# Retrospective analysis of challenging cases for medical examiners of diving

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**Abstract**
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**Introduction:** Assessing a diver's fitness to dive enhances diving safety, with medical examiners of diving (MED) being entrusted with this responsibility. However, the effectiveness of MED training in preparing physicians for this task remains underexplored. In the Netherlands, where any physician can pursue MED qualification, challenging cases can be presented to a board of experts.
**Methods:** This retrospective analysis included all cases presented to a board of experts in the period 2013–2023. Aside from baseline information, cases were coded using the International Classification of Diseases 11th Revision (ICD-11). Additionally, the type of advice given by the board was also recorded.
**Results:** A total of 291 cases could be included, 62.5% were male divers with a median age of 47 years old (interquartile range 29–55). Circulatory (20.9%), respiratory (16.2%), neurologic (14.4%), psychiatric (9.6%) and endocrine (6.5%) disease comprised more than two-thirds of all presented cases. Problems for the MED included multimorbidity, knowledge of guidelines and interpretation of diagnostic data.
**Conclusions:** These results could be used to improve MED courses or serve as a topic for continuing medical education for MEDs, however, further research into generalisability is required.

## Introduction

Although a recreational diver's medical condition may not directly cause a diving accident, it can predispose the individual to risk or impede their ability to respond effectively to emergencies.[1,2] Therefore, assessing fitness to dive is fundamental to ensuring diving safety, a responsibility often entrusted to medical examiners of diving (MED), who are physicians trained in this specific domain. Such standards governing this training are outlined in the Educational and Training Standards for Diving and Hyperbaric Medicine of the European Committee for Hyperbaric Medicine and the European Diving Technical Committee (ECHM- EDTC).[3]

Medical examiner training covers a broad spectrum of topics ranging from general diving protocols to specific dive-related medical conditions. In the Netherlands, any physician can pursue MED qualification by completing courses offered by two accredited providers adhering to the stipulated standards. Although most candidates are general practitioners or sports physicians, diverse medical specialists also participate, reflecting variations in prior knowledge and experience that may influence educational requirements and efficacy.

Despite the relevance of acquired knowledge from MED training and on-going medical education, the evaluation of course effectiveness remains largely unexplored. Evaluating the curriculum poses challenges, as recent MED graduates have limited experience in determining the course content's appropriateness. Traditional research methods, such as surveys or prospective cohort studies, are hindered by potential recollection bias and resource constraints.[4,5]

BOARD OF EXPERTS

In the Netherlands, a 'board of experts' comprising 15 physicians (more details below) and acting as a Board of the Dutch Society of Diving and Hyperbaric Medicine and the Netherlands Association of Sports Medicine, offers a valuable backup resource for MED practitioners. Examiners can freely present dive-related medical queries concerning recreational divers to this board, using their collective

expertise to seek guidance and reflection on challenging cases. This platform, operational for over a decade, provides real-world insights into the issues encountered by MEDs, which may contribute to improvements in the training curriculum and continuing medical education initiatives.

Criteria for a physician to participate in this board of experts were: being currently registered as a physician in the Netherlands, board certification of the applicable specialty, valid MED certification or equivalent, regular examination of patients with respect to diving-related questions of pathology and regular interaction with other board members about the questions posed by the MEDs. The board comprises two cardiologists, two neurologists, an ENT specialist, a pulmonologist, a gynaecologist, a psychiatrist, an internist, an allergologist, with the remainder being sport physicians and a general practitioner with extensive experience in, and knowledge of, scuba and free diving.

## WHY DO MEDS NEED HELP?

This study aimed to determine what type of cases MEDs encounter in daily practice. Given the predominantly male and middle-aged diving population, it was hypothesised that cardiovascular-related inquiries constitute a significant portion of cases presented to MEDs.[6,7]

## Methods

This retrospective analysis encompassed all 291 cases brought before the board of experts from 1 January 2013, to 31 March 2023. According to national law, retrospective analyses are exempt from evaluation by a medical ethics committee. Given that all cases presented to the board were anonymised, this study adhered to European General Data Protection Regulation (GDPR) and national privacy legislation. The protocols for managing medical information adhered to both national and European legislation, as well as the guidelines set forth by the Association of Universities in the Netherlands.

