Knowledge, Perception and Practices of Diving Fishermen in Relation to Decompression Sickness: A Cross Sectional Survey of the Diving Fishermen of Vanga, Kwale County, Kenya

H57/12103/2018

KITHOME KENNEDY MUINDI

A THESIS SUBMITTED TO THE SCHOOL OF PUBLIC HEALTH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF PUBLIC HEALTH OF THE UNIVERSITY OF NAIROBI

2020

DECLARATION OF ORIGINALITY FORM

DECLARATION

I Kennedy Muindi Kithome, the Principal Investigator, understand what plagiarism is and I am aware of the University's policy in this regard.

1. I declare that this thesis is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements.
2. I have not sought or used the services of any professional agencies to produce this work.
3. I have not allowed and shall not allow anyone to copy my work with the intention of passing it off as his/her own work.
4. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy.

Signed 

Date 30 October 2021

ACKNOWLEDGEMENTS

I would foremost like to thank the Commander Kenya Navy for his support in allowing me to take a leave of absence from work to undertake the course and fieldwork that has culminated in this dissertation. I am most grateful for his funding of this work and for granting me access to the Clearance Diving Unit where I worked prior to departing for further studies, and from where the idea of this work originally came.

Sincere thanks go to the diver-fishermen of Vanga, Kwale County, intrepid seafarers for whom I have the utmost respect and admiration. Unfortunately, they cannot be named as I am required to safeguard their privacy, but without whom this study would not have been possible.

I extend my sincere gratitude to my principal academic supervisor, Dr Richard Ayah for his unwavering support and invaluable advice in the completion of this process. Deepest thanks to my academic supervisor, Dr Tom Olewe who patiently walked me through the minefield of proposal development with the utmost patience and dedication.

Thank you to Master Diver WO1 Francis Munene and WO2 Mohammed Mujibu, for your professionalism in the conduct of fieldwork and dedication to the cause of aiding our fellow divers. The fruits of your labour are plain for all to see.

To my dearest wife Dr Faith Mwadime, thank you for your unwavering support and constant encouragement throughout this process. To my daughters, Alexandra, and Hannah, thank you for your patience and understanding.

Thank you also to the Director, all my lecturers and classmates at the School of Public Health for a thoroughly stimulating and challenging two years. To anyone I may have missed sincerest gratitude.

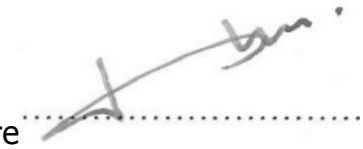
DEDICATION

This thesis is dedicated to my parents, WO1 (Retired) Joseph Kithome Muindi, OGW and Agnes Kithome who have raised me and supported my every undertaking.

Supervisors' Page

This thesis has been submitted with our approval**.**

SUPERVISORS:

Signature  Date- 30 October 2021

Dr. Richard Ayah, MBChB, MSc, PhD
Senior Lecturer, Department of Global and Public Health
College of Health Sciences, University of Nairobi

Signature  Date- 30 October 2021

Dr. Tom Olewe, MBChB, MPH
Lecturer, Department of Global and Public Health,
College of Health Sciences, University of Nairobi

DIRECTOR'S APPROVAL

 30th October 2021

Signature..... Date .....

Prof. Joyce Olenja, PhD,
Chair, Department of Global and Public Health,
College of Health Sciences, University of Nairobi.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Background- Decompression Sickness is the greatest danger to the health and wellbeing of diving fishermen, potentially rendering them permanently disabled or dead.

Published prevalence of decompression sickness in professional and military divers stand at 3.4% and 2.9% respectively. Artisanal diving fishermen suffer disproportionately more, with prevalence ranging from 20 to 94%. There is paucity of data on the prevalence of decompression sickness in Kenya, on knowledge, attitude, and practices of diving fishermen in Kenya.

Study Design- A cross sectional study of a fishing community in Vanga, Kwale County was undertaken from June 2019. Data collection was conducted between July 7th and August 30th, 2020.

Methods- Eligible study subjects were identified from the Beach Management Unit register and screened by administration of an adapted Kenya Navy survey tool. A total of 246 randomly sampled diving fishermen were included in the study. Anonymised sociodemographic data was collected, in addition to data on predictor variables of decompression sickness- knowledge, attitudes and practices of diving fishermen. Categorical data analysis was used. R statistical software was used for data analysis and visualisation.

Results- All study participants (N=246) were male, the median chronological age being 36, range from 19 to 76 years. Nearly all the study participants (99.2%, n=244) had either no formal education or incomplete primary education. Apprenticeship was the main method knowledge was imparted to majority (66.3%, n=163) of diving fishermen. Significant associations between knowledge and decompression sickness, and attitude of diving fishermen and decompression sickness were found. The prevalence of decompression sickness in this community was 28%. Lack of a local health care worker and distance to Kenya Navy recompression chamber were found to be barriers to healthcare access.

Conclusion- This study gives credence to the idea that diving accidents are preventable through training and establishing of standards of safe diving practices.

Recommendation- Continuous skills upgrade with a recertification system developed by Kwale County with assistance from Kenya Navy to address dangerous diving practices.

LIST OF ABBREVIATIONS/ACRONYMS

DCS- Decompression Sickness

EEZ- Exclusive Economic Zone

HBOT- Hyperbaric Oxygen Therapy

HBOTC- Hyperbaric Oxygen Therapy Chamber (Recompression/Decompression Chamber)

SCUBA- Self-Contained Underwater Breathing Apparatus

DEFINITION OF OPERATIONAL TERMS

Apprenticeship: A system of skill acquisition by new fishermen in the trade with on-the-job training. It Includes swimming, canoeing, identification, and knowledge of fish, mounting and mending nets and operation of diving equipment.

Air: a mixture of oxygen (21% by volume), nitrogen (78% by volume), carbon dioxide (0.04% by volume) and other rare gases (< 1% by volume)

Artisanal fishing: low-technology, low capital fishing done mostly close to shore, using simple vessels that are sometimes not motorized

Artisanal fisherman: An individual who earns their living through artisanal fishing. The term encompasses individuals of both sexes and all ages

Attitude- how diving fishermen perceive their conduct of diving operations with regards to decompression sickness i.e., how they view their own susceptibility to decompression sickness

Barriers to care-factors to accessing health services leading to delays in treatment and adverse health outcomes

Barotrauma: the general name for an injury caused by pressure change

Breath hold Diving: immersion underwater on a single breath of inhaled surface air. Also sometimes called skin diving.

Decompression Sickness: a term used to describe the array of symptoms occurring in a diver breathing compressed air at depth when nitrogen gas is eliminated from solution in the blood or tissues forming bubbles.

Decompression sickness case definition-an individual who has ever dived while fishing and developed decompression sickness as determined by administration of a clinically proven survey tool adopted from Royal Australian Navy Health Diving Profile

Decompression Stops: periodic halts in ascent from depth, depending on the depth of the dive and time spent underwater, pioneered by Haldane (1908), and proven to reduce incidence of DCS

Diving practices- SCUBA or breath hold diving for acquiring catch

Dangerous diving practices-perilous acts, known to predispose to decompression sickness, performed while diving for fish, including repetitive immersions, solo dives, omitted decompression stops, omitted rest between dives

In-water recompression attempts to recompress divers who develop symptoms of DCS. This is done on compressed air or oxygen from diving cylinders at the site of the dive, as a first aid measure

Hyperbaric oxygen therapy (HBOT): Use of high partial pressure oxygen to reduce tissue hypoxia and remove residual nitrogen bubbles from solution- Gold Standard for treatment of DCS

Knowledge- familiarity of diving fishermen with the symptoms of decompression sickness

CHAPTER 1: Introduction

1.1 Background

Artisanal fishermen who dive to catch their fish risk succumbing to Decompression Sickness, a condition that when not managed well leads to lifelong disability or even death. Decompression sickness refers to an array of symptoms occurring in a diver breathing compressed air at depth, when nitrogen gas is eliminated from solution in the blood or tissues, forming bubbles (Bennet et.al. 2010). They range from neurological (stroke-like) symptoms when bubbles are lodged in the cerebral circulation, respiratory distress when there's involvement of the cardiopulmonary system, joint or limb pain when they are trapped in the joint space or skin rashes and oedema when they lodge below the skin (INM, 2015).

The Divers Alert Network, an open source, volunteer organization to whom divers report adverse events, publishes regular reports on incidence and prevalence of decompression sickness. It is worth noting that artisanal divers are not captured in these reports. DAN reports shed a light on the global burden of this rare disease. The incidence rate in commercial decompression diving has been reported to be as high as 35.3 per 10,000 person-dives (Imbert et.al. 1992). Among recreational divers, the incidence ranges from 2.0 to 4.0 per 10,000 person-dives (Vann et.al. 2004, Vann et. al. 2005, Pollock et.al. 2008). The lowest incidence is noted to be among scientific and military divers at 0.324 per 10,000 person dives (Luby, 1999).

Global prevalence of decompression sickness among professional dive instructors stands at 3.4%, while for military divers it is 2.65% (Bangasser 1979, Dear 1999). Among artisanal divers (small scale, low-tech, low capital fishermen) prevalence has been known to range between 20% and 94% (Kelleher 1993, Niu 1996, Kawashima 1996, Buorke 1998, DeNoble 2001, Dunford 2002). The prevalence among coastal fishermen in Kenya is not known.

Any gas held in solution can cause damage (barotrauma) during compression- called squeeze, or via expansion on ascent when the pressure decreases (Levett, 2008). In non-expandable spaces such as the middle ear or sinuses, descents of as little as 1 metre are enough to cause pain, swelling or bleeding. Rupture of the tympanic

membrane can easily occur, leading to impaired hearing and problems with balance following endolymph leakage from the middle ear.

During a dive, inert gas dissolves into the tissues over time and due to the increased pressure experienced with depth. Over time, a state of equilibrium between the breathing gas and dissolved tissue called saturation develops. When the diver ascends to the surface, the gas in the tissues diffuses out into the blood and lungs. As the partial pressure of inert gas still in tissues exceeds ambient pressure, bubbles form, resulting in the symptoms of decompression sickness. (Levett, 2008; Vann, 2011). The bubbles exert their effect by mechanically distorting the tissues, by hampering blood flow, and by activating the inflammatory cascade.

In the long term, divers who expose themselves to uncontrolled diving with poor safety precautions experience neurocognitive decline, dysbaric osteonecrosis, hearing loss and lung changes (Taylor et.al. 2006).

There are no specific diagnostic tests that can confirm the diagnosis of decompression sickness. Research to identify useful diagnostic indicators is ongoing. In this study, decompression sickness case definition was taken as an individual who has ever dived while fishing and developed decompression sickness as determined by administration of a clinically proven survey tool adopted from Royal Australian Navy Health Diving Profile (Edmonds et.al. 2002).

Diagnosis of decompression sickness is based entirely on clinical manifestations (Moon, 2014). Decompression sickness is classified into types 1 and 2. Type 1 decompression sickness is usually characterized by musculoskeletal pain and mild cutaneous symptoms. Common type 1 skin manifestations include itching and mild rashes (as distinct from a clear, mottled, or marbled, and sometimes raised discoloration of the skin known as cutis marmorata that may presage the development of the more serious type 2 symptoms), **within 24 hours of a dive**. Less common but still associated with type 1 decompression is obstruction of the lymphatic system, which can result in swelling and localized pain in the tissues surrounding the lymph nodes (Pollock & Buteau, 2017). Type 2 symptoms are considered more severe. They typically fall into 3 categories: neurologic, inner ear, and cardiopulmonary. Neurologic

symptoms include numbness; tingling; muscle weakness; impaired gait, physical coordination, or bladder control; paralysis; or change in mental status **after a dive**. Some neurologic symptoms are commonly described as constitutional, such as headache, light-headedness, unexplained fatigue, malaise, nausea and/or vomiting, or anorexia. Inner ear symptoms include tinnitus, hearing loss, vertigo or dizziness, nausea, vomiting, and impaired balance. Cardiopulmonary symptoms, known as the chokes, include a dry cough, retrosternal pain, dyspnoea, and sometimes pink-stained, frothy sputum. Cardiopulmonary involvement occurs when massive bubble loads obstruct a substantial proportion of the pulmonary vascular bed. Cardiopulmonary DCS usually follows highly provocative dive profiles with a significant omitted decompression stop.

In terms of frequency of manifestations, joint pain and paraesthesia are the commonest presentations, at about 68% of all symptoms of DCS, dizziness and vertigo at 19%, skin changes at 10%, and impaired mental status and coordination make up about 8% of DCS manifestations (Vann et.al. 2011)

Timely first aid and definitive treatment in a decompression chamber leads to resolution of symptoms and elimination of bubbles from solution into alveoli and excretion via the lungs (Vann, 2011). Delays in treatment lead to catastrophic health outcomes for the individual or death (Vann, 2011). The fishermen at the Kenyan Coast are mostly male, and young (Rodden, 2014). Stark health inequities exist, contrary to the constitution (Constitution of Kenya, 2010 Cap 43).

The communities who have lived along Kenya's 640 km-long coastline for hundreds of years venture into the ocean, no more than 5 nautical miles (about 9 kilometres) from shore to harvest ocean flora and fauna, using traps, nets, or immersion into the Ocean with or without breathing apparatus (Rodden, 2014). An area of 200 nautical miles (230,000 square kilometres, half of Kenya's area) from land distinguishes Kenya's exclusive economic zone (EEZ). (Gitonga & Achoki, 2003). This expanse of ocean is for the most part unexplored, with the last survey of the waters off Kenya's coast having been done between 1975 and 1980 (FAO, 1980). The government of Kenya estimates that only 4% of pelagic catch is exploited (GOK, 2005). Exactly how big a problem decompression sickness is in Kenya is not known. What is not in dispute,

however, is that fishing is the principle economic activity of coastal communities, employing anywhere from 50-90 % of able-bodied men (Rodden, 2014; KNBS, 2019), and that diving for fish and other ocean creatures is one of the major harvesting techniques (Mbaru, 2018).

There are an estimated 7 million divers active worldwide, with a further 500,000 more in training each year (Levett, 2008). Diving is done for recreation, to harvest seafood, to undertake construction or for military purposes. Divers are exposed to various risks because of working in the underwater environment. These include, among others, envenomation from poisonous creatures that inhabit this environment, pressure effects, drowning, exposure or hypothermia and decompression sickness (DCS) (Levett, 2008; INM, 2015).

Significance

The significance of the study was to address the knowledge gap of prevalence and factors contributing to occurrence of DCS, which would help in designing of mitigating interventions as well as seamless referrals to Kenya Navy when needed.

This study was important as it determined the prevalence of DCS in a community of artisanal diving-fishermen in Vanga, Kwale County. It also described the knowledge and practices of diving fishermen at the Kenyan Coast, their effects on individual fishermen's health and the consequences to their communities. This study further outlined the attitude of artisanal diving-fishermen towards DCS, in addition to highlighting the barriers to accessing care among diving fishermen in Vanga that put them at considerable risk of DCS.

Definitive treatment of DCS via recompression is only available in one centre in Kenya, a military facility with restricted access. Follow-up rehabilitation for casualties with residual symptoms following unsuccessful recompression is not guaranteed in public health facilities. Fishing employs up to 90% of seaside community residents in Kenya (Rodden, 2014). The injured fishermen's inability to dive following decompression sickness no doubt impacts on their families' livelihoods. Kwale County has a Gini coefficient of .604, making it the second most unequal county in terms of mean expenditure, in Kenya, behind another Coastal County, Tana River (Gini Coefficient of

.631) (KNBS, 2013). The Kenya National Bureau of Statistics in its latest Report on Inequality Trends in Kenya in 2020 showed the Coastal Region still has the highest income inequality in the country, with income Gini coefficients ranging between 0.565 and 0.617 (KNBS, 2021). The high inequality has led to severe poverty in the Coastal Counties, leading landless citizens to live impoverished lifestyles with poor access to basic amenities such as schooling and health facilities (KNBS, 2021).

In line with the 2030 Agenda for Sustainable Development, a study of decompression sickness among coastal artisanal fisher folk in Kenya is aligned with several of the 17 Sustainable Development Goals, namely SDG 1,3,8, and 14 (United Nations, 2016).

African countries have committed to implement the African Union Agenda 2063, a vision, and a plan for a more prosperous Africa in 50 years. The 2030 Agenda for Sustainable Development considers vision 2063 an integral part of it.

All Kenyans have a right afforded to them by the Constitution (2010 Cap 43) to the highest standard of health regardless of their ability to pay. The diving fishermen's inability to get adequate services that would restore their health and allow them to engage in viable economic activities impacts negatively on their health and economic wellbeing.

Kenya only developed a fisheries policy in 2005, forty-two years after independence (Ministry of Livestock & Fisheries Development, 2005). The Kenya National Oceans and Fisheries policy was adopted in 2008. In recognition of the losses the country faced from unlicensed Distant Water Fishing by fleets of vessels from far-off countries, the policy sought to "to enhance the fisheries sector's contribution to wealth creation, increased employment for youth and women, food security, and revenue generation through effective private, public and community partnerships" (Government of Kenya, 2005). The specific objectives of this policy include promotion of safety at sea, generation of maximum employment, maximizing revenue from fisheries and other related activities. A study of decompression sickness addresses these objectives directly by hopefully providing scientifically sound data concerning fishing and diving practices of coastal diving fishermen.

