One conversation during the COVID-19 pandemic has stayed with me ever since. A member of our medical team was speaking with a captain about a crew member who was struggling both physically and mentally. The ship had been at sea for nearly a year, unable to rotate its crews due to global restrictions.

She tried to express her sympathy. "*Captain*," she said, "*I understand. It must be very difficult for him — being at sea so long, unable to return home, unable to go ashore for care. He must be stressed and exhausted.*"

There was a long pause. Then the captain sighed and replied quietly, "*Yes, ma'am. We all feel like that.*"

Moments like these remind us that behind every case we manage through TMAS is a team of individuals living and working together in a confined environment, often far from home for months at a time.
I often encourage our team to take a moment to pause and look around at the world we live in. Take a look at the room you are in and the objects surrounding you. Almost everything you see arrives by sea.
It is estimated that around ninety percent of the world's goods are transported by ships. Behind that enormous global supply chain are the seafarers who spend months away from home, working in difficult and often isolated conditions to keep global trade moving.
Providing medical care to those seafarers, no matter how far away they may be, is both a challenge and a privilege, especially when the nearest hospital may still be two days away.

EVACUATION DECISIONS IN ISOLATED MARITIME SETTINGS: A CLINICAL PERSPECTIVE

by George Ebralidze, MD

Summary: Medical evacuation decisions at sea represent a distinct form of clinical judgement shaped by diagnostic uncertainty, operational constraints, and environmental risk. This article examines how maritime clinicians balance the risks of evacuation against continued onboard care, highlighting the dynamic and context-dependent nature of decision-making. It emphasises the need for training that supports uncertainty management, risk assessment, and effective collaboration between shipboard and telemedical teams.
Keywords: maritime medicine; medical evacuation; TMAS; clinical decision-making; risk assessment; diagnostic uncertainty; remote medicine

INTRODUCTION

Medical evacuation at sea represents one of the most complex clinical decisions faced by ship's doctors and maritime telemedical assistance services (TMAS) [1, 2]. Unlike shore-based medicine, evacuation decisions in maritime settings are rarely based on purely clinical criteria. They are made in environments characterised by isolation, limited diagnostic resources, delayed access to definitive care, and significant operational and environmental constraints.
This perspective aims to explore evacuation decision-making as a distinct form of clinical judgement in isolated maritime settings, where risk assessment extends beyond medical indication alone. As maritime operations increasingly involve expedition vessels, remote itineraries, and prolonged voyages, the relevance of such discussions has become timelier for contemporary maritime medicine.
While international guidelines provide an essential framework for practice, evacuation decisions frequently require contextual interpretation. The central clinical question is often not whether evacuation is indicated in principle, but whether evacuation at a specific moment is safer than continued onboard management.

CLINICAL UNCERTAINTY AND RISK ASSESSMENT

Evacuation decisions at sea are commonly made under conditions of diagnostic uncertainty. Advanced imaging, comprehensive laboratory testing, and immediate specialist consultation may be unavailable. Clinical assessment therefore relies heavily on bedside evaluation, trend monitoring, and interpretation of incomplete information, often supported by telemedical consultation [1, 2]. A systematic review of TMAS in Europe describes teleconsultation as the predominant service and highlights persistent limitations and opportunities for modernisation [3]. In this context, evacuation is not a binary medical decision but a dynamic process of risk assessment. The ship's doctor must balance the potential progression of the medical condition against the risks associated with evacuation itself, including weather conditions, distance to shore, asset availability, night-time operations, and risks to the patient, crew, and rescuers. Recent reports show that point-of-care ultrasound, reviewed remotely via tele-ultrasound, can clarify diagnosis and appropriately expedite emergency evacuation from cruise ships [4]. Evidence from prospective evaluation of air evacuations from cruise ships also suggests high diagnostic accuracy by ship physicians and that the majority of evacuations are clinically warranted [5].

EVACUATION VERSUS CONTINUATION OF ONBOARD CARE

A defining feature of maritime evacuation decisions is the need to weigh medical risk against logistical and environmental risk. In some circumstances, continued onboard management with close monitoring and treatment may be safer than immediate evacuation [6]. However, evacuation may expose the patient and others to greater overall danger, depending on weather conditions, distance to shore, and operational constrains [1].

This contrasts with hospital-based practice, where escalation of care is typically associated with reduced risk. At sea, escalation through evacuation may paradoxically increase overall risk, particularly under marginal conditions. As a result, experienced clinical judgement, situational awareness, and shared decision-making become central to safe maritime medical practice. Close collaboration between the ship's doctor, TMAS, and the vessel's command is essential. Effective communication ensures that medical urgency is understood alongside operational feasibility, allowing for balanced and informed decisions.

IMPLICATIONS FOR TRAINING AND GUIDANCE

As maritime operations expand in complexity, evacuation decisions are likely to become more frequent and more consequential. This highlights the need for training that goes beyond guideline familiarity and explicitly addresses uncertainty management, risk-based decision-making, and communication during high-stakes remote consultations.

Further academic discussion may support the development of guidance and training frameworks that better reflect the operational realities faced by clinicians working at sea.

Points for discussion:

- When does the risk of evacuation outweigh the risk of continued onboard management?
- How much diagnostic uncertainty is acceptable before evacuation is justified?
- How can existing maritime medical guidelines better support context-dependent decision-making?
- What role can shared case-based reflection play in improving evacuation decisions across the maritime community?

CONCLUSION

Evacuation decisions in isolated maritime settings represent a distinct form of clinical judgement shaped by uncertainty, operational constraints, and shared responsibility. Open professional discussion of these realities may contribute to improved training, more realistic guidance, and stronger professional support for clinicians working in remote maritime environments.

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MANAGING MEDICAL CASES AT SEA: OPERATIONAL CHALLENGES IN SHORESIDE CARE AND REPATRIATION

by Vivian Andria

Summary: This article reflects on the practical challenges of delivering telemedical care to seafarers, based on high-volume operational experience. While most cases can be managed remotely, a subset requires timely shoreside evaluation, which may be delayed by administrative, logistical, and regulatory barriers. The discussion highlights how clinical judgement in maritime medicine extends beyond immediate presentation to include anticipated risk, access to care, and operational constraints, underscoring the importance of coordination between TMAS providers, vessels, and port authorities.

Keywords: maritime medicine; TMAS; telemedicine; repatriation; shoreside care; operational constraints; access to care; seafarers

In maritime telemedicine, most cases can be managed remotely, but a small proportion exposes the limits of access to care. I would like to share some reflections from this experience, particularly regarding the management of cases remotely and the coordination of shoreside care when necessary.

