SMOKING AND RISK TAKING IN RECREATIONAL SCUBA DIVERS

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DECLARATION

I, Miriam Armstrong, confirm that this research is entirely my own work carried out during the period January 2005 to August 2012. Where information has been derived or cited from other sources, I confirm this has been indicated in the thesis.

ABSTRACT

SCUBA diving is inherently dangerous. Anecdotal reports suggest that risks may be exacerbated by diver behaviour, particularly tobacco smoking. This thesis reports findings from an internet survey of tobacco use, health and attitudes to risk taking conducted amongst UK members of the Professional Association of Diving Instructors in 2006. The main aims of the study were to assess smoking prevalence and factors associated with tobacco use compared to the UK population and to explore the health impact of smoking on divers, to determine the need for prevention measures in this group.

After adjusting for socio-demographic factors, divers' cigarette smoking prevalence ($p<0.001$) and consumption ($p<0.001$) were found to be lower than the UK population, although non-cigarette smoking prevalence was higher ($p<0.001$). Everyday risk taking scores were significantly associated with cigar or pipe use ($p = 0.037$) and higher cigarette consumption ($p = 0.046$) and dependence ($p = 0.011$) in current smokers. Divers with a professional recreational diving qualification who currently smoked had higher cigarette consumption ($p = 0.001$) and dependence ($p = 0.001$) compared with their non-professionally qualified peers.

Recreational SCUBA divers were less likely to report poor general health than the UK population, but current cigarette smoking was significantly associated with poorer self-assessed health in divers ($p = 0.006$) after controlling for socio-demographic factors.

After adjustment for confounding variables, current cigarette smoking was significantly associated with the occurrence of panic attacks ($p = 0.014$), which was significantly associated with lung problems ($p = 0.016$), and cigarette consumption was significantly associated with the frequency of diving-related illness ($p = 0.037$).

In conclusion, although cigarette smoking prevalence and daily cigarette consumption were significantly lower in divers compared with the UK population, both were found to be associated with poorer health in important ways.

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CHAPTER 1 - GENERAL INTRODUCTION

1.1 The popularity of SCUBA diving

Recreational SCUBA (Self Contained Underwater Breathing Apparatus) diving is an intrinsically risky and fast growing water sport which attracts relatively young adult participants (worldwide median age of 29 years).[1] It requires a reasonably high level of cardio-respiratory fitness from participants to mitigate the risks of transporting and utilising underwater-breathing apparatus within the marine environment.

"Diving is an arduous underwater activity in which environmental conditions affect bodily structure and function." (p4, British Thoracic Society Guidelines on Respiratory Aspects of Fitness for Diving, 2003)

Historically, SCUBA diving has mainly been undertaken for commercial and military purposes, but has undergone a dramatic increase in popularity as a leisure pursuit since the late 1960s. It is difficult to obtain accurate estimates of recreational divers both worldwide and in the UK due to the high number of diver training organisations who compete for membership and are wary of sharing commercially-sensitive information. In addition, not all divers will have undergone a recognised training course and many divers possess multiple qualifications, often from different agencies. The largest UK dive training organisation, the Professional Association of Diving Instructors (PADI Ltd.), trained 73,477 entry-level divers in 2006 and best estimates for the number of 'active' UK recreational divers vary between 100,000 to 300,000.[2]

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[1] Figure obtained from PADI website: http://www.padi.com/scuba/about-padi/PADI-statistics/default.aspx#Graph1 [Accessed 15/5/10].

[2] Personal communication, Alistair Reynolds, British Sub-aqua Club (BSAC) Technical Manager, 22/11/05. This figure relates to the number of divers who have completed a recognised basic diver training programme as opposed to having experienced diving, for example, through 'try dives' on holiday.

Appendix 1 gives a brief overview of the main diver training organisations and those associated with diver safety.

1.2 The health and safety aspects of diving

Diving under water using an external supply of gas, either delivered from the surface or by portable underwater breathing equipment, is recognised by the Health and Safety Executive (HSE) as a hazardous activity.

"Diving at work is a high hazard activity which can be carried out safely if properly planned and the risks managed appropriately." (p4, HSE Diving Health and Safety Strategy to 2010)

The fatal accident rate for the Offshore and Inland / Inshore sectors has typically been in the region of 20-40 per 100,000 (p2, HSE Diving Health and Safety Strategy) which is considerably higher than in construction or agriculture. Due to the known hazards associated with diving with SCUBA equipment and the potentially serious health consequences, legislation exists to enforce appropriate health and safety procedures for diving within an industrial (work) context in the UK (HSE Diving at Work Regulations, 1997). Similar safeguards also exist within the military sector.

Although there is no specific legislation in place for the recreational sector,[3] it is widely accepted by the diving governing bodies (the HSE, the UK marine and coastguard agencies and diver training organisations) that no individual should dive for recreation using SCUBA equipment without previously undergoing a recognised training programme. As a result, there is a very wide range of 'sport' diver training courses available in the UK, from basic to advanced levels as well as specialty-training and adapted training programmes for minors and other groups.

1.3 The perceptions of smoking in recreational SCUBA diving

[3] Except where the HSE Diving at Work Regulations would apply.

Despite the numerous health risks associated with SCUBA diving, many comments have been made in recreational diving magazines and internet chat forums about the number of divers who smoke, sometimes immediately prior to, or after, diving.

"Why do so many divers smoke? This came as a big (unwelcome) surprise. Are there any operators who offer breaks for non-smokers only? Yes, I have tried asking the smokers to stay downwind of me (over and over again!). Most are considerate, but there always seems to be one."
Excerpt from letter to *Diver* magazine, Jul 2000

"On my first diving holiday in the Red Sea last year, I was dismayed by how many boat crew and other divers smoked ….. Smokers, please ask other people on a boat if they mind you smoking. And dive operators, there are probably as many people who don't smoke as do. Consider the possibility of non-smoking liveaboards, or at least designated non-smoking areas or cabins."
Excerpt from letter to *Diver* magazine, Sep 2000

Anecdotal evidence suggests that smoking immediately before, after and even during diving has featured amongst the recreational diving community for many years.

"Well, it must be some years since divers on dive boats lit cigarettes before they were out of the water, though I can recall one of diving's hierarchs whose water entry usually left a cigar stub still smoking on the surface behind him."
Excerpt from editorial comment, *Diver* magazine, Mar 2002

"So for any other nicotine addicts, here's how I got past those cravings at 30m. Fill an empty juice carton with uninhaled smoke and seal the hole. I find Capstan Full Strength the best for second-hand smoke. Join three or four straws together and seal one end, pushing the other end into the carton. Tape the carton into your drysuit (it won't crush under the

pressure) and stick the straws through the neck seal. And there you have it. When you want your fag, just cut off the end of the straw, lie back and enjoy."
Excerpt from letter to *Diver* magazine, Jun 2001

Over the last ten years the informal exchanges taking place via letters to traditional magazines have largely been replaced by online discussion forums; however, criticism continues for diving professionals who smoke, particularly recreational diving instructors.

"Based on a half-life of excess CO in the blood (about 6 hours), and typical CO-haemoglobin levels of smokers (5-10%), SCUBA divers who cannot break the smoking habit should abstain at least 12 hours before any dive. However, many divers do smoke, and sometimes just before a dive. Sadly, it is not uncommon to see dive professionals, divemasters and instructors, smoke during the surface interval between a two-tank dive."
www.mtsinai.org/pulmonary/books/scuba/medical.htm [Accessed 23/3/08)]

"No instructor would consider being drunk when teaching, but many smoke before, after or even while going over the fine points of nitrogen uptake, carbon dioxide, carbon monoxide and oxygenation of the blood."
www.subaqua.co.uk/reference/smoking-and-diving.shtml [Accessed 23/3/08]

These observations are somewhat surprising as the prevalence of cigarette smoking in England has been declining steadily from the mid 1970s to the early 1990s (Goddard, 2008) and is now stabilising at around 21% (22% male; 20% female). In addition, public understanding of the health risks of smoking in the UK is high, with surveys regularly reporting that most smokers say they would like to stop and have tried to give up in the past. In 2008/9 two-thirds of smokers reported they wanted to give up smoking, mainly for health reasons (The Health and Social Care Information Centre, 2011).

1.4 Rationale for examining associations between smoking behaviour and the health effects of tobacco use in recreational SCUBA divers

Informal observation of those embarking on the process of learning to dive suggests:

- A higher proportion of divers than expected (recreational and professional) appear to smoke cigarettes;
- Cigarette smoking is often undertaken immediately prior to, or soon after, a dive by regular smokers;
- A number of divers smoke cannabis immediately prior to, or after, a dive.

Further investigation was considered necessary to determine whether divers do have a higher prevalence of tobacco smoking than would be assumed for the demographic characteristics of this sub-group, particularly age, gender and social class, and whether this behaviour impacted on their health.

A review of the literature identified the following aims for investigation:

AIM 1: To compare the main demographic characteristics of UK recreational SCUBA divers with the general UK population.

AIM 2: To test the hypothesis that UK recreational SCUBA divers are more likely to be tobacco smokers or have higher nicotine-dependence than the UK general population.

AIM 3: To examine the prevalence of tobacco use and smoking behaviour amongst UK recreational SCUBA divers.

AIM 4: To compare self-reported assessments of overall health by UK recreational SCUBA divers with the general UK population.

AIM 5: To investigate the impact of smoking by UK recreational SCUBA divers on their general health and 'fitness to dive'.

AIM 6: To investigate the hypothesis that UK recreational SCUBA divers who smoke, or have a higher nicotine-dependence, are more likely to experience any type of diving-related health incident than non-smoker divers.

AIM 7: To investigate the hypothesis that UK recreational SCUBA divers who smoke, or have higher nicotine dependence, are more likely to take risks than non-smoker divers.

Chapter 2 presents the findings of the literature review in depth.

CHAPTER 2 - REVIEW OF THE LITERATURE

2.1 Search strategy

In December 2005 a comprehensive search strategy was devised to explore the published literature with regards to smoking behaviour and the health effects of SCUBA diving. Section 2.1.1 sets out details of the search terms used, the databases trawled and the outputs produced from combining search terms. Very few studies were uncovered that related to prevalence or smoking behaviour amongst recreational SCUBA divers, and as so much of the medical literature referred to the propensity of divers to take additional risks in relation to their health whilst diving (including tobacco, alcohol and illegal drug use) the strategy was subsequently broadened to include perceptions of risk and risk taking behaviour in recreational divers so that its role in affecting health outcomes could be better understood. A summary of the findings is presented in Table 2.1.