## CONTEXT

In the Netherlands, recreational divers are not obligated to undergo dive medical assessments. Nonetheless, many diving associations recommend a fitness-to-dive evaluation by a MED, particularly for diving instructors. Notably, the board of experts does not handle cases concerning occupational and military divers, as the fitness-to-dive assessments for these groups are legally the purview of occupational physicians in the Netherlands. While a clear guideline for freedivers is absent in the Netherlands, the medical and science committee of the International Association for the Development of Apnea (AIDA) suggests medical assessments should be performed.[8]

To assist MEDs in conducting fitness-to-dive assessments, the Dutch Society of Diving and Hyperbaric Medicine (DSDHM) has published various guidelines, such as those pertaining to diving with psychotropic medication and cardiovascular disease, in both Dutch and international peer-reviewed journals.[9,10]

## ANALYSIS

All 291 cases were entered into a separate database, with diagnoses being coded based on the International Classification of Diseases 11th Revision (ICD-11). Cases without an answer from the board of experts were excluded from the analysis. In instances involving multimorbidity two authors (IR and TW) deliberated, selecting the most pertinent diagnosis for inclusion in the database. The nature of advice provided by the board of experts was also coded. Given that this study entailed solely descriptive data, no statistical analyses were undertaken.

## Results

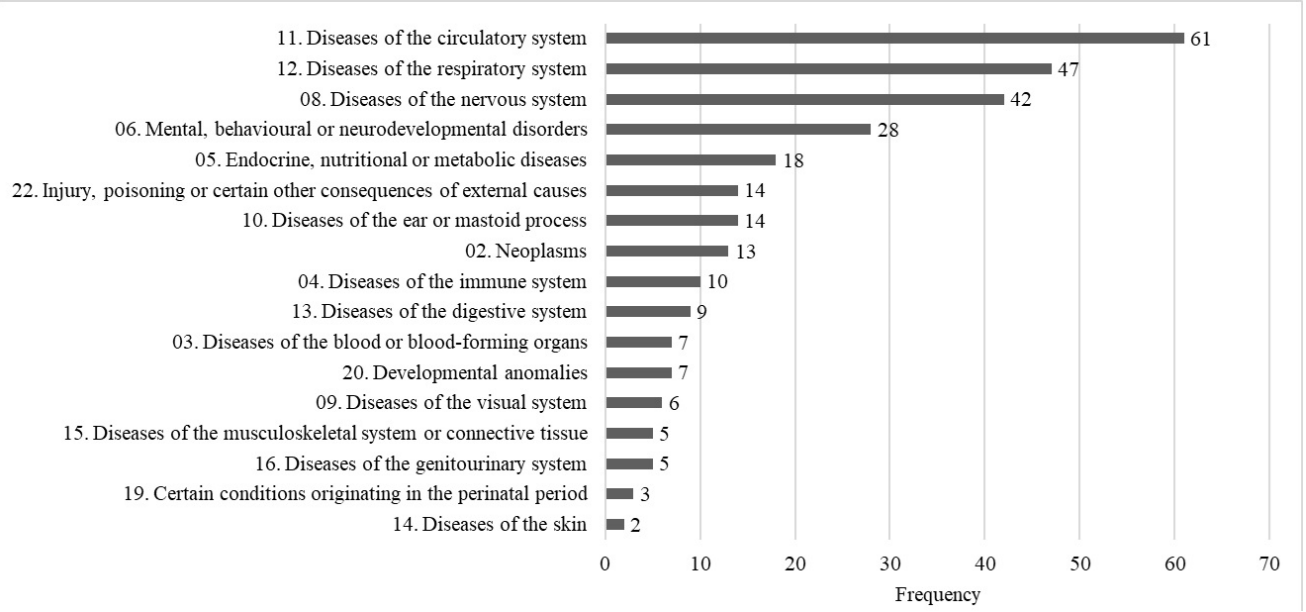
Over the span of 10 years, the board of experts reviewed a total of 291 cases, all of which were included in this study. Among these cases, 62.5% involved male divers (4.5% lacked sex information), with a median age of 47 years (interquartile range 29–55; 18.2% had missing age data). The majority of cases involved recreational scuba divers, with a smaller percentage comprising scuba diving instructors and one freediver, accounting for 92.8%, 6.9%, and 0.3% respectively.

## PREVALENCE OF MEDICAL CONDITIONS

The most prevalent diseases involved the circulatory (20.9%), respiratory (16.2%), and nervous (14.4%) systems. Combined with, mental, behavioural, or neurodevelopmental disorders (9.6%) and endocrine diseases (6.5%, predominantly diabetes mellitus), this accounted for over two-thirds of all cases. Notably, specific diving-related illnesses were the focus of 14 (4.8%) cases presented to the board, as illustrated in Figure 1.