In our work, we typically handle approximately 2500 medical cases onboard vessels each year. Most of these cases can be managed through telemedical guidance alone. However, around 20% require some form of medical evaluation onshore, whether for diagnostic testing, specialist consultation, or treatment that cannot be provided onboard. Only a small percentage, generally between 1 and 2 percent, require emergency medical evacuation.

In medical emergencies, clear cases are typically managed quickly and efficiently, especially when national rescue coordination centres are involved or when the severity of the condition is evident, provided the weather conditions allow for it. However, situations that present greater operational complexity often involve cases that are not immediately life-threatening but still require timely evaluation, diagnostic clarification, or repatriation.

When a TMAS physician evaluates a case, the decision to recommend disembarkation is rarely based solely on the patient's condition during the specific moment. Several factors must be considered simultaneously: the patient's current clinical status, the likelihood of deterioration, the vessel's itinerary, the time to the next port of call, and the resources available onboard in case the patient's condition worsens. A patient may appear stable when a request is made to the port authorities, but the clinical situation may indicate a high probability that further evaluation or treatment will soon be necessary.

Difficulties can arise in practice when local authorities interpret cases that initially seem stable as non-urgent. Administrative procedures, immigration requirements, and limited availability of services during weekends or holidays can delay the disembarkation of ill crew members. In some cases, a vessel may depart before arrangements for medical sign-off or repatriation are finalized, leaving the crew member to seek care at the next port of call. Unfortunately, factors such as the vessel's itinerary, expected arrival time at the next port, weather conditions, and available medical resources are not always considered when these decisions are made.

Dental cases are a common example of this issue. When a crew member experiences dental pain and swelling, despite receiving onboard treatment with analgesics and antibiotics, a shoreside dental examination becomes necessary. Although these situations may not be classified as emergencies, unresolved dental infections can worsen quickly and might significantly impair a seafarer's ability to perform duties safely.

Another frequent challenge involves symptoms that are not immediately severe but may indicate a more serious underlying condition. Abdominal pain, severe headache, intense lower back pain accompanied by neurological symptoms, or signs suggesting renal or cardiac complications may initially appear stable. However, without access to diagnostic imaging or laboratory testing, determining the true nature of the problem may be difficult. In such cases, a timely shoreside evaluation can be essential to rule out potentially serious conditions such as pancreatitis, cholecystitis, cerebral haemorrhage, or infectious diseases.

Continuity of care for chronic medical conditions also presents practical challenges. Seafarers sometimes require replenishment of medications for conditions such as hypertension, diabetes, or dermatologic disorders. In many countries, pharmacies will only dispense these medications with a prescription issued by a locally licensed physician. As a result, even stable patients may need a shoreside medical visit simply to obtain the necessary prescription. Interruptions in treatment may occur for several reasons, including lost or damaged luggage, unexpected extensions of a contract, or delays in signing off due to operational circumstances.

Skin conditions are also a frequent concern. These represent a significant number of medical cases reported onboard

and may include chronic conditions such as eczema or psoriasis. Environmental factors such as temperature changes, work activities, stress, or exposure to different detergents may trigger flare-ups. Although onboard medical inventories may provide temporary relief, definitive treatment often requires a specific prescription that can only be obtained through consultation with a local physician.

There are also situations in which diagnostic imaging becomes necessary. When TMAS physicians recommend studies such as ultrasound or CT scanning, local procedures in some ports require an initial evaluation by a port physician before the test can be authorized. Even when a case has been managed remotely for several days and the need for imaging is clear, this additional step may delay access to diagnostic testing.

The Maritime Labour Convention (2006) establishes that seafarers who require medical care should have access to shore-based facilities and that the level of healthcare available to them should be comparable, as far as possible, to that available to workers ashore. While these principles are widely recognized, the practical implementation of timely access to medical care can sometimes be influenced by administrative procedures and differing interpretations of urgency.

One case that illustrates these challenges involved a 45-year-old seafarer who was evaluated ashore for abdominal pain radiating to the back. After examination, he was diagnosed with cholecystitis and advised to seek follow-up care when possible. From the telemedical perspective, the condition required definitive treatment, and arrangements were initiated for the crew member's disembarkation and repatriation. However, before these arrangements could be completed, the vessel departed and the crew member was advised to pursue repatriation at the next port of call. Situations like this demonstrate how operational timelines and medical planning do not always progress at the same pace.

Seafarers perform an essential role in maintaining global trade and supply chains, often while living and working far from home and with limited access to healthcare resources. The systems that support their medical care at sea rely on cooperation between vessels, telemedical assistance providers, port authorities, and local healthcare facilities. In many cases, this collaboration works well. When challenges arise, they often reflect the complexity of coordinating care across different jurisdictions and operational environments.

Sharing these experiences is intended simply to highlight some of the practical realities of managing medical cases at sea. Continued communication and cooperation among all parties involved can help ensure that seafarers receive timely and appropriate care whenever it becomes necessary.

CME

MEDICAL REPATRIATION OF SEAFARERS: A STRUCTURED CLINICAL GUIDE FOR MARITIME PHYSICIANS BASED ON A TRI-THRESHOLD FRAMEWORK

by James A. Denham

ABSTRACT

In maritime medicine, the decision to delay repatriation may itself become a patient safety risk when prolonged onboard management amplifies diagnostic uncertainty, cumulative risk, and functional impairment in safety-critical roles. Maritime Telemedical Assistance Service (TMAS) decision-making occurs within a uniquely constrained clinical environment characterized by limited onboard resources, delayed access to definitive care, and competing operational demands.

To address the complexity of repatriation decisions in maritime telemedicine, this article introduces a structured tri-threshold framework designed to guide maritime physicians in key clinical decision-making under such pressures as: (1) continuation of onboard management versus evacuation, (2) stabilization sufficient for commercial transfer versus continued hospitalization, and (3) fitness to travel versus fitness for maritime service. The framework offers a practical decision-support structure that may assist maritime physicians in systematically evaluating repatriation timing in complex operational environments. Clear differentiation of these thresholds reduces the risk of "threshold distortion," defined as the subtle recalibration of acceptable clinical risk in response to operational or logistical constraints.

The analysis further situates TMAS recommendations within the legal context of the Maritime Labour Convention (MLC), 2006, as amended, which affirms seafarers' entitlement to adequate medical care and repatriation. Clear documentation of clinical reasoning, including the distinction between transport tolerance and occupational fitness, supports the ethically grounded decision-making and strengthens patient-centred risk management strategy in maritime medical practice.