Table 2.1: Summary of findings of literature review

Combination of terms	Papers identified	Papers included
Diving and Smoking	138	Review / expert opinion – 25 Clinical – 35 Longitudinal study - 4 Retrospective study – 1 Survey - 12
Diving and Risk Taking	40	Review / expert opinion – 11 Clinical - 5 Case study – 6 Survey – 5
Smoking and Risk Taking (attitudes, beliefs, perception)	36	Review / expert opinion - 12 Clinical – 6 Survey – 2
TOTAL	214	124

2.1.1 Literature review search terms and strategy

The following databases were explored using the search terms and strategies outlined below:
PubMed (US Medical);
EMBASE (European Medical);
PsychInfo (psychology);
Web of Science (social science);
IBSS (specialised social science);
PhD Theses Index.

Search terms

The following terms (search textwords in brackets) were tested in a preliminary scoping of the main health and social science databases in 2004 and subsequently refined for use in the main search strategy in 2005, 2010 and 2012:

Tobacco smoking:

Smoking (smok*) – used for smoke, smoker, smoking;
Tobacco (tobacco) – used for tobacco smoking, tobacco dependence, tobacco use disorder NOT smokeless tobacco;
Cigarette (cigar*) – used for cigarette, cigars or cigarillos;
Pipe (pipe);
Hand-rolled (hand-roll*; hand roll*);
Cannabis (cannabi*) – used for cannabis, cannabinoid;
Marijuana (marijuana);
Nicotine (nicotine);
Tar (tar);
Carbon monoxide (carbon monoxide).

Risk taking:

Risk taking (risk-taking; risk taking);
Risk (risk; risk*) - used for risk, risky, risks, risking;
Taking (tak*) – used for taker(s), taking.

SCUBA diving:

Scuba (scuba; SCUBA);
Sub-aqua (sub-aqua; sub aqua; subaqua);
Diving (diving, div*) – used for dive, diver(s), diving.

An individual check on the use of each term plus its truncated version (for example, smoking and smok*) was carried out using PubMed to ensure that more articles were likely to be identified using the truncated version. Three notable exceptions proved to be:

i) 'marjuana' which yielded more articles than 'marijuan*';
ii) 'risk taking' and 'risk-taking' which yielded more articles than 'risk tak*' or 'risk-tak*';
iii) 'scuba diving' and 'subaqua diving' which yielded more articles than 'scuba div*' and 'subaqua div*'.

Search strategy

All relevant articles were identified and then narrowed down by relevance through combining the most appropriate search terms as follows:

Diving and **Tobacco Smoking;**
Diving and **Risk-taking**;
Tobacco Smoking and **Risk-taking**.

Using PubMed as an example, the search for **Tobacco Smoking** became:
#3. Search **"Smoking" [MeSH] (= 74,249);**
#4. Search **SMOK* OR TOBACCO OR CIGAR* OR PIPE OR HAND-ROLL* OR HAND ROLL* OR CANNABI* OR MARIJUANA OR NICOTINE OR TAR OR CARBON MONOXIDE (= 193,166);**
#5. Combining the two search strategies becomes: Search #3 **<u>OR</u>** #4 (= 193,166 articles).

The **search for Diving** became:
#14. Search **"Diving" [MeSH] (= 4,186);**

#15. Search **SCUBA OR SUBAQUA OR SUB-AQUA OR SUB AQUA OR DIVING OR DIVE* OR 'SELF CONTAINED UNDERWATER BREATHING APPARATUS' (= 184,043).**

In this search the 'free terms' gave exponentially more articles than the thesaurus 'key word' search. The results were investigated and found to contain too many irrelevant articles, for example terms such as 'divergence' and 'diverticulosis' included. Therefore the truncated term 'dive*' was removed and the search adapted to:

#20. Search **SCUBA OR SUBAQUA OR SUB-AQUA OR SUB AQUA OR DIVING OR DIVE OR DIVER OR DIVERS OR 'SELF CONTAINED UNDERWATER BREATHING APPARATUS' (= 6,667).**

Combining similar terms:
#21. Search #20 OR #14 **(= 6,667 articles).**

The **search for Risk-taking** became:
#8. Search **"Risk-Taking" [MeSH] (= 8,892);**
#9. Search **RISK TAKING OR RISK-TAKING OR RISK* TAK* OR RISK* BEHAV* OR RISK* (= 61,430).**

As the term 'tak*' was found to produce too many irrelevant results and the search was adapted to:
#10. Search **RISK TAKING OR RISK-TAKING OR RISK* TAKER OR RISK* TAKING OR RISK* BEHAV* OR RISK* (= 61,430).**

Combining similar terms:
#11. Search #8 OR #10 **(= 64,090).**

Further combination of terms produced the following results:
Combine **Diving and Smoking** results: #21 AND #5 **(=138 articles);**
Combine **Diving and Risk-taking** results*: #21 AND #11* **(= 40 articles);**

Combing **Smoking and Risk-taking** results: #11 AND #5 **(= 7,988 articles).**

The latter was further refined to only include attitudes to, beliefs about and perceptions of risk as follows:
e.g. (ATTITUDE [TI] OR ATTITUD* [TI] OR BELIEFS [TI] OR BELIEF* [TI] OR PERCEPTION* [TI]) AND RISK* [TI] AND (SMOKING [TI] OR TOBACCO [TI]) yielded **36 articles**.

All of the articles identified by the final search strategy were sourced from either the British Library or from the UCL library.

The same search strategy was used to conduct updates of the literature in August 2010 and May 2012. All relevant papers have been included in this chapter.

2.2 Overview of the health effects of tobacco smoking

The health effects of smoking are well documented and considerable.

Tobacco smoking is the main avoidable cause of premature death in England and is responsible for more than 80,000 deaths each year (The Health and Social Care Information Centre, Statistics on Smoking: England, 2011). In 2010, approximately one in five deaths of over-35 year olds were attributed to smoking. Over a third of all deaths from respiratory diseases and almost three in ten of all deaths from cancers in this group were estimated to be caused by smoking. The costs of preventing smoking-related illness are also considerable with the net ingredient cost of supplying NHS pharmacotherapies for cessation reaching £66 million in 2010/11 and the NHS treatment of smoking-related morbidity being estimated at £5.2 billion in 2005/6 alone.

Inhaling tobacco smoke introduces nicotine, particulate matter and a wide variety of biological toxins (including carbon monoxide) into the circulatory system via the lung capillary network. The physiological effects of these agents and their role in smoking-related illness are well documented, particularly for the respiratory and cardiovascular systems (The Health and Social Care Information Centre, 2011; Spurzem and Rennard, 2005; Benowitz, 2003; Royal College of Physicians, 2000).

Active smoking has been causally linked to a wide range of illnesses, the most serious being:

Cancer - especially lung cancer, but also of the respiratory tract, oesophagus, bladder, kidney, stomach and pancreas;
Respiratory disease - chronic obstructive lung disease and pneumonia;
Circulatory disease – ischaemic heart disease (including myocardial infarction), strokes and aneurysms;
Digestive disease – stomach or duodenal ulcers.

Passive smoking, or exposure to environmental tobacco smoke (ETS), is similarly associated with lung cancer and strokes. It is also linked to sudden infant death syndrome, asthma, lower respiratory tract and ear infections in children and an exacerbation of pre-existing conditions such as allergies, chronic lung conditions and angina in adults (SCOTH, 2004; IARC 2002).

Apart from its contribution to disease outcomes, tobacco smoking (active and passive) has short-term effects on human physiology than can affect immediate performance or function (Flouris et al, 2010).

A recent review (Barnoya and Glantz, 2005) documented acute health effects for the respiratory (including diminished lung function) and cardiovascular systems, which may be much more affected by exposure to ETS than previously thought (as evidenced by the effects of ETS on cardiovascular risk rates being not too dissimilar from those of active smoking). Explanations cited for this unexpectedly disproportionate effect include profound changes in vascular biology, especially platelet and endothelial function, even after relatively brief exposure to ETS (30 minutes) which can persist for up to 24 hours (Heiss et al, 2008). These insights help explain why the strongest evidence of health effects following legislation to limit ETS in public places relates to the reduction in hospital admissions for cardiac events (Callinan et al, 2010).

Other significant biological effects of ETS involve the endocrine and immune systems and the combined effect of moderate physical exertion on the cardio-respiratory and immune systems in the presence of ETS both in healthy individuals, and those already compromised for lung, cardiac and immune functions (such as allergies). Healthy adults also report headaches, eye and nasal irritation and nausea on exposure to ETS (Eriksen, LeMaistre and Newell, 1988).

These powerful physiological effects, particularly on the respiratory and circulatory systems, are generally accepted by the medical community to have potential ill-effects and consequences for divers' health and safety.

2.3 Overview of the health effects of recreational SCUBA diving

2.3.1 Introduction

Diving is regarded as an inherently hazardous activity by the Health and Safety Executive (HSE) and its principal partner organisations concerned with reducing the mortality and morbidity associated with UK recreational diving (the diver training organisations and the UK Maritime and Coastguard agencies). An overview of the main health effects of SCUBA diving and their likely interaction with tobacco use to pose additional health complications is presented here.

2.3.2 Mortality / accident rates within recreational SCUBA diving

Precise statistics on fatality rates and adverse events in recreational SCUBA diving are notoriously difficult to determine due to incomplete recording and inherent difficulties ascertaining the number of individuals involved or the number of dives undertaken in any particular year. As a result the estimates produced tend to be relatively broad-ranging and are widely regarded as underestimating the problem.[4]

The Divers Alert Network (DAN) is the most comprehensive collector of worldwide recreational dive accident statistics, although its primary focus is divers from the USA and Canada. It principally records numbers of fatalities and incidents of decompression illness requiring medical treatment, although it also records other potentially serious events, for example, divers being left behind at a dive site (DAN, 2008).

DAN works closely with the British agencies with an interest in collating dive accident statistics, for example, the British Sub-Aqua Club (BSAC). BSAC encourages its members to formally record diving incidents and near-misses and compiles an annual report (Cumming, 2009). The findings are also informed by reports from the Royal National Lifeboat Institution (RNLI), Maritime and Coastguard Agency (MCA) and media.

Fatalities

Worldwide, DAN received notification of 138 deaths involving SCUBA diving in 2006 although it only investigates those of US or Canadian citizens (n = 75). Both DAN and BSAC report dive fatality statistics to be gradually reducing over time, although due to the rare occurrence of death, the annual rates of death per 100,000 members vary substantially.[5] BSAC diver fatality rates have fallen steadily from 60 per 100,000 members in 1972 to 15 per 100,000 members in 2006. In 2009, 14 fatalities occurred in the UK, 7 of which were BSAC members (of a total membership of 32,790) giving a dive fatality rate of 21 per 100,000

[4] Personal communication, British Diving Safety Group presentation 23rd September 2005.

[5] Both organisations have recorded fatalities amongst their membership since the early 1960s.

members per year, a small increase on preceding years. The number of dives undertaken per fatality are not known.

Both organisations have also observed that the mean age of fatality is increasing as their membership ages. The mean age of death amongst USA and Canadian divers increased from 42 in 1998 to 48 in 2005 and BSAC reported that divers over 50 years of age were over-represented in fatality statistics in 2009 (comprising of 57% fatalities from 16% of their membership).[6] The most recent DAN report (2008) cited that 38% of fatalities in 2006 were cardiovascular-related and the majority of victims (73%) were classified as overweight or obese by body mass index, which is thought to contribute to the deaths of older members (Denoble et al, 2008).