Kenya Fisheries Management and Development Act (2016) has the main objective of protecting, managing, using, and developing the aquatic resources of the country in a manner which is consistent with ecologically sustainable development, to uplift the living standards of the fishing communities and to introduce fishing to traditionally non-fishing communities and to enhance food security. This study is in line with this policy objective as it sought to identify the main drivers of decompression sickness in a Kenyan fishing community, a major cause of disease and disability in the artisanal fishing community.

Kenya's President Uhuru Kenyatta, while speaking at the Sustainable Blue Economy Conference in Nairobi in November 2018, pledged that as the host country, Kenya would play a leading role in; implementing proper policies and mechanisms to harness the Blue Economy; managing waste for the sake of food security and biodiversity; enforcing sustainable fishing; and ensuring security and safety in the high seas (SBEC, 2018).

CHAPTER 2: Literature Review

This chapter will address current literature on the artisanal diving industry, global perspectives into artisanal dive fisheries, physiology, and health implications of DCS and finally treatment and post-treatment follow up.

2.1 Artisanal diving fishing

Artisanal fishing is low-technology, low capital fishing done mostly close to shore, using simple vessels that are sometimes not motorized (Mbaru, 2018). Kenya marine fisheries are mostly artisanal and employ approximately 12,000 fishermen intensely fishing near shore using non-motorized boats and implementing diving, traps, beach seines, hooks, and lines, spearguns and fence traps (Mbaru, 2012; Kawaka et.al. 2017). This low-technology industry generates 200,000 tonnes valued at 50,000,000 USD, which is the equivalent of 4.7% of Kenya's GDP (Tuda & Wolff, 2015).

Diving for fish and other ocean creatures is one of the major harvesting techniques (Mbaru, 2018). Divers are exposed to various risks because of working in the underwater environment. These include, among others, envenomation from poisonous creatures that inhabit this environment, pressure effects, drowning, exposure or hypothermia and decompression sickness. (Levett, 2008; INM, 2015).

2.2 Global perspectives on artisanal Diving Fisheries

There is a paucity of data on artisanal diving fisheries in Africa. Fishing communities in low-middle income countries in South East Asia, Latin America, and The Caribbean, however, have been extensively studied. These studies have come to a few conclusions that make it imperative to study artisanal diving fisheries in our context.

In Indonesia, a cross sectional study of diving fishermen in 2018 put the prevalence at 38.1% (Syamila et. al. 2018) and showed that diving frequency and pattern of ascent were positively correlated with DCS: odds of DCS were 7 times higher in diving fishermen with more than three dives a day and 6 times higher in divers who perform direct, uncontrolled ascents to the surface.

In Mexico, in a retrospective cohort study, an analysis of decompression sickness (DCS) among diving fishermen over three fishing seasons in 2016 was conducted. It was noted that at least 84.3%

of the respondents had experienced at least one DCS event in the period of study. There was a correlation between age and DCS and in the fishing depths that the divers go to in search of valued species (Huchim-Lara et. al. 2017). Musculoskeletal pain was the commonest manifestation of DCS. Of the 166 fishermen included in the study, one suffered permanent hearing loss, one had spinal injury and subsequent lower limb paralysis, and one died.

In South Korea, a retrospective cohort study of 196 diving fishermen pegged the prevalence of DCS at 84.7% (Su et.al. 2019), an increase from previous in-country studies which had prevalence at 69.5% in 1998 and 61.1 in 2005. This was attributable to decreasing marine resources, repetitive dives (up to 5 per day), longer bottom times and ignorance of the danger posed by unorthodox diving practices (Su et.al. 2019). In South Korea, both men and women take part in diving activities for fisheries. The findings of this study indicated that 100% of the women (24 out of 196) experienced symptoms of DCS. Earlier work by Edmonds et. al. (2002) had shown incidence of DCS among women diving fishers to be three times higher than that of male divers. 68.4% of South Korean diving fishermen learnt diving from older divers through apprenticeship, with only 12 % having received formal training from qualified diving instructors (Su et.al. 2019).

In Brazil in 2014, an exploratory cross-sectional study of artisanal diving fishermen who had been offered recompression treatment in a Brazilian Naval Hospital sought to describe the sociodemographic and epidemiological characteristics of these fishermen. Of the 28 individuals who had suffered DCS, all were male, more than half were aged between 31 and 40, 68% had pain and paraesthesia as the main complaint and 57.1 % were found to have spinal DCS. The mortality rate was 25% (Cavalcante et.al 2014).

2.3 Physiology and Health Implications

Gal (1868) first described a case of paraplegia in a Greek sponge diver. The diver made a spontaneous recovery over two weeks. This case report was not published until 1872 and may have been the first description of neurological decompression sickness in a diver (McIver, 1989). Bauer (1870) published a report of 25 paralysed caisson workers. Four died but the majority recovered within 1 - 4 weeks. Levett (2008) provided a most comprehensive description of the physics of diving, and how an understanding of gas laws explained the clinical manifestations of DCS; Dalton's

law- pressure increases with depth, Henry's law-movement of gases into solution in tissues due to pressure, Boyle's law- pressure and volume are inversely proportional.

Any gas held in solution can cause damage (barotrauma) during compression- called squeeze, or via expansion on ascent when the pressure decreases (Levett, 2008). In non-expandable spaces such as the middle ear or sinuses, descents of as little as 1 metre are enough to cause pain, swelling or bleeding. Rupture of the tympanic membrane can easily occur, leading to impaired hearing and problems with balance following endolymph leakage from the middle ear.

During a dive, inert gas dissolves into the tissues over time and due to the increased pressure experienced with depth. Over time, a state of equilibrium between the breathing gas and dissolved tissue called saturation develops. When the diver ascends to the surface, the gas in the tissues diffuses out into the blood and lungs. As the partial pressure of inert gas still in tissues exceeds ambient pressure, bubbles form, resulting in the symptoms of decompression sickness. (Levett, 2008; Vann, 2011). The bubbles exert their effect by mechanically distorting the tissues, by hampering blood flow, and by activating the inflammatory cascade.
In the long term, divers who expose themselves to uncontrolled diving with poor safety precautions experience neurocognitive decline, dysbaric osteonecrosis, hearing loss and lung changes (Taylor et.al. 2006).

DCS can be prevented by use of dive computers, published dive tables that guide the divers on safe depths and how long they ought to spend there, and algorithms that prescribe ascent rates and safe gas mixtures for breathing. Because other factors such as obesity, intercurrent illness, and cold-water temperature have been shown to increase susceptibility to DCS, fitter individuals are protected from the effects of DCS (Edmonds et.al. 2002; DAN, 2008; Levett, 2008; INM, 2015).

2.4 Treatment of DCS and post-treatment follow-up

Due to paucity of randomised control trials, treatment modalities for decompression sickness are based on case reports, case series, animal studies and clinical judgement (Edmonds et.al. 2002; Vann, 2011). The best first aid is 100% oxygen, which washes off inert gas from the tissues and establishes a large gas gradient on the alveolar surface, which then facilitates diffusion out of the circulation (Hyldegaard, 1991; Vann, 2011). Oxygen is also beneficial to the tissues that were subjected to hypoxia and thus ischaemia, mechanical injury, and biochemical damage, and leads to quicker recovery following therapeutic recompression (Longphre, 2007). In-water recompression (IWR) with oxygen under slight pressure has been attempted in remote localities with some success, but there have been cases of oxygen toxicity with violent seizures (DAN, 2009). Fluids, given orally or parenterally are also beneficial when given cautiously. Glucose containing solutions can cause hyperglycaemia, while hypotonic solutions can cause tissue oedema (Moon, 2003).

The gold standard treatment modality is hyperbaric recompression in a chamber using recompression schedules or tables (Edmonds et.al. 2002). The most widely used are US Navy treatment tables, which are the standard of care in the Kenya Navy recompression chamber. Recompression treatment results in resolution in most cases, mild residual symptoms in some, and serious residual manifestations in others. Those with mild symptoms after treatment, such as tingling or numbness require no follow up, as these resolve spontaneously with time. They may be allowed to dive after 4 weeks of being symptom free. The Kenya Navy's policy in line with other World Navies is to allow operational diving within 7 days of mild manifestations such as joint pains (Kenya Navy, 2018). Ear injuries require re-evaluation after 4-6 weeks. Those with residual neurological deficits require lifelong physiotherapy and rehabilitation.

2.5 Statement of Research Problem

Decompression sickness is a non-communicable syndrome caused by liberation of bubbles in blood or tissues during or after a reduction in environmental pressure (decompression) (Edmonds et.al. 2002; Vann, 2011). Bubbles can have mechanical, embolic, and biochemical effects with manifestations ranging from trivial to fatal. DCS occurs as a direct result of a rapid ascent to the surface from depth, reducing tension

in gases dissolved in the body, leading to entrapment of gas bubbles in tissues, blood vessels, the spinal cord or even the brain (Vann, 2011). DCS affects all individuals who dive as an occupation (for example fishermen, salvage divers, filmmakers, military divers, commercial divers in the oil and gas sector), people who dive recreationally (for example SCUBA divers, breath-hold divers) and people in accidents that involve submersion (Edmonds et.al.2002).

DCS is classified into type 1 and type 2. Type 1 encompasses joint pains (musculoskeletal manifestations). This includes shoulder, elbow, wrist, hand, knee, and ankle pain- an ache, confined to a particular area, always present at rest, occurring after a dive- **within 24 hours.** Type 2 refers to four categories of symptoms: first, numbness, "pins and needles" and muscle weakness; second, urinary incontinence or retention, sensory deficit with a perceived level; third, inner ear symptoms- tinnitus, vertigo, dizziness, nausea, and vomiting; and finally cardiopulmonary symptoms- pleuritic chest pain, increased respiratory rate and cough occurring **after a dive.** Recent studies have alluded to the fact that DCS could be a cumulative disorder, in that multiple "minor" insults of the type 1 variety over many years may predispose divers to serious type 2 DCS, with resultant risk of permanent disability or death (Blatteau et.al. 2015, Howle et.al 2017, Pollock & Butteau, 2017). Risk factors for the development of DCS include unsafe dive profiles (i.e., short, deeper dives, rapid ascent, multiple dives daily, omitted decompression stops and diving without adaptation), altitude exposure, patent foramen ovale (a congenital heart condition), water temperature, age of the diver, aerobic fitness, obesity, dehydration, and exercise at depth. Other factors include over-indulgence in alcohol- which leads to impaired decision making, dehydration, vasodilation, and heat loss further aggravating DCS, and physical injuries. Management of type 1 decompression sickness may be undertaken in the community at tier 1 facilities and involves analgesics and rest. Management of uncomplicated type 2 DCS is reserved for tier 2 and 3 facilities and involves inhaled oxygen, oral or intravenous rehydration and prophylaxis for venous thromboembolism. Complicated type 2 DCS can only be managed in the equivalent of tier 4 facilities and involves recompression and hyperbaric oxygen therapy (HBOT). Pressure in the chamber reduces the volume of the bubbles and does

not actually eliminate the dissolved gas from the body. Recompressing the injured individual in a chamber allows for controlled decompression. HBOT speeds up elimination of gas, improves oxygen delivery to ischaemic tissues, reduces swelling in the tissues and helps restore the damaged endothelium. The outcome of type 1 DCS is complete recovery. With HBOT, casualties recover, but some may have residual symptoms of paraesthesia and paresis that require additional physiotherapy for a prolonged period (Edmonds et.al. 2002, INM, 2015)

DCS disproportionately affects artisanal diving fishermen, as evidenced by published studies in countries with thriving artisanal diving fishing industries such as Brazil, Barbados, India, Vietnam, Mexico, South Korea, Japan, and Indonesia. Studies of artisanal diving fishermen have shown prevalence ranging from 20 to 94%, driven by such factors as socioeconomic pressures, dwindling fish stocks, unorthodox diving practices, barriers to care access including paucity of recompression chambers, economic costs of treatment and false beliefs of invincibility (Cavalcante et. al. 2015; Blatteau et.al. 2015; Huchim-Lara et.al. 2017; Mansingh et.al. 2017). This is in stark contrast to the exceptionally low prevalence rates among military and technical divers, which range from 2.5 to 3.4% (Bangasser 1979, Dear 1999, Divers Alert Network, 2016). Anecdotal evidence of high DCS prevalence in Kenya exists, but there is a paucity of researched data on the magnitude of the problem. Diving fishermen, mostly from Kwale County in the South Coast of Kenya have undergone recompression at the Kenya Navy Base, Mtongwe Chamber with increasing frequency between 2012 and 2018 (Kenya Navy, 2018). The fishermen treated at the HBOT chamber at Kenya Navy Base, Mtongwe and who recover from DCS are trained on safety procedures to avoid recurrence. Despite the training on safety procedures, many of the fishermen return after repeat dive accidents and some eventually succumb to complications of DCS. Survivors remain with neurologic disabilities, which present as urinary and stool incontinence, erectile dysfunction, and lower limb paralysis, thus unable to continue fishing. Given that most divers are the sole breadwinners, these disabilities likely result in depressed socio-economic status of the affected families. Unless primary interventions in the form of training programs are put in place, these diving accidents will continue to occur. This will further compound the already complex socio-economic

conditions of these Kenyan coastal communities, living in counties that are among the top ten (10) poorest and most unequal counties in Kenya (KNBS, 2013). Kwale County has a Gini coefficient of .604, making it the second most unequal county in terms of mean expenditure, in Kenya, behind another Coastal County, Tana River (Gini Coefficient of .631) (KNBS, 2013). The economic costs (treatment, hospitalization), other direct and indirect costs of DCS as reported in the landmark Yucatan Peninsula study of artisanal fishermen, are prohibitive (Huchim-Lara et.al. 2018).

The purpose of this study was first, to ascertain the magnitude of the problem of DCS leading to permanent disability and death in a community of artisanal diving-fishermen in Vanga, Kwale County. Second, this study sought to outline the relationship between knowledge of diving fishermen and decompression sickness. Third, this study aimed to circumscribe the attitudes and practices of artisanal diving-fishermen in Vanga that put them at considerable risk of DCS. Fourth, this study sought to identify barriers to care access among diving fishermen needing care for decompression sickness. This study proposed culturally appropriate intervention measures to mitigate the effects of DCS in the community.

2.6 Theoretical Framework

The Health Belief Model (Abraham & Sheeran, 2005) is a framework that hinges on two pillars; perception of illness (threat perception) and evaluation of behaviours to counteract this threat. Beliefs are enduring individual characteristics which shape behaviour and can be acquired through primary socialization. Beliefs are modifiable. If persuasive methods can be used to change behaviour-related beliefs and these interventions also result in behaviour change, this provides a theoretical and practical basis for evidence-based health intervention. The study was guided by the HBM because the model has previously been applied to explain risk behaviour (smoking, healthy eating, alcohol consumption and sexual behaviour) as well as plan efficacious interventions that have resulted in improved health outcomes (Abraham & Sheeran, 2005).

