



## ARTIKEL PENELITIAN—RESEARCH ARTICLE

# Dive profile of traditional divers in Lombok Indonesia: risks for acute dysbaric disorder?

Eustachius Hagni Wardoyo<sup>1,2\*</sup>, Yoga Pamungkas Susani<sup>1</sup>, Decky Aditya Zulkarnaen<sup>1</sup>, Didit Yudhanto<sup>1,3</sup>, Ida Ayu Eka Widiastuti<sup>1</sup>, Bayu Tirta Dirja<sup>1</sup>, Wahyu Sulistya Affarah<sup>1</sup>, Putu Suwita Sari<sup>1</sup>, Jannatul Cahya Admiyanti<sup>4</sup>, Puji Widyastuti<sup>4</sup>, Putu Cilia Rarasati Kuta<sup>4</sup>

1. Archipelago Medicine, Faculty of Medicine Universitas Mataram, Indonesia

2. Microbiology Department, Faculty of Medicine Universitas Mataram, Indonesia

3. ENT Departement, Faculty of Medicine Universitas Mataram, Indonesia

4. Faculty of Medicine Universitas Mataram, Indonesia

**\*Korespondensi:**

wardoyo.eh@unram.ac.id

### Abstract

Traditional diver is assumed of having acute dysbaric disorder' risk higher than recreational scuba divers. We described dive profile of traditional divers in Lombok Indonesia and possible risk of acute dysbaric disorder.

Acute dysbaric disorder (ADD) symptoms were recorded and corresponding signs were observed. Dive profile is constructed based on justification measurement due to lack of measuring instruments used.

As much as 30 traditional divers were interviewed to fill a questionnaire. All participants are male, aged 20-60 years old (mean 40.7). In one-week, average diving trip was 4.5 times, each trip averagely consists of 4.7 (3-8) dives. Average depth 20.2 (10-50) meters with descent rate and ascent rate of 5.3 meters/minute and 2.6 meter/minute, respectively. Average actual dive time was 55.3 minutes for first dive and 67.5 minutes for following dive. Average ADD' complaints are: extreme tiredness 83.3%, tinnitus 76.6%, headache 73.3%, dizziness 73.3%, muscular pain 63.3%, forgetful 60%, vertigo 56.6% and decreased appetite 50%. In conclusion, repetitive dive and diving in a raw for three consecutive days are possible risks to ADD with 3 prominent symptoms are: extreme tiredness, tinnitus and headache.

**Keywords:** acute dysbaric disorder, traditional diver

## INTRODUCTION

Traditional divers refer to fisherman by profession, no formal dive training and usage of 'traditional' diving gear. Acute dysbaric disorder (ADD) ADD is a condition of failure of the body's adaptation to changes in pressure which occur within 2 weeks after dive. The clinical spectrums are nitrogen narcosis, oxygen toxicity, barotrauma, decompression sickness dan (cerebral) arterial gas embolism (Freiberger, 2016). The clinical spectrum above shows that not all diving injuries require hyperbaric, as research by Kadriyan et al (2015) noted that 13.6% required hyperbaric treatment. Data from the Lombok hyperbaric flashlight, the visit of traditional divers during 2016-2020 is 31.6% vs 66.7% of recreational divers. Furthermore,

Wardoyo & Tarigan (2022) noted that of all visits to hyperbaric flashlights, 13.6% were cases of acute dysbaric disorder (ADD). This study describes the diving profile of traditional fishermen accompanied by a history of ADD' complaints.

## METHODS

A cross-sectional study was conducted in traditional diver village in Sekotong, Lombok. Each respondent was interviewed to fill a questionnaire containing dive profile and ADD' complaints. ADD' complaints was taken from reference (Wardoyo & Tarigan, 2022, DAN, 2001). Physical examination of body mass index, eyesight and eardrum.



## RESULTS

### Respondent' characteristics

As much as 30 respondents are willing to participate the study. All respondents are male, average age 40.7 years old (20-60) with diving experience between 2-42 years (mean 22.4). Body mass index between 16.7-31.8 (mean 22.6).

### Preparation for diving

Preparation for diving is critical for its safety and its success to have sufficient amount of fish, listed in table I below.