Diving at work fatalities are monitored by the HSE. The work undertaken in this arena is extremely wide-ranging, from Offshore diving to those who work in the media or recreational sectors. Divers may be exposed to a considerable amount of risk as a result of their work; however, the effects of exposure are often mitigated by precautionary measures, such as immediate access to hyperbaric treatment facilities. The fatal accident rate for the Offshore and Inland / Inshore sectors is typically in the region of 20-40 per 100,000 dives (considerably higher than in construction or agriculture). Overall, the fatal accident rate for all 'diving at work' activities in the UK is estimated to be 6-7 per 100,000 dives (HSE Health and Safety Strategy), i.e. between one-third and half of that observed in UK recreational divers.

Adverse events (excluding fatalities)

364 adverse events (excluding 14 combined deaths of BSAC and non-BSAC members) were recorded by BSAC in 2010. This was considered

[6] BSAC cites the average age of fatalities as 51 years for 2009, compared to its average membership age of 38 years.

to be in line with recent years, where figures approximate to 400 incidents on average.

The main category of adverse event (as in all previous years, excepting 2007) is decompression illness (DCI). Approximately 120 cases are reported on average per year in the UK but reliable figures are difficult to obtain because symptoms may not be recognised and the total number of dives undertaken per year normally has to be estimated.   A DAN study of its membership (DAN, 2005) found 4.3% of women and 3.3% of males reporting DCI symptoms. Other researchers using US data (Twarog et al, 1995) estimated the overall risk of DCI as being 0.017% of 0.2% of dives. A US internet study (Beckett and Kordick, 2007) of recreational divers (n = 682) found 5.2% of respondents had suspected DCI. A study examining US and Australian subjects (Taylor et al, 2003) reported 4.4% of divers had suffered DCI (n = 346). A questionnaire survey (n = 3078) administered to Japanese recreational divers (Nakayama et al, 2003) found 1.9% reported DCI. A German study (Klingmann et at, 2008) used a questionnaire survey at medical symposia to investigate lifetime incidence of DCI. Within the 429 responders, there was an overall lifetime DCI incidence of 1 per 5463 dives. Hagberg and Ornhagen (2003) in a study of Swedish divemasters and instructors found the incidence of DCI symptoms to be 1.52 for males and 1.27 for females per 1000 dives. A British study (St Leger Dowse et al, 2002) estimated the rate of DCI to be 2.60 times greater in men than women.

The second largest category of adverse incident relates to boating accidents and surface incidents, such as engine failure, fuel problems and 'lost divers'.

The third category is 'ascents' where divers have made an abnormal ascent, typically a rapid ascent, but avoided decompression illness.

The final category is 'non-specific illness or injury' reported by the RNLI after being called for assistance[7], but is suspected to mainly comprise of unrecognised DCI. This category has comprised of around 55 cases per year for the last twelve years.

2.3.3 Physiological effects associated with gaseous exchange / pressure differentials during diving and the effects on health outcomes

Whilst SCUBA diving can have many potential health consequences, some of these problems are inherent to diving with compressed gas. This is because of the effect of the physical gas laws on human physiology, summarised here:

Boyle's Law states that if the temperature remains constant, the volume of a given mass of gas is inversely proportional to the absolute pressure – specifically that gaseous volumes expand when environmental pressure decreases, and contract when pressure increases.

Charles' Law states that is the pressure is constant, the volume of a gas is proportional to the absolute temperature.

Dalton's Law states that the total pressure exerted by a mixture of gases is the sum of the pressures that would be exerted by each of the gases if it alone occupied the volume.

The principal effect of these laws is to change the size of the gaseous cavities, and the partial pressures of gas within tissues, with changing depth.

The respiratory system is the most vulnerable organ to these effects due to the relatively large size of the lungs, their importance in gaseous

[7] Typically the MCA and RNLI respond to around 300-400 emergency calls involving divers per year.

exchange and the delicate nature of the alveolar walls; however, pressure changes affect every existing gaseous cavity, for example, in the sinuses, middle ear and intestine. As a consequence the body cavities and surrounding tissues have to adjust sufficiently to the following events whilst diving to prevent illness or injury:

Gas in cavities needs to change volume without excessive damage to the surrounding tissues. The most serious damage being cerebral arterial gas embolism (CAGE) resulting from rupture of the pulmonary alveolar sacs on ascent. The symptoms of CAGE are often confused with other types of DCI leading to inaccurate diagnoses and therefore reporting figures (DAN, 2008) but the most common injuries are ear or sinus barotraumas, estimated to have occurred in 11% and 6% of divers respectively (Nakayama et al, 2003).

Gas which has dissolved in the body's tissues to high partial pressures at depth needs to diffuse out of the tissues on ascent at a slow enough rate not to form circulating bubbles which may block arterial blood flow and produce symptoms of decompression illness.

The increased density of gas and ambient pressure at depth causes an increase in respiratory effort required and a reduction in breathing capacity. This is proportional to the depth of the diver. The cardio-respiratory system may be required to respond to increased physical effort at depth under these conditions.

Using breathing equipment underwater also requires additional effort due to the increase in dead space and airways conductance resistance. This compounds the effects of breathing gas at a greater density and against the increased hydrostatic pressure of the environment which may lead to shortness of breath. Additional stress is created by extra weight and drag of the equipment. Changes in pulmonary function observed after SCUBA diving have been attributed to airways conductance resistance (Skogstad et al, 1996; Thorsen, Skogstad and Reed, 1999).

The body requires sufficient protection against thermal stress to survive in the marine environment. Cold water is thought to enhance platelet activation (Doubt, 1996; Bosco et al, 2001) and interfere with the performance of higher-order tasks (Vaughan, 1977). Both hypo- and hyperthermia have been associated with diving accidents (Polzler and Eglseer, 1999).

High partial pressures of inert gas within the tissues may produce nervous system effects, the most frequent being ‘inert gas narcosis’ characterised by impaired complex psychomotor performance and mood and behavioural changes (Biersner et al, 1978). The most common form, reported as having affected 12% of divers (Nakayama et al, 2003), is ‘nitrogen narcosis’ which frequently occurs in subjects breathing compressed air at a depth of approximately 30 metres. Other inert gases, such as helium, have been used as a replacement for nitrogen to reduce the narcotic potential of the gas mixture, but tend to produce additional nervous system effects termed high-pressure neurological syndrome (HPNS) at depths of around 200 metres. Tremor is the most prominent feature of HPNS but other symptoms include nausea, vomiting, dizziness and vertigo (Vaernes, Bergan and Warncke, 1988).

High partial pressures of metabolically active gas within the tissues, for example oxygen, may produce serious nervous system effects (Newton, 2001). Oxygen toxicity leading to convulsions is associated with compressed air diving at depths of approximately 40-50 metres or more. For this reason, exceeding 40-50m depth using compressed air is strongly advised against by UK diver training agencies. Oxygen toxicity is also of particular concern to divers using oxygen enriched air (Nitrox) to extend diving times. Poisonous gases, such as carbon monoxide, which may be introduced inadvertently into SCUBA tanks at the surface, for example, through a faulty air compressor (Allen, 1992) or from internal tank corrosion (Temple, Bosshardt and Davis, 1975), will become more concentrated at depth resulting in greater toxicity.

2.3.4 The physical effects of immersion

Immersion in water produces additional physiological changes, particularly on the respiratory and vascular systems, which are well documented (Hall, Bisson and O'Hare, 1990).

Respiratory effects

On submersion of the head there is a voluntary apnoea. On continued immersion of the head there will become a point (determined by arterial carbon dioxide levels) when an involuntary inspiration occurs resulting in the inspiration of fluid (except where reflex laryngospasm occurs).

Inhaling fresh or saltwater have different biochemical and circulatory effects in the lung, both of which can lead to drowning if not treated promptly or effectively (North, 2002).

Cardiovascular effects

On vertical submersion, there is an overall increase in the work of the respiratory and cardiovascular systems due to compression of the body. This compression displaces blood from the limbs into the pulmonary circulation and, together with a minor compression of the chest wall, leads to a rise in intrathoracic blood volume and a corresponding decrease in plasma volume. Cold water produces additional similar effects. Variations in posture during immersion also alter blood pressure and circulatory volume (Schipke and Pelzer, 2001).

2.3.5 Diving-related illnesses

The physiological changes associated with immersion and breathing compressed air at depths of less than 50 metres are generally welltolerated by healthy subjects (Schipke and Pelzer, 2001) for relatively short periods (typically an hour).

Even within these parameters, divers are subject to many potential risks to their health. The most immediate and important diving-specific conditions being the physiological changes associated with breathing compressed air at depth, which have already been described.

Longer-term dive-specific health effects may follow either recovery from an acute episode, such as DCI or ear barotrauma, or develop with repeated exposure to more extreme diving conditions. For this reason, the majority of published studies focus on the long-term health of professional divers or the military, both of whom are more likely to dive much more frequently, and in more arduous conditions, than recreational divers. The HSE commissioned a major study into the long-term effects of diving at work to clarify the UK situation (Macdiarmid et al, 2004).

The primary focus of these studies has principally been lung function (Tetzlaff et al, 1998; Skogstad, Thorsen and Haldorsen, 2000; Skogstad et al, 2002), headache (Englund and Risberg, 2003), neurological disorders (Todnem et al, 1989; Todnem and Vaernes, 1993; Vaernes, Bergan and Warncke, 1988; Aarli et al, 1985; Todnem et al, 1991; Wada et al, 1988), cognitive-behavioural function (Biersner, McHugh and Rahe, 1984; Vaernes, Klove and Ellertsen, 1989; Vaernes et al, 1987; Todnem et al, 1989; Logue et al, 1986; Curley, 1988; Hodgson and Golding, 1991; Bast-Pettersen, 1999), dysbaric osteonecrosis and haemostatic changes (Paciorek and Rolfsen, 1986; Domoto et al, 2001; Olszanski et al, 1997), which are thought to be the foundation for the development of DCI.

There are a limited number of articles reporting on the long term health effects of recreational SCUBA divers. A UK study (McQueen, Kent and Murrison, 1994) found that divers who had suffered neurological DCI were more likely to believe that diving was deleterious to health and show symptoms of psychiatric morbidity. A Swiss study (Slosman et al, 2004) found cognitive performance to be impaired when diving in less than 40 metres depth but even more so in extreme environments (cold) and with higher frequencies of diving (more than 100 dives per year). A survey of experienced recreational divers from the US and Australia (Taylor, O'Toole and Ryan, 2003) found that respondents were more likely than expected to have suffered diving-related injuries, mainly barotraumas (which the authors acknowledge may have influenced their participation). Of these respondents, 4.4% had suffered DCI and 2.3% reported permanent disabilities, principally hearing loss, tinnitus and balance disorder.