LEARNING OBJECTIVES

After reading this article, readers should be able to:

1. **Understand the role and ongoing clinical responsibility of the TMAS physician** during medical evacuation and repatriation cases, including decision-making, continuity of care, and coordination with operational and non-medical stakeholders while the patient remains onboard.
2. **Identify clinical scenarios that warrant medical evacuation or repatriation**, including acute medical, traumatic, neurological, and mental health conditions that exceed onboard or local port medical capabilities, and distinguish these from cases appropriate for continued local management.
3. **Assess fitness to travel and the safety of medical evacuation or repatriation** by evaluating the clinical stability of the patient, tolerance to transport modality, and anticipating the risks, and by determining whether transferring is safer than continued local or onboard care.
4. **Recognize how non-medical restrictions can influence evacuation and repatriation decisions**, including operational, immigration, legal, and logistical barriers, and define "threshold distortion" as a deviation of clinical decision-making that is driven by these factors.
5. **Apply ethical and professional principles when faced with threshold distortion** by maintaining clinical judgment focused on the patient, despite competing non-medical pressures, and by considering how constrained decisions may be perceived by patients, families, and external stakeholders.
6. **Maintain continuity of care and implement risk-mitigation strategies when repatriation is delayed**, by ensuring ongoing monitoring, treatment optimization, documentation, communication, and coordination among TMAS physicians, onboard personnel, port facilities, and case management teams.
7. **Understand ethical and legal responsibilities under the amended Maritime Labour Convention** and incorporate these obligations into clinical and operational decision-making related to medical care and repatriation.

Keywords: maritime medicine; TMAS; medical repatriation; clinical decision-making; risk assessment; tri-threshold framework; seafarers; telemedicine

1. INTRODUCTION

In the maritime medicine environment, the concept of time does not carry the same clinical neutrality as it often does on land. A seafarer who remains on board with an unresolved medical condition faces a progressively constrained care environment with limited diagnostic capability, intermittent monitoring, variable crew medical competence, and delayed access to specialist intervention. While some conditions can be stabilized at sea, others can evolve unpredictably in the absence of definitive evaluation.

Diagnostic uncertainty may persist longer than what is normally acceptable on land, and subtle clinical deterioration may go unnoticed. Psychiatric symptoms can worsen due to isolation and operational stress. Even in cases where overt deterioration does not occur, a prolonged symptom burden can impair functional performance in a safety-sensitive environment. For these reasons, decisions about repatriation are not just logistical matters; they are critical risk management choices that have direct implications for patient safety and the welfare of the crew. Recognizing the safety implications of delayed repatriation is essential before discussing operational feasibility or regulatory obligations.

2. ROLE AND RESPONSIBILITIES OF THE TMAS PHYSICIAN

Maritime Telemedical Assistance Services (TMAS) physicians play a crucial role in the medical management of sick and injured seafarers, particularly in those cases where evacuation or repatriation may be required. Unlike clinicians who are at shore, TMAS physicians assist patients who work in complex environments characterized by geographic isolation, limited onboard medical resources, variable access to port-based healthcare, and involvement with multiple non-medical stakeholders. As a result, their responsibilities can extend far beyond immediate clinical advice to cover longitudinal surveillance of patient care until definitive treatment or repatriation is achieved.

The TMAS physician is responsible for the ongoing care of the seafarer while the patient remains onboard or under the ship's operational control. This responsibility includes close assessment of the patient using developing information, providing guidance to onboard ship officers, and conducting timely reassessments to determine if the level of care needs to be escalated. Most importantly, the TMAS physician must anticipate any possible deterioration of the patient's condition and respond proactively, especially when evacuation or repatriation may be delayed.

> *In this context, the TMAS physician's critical role is to exercise sound clinical judgment, provide clear and actionable care guidance, and anticipate potential deterioration to prevent avoidable harm until definitive care or repatriation is arranged.*

During repatriation and evacuation scenarios, the TMAS physician acts as the primary clinical decision-maker regarding medical necessity, fitness to travel, and the timing of transfers. These decisions must be coordinated with shipboard personnel, port-based medical facilities, case managers, and, when applicable, with insurers and shipowners. While operational and logistical factors can influence feasibility, the TMAS physician's role is to ensure that clinical judgment remains focused on patient safety and medical needs.

Clear communication and meticulous documentation are essential parts of this role. TMAS physicians must state the clinical rationale for their recommendations, document any changes in the patient's condition, and record all conversations related to delays, restraints, or alternative management strategies. Such documentation not only will support continuity of care but also provide transparency and medico-legal protection in complex or contested cases.

Finally, the TMAS physician must act as an advocate for the seafarer within a multi-stakeholder system. This advocacy involves recognizing when non-medical constraints can jeopardize the patient's safety, appropriately escalate any concerns, and support decisions that prioritize health outcomes, while remaining conscious of the legal and operational frameworks that govern maritime practice.

3. CLINICAL SCENARIOS PROMPTING EVACUATION OR REPATRIATION

Medical evacuation or repatriation is often necessary when the clinical needs of a sick or injured seafarer exceed the diagnostic, therapeutic, or monitoring capabilities available on board the vessel or at the nearest port-based medical facility. While international regulations require vessels to carry medications and medical equipment appropriate to the size of their crew, these resources are mainly intended for initial stabilization and not for prolonged or definitive care and can be inherently limited.

3.1 Limitations of Onboard Medical Capability

Onboard medical care can be limited by human and material factors. While medical supplies on a ship are standardized, they may not include medications suitable for specific conditions or may be insufficient for prolonged treatment, particularly during long voyages, or in cases where repeated or multiple medical events occur. Medications may expire, become depleted, or lack therapeutic alternatives, which can restrict the ability of the physician to adjust treatment as the patient's condition evolves.

In addition, the level of medical training and hands-on experience among ship officers varies significantly. Although officers receive training in first aid and basic medical care, and are dedicated to helping injured or ill colleagues, they often have limited experience in handling complex wounds and burns, stabilizing fractures, establishing or maintaining intravenous access, or providing continuous clinical monitoring over extended periods. These limitations become particularly important when care must be maintained for several days, especially in cases involving complex physical injuries or acute mental health conditions that require continuous observation and structured support.

The physical environment of the vessel poses additional challenges to delivering care. Factors such as limited space, variable lighting, motion of the ship, and the lack of advanced monitoring or imaging capabilities can all contribute to an environment that is less than ideal for managing serious illness or injury beyond the initial stabilization phase.