Table I. Preparation for diving in traditional divers

	How to assess	Remark
Dive site	Team leader decision	30-45 minutes trip Experience Weather and water current Observation
Time	Team leader decision	Between 15:00 – 05:00 7-14 hours span
Body fitness	Voluntary registration Team leader decision	No food restriction No medical check up
Dive profile	No specific dive profile	Repetitive dive 3-8 times
End a dive trip	Team leader decision	Sufficient amount of fish Bad weather Damage diving gear If someone sick Dawn

### Dive profile

Dive trip was recorded varied between respondents, 1-7 times a week. Average 4.5 times a week. Each trip was filled with repetitive dive 4.7 times (3-8). Actual dive time for the first dive was 55.33 minutes (30-60) and following dive 67.5 minutes (30-60). Surface interval were 5-60 minutes (mean 20.16 minutes). Average descent rate 5.33 meters/minute and ascent rate 2.59 meter/minutes.

### Breathing technique and apparatus

Breathing apparatus is consist of surface air compressor and hose. Breathing underwater using hose directly to mouth is not easy. No connective device available (mouthpiece), makes some divers take breath-hold technique in the beginning of ascent for some quite time.

### Diving gear

Diving gear available are goggles 63.33%, eyes-nose mask 36.67%, and fin 43.33%. No dive suit used for all divers.

### After the dive

Complaints that arise are never traced to the type of signs and symptoms or their intensity, not even taken to the health service. Complaints of dizziness or headaches are handle with resting, drink coffee or take over-the-counter medicines. Complaints of ear pain are by drinking warm water or giving ear drops (chloramphenicol). Most of these complaints will handling by themselves. They only examine complaints of paralysis and or anuria. Postponement of diving activities is never certain, depending on subjectively felt conditions or urgent economic needs. Lasts between 3 days or a week.

### Complaints regarding ADD

#### Barotrauma

Complaints of barotrauma that may occur in the past is asked (Fig. 1).

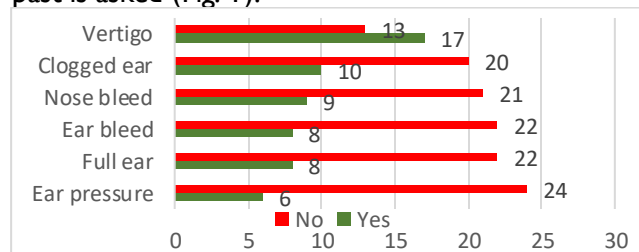


Figure 1. Complaints regarding barotrauma (n=30) From Figure 1 it can be seen that traditional divers (10) feel the most vertigo complaints, followed by clogged ears (10), nose bleed (9), ear bleed and full ears (8 cases each) and ear pressure (6).

#### Nitrogen narcosis

Complaints regarding nitrogen narcosis conditions were asked of respondents. As shown in Figure 2, complaints of forgetfulness are the most frequently experienced by respondents (18), followed by

focus difficulties (10), angry easily (10), sudden euphoria (9), hallucinations (7) and easy sadness (6) (figure 2).

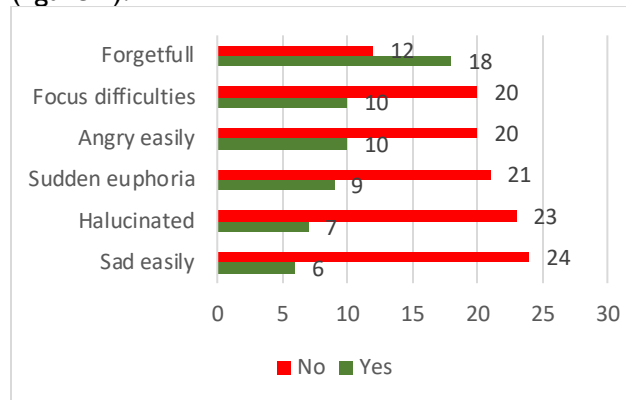


Figure 2. Complaints regarding nitrogen narcosis (n=30)

### Decompression sickness type I

The most common signs and symptoms of type I decompression sickness were tiredness (25), followed by dizziness (22), headaches (22), muscular pain (19), bone and joint pain (15), muscle cramps (8) and skin rash (8) (figure 3).