A review of the long term health effects of recreational SCUBA diving (Walker, 2001) concluded that changes in bone, the central nervous system and the lung (consistent with small airways disease) did occur in some divers who had not experienced a diving accident, but that most of these changes were minor and not likely to affect the diver's quality of life. Nevertheless, it was acknowledged it was possible they would continue to influence the divers' health in the longer-term.

2.3.6 Additional factors affecting health outcomes during diving

It is widely accepted that a diver has to have a reasonable level of cardiovascular and respiratory fitness in order to avoid injury from the risks of pressure changes (British Thoracic Society, 2003); however, there are numerous additional factors that can contribute to unfavourable health outcomes. An overview is provided here:

2.3.6.1 Factors specific to the marine environment

There are many varied and unpredictable factors introduced by the marine environment which may not be planned for, or possible to control. The most common factors include adverse weather conditions, seasickness, dehydration, hypothermia, hyperthermia, dangerous marine creatures, infections, strong currents, poor visibility and physically unsafe environments (including overhead environments).[8]

2.3.6.2 Diving equipment

The term 'diving equipment' refers to any physical object which is deemed necessary to diving activity. Its purpose may be essential for survival within the marine environment, such as buoyancy control and breathing devices, or carried as additional equipment used for a particularly activity, for example, photography, welding or propulsion devices.

The annual BSAC National Diving Committee Diving Incidents Reports includes equipment problems as one of its major categories. Difficulties with equipment mainly result from operator errors, such as: the improper selection of equipment for conditions; misreading or failing to read displays during diving; misunderstanding the purpose or application of pieces of equipment; forgotten or lost equipment or lack of appropriate maintenance. Occasionally incidents result from equipment failures, such as regulator freeze in cold water or valves seizing, but this is less commonly reported.

In either instance, prompt action usually needs to be taken to remedy the problem, which may mean terminating the dive early.

2.3.6.3 Diver technique (including training and experience)

Diver technique is another category of incident regularly reported in the annual BSAC Report. Divers contribute to accidents, for themselves or others, through a lack of appropriate training, failure to follow guidelines or procedures, poor selection of dive sites or methods of entry and loss of buoyancy control, anxiety or panic whilst diving.

[8] The term 'overhead environments' describes circumstances in which the diver could not directly ascend to the surface should they choose to do so. It occurs in many forms, most commonly during wreck and cave diving.

Technical divers are also regarded as having excess risk for fatal accidents due to the increased complexity of diving with gas mixtures other than compressed air (Smith, 1995).

2.3.6.4 Individual attitudes to safe diving practices

Numerous authors' comments permeate the literature where divers are felt to have compromised their safety through personal choice. Both alcohol (Kizer and Milroy, 1981; Eckenhoff, 1989; Michalodimitrakis and Patsalis, 1987) and illegal recreational drugs (Unsworth, 1982; Chesneau et al, 2000; St Leger Dowse et al, 2011) have been discussed as contributory factors to diving fatalities or accidents and tobacco smoking is thought to increase the severity of DCI symptoms where they occur (Buch et al, 2003). A more thorough review of the diving literature relating to tobacco smoking is discussed in the next section.

Other behaviours cited as irresponsible are diving before recovery from jetlag, excessive fatigue and diving with medical conditions known to be contraindicated in SCUBA diving (Taylor, O'Toole and Ryan, 2002).

2.3.6.5 Fitness to dive (pre-dive) – the role of the diving medical

There are a wide range of medical conditions that are known to pose excess risk for fatal diving accidents. The most important are respiratory disease but particularly asthma (Jenkins et al, 1993), poor physical fitness, overweight, multiple risk factors for cardiovascular disease, long-term conditions such as diabetes or epilepsy and structural abnormalities of the heart such as patent foramen ovale (Knauth et al, 1997; Schwerzmann and Seiler, 2001) and lungs (Smith, 1995).

Other factors such as diving with short-term illnesses, such as upper respiratory tract or sinus infections, and the concomitant use of prescribed medication, medicines available on general sale or alternative medicinal therapies are also recognised as potentially complicating factors (Harrison, 1992; St Leger Dowse, Cridge and Smerdon, 2011).

Medical examination

Medical screening, alongside diver training, has long been relied on to prevent accidents. In the UK, it is compulsory for those who ‘dive at work’ to pass an annual medical examination by a doctor who has been approved by the HSE. Nevertheless, there is no current requirement for recreational divers to undertake an annual medical, unless they choose to do so. Instead, the main UK diver training agencies recently introduced a ‘self-assessment’ procedure whereby divers identify their own health risks using a pre-determined questionnaire. Referral for a diving medical is prompted by a positive response to one of the questionnaire items.

As well as meeting the general requirements for health and fitness identified by the questionnaire, diving physicians are also asked to assess the following specific requirements of respiratory fitness for sport diving (British Thoracic Society, 2003):

- The subject may be required to swim in strong currents;
- The subject may be required to rescue a companion (dive buddy) in the event of an emergency;
- The diving environment is associated with a risk of lung rupture;
- The gas breathed by the diver may be very cold.

It should be noted that there is ongoing debate about the optimal approach to medically assessing an individual’s ‘fitness to dive’. A Scottish study (Glen, White and Douglas, 2000) found that routine medical examinations were of limited value, whilst a study of Australian subjects (Taylor, O’Toole and Ryan, 2002) found that, after their entry-level medical, many divers continued to dive with conditions that were medically contraindicated - although it was not known whether these conditions were undeclared at the entry-level medical or had developed subsequently.

It should be stressed that the presence of the majority of medical risk factors does not automatically prevent an individual from participating in recreational diving, instead that a through assessment by a suitably trained diving physician (including an accurate history and measurement of lung function) is warranted (Glen, White and Douglas, 2000; Jenkins etc al, 1993).

Specific health considerations for female divers

In contrast to previous beliefs, women are now not considered to be at a greater health disadvantage whilst diving, for example from decompression illness during menses (Lee et al, 2003), than their male counterparts. Nevertheless, there is sufficient evidence to suggest that women should avoid diving whilst pregnant to prevent damage to the foetus from circulating bubbles produced during the dive (Newhall, 1981) or from hyperbaric treatment (Fujikura, 1964).

2.3.6.6 Illness or injury arising during, or post, SCUBA diving and access to medical treatment

Divers are at risk from a broad spectrum of physical injuries and illnesses, ranging from pre-existing health problems to those sustained by trauma or infection during diving, or due to the unique health risks posed by using compressed gases within the marine environment.

Serious physical illness or injury may occur during diving or become apparent sometime afterwards, for example, DCI symptoms may take over six hours to manifest. Diagnosis and treatment is often complicated by the presence of non-specific symptoms, such as dehydration and fatigue.

Psychological stress and anxiety are also known contributory factors to diving injuries (Morgan, 1995; Colvard and Colvard, 2003). Divers with elevated levels of anxiety and poor coping skills are at a greater risk of developing panic reactions than those possessing more appropriate responses to stress. (Anegg et al, 2002). Panic attack is commonly reported amongst divers, with females being more likely to report having experienced an attack (Colvard and Colvard, 2003). Other diving-specific stress responses include hyperventilation, 'blue orb' syndrome (agoraphobia) and perceptual narrowing, as well an exacerbation of symptoms associated with pre-existing mental health conditions.

Many diving injuries can be treated on-site but those requiring medical intervention can be hampered by the availability of suitably trained staff or equipment, such as oxygen on board or the location of decompression chambers relative to the dive site. In remote areas access can be extremely limited and require boat or helicopter rescue.

2.3.6.7 Risk taking in recreational SCUBA diving

2.3.6.7.1 Overview and definitions

There is a large literature on risk taking behaviour at an individual level, for example see the review conducted by Roberti (2004), and at a population level, for example see Turner, McClure and Pirozzo (2004). In contrast, there are very few papers of either type focusing on risk taking within SCUBA diving. The following definitions will be used to summarise the literature relevant to this thesis:

Risk taking: The behaviour must have a potentially non-injurious outcome as well as one that can result in harm and the behaviour must be volitional (Irwin and Millstein, 1992).

Sensation seeking: A [personality] trait defined by the seeking of varied, novel, complex and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experience (Zuckerman, 1994, p27).

The widely accepted model of sensation seeking as a motivating factor for choosing more risky behaviour, is based on a complex interaction between genetic, biological, psychosocial, familial and environmental factors which influence certain outcomes, especially individual attitudes, behaviours and preferences (Roberti, 2004; Irwin and Millstein, 1992).

2.3.6.7.2 Sensation seeking and tobacco use

Sensation seeking has been strongly linked to a number of risky health behaviours, especially risky sexual behaviour, alcohol misuse, recreational drug use (Roberti, 2004) and specifically tobacco use (Roberti, 2004; Zuckerman, 1979; Zuckerman, Ball and Black, 1990; Zuckerman and Neeb, 1980; Carton, Jouvent and Widlocher, 1994; Gurpegui et al, 2007; Spillane, Smith and Kahler, 2010). A greater proportion of high sensation seekers engage in these activities than low sensation seekers.

Although the links between sensation seeking and risky health behaviours, such as tobacco use, have been observed for many years, it is only relatively recently that deeper insights into the possible nature of these associations have been uncovered. Genetic factors are now thought to account for approximately half of observed variability in smoking rates and many of the traits associated with high smoking levels are believed to be connected by the same genes (McClernon and Gilbert, 2007, p215). For example, some of the genes that contribute to an individual's vulnerability to experience higher than normal levels of stress or negative mood states also appear to predispose them to smoking. In addition, the genes that predispose an individual to impulsivity and sensation seeking also predispose them to a range of compulsive behaviours such as smoking and recreational drug use. Nevertheless, the broader, more holistic, model of smoking behaviour being determined by complex interactions between genetic, individual and wider environmental factors still prevails.

2.3.6.7.3 Sensation seeking and high adrenaline sports

Sensation seeking has been linked to participation in extreme or high adrenaline sports for many years (Zuckerman, 1983; Jack and Ronan, 1998; Roberti, 2004). In addition self-reported risky behaviours, such as drinking and driving, are strongly associated with the occurrence of injury (Turner, McClure and Pirozzo, 2004) although there is some ambiguity over whether accident rates are mitigated by training in high performance extreme sports. For example, novice skiers who have had accidents score more highly on sensation seeking than novices without accidents, and more experienced skiers score higher on sensation seeking scales than novices (Zuckerman, 1992); however, the rate of injury has been shown to be lowest in the more experienced, high sensation seeking skiers (Bouter et al, 1988; Cherpitel et al, 1998).