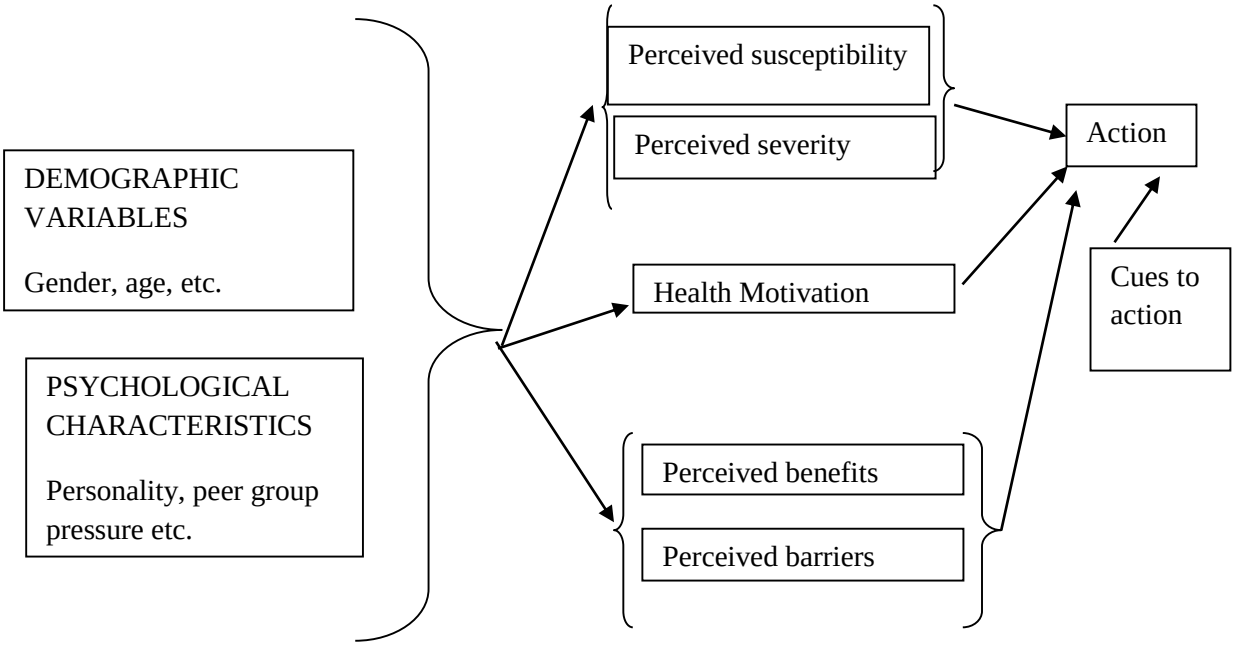
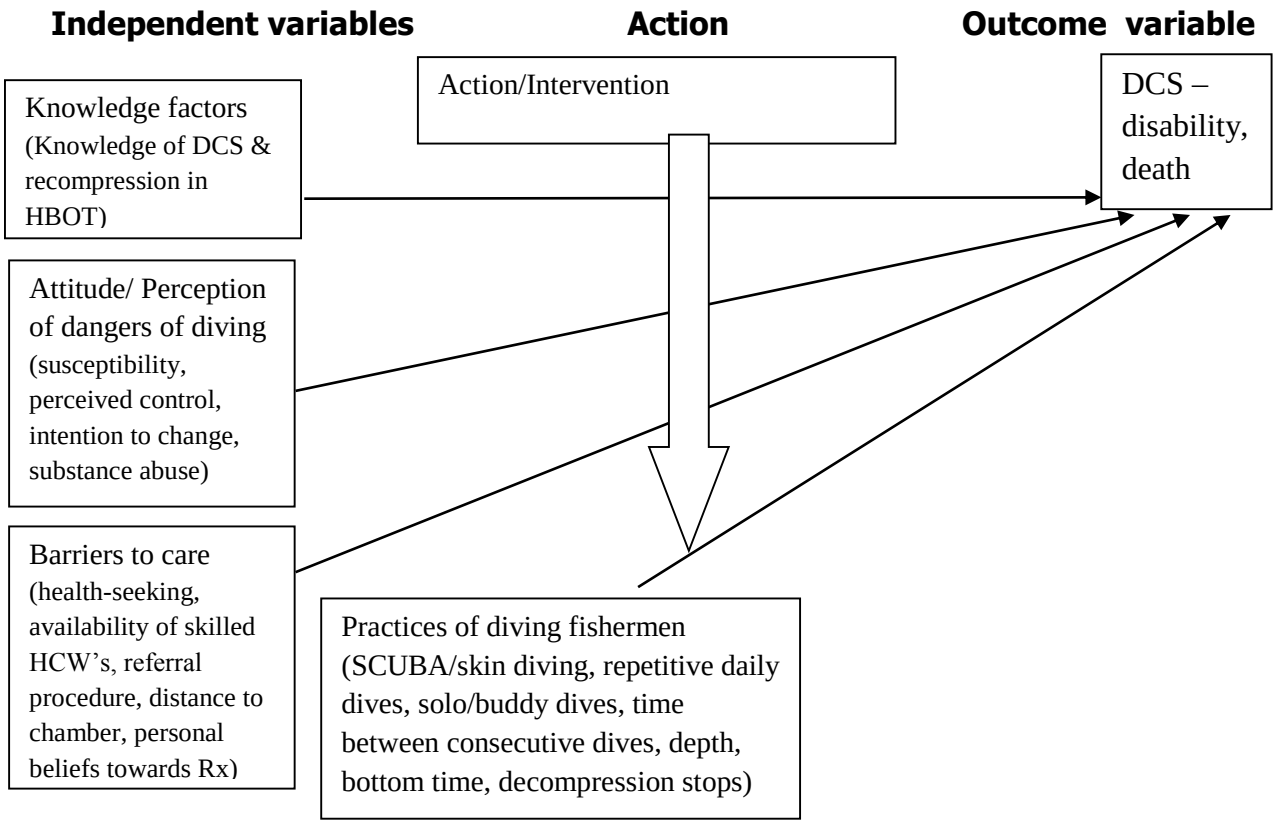


Figure 1: The Health Belief Model (Abraham & Sheeran, 2005)

2.7 Conceptual Framework

This provides a way to understand how the independent variables relate with the outcome variable.

Figure 2: conceptual framework



2.8 Justification

The justification of this study was to address the knowledge gap of prevalence and factors contributing to occurrence of DCS. This would in turn help in the design of mitigating interventions and seamless referrals to Kenya Navy when needed.

Kenya Navy recompression chamber records for the period 2012-2018 showed 13 referrals for recompression in 2012 from various diving communities along the Kenyan Coast, 20 in 2013, 25 in 2014, 16 in 2015, 23 in 2016, 31 in 2017 and 33 in 2018. There were 2 mortalities in 2016, 2017 and 2018. All were divers with a history of previous treatment for decompression sickness.

This study provided a better understanding of the burden of this non-communicable disease by determining the prevalence of decompression sickness, a condition that may lead to permanent disability or death, in a fishing community at the Kenyan coast. It also sought to delineate any associations between how fishermen dive and their disease occurrence. Recommendations to County Health teams that provide emergency first aid and Ministry of Defence that provides definitive recompression therapy will, in the long term, help reduce prevalence, facilitate seamless referrals of diving casualties and initiate training of fishermen on safe diving practices.

2.8.1 Research Questions

1. What is the magnitude of decompression sickness among the diving fishermen of Vanga, Kwale County?
2. What is the relationship between knowledge and decompression sickness?
3. What are the perceptions of diving fishermen towards decompression sickness?
4. What is the relationship between diving practices and decompression sickness?
5. What are the barriers to care access among diving fishermen needing care for decompression sickness?

2.9 Broad Objective

To determine the relationship between knowledge, perceptions and practices of diving fishermen and decompression sickness

2.10 Specific Objectives

1. To determine the magnitude of the problem of decompression sickness among diving fishermen
2. To assess the knowledge of diving fishermen
3. To evaluate diving fishermen's perceptions towards decompression sickness
4. To determine the relationship between diving practices and decompression sickness
5. To document the barriers to care access among diving fishermen.

CHAPTER 3: Methodology

3.1 **Study Design**

A cross sectional survey to determine magnitude of decompression sickness at time of study, knowledge, attitude, and diving practices among coastal fishermen that may precipitate decompression sickness (DCS) was conducted between July and August 2020. The study was carried out in Vanga village, Lungalunga Sub County of Kwale County, one of the coastal fishing communities that have contributed patients to the Kenya Navy for therapeutic recompression following diving accidents.

3.2 **Study Area**

Kwale County is in the South Coast of Kenya. It borders Taita Taveta County to the North West, Kilifi County to the North East, Taita Taveta and Kilifi Counties to the North, Mombasa County and The Indian Ocean to the East and The United Republic of Tanzania to the South. The County is in the South Eastern corner of Kenya, lying between latitudes 30 3 and 40 45 South and longitudes 38 31 and 39 31 East (Mvurya, 2013). Only 10% of Kwale residents, the main source of patients attended to at the Kenya Navy HBOT facility, have a secondary education, and 39% have no formal education whatsoever (Ngugi, 2013). The study was carried out in Vanga village, Lunga Lunga Sub County of Kwale County where artisanal fishing is the main economic activity (KNBS, 2013). The Worldwide Fund for Nature (WWF) recognizes the entire South Coast of Kenya as an area of exceptional biodiversity, and Vanga as one of 21 sites of profound ecological importance along the entire East African Coast. Fisheries are managed through Beach Management Units- associations of fishers, boat owners, fish traders and other users of the fisheries around the fish landing site (usually a beach) (East African Wildlife Society (EAWS), 2017). The BMU's provide important governance structures that allow the community to coordinate among themselves and with authorities (FFI/EAFW, 2017). Fishing through diving is conducted in the reef using spear guns or nets after launching the fishermen from motorized canoes, outrigger canoes (Ngalawa) or open fishing boats- traditional dugout canoes (Mashuwa) (Fondo, 2004).

Kenya Navy Base, Mtongwe is the Country's main Naval Base and site of the Kenya Navy Sick Bay- as the Naval Hospital is known. Also located at the Naval Base is the Hyperbaric Oxygen Therapy (HBOT) or recompression Chamber, used for training and treating Kenya Navy Clearance Divers, as well as for offering treatment to civilian dive casualties.

3.3 **Study Population**

The study was carried out among the diving fishermen of Vanga village, Kwale County- encompassing actively diving and currently inactive divers. An estimate of the target population of diver fishermen based on Kenya National Bureau of Statistics data from 2019 put the number at 1000. The male population of Vanga aged 15-64 stood at 12,321. KNBS estimated 40% of them to be engaged in fishing as the main economic activity. Diving for fishing being a very niche occupation, the probable number of all fishermen who dive was thought by the principal investigator not to exceed 500 from anecdotal accounts (Kenya Navy, 2018). The Vanga beach management unit register used in this study had a total of 330 registered members, of whom 250 were diving fishermen, both breath hold and SCUBA divers (Kithome, 2020). The others comprised boat owner and fish traders.

3.4 **Inclusion/Exclusion Criteria**

3.4.1 **Eligibility Criteria:** All fishermen who ply their diving trade and fit the **case definition** (an individual who has ever dived while fishing and developed decompression sickness as determined by administration of a clinically proven survey tool adopted from Royal Australian Navy Health Diving Profile) (Edmonds C et.al. 2002) were eligible for inclusion in the study.

3.4.2 **Exclusion Criteria:** Diving fishermen who did not appear in the Beach Management Unit register were excluded from the study. A National ID card and annual subscription fee are prerequisites for registration by the Beach Management Unit (BMU). Some diving fishermen who live and work in Vanga are not Kenyan nationals, and their immigration status in unclear. The inability of the principal investigator to find any written record of these fishermen led to them being excluded

from the study. This is despite their registered colleagues confirming that they undertake the same work.

3.5 **Sample Size**

The sample size for this study was determined using the formula according to Naing (2006) and was 246 individuals. The study population was 12,321. KNBS (2019) estimated 40% of them to be engaged in fishing as the main economic activity (4,928), with divers making up 10% of the total fishermen. The beach management unit (sampling frame) had 330 registered members. The Z statistic was 1.96, p was 0.8, d was 0.05. The P (prevalence from previous studies) was 0.8 (80%), the average prevalence from the 4 landmark studies evaluated in the literature review, range 20-94%

$$\text{Sample size} = \frac{Z_{1-\alpha/2}{}^2 p(1-p)}{d^2}$$

Formula according to Naing (2006)

Where $Z_{1-\propto/2^2=}$ statistic corresponding to the level of confidence

p= prevalence from previous studies

d = precision, corresponding to the effect size

1.96^2 x 0.8 (1-0.8)/ 0.05^2= 246

3.6 **Sampling**

Random sampling was employed. The sampling frame was the Beach Management Unit Register of currently active and registered diving fishermen who ply their trade in Vanga. Randomly selected fishermen were screened using the Modified Kenya Navy Health Diving Profile currently applied in clinical practice at the Kenya Navy Sick Bay following adaption from Royal Australian Navy Health Dive Profile (Edmonds, et.al. 2001, see Appendix) and Australian Standard AS4005.1. All diving fishermen passed the screening and had the structured questionnaires administered. Questionnaires

were supplemented by direct visual observation by the principal investigator and research assistants.

3.7 **Variables**

Sociodemographic characteristics- such as age, religion, and education level. The scope of education level was widened beyond formal education to include apprenticeship- a system of skill acquisition by new fishermen in the trade with on-the-job training, including swimming, canoeing, identification and knowledge of fish, mounting and mending nets and operation of diving equipment.

3.7.1 Predictor variables

Attitude of diving fishermen (Perception of susceptibility to DCS, perception of severity of DCS, substance abuse (stress coping), perceived control, intention/ readiness to change, distrust of health care, trust in traditional medicine)

Knowledge of diving fishermen- information about DCS symptoms

Diving practices- type of diving method (SCUBA or skin diving), number of dives in a day, time taken between consecutive dives, are dives undertaken alone or with a buddy-diver, greatest depth ever attained during dive, bottom time (time spent under water) and mandatory decompression stops,

Barriers to care access- Measure of knowledge of diver fishermen about local health workers who know about symptoms of decompression sickness, ease of access to public health facility by fishermen, ease, or difficulty of referral for specialised treatment from frontline medical personnel, personal beliefs towards treatment.

3.7.2 Outcome variable

decompression sickness leading to permanent disability or death.

3.8 **Data Collection**

Data was collected by administration of structured questionnaires following successful screening with the Modified Kenya Navy Health Diving Profile by the principal

investigator and research assistants. Respondents were identified from the Beach Management Unit register.

3.8.1 **Materials**

This study utilized printed Health Diving Profiles, questionnaires, audio-recording equipment (cellular telephone) and a laptop computer to collect, record, code and analyse study data.

3.8.2 **Training Procedures**

Research assistants were trained by the key investigator on understanding the modified Kenya Navy Health Diving Profile and administering questionnaires.

3.8.3 **Quality Assurance Procedures**

Questionnaires and Kenya Navy Health Diving Profile were to be pretested in a pilot study in a fishing community not dissimilar to Vanga to ensure clarity of the instruments and their validity. Owing to the onset of COVID-19 and subsequent restriction of movement between the two coastal counties where the principal investigator and the study subjects live, this was unfortunately not undertaken. Questionnaires were afterwards administered and collected by the research assistants, themselves trained and active Kenya Navy Clearance Divers with years of diving experience and extensive knowledge of the locality, including the local dialects spoken in Vanga. This was projected to increase response from the diving fishermen.

3.9 **Ethical Consideration**

The principal investigator was bound by the Hippocratic Oath, Code of Conduct of the Kenya Defence Forces and Public Servants Professional Code of Ethics which demanded observing absolute confidentiality of study participants. Serial numbers and codes were used in lieu of names to safeguard confidentiality of study participants. Permission was sought from them and consent forms duly signed or initialled in the case of those diving fishermen unable to write owing to have little to no formal education (Appendix). This research proposal was submitted to the KNH/UON Ethics

and Research Committee (ERC) for ethical review and received approval on 5 March 2020 (P1027/12/2019) (Appendix).

3.10 **Recruitment and Consenting Procedures**

Informed consent was obtained from study subjects. The consent form was translated from English into colloquial Kiswahili spoken in the locality, for those diving fishermen unable to read and understand English. The participants were guaranteed confidentiality. Serial numbers were used instead of names of the participants.

3.11 **Data Management**

The raw data was entered into Microsoft Excel, proofread, and counterchecked for any missing information or duplicated responses.

3.12 **Data Analysis**

After cleaning, the data was exported from Microsoft Excel to R. R statistical software was used in all analyses and data visualization.
Categorical data analysis was used to analyse the collected data. This was because the principal investigator's main objective was to determine the relationship between two categorical variables. Since the principal investigator measured only categorical variables, frequencies were analysed. Analysis was done on the number of responses that fall into each combination of category. To see whether there was a relationship between these categorical variables the principal investigator was guided by the Pearson's chi-square test statistic to compare the frequencies observed in the categories to the frequencies he might have expected to get in those categories by chance.

3.12.1 **Sociodemographic data**

Anonymised sociodemographic data was collected from the study respondents. It included age as per National Identity Card, education level attained, apprenticeship training, religion, and marital status. Descriptive statistics namely measures of central tendency- mean, median- were used to analyse age in years and age at debut of diving. Measures of spread i.e., range and quartiles were used to analyse both these

age parameters. Frequencies were used to analyse education, religious affiliation, and marital status.

3.12.2 **Knowledge of diving fishermen and decompression sickness.**

Knowledge was determined by evaluating familiarity of diving fishermen with the symptoms of decompression sickness i.e., whether the divers' perception or knowledge exposed them to the risk of contracting decompression sickness (ascertaining if there exists a relationship/association between the measured variables and decompression sickness). A two-by-two contingency table was created, and Pearson Chi square test used to test whether the two variables were independent. Odds ratio was determined. Results were considered significant when $p<0.05$ i.e., 95% confidence interval.

3.12.3 **Attitude of diving fishermen towards decompression sickness**.

The attitude of diving fishermen was determined by evaluating how they perceived their conduct of diving operations with regards to decompression sickness. A two-by-two contingency table was created, and Pearson Chi square test used for association between diving fishermen's attitude and incidence of decompression sickness. Odds ratio was determined. Results were considered significant when $p<0.05$ i.e., 95% confidence interval.

3.12.4 **Diving practices and decompression sickness**

The diving fishermen of Vanga, Kwale County were found to employ two methods of diving: SCUBA i.e., use of Self-Contained Underwater Breathing Apparatus, and breath hold diving i.e., immersion on a single breath of inhaled surface air. A two-by-two contingency table was created, and Pearson Chi square test used to test for association between the diving method employed and incidence of decompression sickness. Odds ratio determined. Results were considered significant when $p<0.05$ i.e., 95% confidence interval.