3.2 Limitations of Port-Based Medical Facilities

Port clinics and local hospitals may also lack the resources required to provide definitive care. Common limitations include restricted access to specialised services, advanced imaging, surgical capability, intensive care, or rehabilitation facilities. In some regions, language barriers, variability in standards of care, and administrative and immigration constraints may further complicate timely evaluation and treatment.

When local facilities cannot provide care comparable to that required by the patient's condition, continued management in such settings may expose the seafarer to further risks, making evacuation to a higher-level centre or repatriation medically necessary.

3.3 Clinical Scenarios Commonly Requiring Escalation

Clinical situations that frequently surpass onboard and local care capabilities include acute traumatic injuries requiring surgical intervention, life-threatening medical emergencies such as acute coronary syndromes or cerebrovascular events, severe neurological injuries needing an evaluation by a specialist, and mental health conditions where structured support, monitoring, or proximity to family is required. In these scenarios, recognizing early the availability of resources is essential to avoid delays that may worsen outcomes.

Case Vignette

A seafarer developed an acute depressive episode following a distressing telephone conversation with a family member while the vessel was at sea. The ship's Master provided initial support and contacted the maritime Telemedical Assistance Service (TMAS) for guidance. Based on the information available at the time, the TMAS physician recommended close observation of the seafarer while arrangements were made for an online psychological consultation.

Due to personnel limitations and operational duties, continuous watch of the seafarer could not be guaranteed. No psychotropic medications were available on board, and options for immediate escalation of care were restricted by the vessel's location and operational constraints. The Master committed to regular welfare checks and increased engagement with the seafarer.

Several hours later, the seafarer was missing from his quarters. A thorough search of the vessel was conducted without success, prompting the initiation of a maritime search and rescue operation. Despite these efforts, the seafarer was not found.

This case exemplifies the limitations of onboard medical resources in handling acute mental health crises, especially when continuous observation, pharmacologic intervention, and immediate access to specialized care are unavailable. It emphasizes the importance of recognizing early warning signs of escalating crises and the challenges to protect vulnerable individuals in non-clinical environments.

4. FITNESS TO TRAVEL AND RISK–BENEFIT ASSESSMENT OF TRANSFER VERSUS LOCAL CARE *IS TRANSFER SAFER THAN STAYING?*

Decisions regarding medical evacuation or repatriation require a careful evaluation of the seafarer's clinical stability, potential progression of their condition, and the risks associated with the transfer, compared to continuing care onboard or the next port. Unlike practices on land, these decisions are often made with incomplete information, limited diagnostic capability, and under rapidly changing operational constraints.

4.1 Fitness to Travel: A Dynamic, Not Binary Concept

Fitness to travel in the maritime context should not be viewed as a simple yes-or-no decision but rather as an assessment of risks that depend on a specific time and circumstance. A seafarer who appears clinically stable at the time of evaluation may still experience a decline in health during transfer due to disease progression, interruptions in treatment, environmental exposure, or logistical delays.

Key elements that influence fitness to travel include:

- Hemodynamic and respiratory stability.
- Level of consciousness and neurological status.
- Pain management and need for ongoing interventions.
- Risk of sudden deterioration during transfer.
- Ability to maintain required monitoring and care while transferring.

Most importantly, the criteria for deeming a seafarer "fit" for travel must consider not only the act of transport itself but also the realities of pre-transfer waiting time and post-transfer continuity of care.

4.2 Risk–Benefit Balance: Transfer Versus Continued Local or Onboard Care

The decision to evacuate or repatriate should be guided by a structured comparison between:

- the **clinical risks of transfer**, and
- the **risks of delayed or suboptimal care** if the seafarer remains onboard or in a port facility.

Transfer-related risks may include physiological stress, limited access to advanced life support during transport, weather-related hazards, and prolonged transport times. Conversely, staying onboard or receiving local care may expose the seafarer to inadequate treatment options, insufficient monitoring, or the inability to manage foreseeable complications.

Mental health conditions require special consideration in this balance. Even in the absence of immediate medical instability, the lack of continuous supervision, the inability to provide pharmacological treatment, or the absence of specialized psychological care may shift the risk–benefit equation in favour of early disembarkation or repatriation.

4.3 Anticipating Deterioration and Escalation Thresholds

A critical component of the TMAS physician's role is to anticipate not only the current clinical status of the seafarer but also potential courses of deterioration. This includes recognizing conditions where delaying further actions could lead to irreversible harm, even if short-term stability is maintained.

Indicators that should encourage reconsideration of continued management onboard or locally include:

- Escalating care requirements that exceed available resources.
- Inability to guarantee appropriate monitoring or supervision.
- Progressive symptoms despite initial supportive interventions.
- Increasing risk to the seafarer's safety or to vessel operations.

In this context, the absence of deterioration should not be interpreted as proof of safety, particularly when the clinical course is unpredictable, and supervision is inherently limited.

4.4 Operational and Systemic Factors Influencing Clinical Decisions

Risk–benefit assessments are not made in isolation. Factors such as vessel itinerary, distance to a suitable port, weather conditions, crew replacement availability, and relevant contractual or regulatory frameworks all play a role in determining the feasibility and timing of transfer decisions. Although these factors are not medical in nature, they significantly impact clinical risk and should be considered by the physician.

The main challenge lies in balancing medical prudence with operational reality, ensuring that logistical convenience does not override the safety or professional responsibility of the patient.

> *In maritime medicine, the decision to transfer a seafarer is rarely about whether evacuation is possible, but whether continued onboard or local care remains defensible in light of foreseeable risks and system limitations.*

5. ETHICAL AND PROFESSIONAL RESPONSIBILITIES IN THE PRESENCE OF NON-MEDICAL CONSTRAINTS

Clinical decision-making in maritime medicine occurs in a complex environment. Maritime telemedical physicians often navigate at an intersection between medical judgment, commercial pressure, regulatory requirements, immigration restrictions, and operational feasibility.

When external pressures begin to influence the clinical threshold for evacuation, repatriation, or continued onboard management is recommended, threshold distortion may occur. While these factors can influence the practical execution of decisions, they should not redefine the clinical threshold at which escalation of care becomes necessary.

5.1 Primacy of Clinical Judgment and Dual Loyalty

The maritime TMAS physician's primary professional obligation is to the health and safety of the seafarer. This obligation requires that decisions regarding evacuation or repatriation be based on clinical assessment and foreseeable risk, rather than on cost, itinerary disruption, or administrative complexity.