2.3.6.7.4 Sensation seeking in recreational SCUBA divers

SCUBA diving is often categorised as an extreme sport and as an example of an activity that attracts individuals who are high sensation seekers (Zuckerman, 1983); however, this view is disputed within the professional dive community who have invested considerable resources over recent decades to commission research to identify the risks inherent in diving (Acott, 2005) or to compare the severity of various types of risk in diving (Paras, 1997) and to promote better risk management in order to reduce the morbidity and mortality associated with SCUBA diving in both the occupational (Sayer, 2004) and recreational (Nimb, 2004) sectors.

As a result there is a wealth of literature emphasising the importance of health and safety style risk assessments as an integral part of dive planning to manage risk and prevent or limit diving injuries with all types of equipment and conditions. The formation of the British Diving Safety Group is a practical example of how the collective knowledge and resources possessed by the a variety of organisations ranging from the Royal Navy and Coastguard through to the smallest of UK diving membership organisations has been strategically and pragmatically applied to increase diver safety. In addition the main diver training organisations now argue that the training standards and programme content required to complete basic recreational diver training are currently sufficiently stringent and theoretically demanding enough to effectively screen out individuals who might have a lax approach to diver safety or behave recklessly with regards to the welfare of fellow water users or the marine environment (personal communication, BDSG presentation 23rd September 2005).

In contrast to the considerable wealth of literature regarding the prevention and management of risk, there is a relative paucity of literature specifically addressing risk taking attitudes and behaviour by divers.

Within these studies a wide variety of investigative approaches has been taken, ranging from psychoanalytic perspectives (Hunt, 1995; Hunt, 1996) to comparisons with different psychological theories, such as the self-regulation concept (Bonnet et al, 2003). Most employ convenience groups involved in high adrenaline sports and use Zuckerman's Sensation-Seeking Scale (models IV and V) for Thrill and Adventure Seeking to assess differences between the study groups (divers) and controls.

Divers scored higher than controls on this scale in all studies of this type. Heyman and Rose (1980) compared novice college divers with non-diving students, Guszkowska and Boldak (2010) compared more experienced recreational SCUBA divers with non-sports enthusiasts and Biersner and LaRocco (1983) compared US Navy divers with non-diving Navy counterparts. Also Bonnet et al (2003) found that divers with injuries scored higher on Thrill and Adventure Seeking than divers without injuries.

Although divers consistently scored higher sensation seeking scores than controls, Guszkowska and Boldak (2010) observed that SCUBA divers scored significantly lower sensation seeking scores than other extreme sports enthusiasts, especially experienced parachutists ($p = 0.033$), alpinists ($p = 0.001$), wakeboarders ($p = 0.001$) and snowboarders ($p < 0.001$). The authors concluded that the sports groups investigated were not homogenous with regards to sensation seeking and that specific sports, or events within that sport, should be analysed separately.

Another indication that the sensation seeking profile of divers (and possibly other extreme sports enthusiasts) may be more complicated than initially presumed comes from the use of recreational drugs. A recent prevalence study of illicit drug use (St Leger Dowse et al, 2011) amongst UK recreational divers (n = 531) found that 22% of respondents had used illegal drugs of some kind since learning to dive, with cannabis being the most popular choice; however, compared to 2007/8 British Crime Survey figures, divers were less likely to use any type of illegal drug than the general UK population with just 3.5% of divers using in the previous twelve months compared to 9.3% of the population. Similarly, a US survey of divers' risky behaviours (Beckett and Kordick, 2007) found that 3.3% of divers had used illegal drugs within twelve hours of diving compared to the British study, which found 4% of divers (n = 22) had used illegal drugs within 24 hours before diving. These figures raise the possibility that although divers are motivated by sensation seeking, they choose to modify their behaviour to certain types of risk, particularly recreational drug use, when engaging in their sport or outside.

2.3.6.7.5 Risky diving practices and injury in recreational diving

One survey was identified (Beckett and Kordick, 2007) which sought to examine the relationship between adherence to safe diving protocols and risky diving behaviours (defined as diving with pre-existing medical conditions, use of tobacco, alcohol and recreational drugs) with US recreational SCUBA diver injuries.

682 respondents completed the internet survey and 80.6% were certified divers (qualified to at least entry-level) versus 19.4% uncertified. Fewer certified divers (51.7%) reported dive injuries than non-certified divers (75.0%) and this difference was significant ($p<0.001$) suggesting that diver training plays an important role in reducing injuries.

Although current use of tobacco (18.5%), alcohol (44.5%) or recreational drugs (3.2%) within 12 hours of diving and pre-existing medical conditions (32.7%) were recorded in this study, no significant associations were found with diving injuries.

2.4 Overview of the possible effects of tobacco smoking on the health of recreational SCUBA divers

Despite there being a limited number of studies directly investigating the impact of tobacco use on divers' health, there are some accepted beliefs shared amongst the diving community that have led to specific advice being adopted by diving doctors and issued to divers on the effects of smoking on their health; however, the lack of evidence cited in the literature has led to more cautionary approaches to condemning tobacco use by some of the diver training agencies:

"It is neither practical nor desirable to ban all smokers or people who drink alcohol from diving. However, divers should be encouraged not to smoke or drink alcohol prior to diving." (BSAC, 1998, p17)

"Whilst smoking is not recommended, there is currently little evidence that smoking by itself predisposes anyone to diving-related illness, unless it has produced or exacerbated lung disease." (DAN, 2003, p196)

The extent of the evidence available is documented here.

2.4.1 Physiological effects of smoking on divers' health

There appears to be widespread agreement within the dive community that active tobacco smoking is detrimental to a diver's health and could compromise their physical fitness to dive in the short and longer term although the exact pathophysiological mechanisms associated with smoking and diving are not yet fully understood (Dillard and Ewald, 2003).

There is evidence (Buch et al, 2003) that smoking may increase the severity of DCI symptoms where they occur and that this is proportional to the number of cigarettes smoked (heavy smokers vs. light smokers, OR = 1.56, 95% CI 1.09, 2.23; heavy smokers vs. non-smokers, OR = 1.88, 95% CI 1.36, 2.60). The findings suggest a dose-response relationship between pack-year exposure and severity of DCI, but tobacco smoking has not yet been causally linked with an increased risk of DCI (Wilmshurst et al, 1994; Buch et al, 2003). Nevertheless, the treatment of DCI appears to be affected by smoking, with smokers releasing nitrogen more slowly from skeletal muscle than their non-smoking counterparts (Hart and Strauss, 2010).

It is also suspected that divers with heavy smoking histories are more likely to develop pulmonary function decline than non-smokers (Dembert et al, 1984); however, the total picture is complicated by the studies principally being carried out in professional divers and the military, where divers tend to be younger and have higher fitness levels and better lung function than the general population. In addition the repetitive diving required by certain occupations tends to produce larger lung volumes than in standard reference populations, attributed in part to increased respiratory effort and training (Fitzpatrick and Conkin, 2003).

Chong, Tan and Lim (2008) found no differences in lung function between Republic of Singapore Navy divers who smoked and non-smokers. Suzuki (1997) found no differences in static lung volumes between smokers and non-smokers in an active group of Japanese Navy divers (n = 71; mean age approximately 34 years)[9] except that the peak expiratory flow rate in smokers was significantly lower ($p < 0.05$), which concurs with previous reports of divers experiencing reduced expiratory flow rates in the longer term (Skogstad et al, 2002) and with the age-related decline seen in the general population. Sekulic and Tocilj (2006) found a significant difference

[9] Mean age of smokers = 33.5 years; mean age of non-smokers = 34.6 years.

in lung function between smokers and non-smokers in Croatian military divers, but only for inspiratory vital capacity (reduced in smokers) and not for expiratory flow levels, whereas Tetzlaff et al (2006) found that a combined exposure to diving and smoking contributed to a decline in 1-second forced expiratory volume in German military divers.

Cirillo et al (2003) demonstrated that asthmatic subjects, or those with allergies who are non-asthmatic, develop early airway hyper-responsiveness with SCUBA diving. Tetzlaff et al (1998) also demonstrated an increased prevalence of airways hyper-responsiveness in experienced divers to non-specific inhalation stimuli. Given that both smokers and divers are at increased risk of airway hyper-responsiveness, it has been suggested that smokers with airways hyper-responsiveness may be at equal, or greater risk, than asthma patients whilst diving (Dillard and Ewald, 2003) and that smokers should be tested for small airways disease in diving medical examinations (Wilmshurst et al, 1994).

The latter study also examined the associations between smoking and cardio-respiratory abnormalities in recreational divers with the neurological manifestation of DCI and concluded that pulmonary abnormalities, and probably smoking (a nearly-significant relationship), increased the risk of neurological symptoms even with conservative dive profiles (Wilmshurst et al, 1994).

Despite reports highlighting that more than 14% of diver fatalities in 2002 had a chronic history of circulatory disease (DAN, 2004) and that 38% of fatalities in 2006 were from heart disease (DAN, 2008), no studies were found that examined the long term effects of diving on cardiovascular function or its associations with cigarette smoking. Nevertheless, it is thought likely that carbon monoxide from tobacco smoke inhalation could prove fatal whilst diving, for example if the tank air supply had already been contaminated by engine exhaust fumes or a faulty air compressor (Allen, 1992). In this instance, the increased rate of formation of blood carboxyhaemoglobin or the depletion of oxygen in the air supply by the presence of toxic gases or rust with depth (Temple, Bosshardt and Davis, 1975) could result in hypoxia and possible loss of consciousness.

Overall the main diver training agencies and the diving medical community advise against active tobacco smoking before diving, although the estimates of how long divers should abstain, before or after diving, vary.

"Diving should be avoided until any condition causing [lung] congestion is completely healed, and divers should not smoke for several hours before a dive. Smokers should consult a pulmonary physician before engaging in diving." (PADI, 1996, p2-59)

"The possibility of a heart attack (the number one killer of divers) is increased with smoking. Divers should refrain from these activities before diving and for about four hours afterwards."
www.spc.int/coastfish/News/Fish_News/104/Scuba_Safety_104.pdf
[Accessed 23/4/08]

"Based on a half-life of excess CO in the blood (about 6 hours), and typical CO-haemoglobin levels of smokers (5-10%), SCUBA divers who cannot break the smoking habit should abstain at least 12 hours before any dive."
www.mtsinai.org/pulmonary/books/scuba/medical.htm [Accessed 23/4/08]

"While at depth, the hypoxic effect of excess CO will be somewhat (but not completely) mitigated by the higher blood oxygen level that also occurs at depth. In final analysis, we really don't know to what extent smoking causes problems in divers, but common sense (and basic physiology) makes it a dumb practice to smoke and dive."
www.mtsinai.org/pulmonary/books/scuba/gaspress.htm [Accessed 23/4/08]

At the time of writing there was little, if any, discussion on the effects of passive smoking on the immediate physical fitness of all individuals preparing to dive. Nevertheless, given that passive smoking is a serious risk to those with cardiovascular disease (Barnoya and Glantz, 2005) and cardiovascular disease is reported as a major cause of diver fatalities (DAN, 2008) then further research in this area may be important in reducing diver deaths in future.