3.12.5 **Barriers to care access among diving fishermen.**

Data on barriers to care access among diving fishermen was analysed using frequencies. Presence of a health care worker with knowledge of decompression sickness, average time of referral from Vanga to Kenya Navy for emergency recompression, access to the recompression chamber and cost, if any, associated with transport or treatment.

3.12.6 **Magnitude of decompression sickness**

Magnitude of decompression sickness was determined from computing frequency of diving fishermen who had decompression sickness as a proportion of all diving fishermen. Odds of decompression sickness was also calculated with 95% confidence interval.

Chapter 4: RESULTS

4.1 Sociodemographic Profile

All the study participants (N=246) were male, the median age being 36, range from 19 to 76 years. Nearly all the study participants (99.2%, n=244) had either no formal education at all or had failed to complete primary education). Only 2 diver fishermen (0.8%) had completed secondary school. Almost all the study respondents (93.5%, n=230) were married, with a few (6.1%, n=15) being single and hardly any (0.4%, n=1) were divorced (N=246). Nealy all the study respondents were Muslim (97.6%, n=240) and the rest Christian (2.4%, n=6) (N=246). The divers' age median 20 years at debut ranged from 13 to 35 years. Training by apprenticeship was found to be the main technique through which knowledge was imparted to majority (66.26%, n=163) of diving fishermen. A minority of diving fishermen (33.74%, n=83) were self-taught and had received no apprenticeship training at all (N=246). A total of 177 (72%) divers did not contract DCS type 1 and 69 (28%) did (N=246). Of the 69 study participants who were adjudged to have developed decompression sickness type 1, 55.1% (n=38) were breath hold divers while 44.9% (n=31) were SCUBA divers.

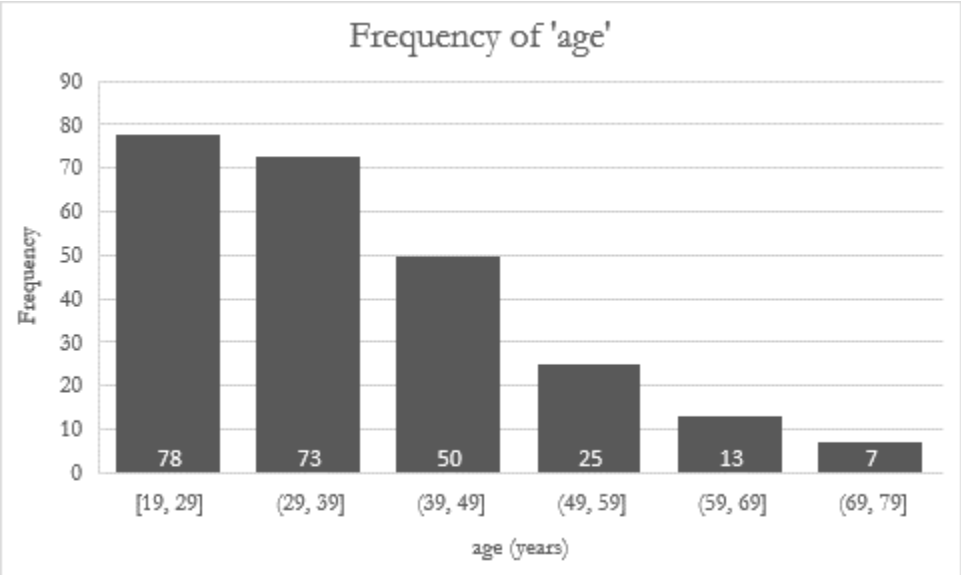
Table 1

Sociodemographic characteristics, diving fishermen, Vanga, Kwale County, 2020

Variable	Category	Frequency (n)	Percentage (%)
sex	female	0	0
	male	246	100
age	19-29	78	31.7
	29-39	73	29.7
	39-49	50	20.3
	49-59	25	10.2
	59-69	13	5.3
	69-79	7	2.8
education	Formal-complete	2	0.8
	No formal education	244	99.2
education	apprenticeship	163	66.3
	No apprenticeship	83	33.7
Marital status	married	240	97.6
	single	15	6.1
	divorced	1	0.4
religion	Muslim	240	97.6
	Christian	6	2.4

Figure 4

Age frequency distribution, diving fishermen, Vanga, Kwale County, 2020



4.2 Knowledge of diving fishermen

There was a significant association between diver fishermen's knowledge of the symptoms of decompression sickness and whether these symptoms were because of decompression sickness $p< 0.05$ ($p= 0.00000023529872$). Majority of diving fishermen who developed decompression sickness (57.3%, n=141) were aware of the symptoms of this non-communicable disease. The rest did not know (42.7%, n=105). The symptoms experienced by the divers are a true indication/ are associated with decompression sickness.

Table 2 Knowledge of diving fishermen, Vanga, Kwale County, 2020

		Developed DCS		
		No (%)	Yes (%)	Total (%)
Knowledge	No (%)	92 (87.6)	13 (12.4)	105 (42.7)
	Yes (%)	85 (60.3)	56 (39.7)	141 (57.3)
Total (%)		177 (72)	69 (28)	246 (100)

Total observations: N=246; Odds ratio= 4.63 (95% c.i 2.30-9.92); χ^2 = 22.28; p= 0.00000023529872

4.3 Attitude of diving fishermen towards decompression sickness

There was a significant association between divers' attitude and decompression sickness (p=0.016). Nearly all the study respondents (94.3%, n=232) reported that their conduct of diving operations made them vulnerable to decompression sickness. The rest (5.7%, n=14) did not think how they dived had any effect on their susceptibility to decompression sickness (N=246). This attitude, not associating how one dives with susceptibility to decompression sickness, appears to have been protective to this small proportion of diving fishermen.

Table 3

Attitude of diving fishermen towards decompression sickness, Vanga, Kwale County, 2020

		Developed DCS		
		No (%)	Yes (%)	Total (%)
Attitude to DCS	No (%)	14 (10)	0 (0)	14 (5.7)
	Yes (%)	163 (70.3)	69 (29.7)	232 (94.3)
Total (%)		177 (72)	69 (28)	246 (100)

Total observations: N=246

4.4 Diving practices and decompression sickness

Of the 69 diving fishermen who developed decompression sickness, 38 were breath hold divers and the rest, 31, were SCUBA divers. The diving method had no significant effect whether a diver would contract decompression sickness or not (p=0.32).

Some of the diving fishermen (16.3%, n=40) reported to moving from net and trap fishing to diving much later in life than the median age of 20 years due to availability of Self-Contained Underwater Breathing Apparatus (SCUBA) in Vanga fisheries beginning from 2001(McClanahan & Mangi, 2004).

The diving fishermen's work week was heavily influenced by religious affiliation since the Muslim diver fishermen who made up 97.6%, n=240 of study respondents rested on one day a week only- Friday for prayers. This time was also devoted to boat maintenance work, mending nets, refilling SCUBA cylinders from a compressor and recovering from the rigors of diving. A small minority of study respondents 2.4%, n=6 was Christian.

Table 4

Diving practices of diving fishermen, Vanga, Kwale County, 2020

		Developed DCS		
		No (%)	Yes (%)	Total (%)
Diving method	SCUBA (%)	92 (74.8)	31 (25.2)	123 (50)
	Skin diving (%)	85 (69.1)	38 (30.9)	123 (50)
Total (%)		177 (72)	69 (28)	246 (100)

Total observations: N=246; Odds ratio= 1.3 (95% c.i 0.73-2.42); χ^2 = 0.9; p-value= 0.3

4.5 Barriers to care access among diving fishermen

The barriers to care access were:

1. Absence of a health worker
2. Time to referral for recompression therapy
3. Mode of access to transportation
4. Fees- transport, treatment, time away from work

Majority of the study respondents (61%, n=150) said there was no local health care worker in Vanga or anywhere in Kwale who is familiar with DCS. A few (8.1%, n=20) did not know. A large proportion (30.5%, n=75) said they were not sure. Almost none of the study participants (0.4%, n=1) said they knew of a healthcare worker they could defer to in case of a diving accident. Almost all i.e., 94.2%, n=65 of the diving fishermen who were adjudged to have developed decompression sickness Type 1 did not receive recompression therapy.

Four (4) diving fishermen had received recompression therapy for decompression sickness at Kenya Navy (5.8%). Time to referral was 3 hours for the first individual, 4 hours for two of the others and 8 hours for the final diving fisherman. All the 4 casualties accessed the treatment facility through private means. A total of 177 (72%) divers did not contract DCS type 1 and 69 (28%) did; of those who did 38 (55%) were skin divers and 31 (45%) were SCUBA divers.

The Kenya Navy treatment protocols for civilian diving casualties state that no payment for recompression services is envisioned (Kenya Defence Forces, 2010). Even though the diving fishermen were not charged any fees for the treatment received at Kenya Navy, they were made to reimburse their employers (boat owners) for transport to and from the Recompression Chamber, time away from work, and for subsequent treatment for residual symptoms following decompression sickness. One respondent has been treated three times for decompression sickness and remains an active diver despite residual health problems.

Table 5

Diving fishermen resident in Vanga, Kwale County treated at Kenya Navy Recompression Chamber

	Debut (current age)	Diagnosis (DCS)	Diving Method	Diving Practices			Treatment	Time to referral	Residual Symptoms
				DS	BK	>1D			
1	33 (48)	Type 1	SCUBA	1	1	0	Once	4 Hours	Nil
2	20 (24)	Type 2	SCUBA	1	0	1	Once	4 Hours	Nil
3	35 (46)	Type 2	SCUBA	0	0	1	Once	8 hours	Erectile dysfunction
4	21 (27)	Type 2	SCUBA	1	0	1	Thrice	3 Hours, each time	Pin-and-needle sensation both feet

Key

DS- decompression stops on ascent back to the surface. 1= yes, 0= no

BK- Breaks between dives, minimum one hour. 1=yes, 0=no

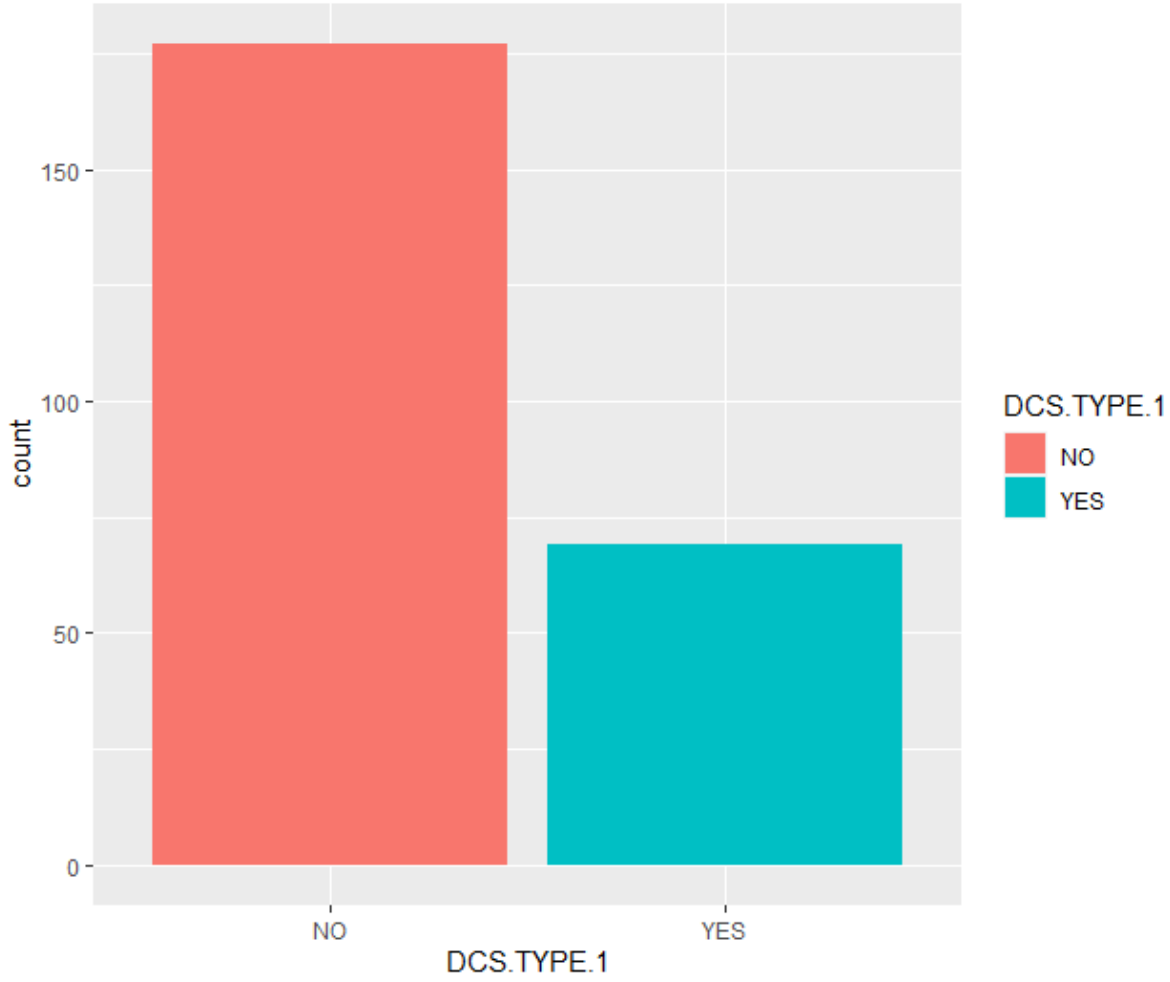
>1D - Multiple daily dives (more than one dive). 1=yes, 0=no

4.6 Magnitude of the problem of decompression sickness among diving fishermen

A total of 177 (72%) divers did not contract DCS type 1 and 69 (28%) did; of those who did 38 were skin divers and 31 were scuba divers (OR 1.33, 95% confidence interval 0.73-2.42) N=246

Figure 5

Magnitude of Decompression Sickness in Vanga, Kwale County,2020



Chapter 5: DISCUSSION

5.1 Discussion

All the diving fishermen who took part in this study were male. The predominance of one gender in dive fisheries is in line with other previous studies of artisanal diving fishing communities in South America and South East Asia (Cavalcante et.al. 2014; Syamila, 2018). South Korean fisheries remain the lone exception, where a few divers who fish remain women (12.2%) (Cha et.al. 2019). In this Korean study, 100% of the female divers experienced symptoms of decompression sickness. It has previously been established that female sex is an independent risk factor for decompression sickness. Edmonds et al (2002)'s study, showed that the incidence of DCS symptoms in female divers was three times higher than those of male divers.

In the ongoing pilot of Universal Health Coverage (UHC) in select counties, select health services as defined in the Kenya Essential Package of Health are being offered at no charge. Maternal care may be singled out for a conscious effort to incorporate the male gender both to provide support to the expectant partner, and as a gateway to accessing other hospital services. These include non-communicable disease screening, HIV testing, care, and treatment (Wangia & Kandie, 2020). Immediately prior to UHC pilot, the number of health facilities offering the Kenya Essential Package of Health (KEPH) increased from 41% to 55% between 2013 and 2016 (Wangia & Kandie, 2020), with the biggest increase seen in maternal health. In another program area that forms part of HIV care, voluntary male medical circumcision (VMMC), only one gender is clearly the intended target. However, this initial contact with male members of the community served as a jump off point to identify and rope in sexual partners for incorporation into care and treatment where necessary. Non-communicable disease prevention, diagnosis, treatment and follow up forms an integral part of UHC (Kiarie et.al. 2018). Therefore, despite the preponderance of the male gender in diving fisheries in Vanga, Kwale County, there is a case for targeting this demographic at high risk for a potentially fatal non-communicable disease, both to offer them emergency and routine health services, and to incorporate both their partners and other female community members, such as fish traders, into care.

In this study the magnitude (point prevalence) of decompression sickness was 28%. This finding agrees with previously studied diving fishing communities around the world where prevalence has been found to range from 20-94% (Kelleher, 1993; Niu, 1996; Kawashim, 1996; Buorke, 1998; DeNoble, 2001, Dunford, 2002).

This prevalence is close to the lower end of this spectrum of previously studied diving fishing communities. The proportion of those who did not have DCS exceeds those who did. There was no statistically significant difference between diving fishermen who contracted decompression sickness and those that did not.

Despite the absence of statistical significance, the effect size of DCS among divers should not be ignored (OR 0.39, 95% confidence interval 0.73-2.4) This is because of the documented cumulative risk of the more serious type 2 DCS, resulting from multiple episodes of the milder type 1 (Blatteau et.al. 2015, Howle et.al 2017, Pollock & Butteau, 2017), the toll decompression sickness takes on the overall health of diving fishermen by way of the life-long residual symptoms of decompression sicknes s (Edmonds et.al. 2002, INM, 2015) and the potential for mortality from decompression sickness.

Although this study did not investigate the economic costs of DCS, the impact of the loss of income by a diving fisherman who has DCS cannot be ignored. Even though Kenya Navy does not charge the diving fishermen for recompression treatment, the boat owners recover the costs of transport to and from the Kenya Navy recompression chamber, the costs of adjunct treatment such as intravenous fluids and antibiotics, and any rehabilitation costs such as physiotherapy. The diving fishermen also are unable to earn any money if they are not fishing.