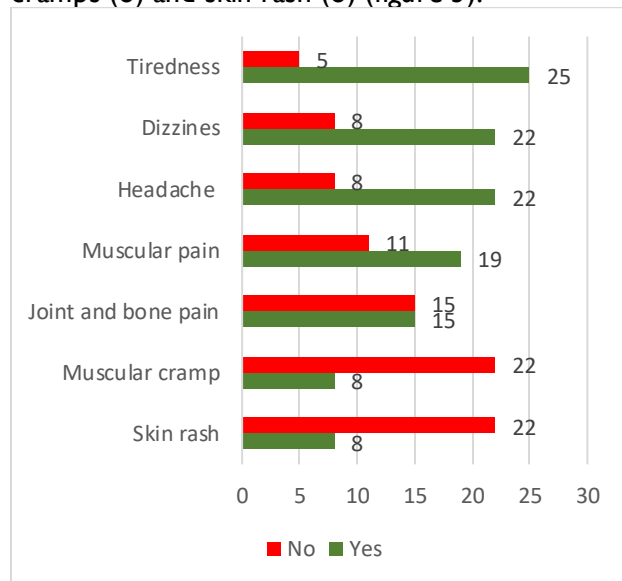


Figure 3. Complaints regarding decompression sickness type I (n=30)

### Decompression sickness type II and arterial gas embolism

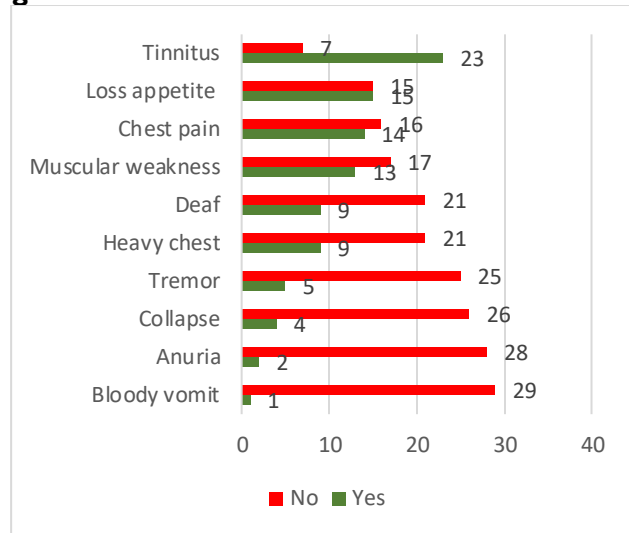


Figure 4. Complaints regarding Decompression sickness/ Arterial gas embolisms.

Complaints regarding decompression sickness type II/Arterial Gas Embolism are: tinnitus (23), loss appetite (15), chest pain (14), muscular weakness (13), deaf and heavy chest (each 9), tremor (5), collapse (4), anuria (2) and bloody vomit (1) (Figure 4).

## DISCUSSION

Traditional divers are dominated by fishermen looking for fish, who are oriented towards getting as much fish as possible, so there is a risk of ignoring the safety factor of diving. Low quality diving equipment, using a normal surface air compressor connected to a long hose (up to 60 meters), water goggles and a flashlight. Air mouthpiece/regulator is not used by fishermen. This regulator acts as a valve that will open and lower the air pressure according to the negative pressure of inspired air. Without a regulator, over-inflation of the lungs results in pulmonary barotrauma, due to tension trapped air. Furthermore, it can cause mediastinal emphysema or pneumothorax (Stephenson, 2009). Traditional divers dive when they are not at sea in their spare time and do it without careful dive planning. Diving at night is preferred because it is the best time to catch fish and lobsters (Rakhman, 2018).



Acute dysbaric disorder is a disorder that is obtained due to the transfer of two different pressures which can be acute or chronic. Occupations/activities that are at risk of experiencing ADD include divers, underground tunnel workers, astronauts, pilots and air crew. Diving injury is included in this group, although the European Committee for Hyperbaric Medicine compiled a Descriptive Classification of Diving Dysorders (1996) (Desola, 1996), but it is not widely adopted because of its impracticality. The forms of the disease can be divided into, changing from low to high pressure (barotrauma), surviving high pressure inhalation of atmospheric air (oxygen toxicity, nitrogen narcosis, dysbaric osteonecrosis) and rapid loss of pressure (decomoredial disease, arterial gas embolisms, acute mountain sickness), high altitude pulmonary edema, high altitude cerebral edema) (Wardoyo & Tarigan (2022), Freiburger J, (2016)).

### **Barotrauma**

Barotrauma occurs due to an increase in partial pressure that is too fast and cannot be followed by equalization of external pressure with the pressure of hollow organs in the body. In diving, this usually occurs when heading to the depth (descent). The risks related to how fast to go to depth (descent rate) were not explored in this study, due to limited diving equipment (we did not use diving hours), so the risk of barotrauma was obtained by looking at the impact of barotrauma on the body as indicated by signs and symptoms.