2.4.2 Smoking prevalence in recreational divers

The prevalence of tobacco smoking amongst UK recreational divers is difficult to ascertain accurately because of problems with identifying the total population of divers and because the diver training organisations are reluctant to survey their members for lifestyle behaviours or to share this information externally.[10] Unsurprisingly the picture is currently unclear, although all published reports indicate that smoking levels are lower than in the general population.

Estimates of prevalence have mainly been obtained as secondary outcomes of other studies of recreational divers' health. The most recent study (St Leger Dowse, Cridge and Smerdon, 2011) obtained a figure for smoking prevalence as part of a wider survey of divers' use of illegal drugs and prescription and non-prescription medicines. Questionnaires were circulated to diving clubs, schools, dive shows and at conferences and an overall response rate of 26% provided 531 cases, of which 10% of respondents were current smokers (11.1% male; 7.6% female).

An earlier study (St Leger Dowse et al, 2002) compared the diving habits and histories of 2250 UK male and female recreational divers. In this study 28% of divers (34% male; 22% female) admitted to having smoked cigarettes during their diving careers (ever-smokers). Data for current smokers was not available.

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[10] Personal communication, British Diving Safety Group presentation 23rd September 2005.

A review of the medical records (n = 2962) of the Scottish Sub-Aqua Club (Glen, White and Douglas, 2000) from 1991-1998 found that the prevalence of smoking amongst members rose from 9% to 15% over this period and that this increase was significant ($p = 0.045$).

A study into the role of cardio-respiratory abnormalities, smoking and dive characteristics in relation to DCI (Wilmshurst et al, 1994) reported, as personal communication, the findings of an internal British Sub-Aqua Club survey of a random sample of its members in 1990, of which 17% smoked (177 smokers from a sample of 1028).

Another estimate of prevalence was obtained from the original data of the HSE investigation into the long-term health effects of diving at work (Macdiarmid et al, 2004). This study had concluded that divers at work were significantly less likely to be current smokers than offshore workers ($p < 0.001$); however, a proportion of the randomly-selected control group (237 out of a total of 1032 offshore workers; 23%) were also recreational divers. Smoking prevalence within this sub-group was 20% for current smokers, 30% for ex-smokers and 50% for never-smokers.[11]

Worldwide the picture appears to be more varied, with a Croatian study of diving physicians and diving instructors attending a conference reporting regular smoking levels to be 17% (Stojanovi, Jonji and Stojanovi, 2004) and a German study investigating illness prevalence via questionnaires circulated with a sports diving magazine (Piepho et al, 2008) found smoking levels amongst respondents (n = 322) to be 44.2%. A Netherlands Antilles questionnaire (Weaver et al, 2009) issued to recreational divers (n = 668) in conjunction with spirometry testing just before diving revealed current smoking levels of 13%. A US internet study of certified recreational divers found smoking levels amongst respondents

[11] Personal communication, Dr John Ross, Department of Environmental and Occupational Medicine, University of Aberdeen.

(n = 550) to be 18.5% (Beckett and Kordick, 2007). No other studies reporting prevalence were found.

Smoking levels amongst those who have suffered a serious diving accident have occasionally been reported by DAN. The 2004 DAN Annual Diving Report referred to the percentage of cigarette smokers amongst fatalities (13% in 2002 data) and commented that this had decreased slightly from previously; however, an analysis of data (Buch et al, 2003) from 4,350 adverse events (excluding fatalities) reported to DAN between 1986 and 1997 revealed that 36% of cases smoked.

It is presumed that all of the above figures were based on self-report, as there is no mention of the biochemical validation of tobacco use. Consequently it was determined that some quantification of dependence and tobacco consumption would need to be an essential part of any further investigations into smoking prevalence.

CHAPTER 3 - METHODS

3.1 Identifying the UK recreational SCUBA diver population

The review of the literature highlighted many factors that might interfere with identifying and obtaining a representative sample of the UK recreational SCUBA diver population. Therefore to maximise the support of the recreational diving community, the researcher sought the help of staff at the Health and Safety Executive (HSE) via the Chief Inspector of Diving, Hazardous Installations Directorate, Offshore Division.

Initial discussions took place in April 2005 and continued throughout the year. During that time the researcher spoke to many representatives of the recreational diving community, particularly from the following: HSE Diving Group, HSE Approved Medical Examiners of Divers (AMEDs) network, Aberdeen University Department of Environmental and Occupational Medicine, British Diving Safety Group (BDSG), Professional Association of Diving Instructors (PADI), British Sub-Aqua Club (BSAC), Diving Diseases Research Centre (DDRC), Gosforth Institute of Naval Medicine.

Certain individuals from these groups are listed in the Acknowledgments.

3.2 Definitions used

As a result of preliminary discussions the following definitions were adopted for this study and used to inform the development of the measuring tool (questionnaire):

'Sub-aqua' or 'SCUBA' diving refers to the practice of breathing compressed gases whilst carrying out underwater activities. This includes breathing from a gas supply located underwater (as per SCUBA equipment) or supplied from the surface.

‘Tobacco smoking’ refers to any tobacco product that is lit and the smoke inhaled. It includes any type of cigarettes, cigars, cigarillos, pipe and home-made products (such as hand-rolled cigarettes and ‘joints’ where tobacco has been added before it is smoked). It does not include tobacco that is chewed or non-tobacco plant products that are smoked (e.g. herbal cigarettes or cannabis not containing tobacco).

‘Recreational divers’ were defined as those SCUBA divers not required to undertake an annual medical examination by a HSE-approved medical examiner of divers (AMED) in order to dive.

3.3 Devising the research strategy

3.3.1 Sampling strategy and research design

The literature review revealed that smoking prevalence was likely to be around 17% in UK recreational divers. It was calculated that a sample size of 600 would give a precision estimate of +/- 3.0% for an estimated prevalence of 17%. Therefore a sample size of at least 600 was sought.

Numerous options for sampling strategy and research design were discussed with the HSE, the Royal Navy and other dive agencies.

The HSE AMED networks were keen for the researcher to randomly select a specified number of AMEDs from the network register, and conduct a review of the smoking histories of a random sample of medical records within each practice. This design was rejected, however, as the opportunity to obtain biochemical verification of the results was considered too limited.

Various possibilities for investigating Royal Navy Divers who dive only for recreation rather than military purposes were also discussed together with the possibility of targeting divers who arrive at the Diving Diseases Research Centre in Plymouth for hyperbaric treatment; however, both of these approaches were felt not to reach a wide enough audience for the purposes of this research.

After further discussions, the researcher was invited to present to the members of the British Diving Safety Group (BDSG). The BDSG is hosted by the HSE and comprises the main UK organisations concerned with recreational diver health and safety. It principally consists of the Royal Navy, Maritime & Coastguard Agency and the major UK diver training agencies. The purpose of the presentation would be to secure the co-operation of as many of the UK diver training organisations as possible, in order to access their membership databases as potential sampling frames and thus obtain a representative sample of UK recreational divers.

The presentation to the BDSG was conducted in September 2005 and further meetings obtained with the UK-based PADI International Limited (October 2005), the DDRC (November 2005) and BSAC (November 2005) as a result. The smaller diver training organisations exempted themselves from further discussions at this stage on the grounds of staffing and resource limitations.

Each of the subsequent meetings involved further exploration of how a representative sample of UK recreational divers might be drawn from their records. It was felt that electronic access to members would be a key requirement of the study design as earlier research from the DDRC (St Leger Dowse et al, 2002) had resulted in more than 10,000 hard-copy questionnaires being distributed through the branch networks of the British and Scottish Sub-Aqua Clubs but only achieving a return of approximately 23% over four years. Time and staffing constraints meant that repeating this study design was not feasible; however, all parties agreed that administering a questionnaire to a random sample of divers from the memberships of the main diver training agencies was the most suitable approach.

Further discussions at BSAC headquarters were held to progress this aim but additional limitations were identified, for example, it became apparent that the central membership list relied on accurate member information being sent to them by the branch network, which was an erratic process. In addition, only 13% of central records (approximately 6,500 out of a total of 50,000) were thought to contain email addresses.

In comparison, PADI hosted a number of electronic membership databases, some of which were deemed commercially sensitive (for example, the central database listing all PADI-qualified divers) and therefore not available to the researcher. Instead a member-consent database which contained in excess of 10,000 email addresses would be utilised. This group of divers, not necessarily PADI-trained or UK based, had voluntarily signed up to receive a monthly *Dear Fellow Diver* email communication from PADI Headquarters. As the exact number of UK-based divers was not known, the following criteria were drawn up to identify those for inclusion in the study - being at least sixteen years of age and having lived in the UK for half their lifespan or currently having the UK as their main residence at the time they completed the survey.

After further discussion, the following research strategy was agreed:

- Diver anonymity would be ensured by PADI acting as the intermediary for administering all questionnaires.

- Phase 1: A random sample of 300 divers (the maximum permitted by PADI) would be drawn from the central PADI database and be sent hard-copies of the research questionnaire together with a saliva-sampling kit (Appendix 3). A reminder letter and a new sampling kit would be sent to all participants one month later.

- All anonymous completed questionnaires and saliva samples would be returned directly to UCL in pre-paid envelopes.

- Phase 2: The same research questionnaire would be sent as a weblink embedded in the *Dear Fellow Diver* email over a three month period subsequent to the close of Phase 1 (Appendix 4) with the first phase of the research deemed closed when no more replies were expected.

- The web responses would also be anonymous and only accessed by the researcher.

The approach agreed was consistent with established practice for using the internet to survey a particular sub-group who were familiar with its use (Couper, Traugott and Lamias, 2001) and that a mixed-mode strategy combining both mail and internet surveys, would most likely increase the response rate (Dillman, Clark and Sinclair, 1995) if pre-notification and reminders were issued throughout (Kaplowitz, Hadlock and Levine, 2004).

3.3.2 Piloting

An initial questionnaire (the survey tool – Appendix 5) was drafted with input from staff from the HSE Diving Group from June to August 2005. Piloting of the draft questionnaire was carried out with 27 volunteer recreational divers identified from diving networks over the following months. Divers had obtained a broad range of qualifications from different diver training agencies, including international qualifications. Provision was made within the final questionnaire to classify those with international qualifications into their UK equivalents (known as the CMAS classification system where CMAS Level 2 refers to non-professional divers and CMAS Level 3 refers to divers who have reached at least the first rung of professional diver training). Those responders that were identified as PADI members were informed about the forthcoming survey and asked not to participate in the research proper.

3.3.3 Validity

The literature review identified a need for research into tobacco prevalence amongst divers to be verified with biochemical validation and for dependence to be assessed beyond pack-years. Salivary cotinine was chosen for biochemical testing alongside the widely researched Fagerstrom Test for Nicotine Dependence (Heatherton et al, 1991) as the most accurate and resource-effective tools available for this study.