A study using data from the Kenya Household Health Expenditure and Utilization Survey (KHHEUS) 2018 found that between 1 and 1.1 million Kenyans are pushed into poverty due to OOP payments for health services (Salari et.al.2018). They are mostly rural and suffering from chronic conditions.

Some of the diving fishermen (16.3%), n= 40) reported to moving from net and trap fishing to diving much later in life due to availability of Self-Contained Underwater Breathing Apparatus (SCUBA) in Vanga fisheries beginning from 2001 (McClanahan & Mangi, 2004). Dive fisheries in other jurisdictions previously studied showed a similar

shift from breath hold diving to SCUBA, or surface supply by "hookah" once these became available (Blatteau et.al. 2015, Huchim-Lara et.al. 2018, Cha et.al. 2019). Reasons for this shift have included longer deeper dives (Cha et. al. 2019), ability to obtain more catch (Huchim-Lara et. al. 2018), and removal of dependence on seasonal species (Huchim-Lara et. al. 2018). A reason offered specifically for the for the later debut of a proportion of diving fishermen in Vanga, Kwale County was the diving fishermen receiving a larger proportion of the earnings from the proceeds of sale of the catch. The division has always been agreed upon by the boat owners and diving fishermen themselves to skew in favour of divers due to their perceived increased risk of injury and/or disability.

Knowledge was determined by evaluating familiarity of diving fishermen with the symptoms of decompression sickness. A dearth of formal education has been noted to be a risk factor for decompression sickness through employment of unorthodox diving practices such as prolonged bottom time, solo diving, uncontrolled ascents, and multiple dives in a day (Huchim-Lara et.al. 2017; Cha et.al. 2019). In this study, 99.2% of the study participants had either no education at all or incomplete primary schooling (n=244). This differs markedly from Kenya National Bureau of Statistics population census data from 2019 which reported that a sizeable proportion of residents of Kwale county (37.1%) had left school without completing or never attended formal schooling (KNBS, 2019). In this study, few fishermen had completed formal education up to secondary level (0.8%, n=2) as opposed to 19.4% of Kwale residents having left school after completion (KNBS, 2019).

In the absence of formal education, the diving fishermen of Vanga, Kwale County turned to apprenticeship to gain knowledge and skill to enable them to carry out their work. Majority (66.3%, n=163) of the study respondents had trained as apprentices. Other studies agreed with these findings. Cha et.al. (2019) reported 68.4% of South Korean diving fishermen learnt diving from older divers through apprenticeship, with only 12% having received formal training from qualified dive instructors. Eriksson et. al. (2012) and Blatteau et. al. (2015) as quoted in Winkler (2016), also detail the important role of apprenticeship in Zanzibari and Vietnamese dive fisheries where 72% and 81% of diving fishermen, respectively, learnt their craft through this method.

The apprenticeship training in Vanga, Kwale County encompassed SCUBA diving, spear-gun fishing, boat handling and net placement. In addition, the diving fishermen were trained in acquisition of skills in "clearing"- ridding the face mask of water while diving, without doffing it, and in "equalizing"- the act of performing a Valsalva manoeuvre while descending deeper into the ocean to equalize ambient pressure from the column of water outside the body with middle ear pressure to prevent rupture of the tympanic membrane. The mostly skills-based training in the background of little formal education and understanding of the physics of diving has been shown to be associated with lack of knowledge of the symptoms of decompression sickness, risky diving practices and hence higher incidence of decompression sickness in at least two recent studies (Winkler, 2016; Huchim-Lara, 2017)

In a departure from these recent studies, however, the dearth of formal education amongst the diving fishermen of Vanga, Kwale County did not visibly account for lack of knowledge of possible disabling or life-threatening symptoms of decompression sickness.

The attitude of diving fishermen was determined by evaluating how they perceived their conduct of diving operations with regards to decompression sickness. There was a significant association between divers' attitudes and decompression sickness. The diving fishermen believed that anyone regardless of their age or diving experience can get decompression sickness, and that multiple daily dives increased one's susceptibility to decompression sickness. Substance use and abuse was not common due to religious affiliation and a widely held belief that substance use takes away one's control of situations, both in the water and in life.

The diving method has no significant effect whether a diver will contract decompression sickness or not. Omission of decompression stops on the way back to the surface was noted in both skin diving and SCUBA diving groups. Other risky diving practices such as multiple dives per day and omission of rest periods between dives were also noted in both groups.

A significant majority (61%, n=150) of the study respondents said there was no local health care worker in Vanga or anywhere in Kwale who is familiar with DCS and has

experience providing care to people with DCS. Almost no diving fishermen (0.4%, n=1) said they knew of a healthcare worker they could defer to in case of a diving accident- at the Kenya Navy recompression chamber. This may have been due to perceived mild symptoms of type 1 DCS, distance to the nearest recompression chamber located in neighbouring Mombasa County (125 km) and the conduct of in-water recompression (IWR) to relieve symptoms of decompression sickness while still at sea. A 2019 review of 48 abstracts and papers on the risks and benefits of IWR concluded that this treatment modality has a place in the treatment of decompression sickness especially among remote communities far removed from recompression chambers such as the one at Kenya Navy (Brackett, 2019).

The Gold Standard treatment modality for decompression sickness is recompression in a chamber using recompression schedules or tables (Edmonds et.al. 2002). Favourable treatment outcome is seen in cases where, even after considerable delay to recompression, first aid is administered by a trained health care worker in form of 100% inhaled oxygen and oral or parenteral fluids (Hyldegaard, 1991; Edmonds et.al. 2002; Moon,2003; Longphre, 2007; Vann, 2011). The absence of skilled health workers familiar with decompression makes delays in detection of decompression sickness more likely.

Several countries with diving fisheries and difficulty in access to recompression facilities have developed protocols for in-water recompression at the diving site (Gold, Geater & Aiyarak, 1999; Edmonds, 1999; Pyle, 1999; Blatteau, Jean & Pontier, 2006). IWR reproduces the effect of a recompression chamber by resubmerging the patient. If possible, he is also provided with pure oxygen to breathe. Epidemiological surveys conducted in remote diver communities that practice IWR have demonstrated the effectiveness of this type of treatment (Farm et.al. 1986; Pyle, 1997). Recent experiments on animals have shown that IWR with oxygen (1 h submerged to a depth of 6 m) prevented bubbles and reduced mortality (Mollelorken et.al. 2007).

Four (4) diving fishermen had received recompression therapy for decompression sickness at Kenya Navy (5.8%). The Kenya Navy, one of three armed services of the Kenya Defence Forces, offers emergent recompression treatment to all civilian casualties of diving accidents in fulfilment of its secondary mandate- aid to civil

authority (Constitution of Kenya, 2010 Cap 241 (3) (b)). Time to referral was 3 hours for the first individual, 4 hours for two of the others and 8 hours for the final diving fisherman. All the 4 casualties accessed the treatment facility through private means. A total of 177 (72%) divers did not contract DCS type 1 and 69 (28%) did; of those who did 38 were skin divers and 31 were SCUBA divers.

All the 4 casualties accessed the treatment facility through private means. Even though they were not charged for the treatment received at Kenya Navy, they were made to reimburse their employers (boat owners) for transport to and from the Recompression Chamber, time away from work, and for subsequent treatment for residual symptoms following decompression sickness. One respondent has been treated three times for decompression sickness and remains an active diver despite residual health problems.

5.2 Study Limitations

The subjective memory of fishermen was prone to errors in recall and accuracy, especially if the diving accident occurred years previously. Employment of Kenya Navy recompression chamber treatment log was useful in countering this recall bias for those confirmed cases of DCS that were referred to the Kenya Navy for recompression. Use of two information sources was employed to deal with measurement error. This included questionnaires and the Kenya Navy Health Diving Profile. Since administration of the study tools was integral in deciphering cases from non-cases, the study instruments were administered equally to all eligible diving fishermen. Dive information for depths and duration, whether by SCUBA or breath hold divers, was imprecise due to absence of dive computers and depth gauges in diving fishermen. The depth figures are based mostly on their recall. This made it difficult to draw statistical conclusions on whether dive depth and dive duration were associated with decompression sickness in Vanga. However, collecting statistical dive data was not required to confirm that fishermen are undertaking unsafe dives; the ongoing incidence of diving accidents confirmed this.

5.2 Conclusion

Decompression sickness, a potentially life-altering and likely life-ending non-communicable condition, was found to have a prevalence of 28% among the diving fishermen of Vanga, Kwale County, in keeping with published studies of artisanal diving fishing communities in Asia, North and South America. This finding is a first for artisanal dive-fishing communities in the country and on the continent.

Diving fishermen in Vanga, Kwale County were, for the large part, knowledgeable about the symptoms of decompression sickness. The attitude of diving fishermen and decompression sickness were found to be significantly associated. This was despite the overwhelming dearth of formal education among the study respondents. This fact gives credence to the idea that diving accidents may be prevented through training and establishing of standards of safe diving practices. The barriers to care access were absence of a health worker, time to referral for recompression therapy, mode of access to transportation and fees- transport, treatment, and time away from work

5.3 Recommendations

Kenya Navy as one of the three armed services of the Kenya Defence Forces is mandated to provide aid to civil authority as stipulated in the constitution (2010) and the Kenya Defence Forces Act (2012). It is recommended that the emergency recompression therapy being offered to diving fishermen from Vanga, Kwale County continue in this regard.

Lifesaving recompression therapy is conditional on correct and timely diagnosis of decompression sickness by a healthcare worker familiar with this non-communicable disease. On this basis, it is recommended that skills-based training led by Kenya Navy divers and medical personnel together with Kwale County health authorities be designed and piloted. This training may take the form of a short mentorship program that will be designed and run jointly between the Kenya Navy and Kwale County Government. Skills exchange between diving physicians and Kwale County medical personnel on early diagnosis, first aid and prompt referral for recompression therapy is recommended. This may be followed up by refresher training every two years, or whenever a health worker who has already been trained rotates out of a county health facility.

It is also recommended that communication lines be opened between the Ministry of Defence and the Health Department of Kwale County for coordination of timely referrals of diving accident victims.

It is recommended that the proposed training program addresses unsafe diving practices among diver fishermen in Vanga, long known to predispose diving fishermen to DCS. The training may take the form of workshops on the conduct of safe diving practices and advance planning of dive excursions. A training program in Vietnam in 2015 targeted unsafe diving practices such as unsafe ascents and incorporated in-water recompression (IWR) as a treatment modality in remote diving fishing communities far away from recompression chambers. The program resulted in diving fishermen reducing bottom time and dive depth, leading to reduction in mortality and incidence of decompression sickness by 75% (Blatteau et.al.2015).

Future research on the state of dive fisheries in other Kenyan communities (coastal and inland) where diving fishing is known to be conducted is recommended. A national overview of the state of dive fisheries, trends in diving and drivers of diving practices is recommended.

Traditional diving fishermen in Vanga understood that diving had inherent risks associated with increased pressure in the underwater environment. The commonest side-effect of breath hold diving was perforated ear drums, due to traditional diving fishermen's inability to equalize pressures on either side of the tympanic membrane, a practise known as "equalizing." Interestingly, once a diver had experienced tympanic rupture, the discomfort associated with diving at depth disappeared for good. As a result, the master diver-fishermen considered what is now known as inner-ear DCS, a badge of honour, and wore it proudly as one would a feather on their cap. It was considered almost a rite of passage to elite diving.

The divers in this study were all male(N=246), mostly married with family responsibilities (93.5%, n=230) and practising Muslims (97.6%, n=240), active 6 days of the week, with only Friday set for rest and recovery, and to repair their boats and nets. Direct observation by the principal investigator showed minimal rest time between dives, multiple daily dives, and solo dives without a dive-buddy. Further

studies are needed to explore any relationship between the rigorous practice of almost daily diving and decompression sickness, and the relationship of the predominance of males in diving fisheries and incidence of decompression sickness.

REFERENCES

1. Bangasser, S. Incidence of Decompression Sickness in Women Scuba Divers (1979) Undersea and Hyperbaric Medical Society (UHMS) annual meeting) (http://archive.rubicon-foundation.org/4549)

2. Bennett M.H, Lehm J.P, Mitchell S.J, Wasiak J. Recompression and Adjunctive Therapy for Decompression Illness: A Systematic Review of Randomized Controlled Trials Anesthesia & Analgesia September 2010 Volume 111 Number 3
3. Betts, N., Baranowski, T., and Hoerr, S. (1996). Recommendations for planning and reporting focus group research. Journal of Nutrition Education 28: 279-281.

4. Blatteau J.E, Pontier J.M, Buzzacott P et al. Prevention and treatment of decompression sickness using training and in-water recompression among fisherman divers in Vietnam Injury Prevention British Medical Journal Published Online First: May 19, 2015, doi:10.1136/injuryprev-2014-041464
5. Blatteau JE, Jean F, Pontier JM, et al. Decompression sickness accident management in remote areas. Use of immediate in-water recompression therapy. Review and elaboration of a new protocol targeted for a mission at Clipperton atoll. Ann Fr Anaesthesia Reanimation 2006; 25:874–83.
6. Bourke A, Verwork C, Dawson R, Cross MR. A Study of The Diving Practices and The Incidence of Decompression Sickness in A Population of Indigenous Diving Fishermen in The Philippines. (Noc Nocan) Undersea and Hyperbaric Medical Society, Inc. (http://www.uhms.org) 1998
7. Brubbak A.O, Neuman T.S, eds. Bennett and Elliot's physiology and medicine of diving. 5th edition. London, WB Saunders, 2003:600 50.
8. Dear G.L, Uguccioni D.M, Dovenbarger J.A, Thalmann E.D, Hanson E, Cudahy E.A. Estimated DCI Incidence in A Select Group of Recreational Divers Undersea and Hyperbaric Medical Society, Inc. (http://www.uhms.org) 1999

9. DeNoble P.J, Sanchez C.A, Fostervold, A, Haukenes O.M, Brubakk A.O, Gerth W.A. Diving Patterns in Lobster Fishermen of Isla Mujeres, Mexico 2001
10. Doolette D, Craig D. (1999). Tuna farm diving in South Australia. Underwater Medical Society Journal 29:115–17.
11. Dunford R.G, Mejia E.B, Salbador G.W, Gerth W.A, Hampson Diving methods and decompression sickness incidence of Miskito Indian underwater harvesters. Undersea & Hyperbaric Medicine: Journal of the Undersea and Hyperbaric Medical Society, Inc 2002 29 (2) 74-85
12. Dardeau MR, Pollock NW, McDonald CM, et al. The incidence rate of decompression illness in 10 years of scientific diving. Diving Hyperbaric Med 2012; 42:195–200.
13. Edmonds C. Australian underwater oxygen treatment of DCS. In: Key E, Spencer MP, eds. In-water recompression. Proceedings for the 48th workshop of the Undersea and Hyperbaric Medical Society; 1999:2–15
14. Edmonds C, Lowry C, Pennefather J, Walker R. (2002). Diving and Subaquatic Medicine 4th Edition (2002). ISBN-13: 978 0 340 80630. (Pp 536-538 Fig 53.1; pp 539 Fig 53.2).