Different types of inquiries emerged for each of the top three medical categories. In cardiovascular disease, concerns primarily revolved around arrhythmia (18% of cases in this category), ischaemic heart disease (13%), and pulmonary embolism (11%), often driven by considerations of multimorbidity prompting consultation with the board. The board's recommendations typically involved referral to existing guidelines, additional diagnostic investigations, or case-specific considerations. Similarly, respiratory disease inquiries focused on spirometry (25%), asthma (21%), and pneumothorax (15%), with the board often advising referral to guidelines or further diagnostic assessments. Neurological disease inquiries predominantly involved diving with epilepsy (21%), post-cerebrovascular events (21%), and multiple sclerosis (12%), usually related to medication side effects or diving resumption timelines, with the board frequently referring to guidelines on diving with these conditions.

**Figure 1**
Overview of ICD-11 classification of presented cases; data are number of cases. The number shown before the categories is the corresponding ICD-11 group




RECOMMENDATIONS GIVEN BY THE BOARD OF EXPERTS

Of all cases reviewed, the board recommended resumption of diving activities in 68 cases (23.4%), with approximately half involving restrictions (such as depth limitation or avoiding drift diving). A 'temporary unfit' recommendation, typically pending additional medical investigations, was advised in almost half (47.8%) of cases of which 108 cases (37.1%) required additional investigations, 24 (8.2%) required a longer complaint-free interval and 7 (2.4%) required treatment. About one-fifth (18%) were deemed 'unfit to dive'. Consensus within the board of experts on the case could not be reached in 3.8% of cases, and in the remaining 5.8%, 'other' recommendations were provided, including changes in medication or advice on diving gases.

## Discussion

To the best of our knowledge, this study represents the first systematic analysis of the cases that MEDs perceive as challenging when assessing recreational divers. The data presented in this study could be used to determine whether the MED course equips physicians adequately for conducting fitness-to-dive assessments. Analysis of inquiries to a board of experts revealed that MEDs most frequently encounter challenges with circulatory, respiratory, and neurological diseases. The nature of inquiries varies across medical categories, with multimorbidity, interpretation of diagnostic data, or unfamiliarity with existing guidelines being common reasons for seeking board consultation. Notably, the board was able to provide clear advice to MEDs in the majority of cases, with consensus unachievable in only 3.8%.

Given the absence of similar analyses, contextualising these findings is challenging. However, it is important to note that our study delineated the national context in the introduction and methods sections, with subsequent sections reflecting solely the authors' interpretation. We believe that a board of experts can offer significant support in complex cases involving multimorbidity or diseases lacking clear guidelines. Nevertheless, some inquiries could be readily addressed by referring to existing guidelines or aiding in the interpretation of diagnostic data, such as electrocardiograms (ECGs) or spirometry. Aside from the Dutch Society of Diving and Hyperbaric Medicine evaluation as to whether guidelines are sufficiently accessible for MEDs, addressing guidelines and issues such as clinical interpretation of spirometry and ECGs within the MED course or continuing medical education may be of value.

A further observation from our data is that cardiovascular, pulmonary, neurological, psychiatric, and endocrine diseases collectively account for more than two-thirds of presented cases posing challenges to MEDs. While guidelines exist for fitness-to-dive assessments in many of these diseases, we advocate for the development of improved guidelines, preferably published in international peer-reviewed journals, to address this gap comprehensively. Additionally, we recommend that MED course organisers should consider allocating more attention to these five categories to better equip MEDs for fitness-to-dive assessments.

Lastly, we think that our study highlights the potential practical utility of a board of experts, as described herein, in offering advice to MEDs in the majority of cases. While this assertion is not directly supported by our data, we believe that such a board could positively influence the quality of

fitness to dive assessments, particularly for MEDs lacking easy access to diving medical colleagues for case discussion or reflection.

STRENGTHS AND WEAKNESSES ANALYSIS

With nearly 300 cases spanning a decade, this dataset provides valuable insights into the challenges MEDs encounter in fitness-to-dive assessments. However, several limitations warrant consideration.

Firstly, the context in which MEDs operate is influenced by local, national, and international legislation, as well as the characteristics of the diving population. Thus, the generalisability of our results may be limited. Nonetheless, it is reasonable to infer that cardiovascular, respiratory, and neurological diseases, especially in cases of multimorbidity and complex medications, present a challenge for MEDs. We encourage our international colleagues to conduct similar studies to elucidate the educational needs of MEDs and optimise MED courses accordingly.