Maritime medicine inherently involves a conflict of dual loyalty. The physician may be contracted by or advise commercial entities, whose operational priorities include cost containment, schedule adherence, and regulatory compliance. While these concerns are not inherently unethical, conflicts can arise when commercial interests clash with patient-centred risk assessments.

Operational considerations are valid factors to determine ***how*** a medically necessary transfer is done. However, they should not dictate ***whether*** clinical escalation is warranted.

Maintaining this distinction is crucial for professional integrity.

5.2 When Non-Medical Barriers Shape Clinical Decisions: Threshold Distortion

Decisions regarding medical evacuation or repatriation at sea can be influenced not only by clinical assessment but also by regulatory, operational, financial, and administrative issues, including the following:

- **Immigration and visa restrictions**, particularly in jurisdictions where seafarers are not eligible for entry.
- **Port state regulations**, including specific limitations on medical landing procedures or requirements prior authorization for disembarkation.
- **Operational pressures**, such as tight schedules, cargo commitments, adverse weather conditions, or limited port calls.
- **Financial and logistical considerations**, including costs associated with deviation, helicopter evacuation, medical escorts, or hospital care in specific locations.
- Anticipated delays in obtaining appointments onshore for further medical care.

While these factors are external and do not alter the seafarer's physiology, they are legitimate realities of maritime operations that may cause delays, alter feasibility, or complicate the implementation of medically indicated transfers.

When these barriers are significant, the thresholds for escalation may gradually shift, a phenomenon described here as **threshold distortion.** This concept relates to mechanisms well recognized in cognitive bias and systems safety literature, such as anchoring effects and normalization of deviance. This distortion occurs when clinicians unintentionally raise the level of acceptable risk due to logistical difficulties, administrative burdens, or commercial disruptions.

Threshold distortion rarely occurs as a straightforward decision that compromises care; rather, it develops subtly. For instance, if a patient is stable, the reasoning may be that he can be reassessed in 24 hours or to see how he responds before considering deviation.

While reassessment is appropriate in many cases, the cumulative effect of repeated deferral results in prolonged exposure to an elevated risk. Identifying this threshold distortion is then crucial because it often evolves incrementally and without a deliberate intention.

Although distortion in maritime practice more commonly manifests as progressive delay, the phenomenon can be bidirectional. Premature evacuation of an inadequately stabilized patient may equally introduce preventable risk, particularly when driven by defensive practice, institutional risk aversion, or heightened sensitivity to potential liability. The challenge for the TMAS physician lies then not in accelerating or deferring transfer reflexively, but in determining the safest moment for repatriation based on clinical readiness. Recognizing that structural and operational forces more frequently favour delay allows clinicians to counterbalance this asymmetry consciously while preserving calibrated medical judgment.

5.3 Immigration and Administrative Barriers as a Case Example

In some jurisdictions, particularly in states where visa waivers do not apply to seafarers requiring medical disembarkation, immigration restrictions may significantly delay or complicate medical disembarkation. The inability to obtain timely entry

clearance may lead to extended onboard management even when there are clear clinical indications for escalation.
Importantly, immigration barriers do not modify the underlying medical risk. They change only the pathway to definitive care. Therefore, physicians must avoid allowing administrative challenges to redefine what establishes as suitable clinical management. Where barriers exist, documentation should clearly reflect:
- The medical indication for escalation.
- The anticipated risks associated with delays.
- The rationale for interim management strategies.

This transparency is essential to ensure patient safety and professional accountability.

5.4 Delayed Disembarkation as an Active Risk Modifier

Delay is not risk-neutral. A lengthy onboard management can impact the clinical risk profile in several ways:
- Continued exposure to a limited monitoring capability.
- Restricted access to advanced diagnostics or specialist input.
- Increased likelihood of sudden deterioration without immediate intervention options.
- Escalating psychological stress for the seafarer and crew.
- Increasing operational constraints over time.

In certain conditions, such as evolving infections, unstable fractures, progressive neurological symptoms, or acute mental health crises, delays can turn a manageable situation into a life-threatening emergency.
Therefore, it is important to understand that a deferred disembarkation should be viewed as an active risk factor and not a passive delay.

5.5 Perception, Trust, and Professional Credibility

Clinical decisions made under operational restrictions are not evaluated only within the maritime context in real time. Instead, they may come under scrutiny by patients, families, regulatory bodies, insurers, or courts. When transfers are delayed in the presence of a foreseeable risk, affected individuals may perceive the decision as being influenced primarily by cost, convenience, or administrative barriers. Even when the original reasoning was clinically justifiable, inadequate documentation or unclear communication can create the impression of compromised judgment.
The TMAS physician must then maintain clarity regarding:
- The limits of acceptable clinical risk.
- The distinction between medical advice and operational decision-making.
- The obligation to communicate foreseeable consequences of delayed escalation.

Maintaining trust will require transparency, structured reasoning, and effective communication of both medical evaluations and system limitations.

5.6 Ethical Consistency in Uncertain Environments

Uncertainty is a fundamental aspect of remote maritime assessment. Diagnostic limitations, changing clinical progressions, and incomplete information make decision-making a challenge. In such environments, ethical consistency requires applying the same standard of anticipated risk as we would in a shore-based setting with comparable resource limitations.
If a condition is not considered safe for prolonged non-specialized management ashore, it should not be reclassified as acceptable simply because the patient is at sea.

6. A STRUCTURED FRAMEWORK FOR DECISION-MAKING UNDER CONSTRAINT

Recognizing clinical risk, identifying threshold distortion, and maintaining ethical consistency are necessary, but not sufficient on their own. In high-pressure maritime environments, structured decision-making helps reduce cognitive drift, enhance transparency, and strengthen defensibility. The following framework serves as a practical cognitive tool for TMAS physicians when assessing evacuation or repatriation under operational constraints.

Step 1 — Define the Clinical Risk Profile

Before considering feasibility, it is important to clearly define the medical situation:
- What is the working diagnosis?
- What complications are reasonably foreseeable?

— What monitoring or interventions may become necessary within the next 24–72 hours?
— What are the consequences if deterioration occurs without advanced support?

This step anchors the decision in pathophysiology rather than logistics.

By documenting clearly anticipated deterioration alongside the current stability status, it will also prevent any premature re-assurance.