15. Farm FP Jr, Hayashi EM, Beckman EL. Diving, and decompression sickness treatment practices among Hawaii's diving fishermen. Sea Grant Technical Paper UNIHI-SEAGRANT-TP-86-01. Honolulu, HI: University of Hawaii Sea Grant College Program, 1986.
16. Flora and Fauna International/ East Africa Wildlife Society (2017) Marine Resources Co Management: Lessons learnt from Kenya an Arcadia Marine Case Study December 2017
17. Fondo E.N. Assessment of the Kenyan Marine Fisheries from Selected fishing areas (2004) Unpublished Postgraduate Fellowship Project United Nations University, Fisheries Training Program, Reykjavik, Iceland
18. Gempp E, Blatteau J.E. Risk factors and treatment outcome in scuba divers with spinal cord decompression sickness. Journal of critical care. 2010; 25(2):236–42. Doi: 10.1016/j.jcrc.2009.05.011

19. Gitonga N.K, Achoki R. Fiscal reforms for Kenya fisheries (2003) Paper prepared for FAO workshop on fiscal reforms for fisheries, Rome, Italy, 14-15 October 2003
20. Gold D, Geater A, Aiyarak S, et al. The indigenous fisherman divers of Thailand: in-water recompression. Int Marit Health 1999; 50:39–48.
21. Government of Kenya (2005) KENYA FISHERIES POLICY Ministry of Livestock and Fisheries Development 29 October 2005
22. Hyperbaric oxygen treatment for decompression sickness Moon, R.E. (2014). Underwater and Hyperbaric Medical Journal volume 41 Number 2.
23. Huchim-Lara O., Salas S., Fraga J., Méndez-Domínguez N., Chin W. Fishermen's Perceptions and Attitudes toward Risk Diving and Management Issues in Small-Scale Fisheries. American Journal of Human Ecology Vol. 5, No. 1, 2016, 1-10 DOI: 10.11634/216796221605760
24. Imbert JP, Fructus X, Montbarbon S. Short and repetitive decompressions in air diving procedure: the commercial diving experience. In: Lang MA, Vann RD, editors. Proceedings of repetitive diving workshop. Costa Mesa (CA): American Academy of Underwater Sciences; 1992. p. 63–72
25. INM lecture series, introductory lecture on hazards of underwater environment (2015). Institute of Naval Medicine, Alverstoke, UK
26. Kenya National Bureau of Statistics. Inequality Trends and Diagnostics in Kenya 2020 Kenya ISBN: 978-9966-102-21-1 November: 2020
27. Kelleher P.C, Francis T.J.R, Smith D.J, Hills. INM Diving Accident Database: Analysis of Cases Reported In 1991 And 1992 Abstract of the Undersea and Hyperbaric Medical Society, Inc. Annual Scientific Meeting held July 7-10, 1993. World Trade and Convention Centre, Halifax, Nova Scotia, Canada (1993)
28. Levett D. Z.H, Millar I.L. Bubble trouble: a review of diving physiology and Disease. Postgrad Med J 2008; 84:571–578. doi:10.1136/pgmj.2008.068320. Received 14 May 2008 Accepted 18 August 2008
29. Liu W, Wang D, Chen H, Liu K, Sun X, Tao H. (2013). Current status of decompression illness in China: Analysis of studies from 2001-2011. Undersea and Hyperbaric Medical Society Journal 40:41-48

30. Longphre JM, Denoble PJ, Moon RE, Vann RD, Freiberger JJ. First aid normobaric oxygen for the treatment of recreational diving injuries. Undersea Hyperbaric Med 2007; 34(1):43-49
31. Luby J. A study of decompression sickness after commercial air diving in the Northern Arabian Gulf: 1993-95. Occupational Med (Lond) 1999; 49:279–83.
32. Mansingh, A.; Singh, P.; Palmer, W.; Best, V. Diving Injuries Presenting to the Hyperbaric Chamber in Barbados: A Review from 1995-2009. West Indian Medical Journal 2017, Vol. 66 Issue 2, p262-268. 7p.
33. Mbaru E.K, Sigana D, Ruwa RK, Mueni EM, Ndoro CK, Kimani EN, Kaunda-Arara B. 2018. Experimental evaluation of influence of FADs on community structure and fisheries in coastal Kenya. Aquatic Living Resource. 31: 6
34. Mbaru E.K. 2012. An assessment of the Kenyan coastal artisanal fishery and implications for the introduction of FADs, MSc Thesis, Rhodes University, South Africa.
35. McClanahan, T.R., Mangi, S.C., 2004. Gear-based management of a tropical artisanal fishery based on species selectivity and capture size. Fish. Manag. Ecol. 11, 51-60
36. McIver N; Treatment of Compressed-Air Decompression Accidents Journal of the Royal Society of Medicine Volume: 82 issue: 2, page(s): 74-79 Issue published: February 1, 1989, https://doi.org/10.1177%2F014107688908200206
37. Moon RE, Vann RD, Bennett PB. The physiology of decompression illness. Scientific American. 1995; 273(2):70.
38. Mvurya S. Kwale County background and history, Kwale County Government https://kwalecountygov.com/kwale/
39. Ngugi E. "Exploring Kenya's Inequality Pulling Apart or Pooling Together?" Kenya National Bureau of Statistics (KNBS) and Society for International Development (SID), 2013
40. Niu KC, Liu SS, Lin DF, Huang KL, Lin YC, Chen LH. A High Incidence of Decompression Sickness in Compressed-Air Workers in Taiwan R.O.C.: An Epidemiologic Study 1996 Undersea and Hyperbaric Medical Society, Inc. (http://www.uhms.org)

41. Pollock NW, Dunford RG, DeNoble PJ, et al. Annual diving report - 2008 edition. Durham (NC): Divers Alert Network; 2008. p. 139
42. Pyle RL, Youngblood D. In water recompression as an emergency field treatment of decompression illness. SPUMS J 1997; 27:154–69.
43. Pyle RL. Keeping up with the times: application of technical diving practices for in-water recompression. In: Key E, Spencer MP, eds. In-water recompression.
44. Report on The Global Sustainable Blue Economy Conference 26th – 28th November 2018 Nairobi, Kenya Prepared by SBEC Technical Documentation Review Committee at A Retreat Held at Lake Naivasha Simba Lodge, Kenya December 5th – 9th 2018
45. Rivera J.C. Decompression Sickness among Divers: An Analysis of 935 Cases. Military medicine1964; 129:314–34.
46. Rodden V. "Analyzing the Dynamics of the Artisan Fishing Industry and LAPSSET Port in Lamu, Kenya" (2014). Independent Study Project (ISP) Collection.1765. https://digitalcollections.sit.edu/isp_collection/1765
47. Salari P, Di Giorgio L, Ilinca S, et al The catastrophic and impoverishing effects of out-of-pocket healthcare payments in Kenya, 2018 BMJ Global Health 2019;4: e001809.
48. Samoilys M.A, Maina G.W. and Osuka K. (2011) Artisanal Fishing Gears of the Kenyan Coast: CORDIO/USAID
49. Taylor C. L, MacDiarmid J.I, Ross J.A.S, Osman L.M, Watt S.J, Adie W, Crawford J.R and Lawson A. Objective neuropsychological test performance of professional divers reporting a subjective complaint of "forgetfulness or loss of concentration" Scandinavian Journal of Work, Environment & Health Vol. 32, No. 4 (August 2006), pp. 310-317 (8 pages)
50. The Constitution of Kenya (2010) Article 43(1) (a)), article 43 (3)
51. The sustainable Development Goals Report, 2016. United Nations Department of Economic and Social Affairs (DESA), 2016
52. Tuda P.M., Wolff M; Evolving trends in the Kenyan artisanal reef fishery and its implications for fisheries management Ocean & Coastal Management Volume 104, February 2015, Pages 36-44

53. Vann RD, DeNoble PJ, Uguccioni DM, et al. Report on decompression illness, diving fatalities and project dive exploration. Durham (NC): Divers Alert Network; 2004. p. 149
54. Vann RD, Freiberger JJ, Caruso JL, et al. Report on decompression illness, diving fatalities and project dive exploration. Durham (NC): Divers Alert Network; 2005. p. 138.
55. Vann R.D, DeNoble P.J, Howle L.E, Weber P.W, Freiberger J.J, Pieper C.F. Resolution, and severity in decompression illness. Aviation, space, and environmental medicine. 2009; 80(5):466–71.
56. Vann RD, Butler FK, Mitchell SJ, et al. Decompression illness. Lancet 2011;377: 153–64.
57. Wangia E., Kandie C. Refocusing on quality of care and increasing demand for services; Essential elements in attaining universal health coverage in Kenya, Ministry of Health Policy Brief, Government of Kenya, 2020

LIST OF FIGURES

Figure 1

Vanga Sea Wall and Jetty (landing site) (courtesy, Author)

Figure 2

Fishing boats moored in the Vanga Channel at low tide (courtesy, Author)

Figure 3

Vanga Beach Management Unit Office (courtesy, Author)

LIST OF APPENDICES

Appendices

Appendix 1

PARTICIPANT INFORMATION AND CONSENT FORM

ADULT CONSENT FOR ENROLLMENT IN THE STUDY

(To be administered in English or any other appropriate language e.g., Kiswahili translation)

Title of Study: Knowledge, Perceptions and Practices of Diving Fishermen in Relation to Decompression Sickness at The Kenyan Coast: A Case of Vanga, Kwale County

Principal Investigator\and institutional affiliation: Kennedy Muindi Kithome, University of Nairobi, School of Public Health. Employee of the Ministry of Defence-Kenya Navy

Introduction:

I would like to tell you about a study being conducted by the above listed researcher. The purpose of this consent form is to give you the information you will need to help you decide whether to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called

'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in medical research. Your decision to participate is entirely voluntary ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal iii) Refusal to participate in the research will not affect the services you are entitled to in this health facility or other facilities. We will give you a copy of this form for your records.

May I continue?

YES / NO

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No. _____

WHAT IS THIS STUDY ABOUT?

The researcher listed above is interviewing individuals who dive in the process of obtaining their catch of fish and other seafood. The purpose of the interview is to find out what the diving fishermen know about the effect of diving on their health and wellbeing, how they conduct their dives and whether they have ever come down with decompression sickness ("the bends"). Participants in this research study will be asked questions about how many of them have ever had decompression sickness and been referred to the Kenya Navy Hospital for Recompression Therapy in the Hyperbaric Oxygen Therapy (HBOT) Chamber, what they know about this condition and how it comes about, how they conduct their dives and whether they face any challenges accessing health services for any diving-related problems.

There will be approximately 270 participants in this study randomly chosen. We are asking for your consent to consider participating in this study.

WHAT WILL HAPPEN IF YOU DECIDE TO BE IN THIS RESEARCH STUDY?

If you agree to participate in this study, the following things will happen:

You will be interviewed by a trained interviewer in a private area where you feel comfortable answering questions. The interview will last approximately 40 minutes.

The interview will cover topics such as personal particulars including age, education level and marital status. Other details will include diver training or apprenticeship, total cumulative experience diving and questions on knowledge of DCS and diving practice. You will participate by filling in a questionnaire and by answering a health profile that I have adapted from the one used to profile Kenya Navy divers. There will also be a group interview conducted by me and other fishermen like you here in Vanga.

After the interview has finished, you will be free to consult the chief investigator for any health-related complaints you may have, unrelated to the study particulars.

We will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include: cross-checking any necessary details, following up on any health problems arising from the post-interview interaction and updating you on the outcome of the study.

ARE THERE ANY RISKS, HARMS DISCOMFORTS ASSOCIATED WITH THIS STUDY?

Medical research has the potential to introduce psychological, social, emotional, and physical risks. Effort should always be put in place to minimize the risks. One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify you in a password-protected computer database and will keep all our paper records in a locked file cabinet. However, no system of protecting your confidentiality can be secure, so it is still possible that someone could find out you were in this study and could find out information about you.

Also, answering questions in the interview may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

ARE THERE ANY BENEFITS BEING IN THIS STUDY?

You may benefit by receiving free medical consultation for any health problems not related to Decompression Sickness, including general health information and non-communicable disease screening. We will refer you to a hospital for care and support where necessary. Also, the information you provide will help us better understand how best to provide diving safety training and seamless referral to Kenya Navy in the event of a diving accident. This information is a contribution to science and decision makers in the County Government and the Ministry of Defence

WILL BEING IN THIS STUDY COST YOU ANYTHING?

Time taken out of your routine activities to answer our questions will be the cost to you.

WILL YOU GET REFUND FOR ANY MONEY SPENT AS PART OF THIS STUDY?

There is no provision for reimbursing money spent by you as part of the study. The principal researcher will come to you, bearing all the commuter cost on himself.

WHAT IF YOU HAVE QUESTIONS IN FUTURE?

If you have further questions or concerns about participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300 Ext. 44102 email uonknh_erc@uonbi.ac.ke.

The study staff will pay you back for your charges to these numbers if the call is for study-related communication.

WHAT ARE YOUR OTHER CHOICES?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without injustice or loss of any benefits.

CONSENT FORM (STATEMENT OF CONSENT)

Participant's statement

I have read this consent form or had the information read to me. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study. I understand that all efforts will be made to keep information regarding my personal identity. By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: Yes No

I agree to provide contact information for follow-up: Yes No

Participant printed name: _____

Participant signature / Thumb stamp _____ **Date** _____

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Researcher 's Name: _____ **Date**: _____

Signature

_____

Role in the study: _____ *[i.e., study staff who explained informed consent form.]*

For more information contact Dr Kennedy Muindi Kithome at 0710316180 from 7 a.m. to 7 p.m.

Witness Printed Name (*If witness is necessary, A witness is a person mutually acceptable to both the researcher and participant*)

Name _____ Contact information _____

Signature /Thumb stamp: _____ Date; _____

KISWAHILI TRANSLATION OF CONSENT FORM

Mimi, Kennedy Muindi Kithome, mwanafunzi wa Chuo Kikuu cha Nairobi, Taasisi ya Afya ya Umma, ninafanya utafiti unaolenga kuelewa kiini cha visa vya vifo na majeraha kati ya wavuvi-wapiga mbizi hapa Kwale, haswa hapa Vanga. Ninaomba usaidizi wako, kupitia kushiriki kwako katika utafiti huu.

Ninanuia kukuuliza maswali yanayohusiana na kazi yako ya uvuvi na kupiga mbizi. Baada ya mazungumzo yetu faraghani, kutakuwa na mkutano wa hadhara kati yangu na wavuvi wenzako, watakao kubali kushiriki kwa hiari yao. Hakuna mtu yeyote atakaye shurutishwa kushiriki. Ikiwa ungependa kushiriki katika utafiti huu wa kisayansi, ninakuomba utie sahihi hapo chini.

"Ninakuhakikishia kwamba nimesoma/ nimesomewa maagizo haya na kuyaelewa. Maswali yote nilio nayo kuhusu utafiti huu yamejibiwa na nimeridhika. Nime mpa mtafiti idhini yangu kujumlishwa katika utafiti."

Sahihi/ Ishara ya Kidole _____ Tarehe _____

Appendix 2

Study Instruments/Tools

QUESTIONNAIRE

Sociodemographic characteristics

1. Age (as per National ID card, if available)
2. Education
    i) secondary education
    ii) primary education
    iii) Never attended school
    iv) Apprenticeship. Please specify under whom, from what age, what skills were imparted……
    ……..
    v) Safety training and operation of diving equipment. Please specify if trained at Kenya Navy or any dive school.....
3. Religion
4. Marital status
    i) Single
    ii) Married
    iii) Divorced
    iv) Separated
    v) Widowed

Attitudes of diving fishermen towards DCS

5. Do you believe anyone, regardless of their age, expertise or diving experience can get DCS?

    i. Yes
    ii. No
        If no, please explain

6. Do you believe making repeated dives on the same day is dangerous and can lead to injury, disability, or death?

i) Yes

ii) No

iii) I do not know

7. Do you smoke cigarettes or use alcohol?
    i. Yes
    ii. No
8. Do you believe over the counter pain medications are sufficient to treat pain symptoms in the joints experienced after a dive?
    i. Yes
    ii. No
9. Do you believe DCS is a possible career-ending or fatal condition?
    i. Yes
    ii. No
        If no, please explain

Knowledge of DCS amongst diving fishermen

10. Do you know the depth limit beyond which treatment in the recompression chamber will not be beneficial?

    i) Yes

    ii) No

If yes, how do you determine how far you dive while working?

i. Using a rope as a depth measurement
ii. Using other measurement tools such as a dive computer
iii. I do not measure depth of dives

11. Have you ever experienced muscle pain, headache, ear pain, chest pain, dizziness, leg weakness, inability to pass urine or loss of consciousness within one hour of completing a dive?

i. Yes

Please specify the exact symptom.....

ii. No

12. Do you suffer from any of the following since your diving accident?
    i. weakness in your legs
    ii. pins and needles sensation in your feet
    iii. difficulty walking/ loss of balance
    iv. difficulty in controlling urine or stool passage
    v. Difficulty in getting or maintaining an erection

13. Have you ever received first aid at any medical facility after experiencing the symptoms above following a dive?
    i. Yes
    ii. No

If yes, how was the experience for you?

14. Have you ever been treated with in-water recompression at the site of the dive following onset of the above symptoms?
    i. Yes
    ii. No

Practices of diving fishermen

15. Have you ever received formal diver training by a certified trainer or Divemaster?
    i. Yes
    ii. No

    If no, how did you learn to dive for fish?

16. Do you always make decompression stops on your way back to the surface?

    i) Yes

    ii) No

    iii) I do not know what decompression stops are

    If yes, please explain

17. Do you usually dive alone?
    i. Yes
    ii. No, I always dive with a buddy-diver
18. Do you usually take breaks between dives of not less than one hour?
    i. Yes
    ii. no
19. Do you dive more than once a day?
    i. Yes
    ii. no

Barriers to Care

20. Is there a health care worker in Vanga or anywhere in Kwale who is familiar with DCS and has experience providing care to people with DCS?

    i) Yes

    ii) No

    iii) Not sure

21. How can you rate the services offered?

    i) Good

    ii) Bad

    iii) I am not aware

22. Have you ever been referred for treatment in the recompression chamber at Kenya Navy Base, Mtongwe by a civilian health worker following onset of symptoms after a dive?

    i. Yes
    ii. No

    If yes,

    i. how long did it take for you to be referred, from the time of your diving accident?
    ii. how did you access the facility- by ambulance or private means of transport?
    iii. how can you rate the services offered?
        a) Good
        b) Bad

    If yes, how many times?

    i. Once
    ii. Twice
    iii. Thrice or more

23. Do you believe that Hyperbaric Oxygen Therapy in a Recompression Chamber can make you well after suffering DCS?

    i. Yes
    ii. No

Appendix 3

MODIFIED KENYA NAVY HEALTH DIVING PROFILE (RESTRICTED DOCUMENT, ADOPTED FROM ROYAL AUSTRALIAN NAVY HEALTH DIVING PROFILE {Edmonds et.al. 2001})

A. DIVING MEDICAL HISTORY (COMPLETED BY DIVER/FISHERMAN WITH ASSISTANCE FROM INVESTIGATOR)
    1. Can you free dive/snorkel? Do you have any problems equalizing pressure?
    2. Date of first scuba dive (approx.)
    3. Number of scuba dives (approx.)
    4. Greatest depth of any dive, if known
    5. Longest duration of any dive

Have you ever had any of the following? (DIVERS ONLY)

	NO	YES	COMMENTS
6. Severe ear squeeze			
7. Rupture of the ear drum			
8. Deafness			
9. Dizziness			
10. Severe sinus squeeze			
11. Severe lung squeeze			
12. Ruptured/ burst lung			
13. Emphysema			
14. Pneumothorax			
15. AGE (Arterial Gas Embolism, air embolism)			
16. Decompression sickness			
17. Near drowning			
18. Severe marine animal injury			
19. Oxygen toxicity			

20. Carbon dioxide toxicity			
21. Dysbaric osteonecrosis (bones)			
22. Any other diving accident			

I certify that the above information is true and complete to the best of my knowledge

Signed.....