Barotrauma is something that is neglected by traditional divers due to limited time to adapt. There are two things that are important: 1. Chasing fish for maximum results (Wardoyo & Tarigan, 2022), 2. Ignoring swimming speed towards depth (Descent rate). Rapid adaptation to the Valsalva technique also requires pausing at the same depth. Therefore, traditional divers are very happy when the tympanic membrane is perforated on both sides. Because barotrauma is often considered a disturbing condition for traditional divers, requests for tympanocentesis are often submitted to health services, especially if a one-sided perforation has occurred.

Ear barotrauma that is known by traditional divers is ear complaints (tinnitus, ear pain, ear fullness and ear pressure) which will disappear if the tympanic

membrane is perforated, which is barotrauma otica media. What is not yet known is inner ear barotrauma. Apart from being at risk of deafness, the brain is also susceptible to experiencing advanced stages of infection. Inner ear barotrauma (IEBt) involves the hearing centers (Cochlear bodies). IEBt identification can use the HOOYAH instrument: 1) H=hard to clear, 2) O=onset of symptoms, 3) O=otoscopic exam, 4) Y=your dive profile, 5) A=additional symptoms and 6) H=hearing (Rozycki et al, 2018). Symptoms that overlap with the Inner Ear DCS (Stagger) need to be analyzed carefully.

Research from Indonesia states that barotrauma and age have a statistically significant relationship (Dulahu et al, 2021).

### **Nitrogen narcosis**

Nitrogen narcosis is a collection of symptoms of altered consciousness, neuromuscular function, and behavior resulting from inhalation of compressed inner gas (Kirkland et al, 2022). Therefore, in diving, nitrogen narcosis is a condition that endangers divers. Symptoms of nitrogen narcosis: drowsiness, euphoria, overconfidence, stubbornness, disturbances in reasoning, calculus, memory and decision making (Joiner, 2001). Nitrogen narcosis occurs when the threshold for nitrogen saturation in the body exceeds the body's ability to compensate for it. Risk factors associated with diving activities are rapid descent, long bottom time duration, predisposing risk factors are fat composition which is characterized by a body mass index (BMI) of more than 25 (table 2). There were 7 respondents who had BMI > 25 (25.4-31.9). Fat tissue has benefits in diving, namely as a heat insulator, buoyancy and energy reserves (Sawatzky, 2013) but the side effects are related to the accumulation of dissolved respiratory gases that are good in fat tissue, while their low vascularity causes nitrogen expenditure at the time of ascent to become slow, the underlying pathophysiology of decompression sickness. The benefits of a heat insulator can be immediately replaced by using a dive suit, energy reserves can be diverted to muscle glycogen stores by exercising (Sawatzky, 2013)

There are 2 conditions that endanger divers: 1. Nitrogen narcosis causes hallucinatory thoughts (narcotic effect), responds to diving buddies as a threat, excessive panic attacks and self-harm



(removing the tube) so that the risk of apnoea / aspiration, 2. Nitrogen narcosis makes divers cannot tell which is surface or sea-bed, panic attacks are often accompanied by a rapid descent into depth.

In this study, there were no symptoms of nitrogen narcosis, but inhalation of compressed nitrogen in the long term can affect concentration, mood and hallucinations.

### **Decompression sickness and arterial gas embolism**

Decompression sickness is a disease that is a reason for traditional divers to access health services due to morbidity and mortality. From the interview results, it is estimated that the research location is in Sepi Hamlet, Buwun Mas Village, Sekotong District, West Lombok. There are 500 traditional diver fishermen and dozens of them are experiencing sequelae of diving injury, such as paralysis, urinary incontinence, and deafness. Data from Wardoyo & Tarigan's study (2022) shows that the percentage of decompression in patients with traditional divers undergoing hyperbaric therapy at Mataram City Hospital reached 31.6% (36/114). Possible risk factors associated with diving activities are repetitive/yo-yo diving, rapid ascent, no safety stops, long dives. While the risk factors associated with predilection are no dive suit, no mouthpiece, muscle cramps and panic attacks. Figure 4 above, complaints seems potential for greater health issue in near future. Risk factors associated with arterial gas embolism were not explored in this study.