Step 2 — Define Resource Capacity and Gaps

Evaluate the capabilities of the vessel and, if relevant or available, the local port medical facility by considering the following:

— Availability of medications and whether supplies are sufficient.
— Monitoring capacity and frequency.
— Crew competence for required procedures.
— Ability to maintain close supervision (especially in mental health cases).
— Access to follow-up consultation.

The central question is not whether care is possible, but whether it is sustainable and adequate given the expected course of events.

Step 3 — Identify External Constraints Explicitly

Rather than allowing non-medical barriers to influence reasoning in an implicit way, we should identify them explicitly. Here are some questions to consider:

— Will visa or immigration restrictions affect the seafarer's ability to disembark?
— Are there any procedural barriers imposed by the port state?
— Is vessel deviation operationally difficult?
— Are there any financial considerations which must be raised?

By stating these constraints openly, we can prevent them from subtly impacting our decisions. This approach turns implicit pressures into a clear and visible context.

Step 4 — Conduct an Explicit Risk–Benefit Comparison

At this stage, compare:

Risks of transfer		Risks of continued onboard or local care
Physiological stress of transport Delays in route Limited in-transit support	«versus»	Probability of deterioration Limited monitoring or intervention capacity Cumulative risk of delay

If ongoing management exposes the seafarer to foreseeable harm exceeding what is deemed acceptable in a similar shore-based setting, escalation of care will remain clinically indicated even if implementation proves to be complex.

Step 5 — Document Reasoning and Communicate Clearly

Structured documentation should include the following:

— Clinical findings and working diagnosis.
— Foreseen complications.
— Limitations of resources.
— Recognized external barriers.
— Clear reasons for transfer or continued management.
— Conditions that would trigger reassessment or immediate escalation.

Clear communication with the master, company representatives, and, where suitable, the seafarer or their family ensures that everyone's expectations are aligned, reducing the chances for misunderstanding later. Documentation serves not just as a protective measure, but also as a tool for clarity.

Step 6 — Dynamic Reassessment

Maritime clinical decision-making is rarely a static process. When transfers are delayed due to constraints, it is important to establish predefined intervals for reassessment. As delays continue, the acceptable level of uncertainty lowers.

Dynamic reassessment helps to ensure that the acceptance of elevated risks does not become a standard practice.

7. AIR TRANSFER AND CONTINUITY OF CARE DURING COMMERCIAL REPATRIATION

Operational planning should be integrated with medical risk assessment. For most non-critical maritime repatriations, transfers are carried out using commercial airlines instead of specialized aeromedical evacuation. While this method is cost-effective and logistically feasible, it poses unique clinical, operational, and regulatory challenges.

The duration of travel usually ranges from 24 to over 40 hours due to layovers, routing constraints, or visa-related issues. For instance, Asian seafarers with visa limitations traveling from South America to their home country might require routing their transit via Europe to avoid the United States, thus increasing total travel time.

Immigration and visa barriers can influence routing decisions and extend overall travel time. Long travels may increase fatigue, stress, and heightened exposure to clinical risks.

The transit phase also introduces specific hazards, such as hypoxia at cabin altitude, immobility-related thrombosis, dehydration, limited access to emergency intervention, psychological stress, fatigue and circadian disruption, and medication timing errors across time zones. For borderline cases, these risks may be clinically significant.

The clinician must understand that although routing decisions are logistical in nature, they have significant medical implications, especially in vulnerable patients.

Therefore, air transfer should be regarded as a distinct clinical phase with its own risk profile, rather than merely as a logistical detail.

7.1 Pre-Flight Clinical Clearance

Clearance to fly does not imply absence of risk; it indicates that the anticipated risk is acceptable under specified conditions. For instance, to declare a seafarer "fit to fly" without a medical escort, one must consider that:

- The patient is hemodynamically stable.
- Breathing air requirements are similar to those of any other passenger and don't require supplemental oxygen.
- The risk of deterioration in an environment with limited resources is low.
- Cabin altitude can be pressurized between 6,000 and 8,000 feet.
- The risk of thromboembolism is low.
- The patients can self-administer their medications.
- Their cognitive status and ability to care for themselves are adequate.

> *Commercial airline repatriation should only be considered when the patient's anticipated residual risk is low, predictable, and unlikely to require an intervention that exceeds what can typically be managed within standard airline emergency capabilities. The patient must be sufficiently stable so that no active medical management is anticipated during the flight.*

7.2 Escort Determination: Nurse or Physician

Decisions regarding whether to use a nurse or physician escort should be based on anticipated instability rather than convenience. An escort may be indicated in the following situations:

Nurse escort:

- Continuous monitoring is required.
- Administration of non-invasive medication is needed.
- There is a limited but predictable risk.

Physician escort:

- The patient has an unstable or potentially unstable condition.
- There is a risk of acute decompensation.
- Advanced clinical decision-making is required.
- There is a need for oxygen titration or an airway risk.

The escort decision should be explicitly documented, including the rationale.

7.3 Medication and Supply Planning

Flight delays and cancellations are common, which is why it is important to be prepared. Not accounting for potential delays can turn a manageable condition into a preventable deterioration. Escorts must carry with them a repatriation bag that includes the following items:
- Sufficient oral medication to last at least 48 to 72 hours beyond the planned arrival time.
- Medications for the control of symptoms as needed.
- A clear, written dosing schedule.
- Copies of medical documentation.
- Contact details of the provider receiving the patient.
- An emergency summary letter.

7.4 Identification of Transit Contingency Hospitals

For long-haul routes, especially those involving transit hubs, contingency planning is essential.
The repatriation plan should identify:
- Hospitals accessible from transit airports.
- Visa feasibility for emergency entry.
- Insurance and payment guarantees.
- Local TMAS or assistance provider contact.

This anticipatory planning is particularly important in multi-leg travel exceeding 24 hours.
Air transfer should not proceed without a defined fallback plan.

7.5 Communication Limitations During Flight

In contrast to care while onboard a vessel, in-flight communication with TMAS is frequently restricted due to several factors, including:
- Absence or restricted in-flight Wi-Fi.
- Limited type of device usage.
- Restrictions on international roaming.
- Time-zone differences.

As a result, in-flight management must be pre-authorized and follow established protocols. If an escort is present, they should be authorized to act within predefined clinical parameters without needing real-time consultation.