Date.....

B. MEDICAL HISTORY

1. Surname Other Names
2. Date of birth
3. Address
4. Sex
5. Marital Status
6. Formal dive training (school)
7. Do you have any disease or disability at present?
8. Are you taking any medicines or other drugs?

Have you ever had, or do you now have any of the following?

	No	Yes	Notes on history
9. High blood pressure			
10. Abnormal shortness of breath			
11. Bronchitis or pneumonia			
12. Pleurisy or severe chest pain			

13. Coughing up blood			
14. Tuberculosis			
15. Chronic or persistent cough			
16. Pneumothorax (collapsed lung)			Military Standards Traumatic pneumothorax RTD after 3 months, spontaneous permanently unfit
17. Asthma or wheezing			Military standards DQ if exacerbated by extreme exercise, breathing cold dry air, increased inspiratory effort, hypertonic saline inhalation, panic
18. Other chest complaint or injury or operation on chest or lungs			
19. Sinusitis			
20. Deafness or ringing noises in ear			
21. Discharging ear			
22. Eye or visual problems			
23. Dental procedures			
24. Fainting, blackouts, fits or epilepsy			Military Standards permanently unfit

25. Severe headache or migraine			Military standards exclude if visual, motor, sensory disturbance
26. Severe depression			
27. Claustrophobia			
28. Any psychiatric illness			
29. Kidney or bladder disease			
30. Indigestion or peptic ulcer			
31. Vomiting blood or rectal bleeding			
32. Jaundice or hepatitis			
33. Malaria			
34. Venereal disease			
35. HIV status (Optional)			
36. Hernia or hemorrhoids			
37. Any skin disease			
38. Allergies			
39. Concussion or head injury			Military standards exclude severe head injury unless no neurological sequalae >

			10years, >1 year moderate, > 1 month mild
40. Any major joint or back injury			
41. Any fractures			
42. Any paralysis or muscle weakness			
43. Dentures			
44. Seasickness			
45. Do you smoke			
46. Approximate number of cigarettes a day			
47. Have you ever been unable to work for medical reasons			
48. Have you ever been in hospital for any reason?			
49. Have you ever had any operations?			
50. Have you had any other illness or injury			

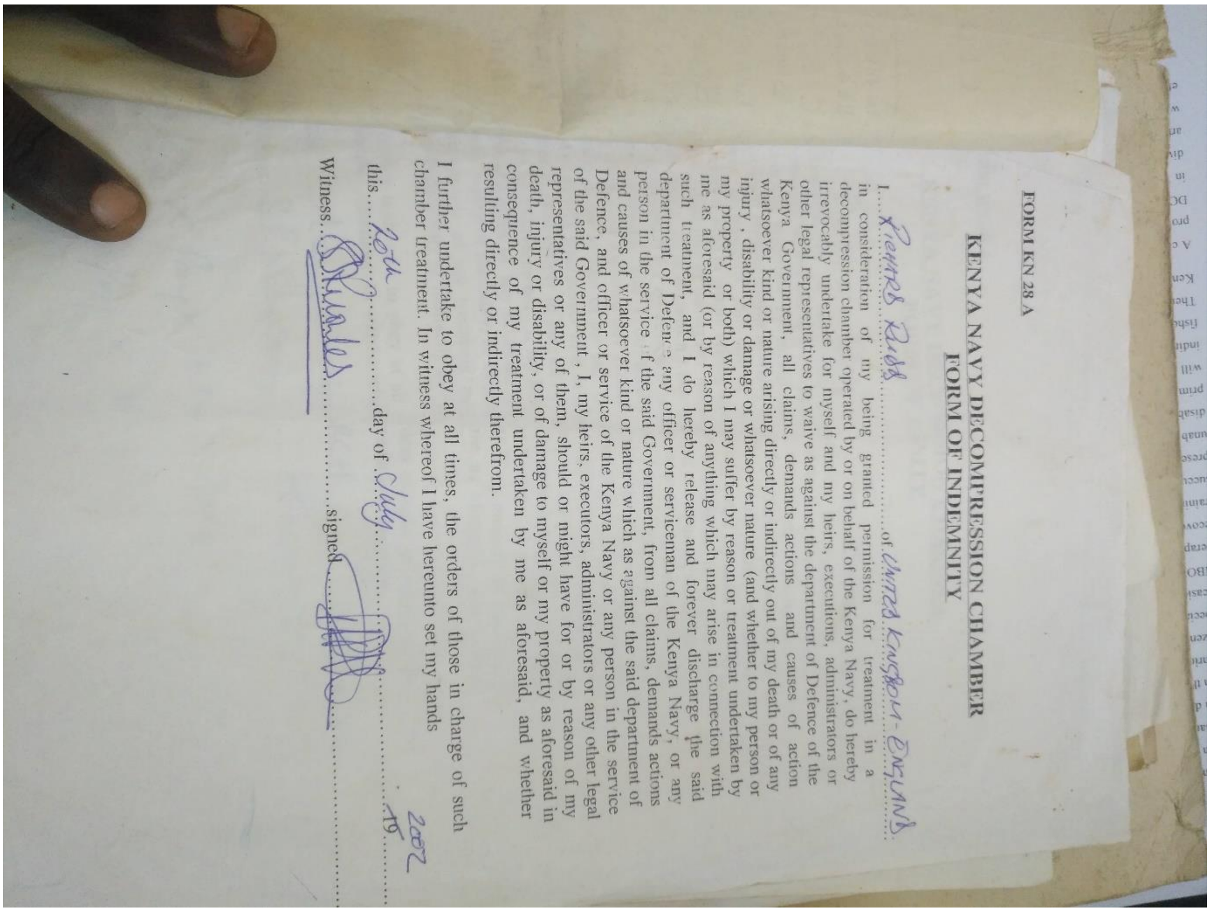
not mentioned in this list?			
51. Have you ever had your chest x-rayed? Was it normal or abnormal? (examine if film available)			

Additional history (taken by Doctor)

Appendix 4

Kenya Navy Decompression Chamber Indemnity Form Sample

(Reproduced with permission)



FORM KN 28 A

KENYA NAVY DECOMPRESSION CHAMBER
FORM OF INDEMNITY

I....Pierres Rudd..................of United Kingdom-England..........
in consideration of my being granted permission for treatment in a decompression chamber operated by or on behalf of the Kenya Navy, do hereby irrevocably undertake for myself and my heirs, executions, administrators or other legal representatives to waive as against the department of Defence of the Kenya Government, all claims, demands actions and causes of action whatsoever kind or nature arising directly or indirectly out of my death or of any injury, disability or damage or whatsoever nature (and whether to my person or my property or both) which I may suffer by reason or treatment undertaken by me as aforesaid (or by reason of anything which may arise in connection with such treatment, and I do hereby release and forever discharge the said department of Defence any officer or serviceman of the Kenya Navy, or any person in the service of the said Government, from all claims, demands actions and causes of whatsoever kind or nature which as against the said department of Defence, and officer or service of the Kenya Navy or any person in the service of the said Government, I, my heirs, executors, administrators or any other legal representatives or any of them, should or might have for or by reason of my death, injury or disability, or of damage to myself or my property as aforesaid in consequence of my treatment undertaken by me as aforesaid, and whether resulting directly or indirectly therefrom.

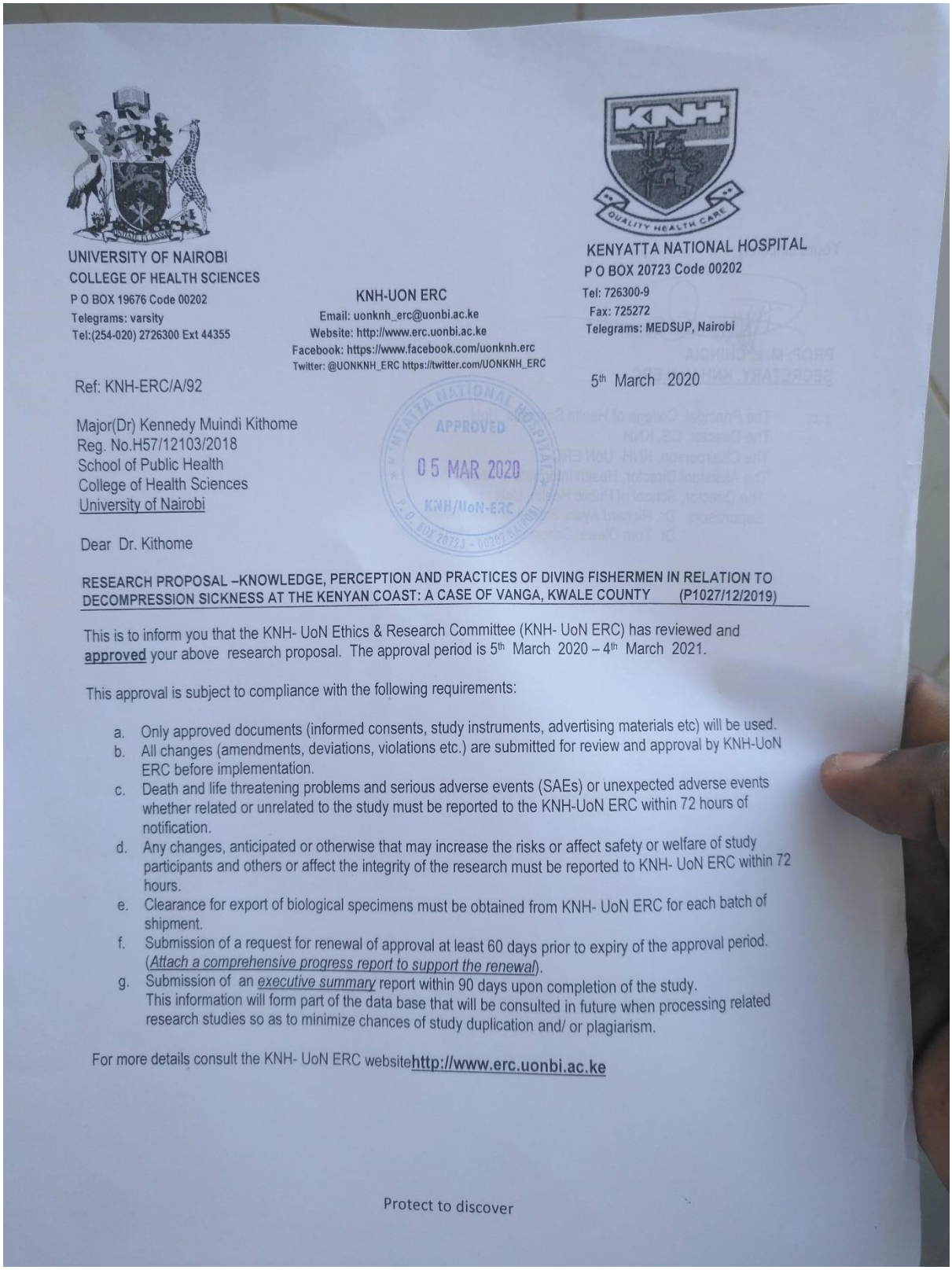
I further undertake to obey at all times, the orders of those in charge of such chamber treatment. In witness whereof I have hereunto set my hands

this....20th..........day of July.................~~19~~ 2002.......

Witness.......................signed.......................

Appendix 5

KNH-UON ERC APPROVAL LETTER



UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
Tel:(254-020) 2726300 Ext 44355

KNH-UON ERC
Email: uonknh_erc@uonbi.ac.ke
Website: http://www.erc.uonbi.ac.ke
Facebook: https://www.facebook.com/uonknh.erc
Twitter: @UONKNH_ERC https://twitter.com/UONKNH_ERC

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/92

5th March 2020

APPROVED
05 MAR 2020
KNH/UoN-ERC

Major(Dr) Kennedy Muindi Kithome
Reg. No.H57/12103/2018
School of Public Health
College of Health Sciences
University of Nairobi

Dear Dr. Kithome

RESEARCH PROPOSAL –KNOWLEDGE, PERCEPTION AND PRACTICES OF DIVING FISHERMEN IN RELATION TO DECOMPRESSION SICKNESS AT THE KENYAN COAST: A CASE OF VANGA, KWALE COUNTY (P1027/12/2019)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 5th March 2020 – 4th March 2021.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website **http://www.erc.uonbi.ac.ke**

Protect to discover

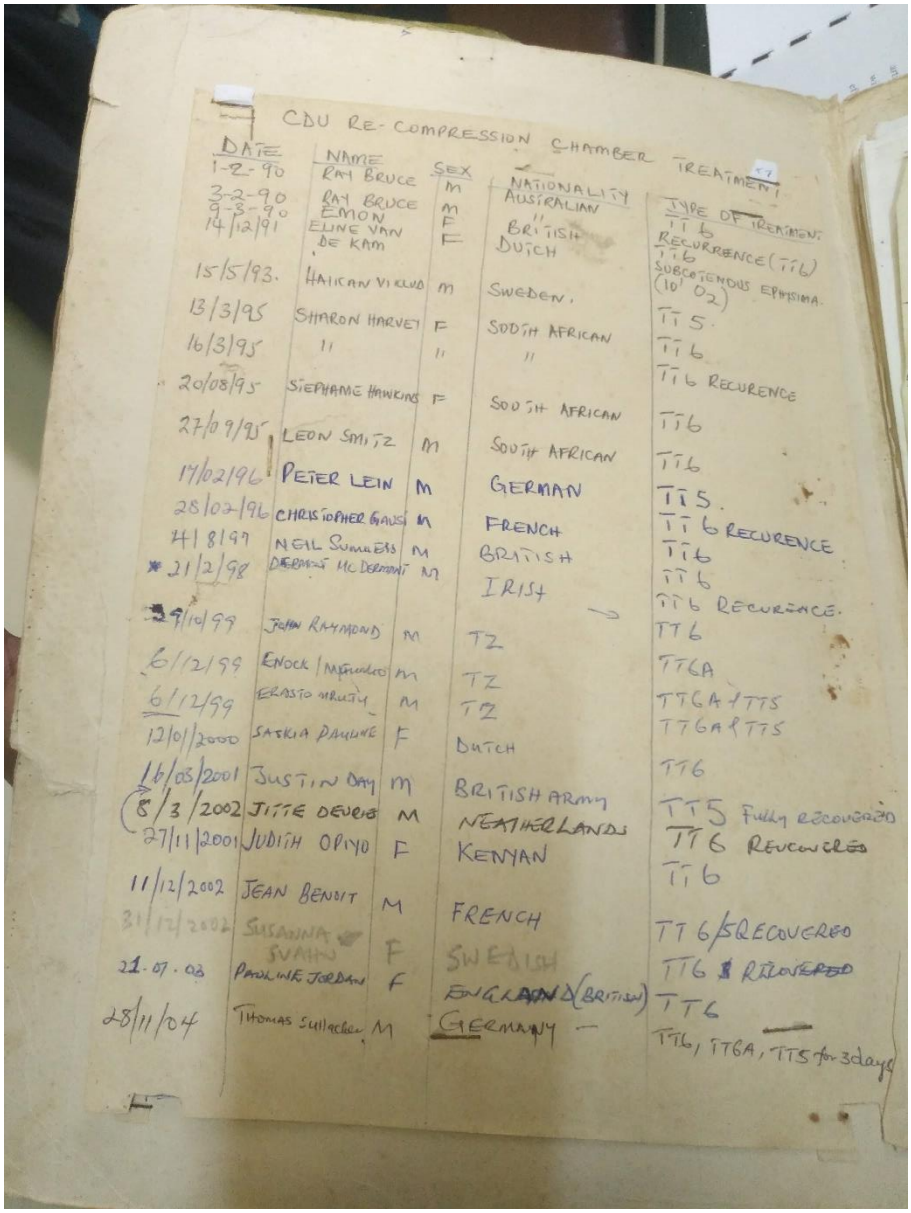
Yours sincerely,

PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information, KNH
The Director, School of Public Health, UoN
Supervisors: Dr. Richard Ayah, School of Pubic Health,UoN
Dr. Tom Olewe, School of Public Health, UoN