Previously validated questions from the Census and General Household Surveys were utilised to collect general health and demographic data. The Self-Coded version of the National Statistics Socio-economic Classification (NS-SEC) was also included.

Questions relating to general risk were obtained on the advice of the HSE from research they had commissioned with Cardiff University, *The scale and impact of illegal drug use by workers* (HSE, 2004). This survey examined risk-taking attitudes amongst a representative sample of the UK adult working population alongside illegal drug use.

Questions relating to diving risk were drafted with input from the pilot questionnaires and finalised with staff at PADI Headquarters and the HSE.

3.3.4 Reliability

Internal consistency in reporting was obtained by assessing agreement between questions probing similar content and also by utilising salivary cotinine results, where available.

External consistency (such as test-retest reliability) was not considered appropriate for this survey due to practical limitations, such as anonymity, and as diving responses were expected to change due to the respondents being active divers.

3.3.5 Timescales

Permission for the research to proceed was obtained by PADI International Limited from its US parent company in early 2006.

Phase 1 of the research commenced in April 2006 with the follow-up letter being sent in May, informing respondents of the forthcoming web-based questionnaire and specifically asking them to return the hard-copy with the saliva sample instead of participating in the electronic survey. To protect anonymity, the complete user-packs were couriered from UCL to PADI Headquarters where the computer-generated random sample was selected and address labels attached before posting. All undelivered packs were to be returned to PADI Headquarters.

Phase 1 of the research was declared complete in June 2006, with 30% (99 out of 300) hard-copy questionnaires returned. Cotinine samples were obtained for 85% of questionnaires returned (n=84). The samples were refrigerated on arrival and couriered for laboratory analysis as soon as possible.

Phase 2 ran from July to October 2006. 689 web-based questionnaires were received in this time period, of which 78 were excluded from the final analysis on the basis that they were not currently UK-based, or had not spent sufficiently long (a minimum of half of their lifespan) living in the UK. Another two responders were excluded for being under sixteen years old.

3.4 Analysing the results

Combining the valid survey returns from Phases 1 and 2 resulted in 698 questionnaires being analysed using SPSS version 19 for Windows.

The raw data were inspected for salience and any nebulous responses were reclassified as missing data and recorded as 777. Genuinely missing data were recorded as 999 and intentionally missing data were recorded as 888 so that distinctions could be made if required. Listwise deletion was adopted as the primary treatment for all missing data in the analyses.

Free text responses were divided into exploratory groupings and then assigned to an appropriate category according to theoretical considerations or relevant questions in the survey tool, for example, the ‘any other illness’ category provided additional information to help classify certain responses.

Quantitative responses were converted to a common denominator, for example, all tobacco usage data was converted to units per day.

Numerical and graphical displays of descriptive data were provided for all item responses in the early stages of analysis. Subsequently responses were regrouped and recoded in accordance with the requirements of the latter stages of analysis.

The overall approach to analysis was as follows:

- univariate analysis – exploratory analysis using graphical and numerical displays;
- bivariate analysis – regrouping and recoding variables according to the hypotheses investigated;
- multivariate analysis – further investigation of hypotheses by exploring the influence of and controlling for major variables.

Due to the large number of tests to be conducted, statistical advice was sought early on with regards to any adjustments required for multiple testing, for example the Bonferroni method of shared significance levels. It was agreed that this might be an issue for certain analyses, but because the research area was primarily exploratory then all findings should be regarded as provisional and reported as such, except where biochemical validation or some other independent means of verification was available. In addition, the presentation of test results would require some consideration due to the scale of the factors investigated. Therefore for practical reasons the results of statistical tests have been included as an integral part of the narrative and have only been presented as numbered Tables where further analyses or comparisons of results have occurred.

The primary level of statistical significance adopted throughout the research was $p =< 0.050$, unless stated otherwise.

Where bivariate correlations were performed then both linear (Pearson) and non-linear (Spearman) relationships were investigated. Any appreciable differences between test results for linear and non-linear relationships were graphically re-examined for outliers. Where there was ambiguity over test results with borderline significance levels, then the more conservative value (Spearman) was usually adopted, but each case was considered separately.

The particular statistical approach taken and specific considerations applied to each research aim is detailed in subsequent chapters.

CHAPTER 4 - WHETHER UK RECREATIONAL SCUBA DIVERS ARE MORE LIKELY TO BE TOBACCO SMOKERS OR HAVE HIGHER NICOTINE DEPENDENCE THAN THE UK GENERAL POPULATION

4.1 Introduction

The review of the literature and separate discussions with members of the British Diving Safety Group confirmed that there was no common understanding of the principal demographic characteristics of the UK recreational diving population. Although individual diver training agencies kept basic demographic information about the characteristics of their particular membership base, they were reluctant to share this information with the researcher in case it became accessible to rival agencies.

Instead the overarching picture of the UK recreational diving population has been informed by surveys conducted through existing diver networks, such as members of the British and Scottish Sub-Aqua Clubs (St Leger Dowse et al, 2002; St Leger Dowse et al, 2011; Glen, White and Douglas, 2000). The latter examined the existing medical records of the Scottish Sub-Aqua Club (n = 2962) and found that within the available age range (15-66 years) men were over-represented at all ages (approximately by 3:1) with women only constituting nearly half of all divers from 21-30 years.

The earliest questionnaire survey of UK recreational divers (St Leger Dowse et al, 2002) obtained 2250 responses (53% male, 47% female) with an age range of 14–81 years. Women were slightly over-represented in the younger age groups (up to 40 years) and men were over-represented beyond 40 years, although a gender bias could have occurred in returning questionnaires as the study's principal aim was to examine gender differences in decompression sickness with the menstrual cycle.

A more recent questionnaire survey (St Leger Dowse et al, 2011) investigating illegal drug use amongst UK recreational divers obtained 479 responses (66% male, 34% female) within the age range 16-59 years. No further breakdown of gender ratio by age group is available.

All of the UK population-based surveys mentioned above recorded self-reported current smoking behaviour, although none used biochemical verification for their findings.

4.2 Methods

Given the limited information available regarding the population characteristics of UK recreational divers it was decided to collect detailed demographic information for comparison with national studies.

The two national studies chosen for comparison were:

1) The General Household Survey (GHS) 2006 (Goddard, 2008) – observational comparisons available for age, gender, socio-economic group, highest educational qualification, marital status, living arrangements and ethnicity;

2) The Smoking Toolkit Study (West, 2006) – statistical comparisons available for age, gender and social class.

Other national surveys, for example from the Labour Force Survey and British Crime Survey, were also accessed where relevant.

Comparisons in smoking prevalence and nicotine dependence (measured by salivary cotinine and FTND score) were examined observationally in relation to the 2006 General Household Survey and statistically in relation to the Smoking Toolkit Study.

4.3 Results

4.3.1 Demographic comparisons between the diving sample and the UK general population

Demographic data was acquired for 584 subjects. Table 4.1 summarises the main demographic characteristics of divers in this study. Age is positively skewed but within the boundaries of normal distribution (skewness z-score = 1.15). The gender ratio was 70:30 and males were significantly older than females ($t = 7.03$; $DF = 582$; $p<0.001$).

Table 4.1: Summary of age distribution by gender for diving sample

DIVING SAMPLE	% [n]	Average age	Dispersion measures
Male	70 [407]	Mean = 41.58 Median = 42.00 Mode = 40	SD = 9.78 Range = 50 (16 – 66)
Female	30 [177]	Mean = 35.42 Median = 34.00 Mode = 26	SD = 9.65 Range = 45 (17 – 62)
Total sample	100 [584]	Mean = 39.72 Median = 39.50 Mode = 35	SD = 10.12 Range = 50 (16 – 66)

4.3.1.1 Comparisons with data from the General Household Survey

Demographic comparisons were made where the diving data could be configured to match that of the GHS (using information supplied by the GHS Reports). Weighted GHS data (adjusted to reflect known UK population parameters) quoted for adults aged sixteen and over has been included in the tables below. Rounding of figures has been conducted to match that of the GHS, for example values greater than, or equal to, 0.5 have been rounded upwards unless stated otherwise (which occasionally results in total percentages = 101%).

Age and gender

Compared to GHS data, 16-24 year olds and those aged 55 or over were under-represented in the diving sample. All other ages (25-54 year olds) were over-represented (Table 4.2).

Table 4.2: Population distribution by age and gender

	GHS 2006 dataset			Diving sample		
Age range in years	% male	% female	% total	% male [n]	% female [n]	% total [n]
16-24	15	14	15	3 [14]	10 [17]	5 [31]
25-34	16	16	16	21 [84]	42 [75]	27 [159]
35-44	20	19	19	35 [144]	30 [53]	34 [197]
45-54	16	16	16	32 [131]	14 [25]	27 [156]
55-64	15	14	15	8 [33]	4 [7]	7 [40]
65+	17	21	19	0 [1]	0 [0]	0 [1]
TOTAL	**99**	**100**	**100**	**99** [407]	**100** [177]	**101** [584]

Males were over-represented in the diving sample at all ages except 16-24 years (Table 4.3). Females were only over-represented at 16-24 years of age with representation generally decreasing with age.

Table 4.3: Percentage of males to females by age

	GHS 2006 dataset		Diving sample	
Age range (yrs)	% male	% female	% male [n]	% female [n]
16-24	51	49	45 [14]	55 [17]
25-34	49	51	53 [84]	47 [75]
35-44	50	50	73 [144]	27 [53]
45-54	48	52	84	16

			[131]	[25]
55-64	51	49	83 [33]	18 [7]
65+	44	56	100 [1]	0 [0]
TOTAL	**49**	**51**	**70** [407]	**30** [177]

Socio-economic group and education

Social class was obtained by incorporating the Self-Coded version of the National Statistics Socio-economic Classification (NS-SEC) into the questionnaire. Full time students were excluded from this analysis. Divers were more likely to be classified as Professional & Managerial workers than the UK population (Table 4.4) with Intermediate and Routine & Manual workers being under-represented in the diving sample.

Table 4.4: Three-class socio-economic classification by gender

	GHS 2006 dataset			**Diving sample**		
Three-class NS-SEC	% male	% female	% total	% male [n]	% female [n]	% total [n]
Managerial & professional	41	33	37	75 [302]	88 [152]	79 [454]
Intermediate	18	25	22	13 [53]	9 [16]	12 [69]
Routine & manual	41	42	41	12 [46]	2 [4]	9 [50]
TOTAL	**100**	**100**	**100**	**100** [401]	**99** [172]	**100** [573]

Labour Force Survey (LFS) 2006, Quarter 4 figures (DFES, 2007) were used to compare national data for educational qualifications (Table 4.5).

There have been many revisions to the classification of qualifications for the LFS. The classification used here was for ‘Level 4 and above’ to include foundation or first degrees, recognised degree-level professional qualifications, higher degrees, postgraduate qualifications, NVQ Level 4 or above, nursing or teaching qualifications, HE Diplomas, HNC/HND or equivalent vocational qualifications.