8. DIFFERENTIATING FITNESS TO TRAVEL FROM FITNESS FOR MARITIME SERVICE

In maritime medicine, it is important to distinguish between clearance for commercial air travel and clearance for continued sea service. These evaluations have different clinical purposes and operate under distinct risk thresholds.
Fitness to travel refers to the individual's short-term physiological stability under controlled conditions, which is necessary to tolerate commercial air transport with limited onboard medical capability. The objective is to ensure the safe transfer to their home country for definitive evaluation and treatment. If the individual cannot safely tolerate this transport period, continued hospitalization is required until stabilization is achieved.
Fitness for maritime service, however, requires sustained functional capacity in a physically demanding, safety-critical, and medically isolated occupational environment. It assumes the individual can work shifts, withstand environmental stressors, and function autonomously without immediate access to advanced medical care for extended periods.
The key medical question in this context is whether the patient's anticipated in-flight risk is low, predictable, and unlikely to require intervention beyond standard airline emergency capabilities.
A seafarer may therefore be clinically stable, adequately managed for pain, and fit for commercial transport, yet remain medically unfit to resume their tour of duty at sea. This distinction is especially important in cases involving:
- Recent infections requiring follow-up evaluation.
- Musculoskeletal injuries with incomplete functional recovery.
- Cardiac or neurological symptoms that need further investigation.
- Psychiatric conditions that are stabilized but require structured support.
- Conditions with uncertain trajectory under occupational stress.

Failure to differentiate between these thresholds can lead to inappropriate continuation of duty or unnecessary medical evacuation. Clear documentation should therefore specify:

1. The rationale for fitness to travel.
2. The anticipated risk during transit.
3. The reasons continued maritime service is not medically appropriate.

By explicitly separating these determinations, we enhance clinical clarity, protect professional integrity, and support transparent communication with employers, insurers, and regulatory authorities.

A seafarer may therefore be clinically stable and cleared for commercial air transfer yet still be medically unfit to resume duty at sea. It is essential to differentiate these thresholds to avoid conceptual conflation and inappropriate redeployment decisions. The contrasting criteria governing transport clearance and occupational fitness are summarized in Box 1.

Box 1. Distinguishing Fitness to Travel from Fitness for Maritime Service

Domain	Fitness to Travel (Commercial Air Transfer)	Fitness for Maritime Service
Primary objective	Safe transport to definitive care	Sustained occupational performance at sea
Time horizon	Short-term (typically 12–48 hours)	Prolonged (weeks to months)
Clinical requirement	Physiological stability during transit	Functional resilience under isolation
Medical access	Emergency diversion possible; advanced care upon arrival	Delayed access; limited onboard resources
Monitoring	Minimal; no continuous medical supervision	Self-reliance or basic crew support
Physical demand	Limited mobility; low exertion	Potentially strenuous and safety-critical tasks
Environmental conditions	Controlled cabin environment	Variable maritime conditions (weather, motion, shift work)
Follow-up availability	Structured evaluation after arrival	Follow-up often delayed or logistically constrained
Decision implication	Clearance for transport	Clearance for redeployment to duty

9. LEGAL AND ETHICAL OBLIGATIONS UNDER THE MARITIME LABOUR CONVENTION

The Maritime Labour Convention (MLC), 2006, as amended, establishes a binding framework that governs seafarers' right to medical care, financial protection, and repatriation. Under the Convention, shipowners are required to ensure that seafarers have access to prompt and adequate medical care that is as comparable as possible to what is available ashore. In cases of illness or injury, the shipowner is responsible for covering medical expenses, paying wages during the period of incapacity (within defined limits), and arranging repatriation when the seafarer can no longer perform their duties or if continued service would jeopardize their health.

For TMAS providers, these obligations are not merely abstract regulatory provisions; they have a direct impact on clinical decision-making. Deciding whether a seafarer should remain onboard, be hospitalized ashore, or be repatriated involves more than just making a medical judgment. It takes place within a legal framework that affirms the seafarer's right to appropriate care and safe return when medically justified.

The MLC does not set specific clinical thresholds; however, it establishes minimum standards that must inform those thresholds. When continued onboard management cannot provide care reasonably comparable to shore-based treatment, repatriation may become not only clinically appropriate but legally required. Conversely, premature repatriation without medical justification may expose shipowners to claims of inadequate care or improper medical discharge.

The interface between clinical discretion and legal obligation underscores the importance of structured documentation. TMAS recommendations should clearly record:

- The clinical rationale for onboard continuation or evacuation.
- The assessment of stability for transport.
- The distinction between transport clearance and occupational fitness.
- The medical justification for repatriation.

Such documentation protects the seafarer's rights, supports shipowner compliance, and mitigates medico-legal risk. Most importantly, it reinforces that clinical decisions are guided by patient welfare within the framework of international maritime law.

10. PRACTICAL INTEGRATION AND CLINICAL PEARLS

Several decision checkpoints can assist TMAS physicians in maintaining threshold integrity:

1. Define the current clinical status and trajectory. Identify if the patient's condition is stable, improving, or evolving unpredictably. Tracking trends is often more important than just taking a single snapshot of the situation.
2. Differentiate medical indication from operational feasibility. A transfer may be medically necessary but could be impractical at the moment. By documenting this distinction, you preserve clinical clarity and medico-legal defensibility.
3. Articulate the risk of delayed action. Instead of simply asking yourself if the patient can remain onboard, ask what specific deterioration would trigger immediate escalation and whether that deterioration can be safely managed at sea.
4. Reassess decisions proactively rather than reactively. Conduct scheduled clinical reviews to avoid incremental drift and prevent threshold distortion. This proactive approach helps ensure that decisions remain appropriate over time.

Common pitfalls include the normalization of deviance (for example, thinking, "he has remained stable so far"), over-reliance on incomplete onboard assessments, and the unconscious absorption of commercial pressures into clinical reasoning. Being aware of these cognitive patterns can serve as a protective strategy.

Early, calibrated decision-making does not mean acting hastily; rather, it involves anticipatory risk management. The goal is not to achieve either maximal evacuation or maximum endurance, but to maintain proportionality that is rooted in clinical readiness.

11. CONCLUSION

Medical repatriation at sea is not merely a logistical arrangement but a time-sensitive clinical decision embedded within a complex operational system. Delayed transfer may permit preventable deterioration; premature evacuation of an insufficiently stabilized patient may introduce avoidable harm. The central challenge is not speed, but calibration.

This article has proposed that repatriation decisions operate at the intersection of three dynamic thresholds: clinical stability, operational feasibility, and legal entitlement. When these thresholds are not consciously differentiated, they may converge in ways that distort judgment. Such distortion reflects mechanisms described in cognitive bias and systems safety literature, including anchoring effects and normalization of deviance. In maritime practice, structural forces often shift tolerance toward delay, incrementally redefining acceptable risk without deliberate intent.