Appendix 6

Sample Kenya Navy recompression chamber treatment log (Reproduced with permission)



CDU RE-COMPRESSION CHAMBER TREATMENT

DATE	NAME	SEX	NATIONALITY	TYPE OF TREATMENT
1-2-90	RAY BRUCE	M	AUSTRALIAN	TT6
3-2-90	RAY BRUCE	M	"	RECURRENCE (TT6)
9-3-90	EMON	F	BRITISH	TT6
14/12/91	ELINE VAN DE KAM	F	DUTCH	SUBCUTENOUS EPHYSEMA (10' O2)
15/5/93.	HAICAN VIKLUD	M	SWEDEN.	TT5.
13/3/95	SHARON HARVEY	F	SOUTH AFRICAN	TT6
16/3/95	"	"	"	TT6 RECURENCE
20/08/95	STEPHANIE HAWKINS	F	SOUTH AFRICAN	TT6
27/09/95	LEON SMITZ	M	SOUTH AFRICAN	TT6
17/02/96	PETER LEIN	M	GERMAN	TT5.
28/07/96	CHRISTOPHER GAUSI	M	FRENCH	TT6 RECURENCE
4/8/97	NEIL SUMMERS	M	BRITISH	TT6
* 21/2/98	DERMOT MC DERMOTT	M	IRISH	TT6
29/10/99	JOHN RAYMOND	M	TZ	TT6 RECURRENCE.
6/12/99	ENOCK	M	TZ	TT6
6/12/99	ERASTO	M	TZ	TT6A
12/01/2000	SAFRIA PAULINE	F	DUTCH	TT6A/TT5
16/03/2001	JUSTIN DAY	M	BRITISH ARMY	TT6ART5
8/3/2002	JITTE DEVRIS	M	NEATHERLANDS	TT6
27/11/2001	JUDITH OPIYO	F	KENYAN	TT5 Fully RECOVERED
11/12/2002	JEAN BENOIT	M	FRENCH	TT6 RECOVERED
31/12/2002	SUSANNA SVAHN	F	SWEDISH	TT6
21.07.03	PAULINE JORDAN	F	ENGLAND (BRITISH)	TT6 RECOVERED
28/11/04	THOMAS SULLACHER	M	GERMANY	TT6
				TT6, TT6A, TT5 for 3days

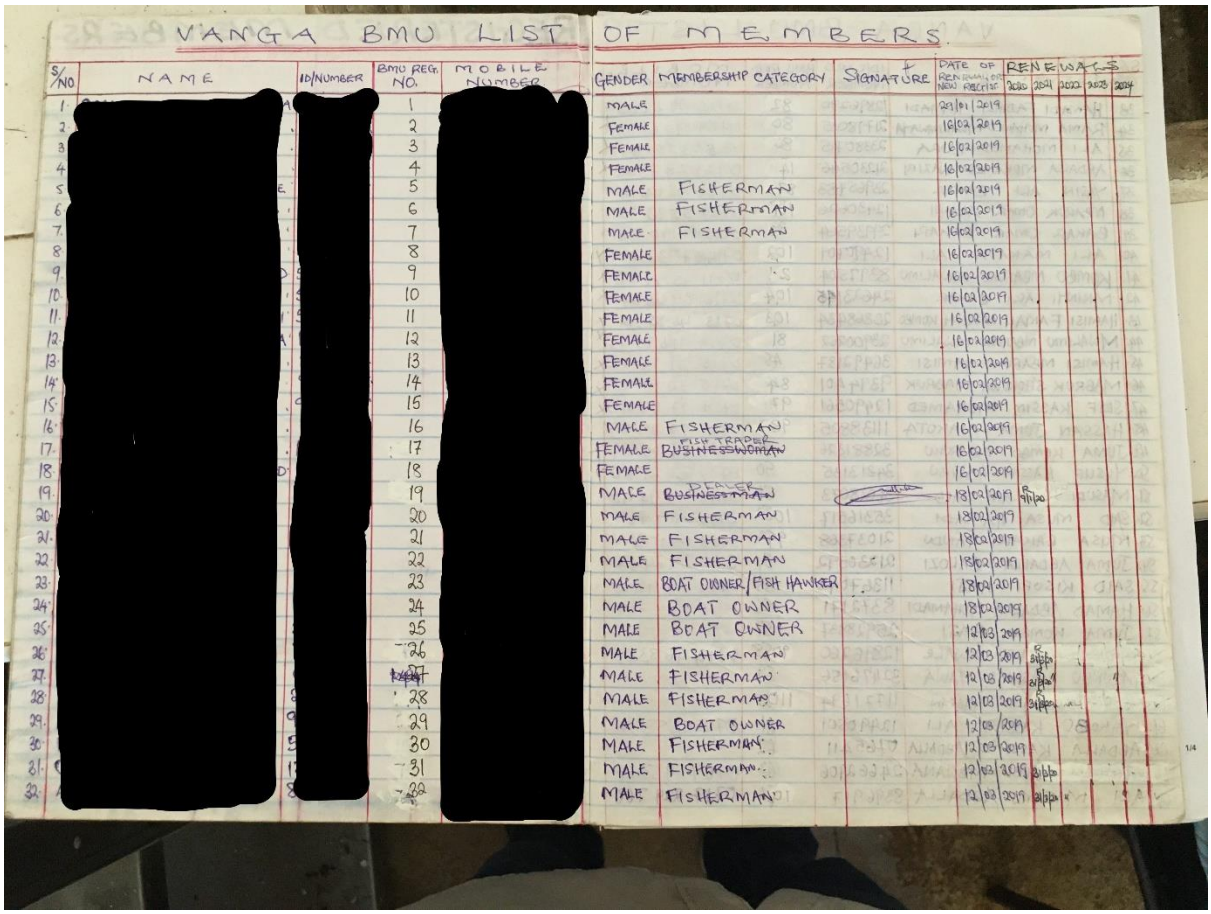
Appendix 7

Vanga Beach Management Unit Register Sample page

(Reproduced with permission)

Vanga Beach Management Unit Register Sample page

(Reproduced with permission)

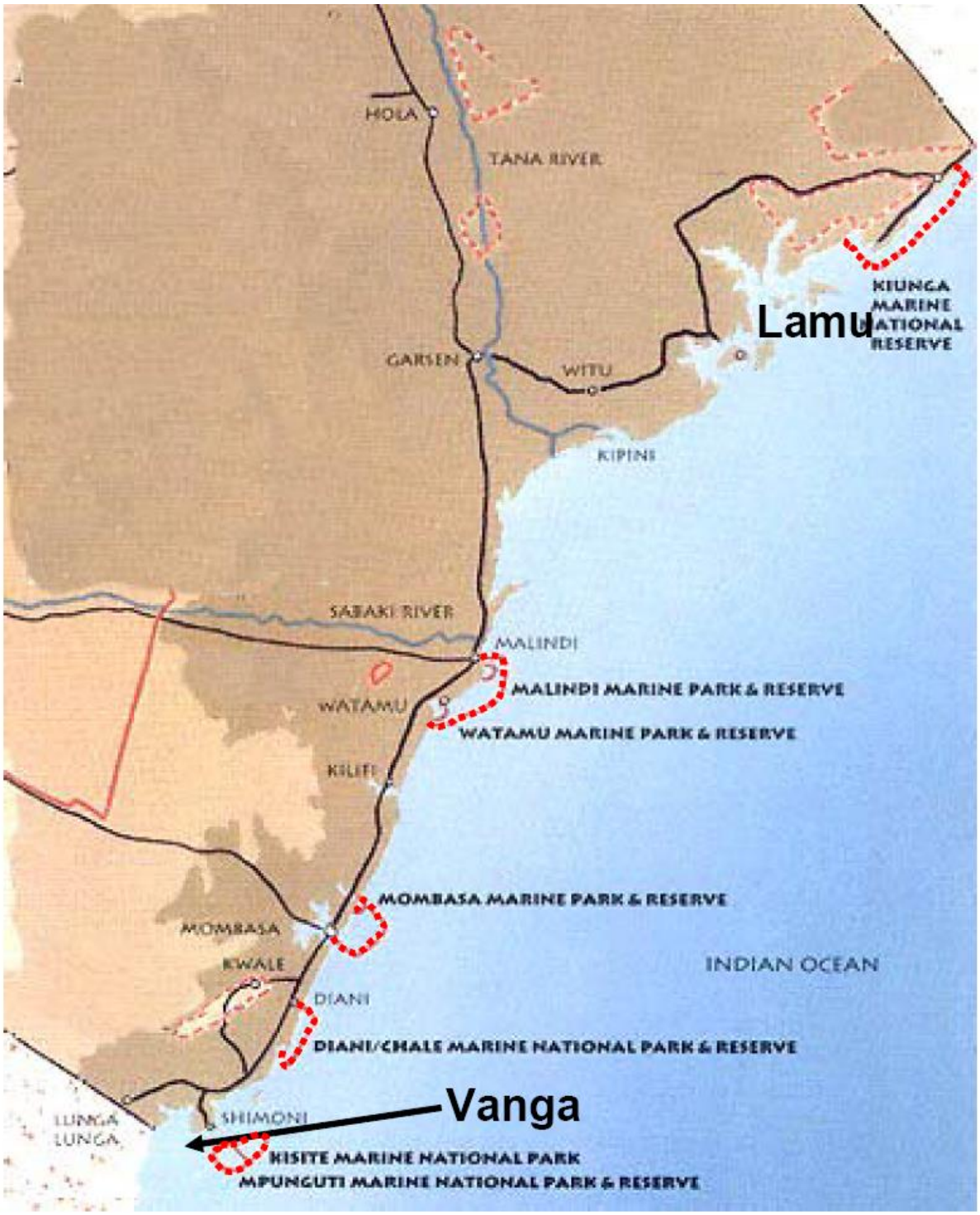


VANGA BMU LIST OF MEMBERS

S/NO	NAME	ID/NUMBER	BMU REG. NO.	MOBILE NUMBER	GENDER	MEMBERSHIP CATEGORY	SIGNATURE	DATE OF REGISTRATION OR RENEWAL	RENEWALS 2020	2021	2022	2023	2024
1	[redacted]	[redacted]	1	[redacted]	MALE			23/01/2019					
2			2		FEMALE			16/02/2019					
3			3		FEMALE			16/02/2019					
4			4		FEMALE			16/02/2019					
5			5		MALE	FISHERMAN		16/02/2019					
6			6		MALE	FISHERMAN		16/02/2019					
7			7		MALE	FISHERMAN		16/02/2019					
8			8		FEMALE			16/02/2019					
9			9		FEMALE			16/02/2019					
10			10		FEMALE			16/02/2019					
11			11		FEMALE			16/02/2019					
12			12		FEMALE			16/02/2019					
13			13		FEMALE			16/02/2019					
14			14		FEMALE			16/02/2019					
15			15		FEMALE			16/02/2019					
16			16		MALE	FISHERMAN		16/02/2019					
17			17		FEMALE	~~BUSINESSWOMAN~~ FISH TRADER		16/02/2019					
18			18		FEMALE			16/02/2019					
19			19		MALE	~~BUSINESSMAN~~ DEALER		18/02/2019	9/20				
20			20		MALE	FISHERMAN		18/02/2019					
21			21		MALE	FISHERMAN		18/02/2019					
22			22		MALE	FISHERMAN		18/02/2019					
23			23		MALE	BOAT OWNER/FISH HAWKER		18/02/2019					
24			24		MALE	BOAT OWNER		18/02/2019					
25			25		MALE	BOAT OWNER		12/03/2019					
26			26		MALE	FISHERMAN		12/03/2019	8/20				
27			~~27~~		MALE	FISHERMAN		12/03/2019	8/20				
28			28		MALE	FISHERMAN		12/03/2019	8/20				
29			29		MALE	BOAT OWNER		12/03/2019					
30			30		MALE	FISHERMAN		12/03/2019					
31			31		MALE	FISHERMAN		12/03/2019	8/20				
32			32		MALE	FISHERMAN		12/03/2019	8/20				

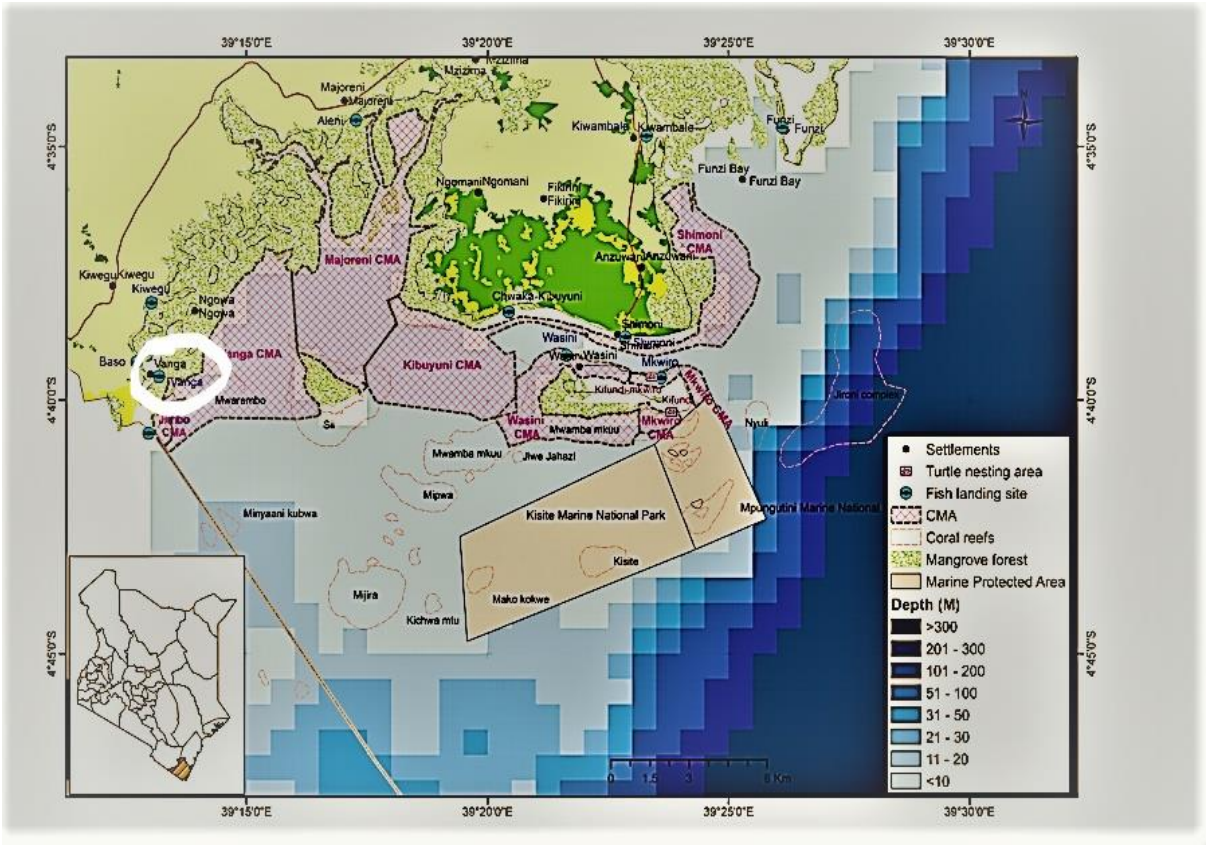
Appendix 8

MAP OF VANGA, KWALE COUNTY (courtesy of Kenya Wildlife Service, 2005)



Appendix 9

Vanga village, Lungalunga Sub County, Kwale County hydrographic map showing grid coordinates, water depth and fish landing site (Courtesy of COMRED Coastal Consulting, 2016, with permission)



Appendix 10

a) Betts et al./FOCUS GROUP RESEARCH GUIDING PRINCIPLES

Journal of Nutrition Education Volume 28 Number 5 September October 1996

Items for consideration.

When conducting research:

1. Select a theoretical or conceptual framework before conducting research.
2. Choose data collection methods based on their appropriateness for addressing the research question(s).
3. Describe in detail how the focus groups were conducted.
4. Choose an analysis method appropriate to address the research question(s).

Questions to ask when planning a manuscript:

1. Was something new or of broad-based interest learned from the research?
2. Do the results make a unique and significant contribution to a body of knowledge?
3. Were the methods adequately described and employed with substantial rigor?
4. Were enough focus groups conducted to show repeated themes across groups?

b) Huchim-Lara et al. (2016) Fishermen's Perceptions and Attitudes toward Risk Diving and Management Issues in Small-Scale Fisheries American Journal of Human Ecology Vol. 5, No. 1, 2016, 1-10 DOI: 10.11634/216796221605760

1. How long have you been fishing and used diving as a fishing method?

2. In your opinion, are there any risks associated with your fishing activity?

3. How are the health issues you mentioned related with lobster fishing or diving?

4. Do you have access to health insurance? How would you get medical treatment in case of a fishing related accident?

5. Is working in and under ocean related with higher risk of injury?

6. How do you think supply and demand of lobster are related to your health or relate to the risk of repetitive injury?

7. Do you carry out activities for marine resources conservation purposes?