**Before diving.** This stage is not carried out by traditional divers. What is ignored as a risk that needs to be anticipated is the dive profile plan and the selection of dive teams. Unfit divers are at risk for nitrogen narcosis, hypoglycemia and hypothermia. Smoking is done at least 12 hours before diving, do not smoke between two dives to prevent hypoxia.

**During the dive.** The dive profile performed (yo-yo and repetitive dives) is at high risk for the formation of nitrogen bubbles, which manifest as decompression sickness or arterial gas embolism. Descent speed that is too fast increases the risk of barotrauma. Intermittent breath-holding should not be done, because it increases the risk of lung over-expansion which can cause alveoli rupture.

This risk can be reduced by equipping a mouthpiece on diving gear. Diving to accomplish the fishing target is also very dangerous, because it tend diver to have multiple dives. Hence, suggestions for meeting targets must be balanced with the number of divers, the maximum number of dives for each diver and careful dive planning.

**After the dive.** It is very important that after diving, divers do not take a warm bath, do not get massages and do not smoke. Warm baths and massage may increase the risk of releasing dissolved nitrogen in tissues with or without manifesting decompression syndrome. Any complaints felt after diving should be examined by a health service. The 'nitrogen savings' increases with more dives, which may require a 'nitrogen wash-out' using hyperbaric oxygen therapy.

### **Research Strengths and Limitations**

Research related to traditional diving activities has not been much explored compared to recreational/technical divers. The morbidity of diving injury in traditional divers could not be measured in this study because the number of respondents was limited and the respondents were active divers. This morbidity is recognized by active divers of their parents or colleagues who experience sequelae of diving injuries such as walking paralysis, urinary incontinence which causes them to be unable to make a living. Risk factors cannot be measured statistically due to the absence of controls and active cases. Measurement justification is used in this study.

### **DISCLAIMER**

In this study, the measurement data needs to be justified considering that the respondents did not have a standard measuring instrument. Examples: 1 is related to time; a cigarette ( $\pm 15$  minutes), a glass of hot coffee (10 minutes), a cigarette and a glass of coffee ( $\pm 30$  minutes); 2 is related to the depth of one roll of hose ( $\pm 25$  meters), two rolls ( $\pm 50$  meters). Statistical test was not mention due to un-significant result.



## CONCLUSION

The predominant signs and symptoms of ADD are fatigue, followed by tinnitus, headache, dizziness, bone and joint pain and decreased appetite. Not much is done by traditional divers to overcome the complaint. Only complaints of not being able to walk and anuria made respondents access the primary health care

## REFERENCES

- Alexander AM; Martin N. 2021. Arterial Gas Embolism. Treasure Island (FL): StatPearls Publishing; 2022 Jan- Februari 2022. Laman: <https://www.ncbi.nlm.nih.gov/books/NBK546599/>
- Anonim. Chapter 14. Disorder of Oxygenation and Carbon dioxide Elimination. [https://uk.sagepub.com/sites/default/files/4\\_cook-disorders\\_of\\_oxygenation\\_and\\_carbon\\_dioxide\\_elimination\\_0.pdf](https://uk.sagepub.com/sites/default/files/4_cook-disorders_of_oxygenation_and_carbon_dioxide_elimination_0.pdf)
- Atwell J; Murphy-Lavoie HM; Hendriksen S; Cooper JS.2021. Dysbarism. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Akses 3 Februari 2022. Laman: <https://www.ncbi.nlm.nih.gov/books/NBK537266/>
- DAN 2001 Report on DCI, Diving Fatalities, and—Divers Alert Network <https://www.yumpu.com/en/document/view/26979213/dan-2001-report-on-dci-diving-fatalities-and-divers-alert-network>
- Desola J, 1996. Descriptive Classification of Diving Disorders. 4<sup>th</sup> report. Coordinating Committee of Hyperbaric Medical Centres. Barcelona, Spain. Available at: <https://www.cccmh.com/CLASSIF4.pdf>
- Dulahu WY, A Mursyidah, Pomalango ZB. Risk Factor that affect the incidence of ear barotrauma in traditional diver fisherman. Jurnal Aisyah Jurnal Ilmu Kesehatan. Vol 6 (2021) DOI : [10.30604/jika.v6i1.778](https://doi.org/10.30604/jika.v6i1.778)
- Freiberger J. Acute dysbaric disorder. Undersea and hyperbaric medicine society-UHMS [Internet]. 2016 [cited 2022 Jan 14]. Available from: <https://www.uhms.org/publications/pressure/acute-dysbaric-disorders.html>
- Joiner JT. Diving physiology. In *NOAA Diving Manual* (ed. Joiner JT) (Dest Publishing Co., 2001
- Kadriyan H, Wardoyo EH, Noviyani NMR, Incidence of Diving-Related Illness in Lombok: The Need of Comprehensive Tourism Medical Care? Proceeding Tropical Tourism Outlook Conference: Balancing Development and Sustainability in Tourism Destinations. Lombok, 29-31 July 2015.
- Kennedy-Little D; Sharman T. 2021. Pulmonary Barotrauma. Treasure Island (FL): StatPearls Publishing; 2022 Jan- Februari 2022. Laman: <https://www.ncbi.nlm.nih.gov/books/NBK559293/>