Secondly, the absence of a centralised registry makes it challenging to ascertain the total number of MEDs and fitness-to-dive assessments performed in the Netherlands, i.e., the denominator is missing. Variations may exist in the types of cases encountered by general practitioners or sports physicians compared to specialists, as well as in the nature of inquiries posed to the board of experts. Additionally, the organisational setting of MEDs, whether working collaboratively or independently, remains undocumented and could have impacted our findings.

Lastly, while the ICD-11 classification provides a standardised method for case description, it has its limitations. Cases may encompass elements from multiple medical categories, complicating classification. Although we opted to present the 'main problem' for clarity, an alternative approach involving the presentation of all problems could have provided deeper insight into diseases within the diving community and cases MEDs encounter. The 'all problems' approach did not alter the identification of the top five categories responsible for the majority of cases, therefore we chose to present the current data. However, we would like to underscore that while these five categories are responsible for the majority of the presented cases, other categories could very well be a challenge for MEDs and deserve the proper attention in MED courses and continuing education.

## Conclusions

This retrospective analysis of nearly 300 fitness-to-dive assessments conducted by MEDs in the Netherlands demonstrates that circulatory, respiratory, neurological, psychiatric, and endocrine diseases collectively constitute a significant proportion of cases presenting challenges. While some cases are complex, involving multimorbidity, others entail less intricate queries regarding test data interpretation. We feel these data can be of value to improve MED courses or suggest topics for continuing medical education for MEDs. However, further research is necessary to confirm whether these findings can be generalised before adapting the MED course framework as described by the ECHM-EDTC.

## References


1 Lock G. Under pressure: Diving deeper with human factors. 1st ed. Wiltshire: Human in the System Consulting; 2019.

2 Turner BL, van Ooij PA, Wingelaar TT, van Hulst RA, Endert EL, Clarijs P, Hoencamp R. Chain of events analysis in diving accidents treated by the Royal Netherlands Navy 1966-2023. Diving Hyperb Med. 2024;54:39–46. doi: 10.28920/dhm54.1.39-46. PMID: 38507908. PMCID: PMC11227959.

3 Joint Educational Subcommittee of the European Committee for Hyperbaric Medicine (ECHM) and the European Diving Technical Committee (EDTC). Educational and Training Standards for Physicians in Diving and Hyperbaric Medicine. 2011. [cited 2024 April 9]. Available from: http://www.echm.org/documents/ECHM-EDTC%20Educational%20and%20Training%20Standards%20(2011).pdf.

4 Simpson G, Roomes D. Scuba diving medical examinations in practice: a postal survey. Med J Aust. 1999;171(11-12):595–8. doi: 10.5694/j.1326-5377.1999.tb123812.x. PMID: 10721340.

5 Sames C, Gorman D, Mitchell S. Postal survey of fitness-to-dive opinions of diving doctors and general practitioners. Diving Hyperb Med. 2012;42:24–9. PMID: 22437972. [cited 2024 April 9]. Available from: https://dhmjournal.com/images/IndividArticles/42March/Sames_dhm.42.1.24-29.pdf.

6 Strauss MB, Busch JA, Miller SS. Scuba in older-aged divers. Undersea Hyperb Med. 2017;44:45–55. doi: 10.22462/1.2.2017.8. PMID: 28768085.

7 Lippmann J, Taylor D McD, Stevenson C, Mitchell S. The demographics and diving behaviour of DAN Asia-Pacific members with and without pre-existing medical conditions. Diving Hyperb Med. 2016;46:200–6. PMID: 27966201. [cited 2024 April 9]. Available from: https://dhmjournal.com/images/IndividArticles/46Dec/Lippmann_dhm.46.4.200-206.pdf.

8 Medical and Science Committee of the International Association for the Development of Apnea (AIDA). Medical recommendations for organizers of competitions under auspices of AIDA International. 2019. [cited 2024 April 9]. Available from: https://drive.google.com/file/d/1J8dFwY9S3x4el66sWghRSF-Yhbb0u46k/view.

9 Querido AL, Ebbelaar CF, Wingelaar TT. Diving with psychotropic medication: review of the literature and clinical considerations. Diving Hyperb Med. 2023;53:259–67. doi: 10.28920/dhm53.3.259-267. PMID: 37718301. PMCID: PMC10735636.

10 Rienks R, Buwalda M, Bucx J, Dubois E, Wingelaar T, van Hulst R. Cardiovascular risk assessment in divers: toward safer diving. Undersea Hyperb Med. 2022;49:355–65. PMID: 36001568.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