Recognizing threshold distortion as a systems phenomenon reframes delayed repatriation as a patient safety issue rather than an administrative inconvenience. It also clarifies the professional obligation of the TMAS physician: to maintain clinical independence while navigating regulatory, logistical, and commercial realities.

The amended Maritime Labour Convention establishes clear duties regarding medical care and repatriation. Yet regulatory compliance alone does not ensure proportional decision-making. Only disciplined clinical leadership, structured reassessment, and explicit separation of medical indication from operational constraint can preserve threshold integrity.

Repatriation, therefore, should not be viewed as an endpoint of care but as a safety intervention whose timing requires deliberate judgment. When approached through a calibrated framework rather than reactive logistics, it becomes a measurable component of maritime patient protection.

CME Quiz

1. A 48-year-old chief engineer develops chest pain at sea. Initial onboard evaluation and ECG transmission suggest non–ST elevation acute coronary syndrome. The vessel is 36 hours from the nearest port. He is hemodynamically stable after treatment. What is the primary decision threshold being addressed?

a) Fitness for maritime service.
b) Stabilization for commercial air travel.
c) Continuation of onboard management vs. evacuation.
d) Immigration feasibility for disembarkation.

2. A seafarer treated ashore for acute appendicitis is stable 72 hours post-surgery and cleared by the local hospital for air travel home. He remains weak and requires analgesics. Which statement best reflects appropriate TMAS reasoning?
a) Clearance for air travel implies readiness to resume sea duty.
b) Stability for transport and occupational fitness are distinct determinations.
c) Commercial pressure justifies early redeployment.
d) Immigration clearance determines medical fitness.

3. Which of the following best describes “threshold distortion”?
a) Failure to follow evacuation protocols.
b) Overestimation of medical risk.
c) Subtle recalibration of acceptable clinical risk due to operational pressures.
d) Misinterpretation of immigration law.

4. Under the Maritime Labour Convention (MLC), 2006 (as amended), shipowners are obligated to:
a) Guarantee return to work after illness.
b) Provide medical care comparable, as far as practicable, to that available ashore.
c) Authorize only the most cost-efficient treatment.
d) Transfer all cases via medical evacuation aircraft.

5. A seafarer with worsening depression expresses passive suicidal ideation. The vessel is on a tight port schedule. The captain prefers to “monitor for a few more days.” What is the most appropriate response based on the framework?
a) Continue onboard monitoring if the patient agrees.
b) Delay decision until symptoms worsen.
c) Recognize cumulative psychiatric risk and evaluate early repatriation.
d) Base the decision primarily on port logistics.

6. Which documentation element most effectively mitigates medico-legal risk in repatriation decisions?
a) Recording estimated travel cost.
b) Documenting captain’s operational concerns.
c) Explicitly distinguishing transport clearance from occupational fitness.
d) Minimizing diagnostic uncertainty in the record.

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ANSWERS: 1C. Continuation of onboard management vs. evacuation; 2B. Stability for transport and occupational fitness are distinct determinations; 3C. Subtle recalibration of acceptable clinical risk due to operational pressures; 4B. Provide medical care comparable, as far as practicable, to that available ashore; 5C. Recognize cumulative psychiatric risk and evaluate early repatriation; 6C. Explicitly distinguishing transport clearance from occupational fitness

INFORMATION FOR AUTHORS

The International Maritime Health will publish original papers on medical and health problems of seafarers, fishermen, divers, dockers, shipyard workers and other maritime workers, as well as papers on tropical medicine, travel medicine, epidemiology, and other related topics.

Typical length of such a paper would be 2000–4000 words, not including tables, figures and references. Its construction should follow the usual pattern: abstract (structured abstract of no more than 300 words); key words; introduction; participants; materials; methods; results; discussion; and conclusions/key messages.

Case Reports will also be accepted, particularly of work-related diseases and accidents among maritime workers.

All papers will be peer-reviewed. The comments made by the reviewers will be sent to authors, and their criticism and proposed amendments should be taken into consideration by authors submitting revised texts.

Review articles on specific topics, exposures, preventive interventions, and on the national maritime health services will also be considered for publication. Their length will be from 1000 to 4000 words, including tables, figures and references.

Letters to the Editor discussing recently published articles, reporting research projects or informing about workshops will be accepted; they should not exceed 500 words of text and 5 references.

There also will be the section Chronicle, in which brief reports will be published on the international symposia and national meetings on maritime medicine and health, on tropical parasitology and epidemiology, on travel medicine and other subjects related to the health of seafarers and other maritime workers. Information will also be given on training activities in this field, and on international collaborative projects related to the above subjects.

All articles should be submitted to IMH electronically online at www.intmarhealth.pl where detailed instruction regarding submission process will be provided.

Only English texts will be accepted.

Manuscripts should be typed in double line spacing on numbered pages and conform to the usual requirements (Ref.: International Committee on Medical Journals Editors. Uniform Requirements for Manuscripts Submitted to Biomedical Journals, JAMA, 1997; 277: 927–934).

Only manuscripts that have not been published previously, and are not under consideration by another publisher, will be accepted.

Full texts of oral presentations at meetings (with abstracts printed in the conference materials) can be considered.

All authors must give written consent to publication of the text.

Manuscripts should present original material, the writing should be clear, study methods appropriate, the conclusions should be reasonable and supported by the data. Abbreviations, if used, should be explained.

Drugs should be referred to by their approved names (not by trade names). Scientific measurements should be given in SI units, except for blood pressure, which should be expressed in mm Hg.

Authors should give their names, addresses, and affiliations for the time they did the work. A current address of one author should be indicated for correspondence, including telephone and fax numbers, and e-mail address.

All financial and material support for the reported research and work should be identified in the manuscript.

REFERENCES

References should be numbered in the order in which they appear in the text. At the end of the article the full list of references should give the names and initials of all authors (unless there are more than six authors, when only the first three should be given followed by: et al.).

The authors' names are followed by the title of the article; the title of the journal abbreviated according to Medline; the year of publication, the volume number; and the first and last page numbers. **Please note:** References you should include DOI numbers of the cited papers (if applicable) – it will enable the references to be linked out directly to proper websites. (e.g. Redon J, Cifkova R, Laurent S et al. Mechanisms of hypertension in the cardiometabolic syndrome. J Hypertens. 2009; 27(3): 441–451, doi: 10.1097/HJH.0b013e32831e13e5.).

Reference to books should give the title, names of authors or of editors, publisher, place of publication, and the year.

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