- Kirkland PJ, Mathew D, Modi P, et al. Nitrogen Narcosis In Diving. [Updated 2022 Aug 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK470304/>
- Lee YI, Ye BJ. Underwater and Hyperbaric Medicine as a Branch of Occupational and Environmental Medicine. *Annals of Occupational and Environmental Medicine* 2013; 25(1): 39. DOI: [10.1186/2052-4374-25-39](https://doi.org/10.1186/2052-4374-25-39)
- McCall C. 2021. 7 Things You Should Never Do Immediately After Diving. Akses 5 Februari 2022. Laman: <https://blog.padi.com/7-things-you-should-never-do-immediately-after-diving/>
- McKnight CL; Burns B.2021. Pneumothorax. Treasure Island (FL): StatPearls Publishing; 2022 Jan- Akses 5 Februari 2022. Laman: <https://www.ncbi.nlm.nih.gov/books/NBK441885/>
- NOAA. Chapter 2: Physics of Diving. Akses 5 Februari 2022. Laman: <https://www.ehs.ucsb.edu/files/docs/ds/physics.pdf>
- NOAA. Chapter 3: Diving Physiology. Akses 5 Februari 2022. Laman: <https://www.ehs.ucsb.edu/files/docs/ds/physio.pdf>
- Nord DA, Racznik GA, Chimiak JM. Chapter 3: Environmental Hazards & Other Noninfectious Health Risks. *Scuba Diving: Decompression Illness & Other Dive-Related Injuries*. Akses 5 Februari 2022. Laman: <https://wwwnc.cdc.gov/travel/yellowbook/2020/noninfectious-health-risks/scuba-diving-decompression-illness-and-other-dive-related-injuries>
- Pulley SA. 2019. Decompression Sickness. Medscape. Available at: <https://emedicine.medscape.com/article/769717-overview#a4> accessed February 2<sup>nd</sup> 2022
- Rozycki SW, Brown MJ, Camacho M. Inner ear barotrauma in divers: an evidence-based tool for evaluation and treatment. *Diving Hyperb Med*. 2018 Sep 30;48(3):186-193. doi: [10.28920/dhm48.3.186-193](https://doi.org/10.28920/dhm48.3.186-193). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6205852/>
- Sawatzky D. Obese divers beware 'saturated fat'. *Divermag* May 23, 2013 [internet] <https://divermag.com/obese-diversc383baab7bef8067e8c9786a45d8006c492489841a98fe37723e304bb1ddd030c2c383baab7bef8067e8c9786a45d8006c492489841a98fe37723e304bb1ddd030aObeware-c383baab7bef8067e8c9786a45d8006c492489841a98/> Accessed Nov 1<sup>st</sup>, 2022
- Texas A&M University. Diving Safety Manual Texas A&M University at Galveston 2019-2020. [https://www.tamug.edu/diveprogram/No%20Show/Diving\\_Safety\\_Manual.pdf](https://www.tamug.edu/diveprogram/No%20Show/Diving_Safety_Manual.pdf)
- US Navy, 2016. US Navy Diving Manual. Rev7. COMMANDER, NAVAL SEA SYSTEMS COMMAND
- Wardoyo EH & Tarigan DRM. Acute Dysbaric disorders: A case series in the Hyperbaric center in Lombok 2016-2020. 2nd Global Health and Innovation in conjunction with 6th ORL Head and Neck Oncology Conference (ORLHN 2021). *Advances in Health Sciences Research*, volume 46. Feb 2022. DOI: [10.2991/ahsr.k.220206.054](https://doi.org/10.2991/ahsr.k.220206.054)