LFS figures are for adults of working age only (males aged 16-64 and females aged 16-59). The diving sample contained one male aged 66 years (qualified to Level 4) and two females aged 60 (Level 4) and 62 years (Level 3) which were excluded from the comparison.

Table 4.5: Highest educational qualification by gender

HIGHEST EDUCATION	**Labour Force Survey % estimate – England 2006**			**Diving sample**		
Highest qualification	% male	% female	% total	% male [n]	% female [n]	% total [n]
Level 4 (first degree) and above	28	28	28	64 [259]	73 [128]	67 [387]
Level 3 (below first degree) and below	72	72	72	36 [147]	27 [47]	33 [194]
TOTAL	**100**	**100**	**100**	**100** [406]	**100** [175]	**100** [581]

The diving sample was much more likely to be qualified to degree-level and above compared to the UK population.

Marital status and living arrangements

Although the overall picture of marital status was similar in the diving sample to the UK population (Table 4.6) there were some important differences. Female divers were less likely to be married and more likely to be either single or cohabiting than their UK counterparts. In contrast, male divers were less likely to be single and more likely to be married. All divers were less likely to be widowed.

Table 4.6: Marital status by gender

	GHS 2006 dataset			Diving sample		
Marital status	% male	% female	% total	% male [n]	% female [n]	% total [n]
Single	27	21	24	21 [86]	35 [61]	25 [147]
Married	52	50	51	58 [235]	37 [66]	52 [301]
Separated	2	2	2	2 [8]	2 [3]	2 [11]
Divorced	5	8	6	8 [33]	5 [9]	7 [42]
Widowed	3	10	7	1 [4]	0 [0]	1 [4]
Cohabiting	10	10	10	10 [41]	22 [38]	14 [79]
TOTAL	99	101	100	100 [407]	101 [171]	101 [584]

There were some clear differences between the diving sample and the UK population with regards to living arrangements (Table 4.7). Divers were much more likely to live alone up to the age of 44 years and much less likely to live alone from 65 years onwards.

Table 4.7: Percentage of men and women living alone by age and gender

	GHS 2006 dataset		Diving sample	
Age range in years	% male living alone	% female living alone	% male [n]	% female [n]
16-24	4	2	21 [3]	12 [2]
25-44	14	8	27 [61]	25 [31]
45-64	16	14	10 [17]	19 [6]
65-74	21	31	0 [0]	0 [0]
75+	32	61	0 [0]	0 [0]
TOTAL	15	17	20	23

			[81]	[39]

Ethnicity

Ethnic minority groups were slightly less likely than expected to be included in the diving sample, although differences were small (Table 4.8).

Table 4.8: Ethnic group of respondents

Ethnic group	**GHS 2006 dataset %**	**Diving sample %** [n]
White	91	96 [550]
Mixed race	1	1 [8]
Asian or Asian British	6	1 [5]
Black or Black British	2	1 [7]
Other ethnic group	1	1 [6]
TOTAL	**101**	**100** [576]

4.3.1.2 Comparisons with data from the Smoking Toolkit Study

Observational comparisons between the main population characteristics of national survey samples and samples from the diving community suggest there are important demographic differences between them (Table 4.9).

Table 4.9: Summary of demographic characteristics of national survey and diving study samples

Study	**% male**	**% female**	**% routine & manual**	**Mean age (years)**	**Median age (years)**
GHS 2006	49	51	41	Not recorded	45
Smoking toolkit	46	55	54	47.79	46

2006					
PADI UK statistics 2006[12]	66	34	Not recorded	Not recorded	29
PhD diving research 2006	70	30	10	39.72	40
Scottish Sub-Aqua Club audit	76	24	Not recorded	Not recorded	31-35 (banded)
St Leger Dowse et al, 2002	53	47	Not recorded	Not recorded	31-40 (banded)
St Leger Dowse et al, 2011	66	34	Not recorded	Not recorded	42

Socio-economic data has not been recorded in previous UK diver surveys but statistical comparisons between demographic data from the Smoking Toolkit Study and the PhD diving sample revealed that significant differences existed for age, gender and social class (Table 4.10).

Table 4.10: Significant demographic differences between the diving dataset and the smoking toolkit dataset (2006)

	Diving dataset (N = 584)	**Smoking Toolkit dataset 2006 (N = 25307)**	**Statistical test**	**DF**	**Significance two-tailed *p***
Age	Mean = 39.72 SD = 10.14	Mean = 47.79 SD = 18.63	t = -10.44	25889	P<0.001
Gender	69.7% male 30.3% female	45.5% male 54.5% female	Chi-square = 135.03	1	P<0.001
Social class	9.5% routine & manual 90.5% other groups	53.9% routine & manual 46.1% other groups	Chi-square = 23648.13	1	P<0.001

4.3.1.3 Comparisons of demographic data by collection method in the diving study

[12] Figures obtained from PADI website (accessed 15/5/10) represent all diver certifications. Source: http://www.padi.com/scuba/about-padi/PADI-statistics/default.aspx#Graph1

It is recognised that different data collection techniques can target and recruit subjects from different sub-groups. The main demographic characteristics of the diving sample were compared by sampling method to assess any differences (Table 4.11).

Table 4.11: Comparison of demographics by sampling method

Study	**% male**	**% female**	**% routine & manual**	**Mean age [SD]**	**Median age (years)**
Random sample (n = 89)	69	31	9	38.01 [10.11]	36.50
Internet survey (n = 609)	70	30	10	39.98 [10.13]	40.00

The randomly selected group from the PADI database were slightly younger than the internet responders, otherwise both groups were virtually identical.

4.3.2 Smoking behaviour in the diving sample and the UK general population

4.3.2.1 Reliability of smoking data

Information on smoking behaviour was collected from 698 subjects. This number was consistent with the estimated sample size required to predict prevalence levels within three percentage points of the true population value (estimated prevalence level = 17%; estimated sample size = 600; precision estimate = +/- 3.07%).

Biochemical verification of self-reported smoking status has not been conducted in previous surveys of UK recreational divers. In this study the reliability of smokers' responses was assessed against salivary cotinine levels (collected from a random sample of 300 divers from the central PADI membership database) using a cut-point of 12ng/ml (Jarvis et al, 2008) to validate current smoking status. Although only 84 saliva samples were usable out of 99 returned (for reasons of insufficient volume or contamination) high levels of agreement were found for cigarette and cigar or pipe smoking. As expected, lower levels of agreement were found for smoking cannabis with tobacco with under-reporting more likely to occur.

Table 4.12: Reliability of self-reported smoking status

Smoking status	N	% agreement	*p*
Current cigarette	84	93	<0.001
Current cigar or pipe	84	87	0.001
Current cannabis	84	79	0.252

4.3.2.2 Comparisons with data from the General Household Survey

Table 4.13 illustrates the different levels of tobacco use between divers and the UK general population. All national figures were obtained from the 2006 General Household Survey unless stated otherwise.

Table 4.13: Comparison of smoking prevalence between recreational divers and the UK general population:

Type of tobacco use	**% smoking - National data 2006/7**	**% smoking - Diving data 2006**
Current cigarette smoking	22	19
Current cigar/pipe smoking	4	7
Current cannabis smoking	8[13]	8

Cigarette smoking was observed to be lower amongst divers whilst cigar or pipe use was higher and cannabis smoking was at a similar level.

Demographic data was available for a further breakdown of cigarette smoking by gender (Table 4.14). Divers were less likely to smoke at all ages, bar those aged 60 and over, although the small number of cases

[13] Source: UK Home Office, *British Crime Survey 2006/7*, London 2007.

involved in each age band means these figures must be treated with caution.

Table 4.14: Diver versus national cigarette smoking levels by age and gender

	GHS 2006 dataset			Diving sample 2006		
Age group	% males smoking	% females smoking	% total smoking	% males smoking [n]	% females smoking [n]	% total smoking [n]
16-19	20	20	20	20 [1]	0 [0]	14 [1]
20-24	33	29	31	0 [0]	0 [0]	0 [0]
25-34	33	26	30	25 [21]	12 [9]	19 [30]
35-49	26	25	25	17 [37]	22 [14]	18 [51]
50-59	23	22	22	19 [15]	6 [1]	16 [16]
60+	13	12	12	14 [2]	50 [1]	19 [3]
Overall prevalence	**23**	**21**	**22**	**19** [76]	**14** [25]	**17** [101]

Comparator data was also available for social class (Table 4.15) using the National Statistics Three-Class self-report Socio-economic Classification.

Table 4.15: Diver versus national cigarette smoking levels by 3 class NS-SEC and gender

	GHS 2006 dataset			Diving sample 2006		
NS-SEC	% male	% female	% total	% male [n]	% female [n]	% total [n]
Professional & Managerial	17	14	15	19 [58]	14 [21]	17 [79]
Intermediate	22	20	21	21 [11]	19 [3]	20 [14]

Routine & Manual	32	28	29	13 [6]	0 [0]	12 [6]
TOTAL	**23**	**21**	**22**	**19** [75]	**14** [24]	**17** [99]

Smoking levels between divers and the UK general population were similar for Professional and Managerial and Intermediate workers and this was also apparent for gender in these groups. In contrast, the level of smoking amongst divers with Routine and Manual occupations was much lower than that of their national counterparts; however, there were low numbers of divers from this occupational group in the study and therefore caution is required in interpreting these findings.

Data for marital status was available (Table 4.16) with divers again having lower smoking levels at all age groups, although the GHS pattern of married people smoking less than their non-married counterparts (with the exception of 16-24 year olds) appears to be similar in divers; however, the low number of cases requires caution with interpretation.

Table 4.16: Diver versus national cigarette smoking levels by age and marital status

	GHS 2006 dataset: % smokers			**Diving sample 2006: % smokers**		
Age group	never married	married or cohabiting	previously married	never married [n]	married or cohabiting [n]	previously married [n]
16-24	23	35	42	3 [1]	0 [0]	0 [0]
25-34	34	26	48	20 [22]	15 [13]	50 [2]
35-49	32	22	39	19 [15]	17 [33]	18 [7]
50-59	29	20	32	0 [0]	17 [14]	17 [2]
60+	12	11	15	0 [0]	15 [2]	33 [1]
Overall	**27**	**20**	**25**	**17**	**16**	**21**

prevalence				[38]	[62]	[12]

4.3.2.3 Comparisons with data from the Smoking Toolkit Study

Where the GHS comparisons were observational, the Smoking Toolkit dataset allowed statistical comparisons to be made.

4.3.2.3.1 Bivariate analysis of current tobacco use

Current cigarette smoking

A lower percentage of the diving sample (18.8%) smoked cigarettes than the Smoking Toolkit sample (25.5%) and this difference was significant (*p*<0.001).

Current cigarette smoking:

Independent variables	N	% non smokers [n]	% smokers [n]	Fisher's Exact (p)
Diver dataset	698	81.2 [567]	18.8 [131]	<0.001
Toolkit dataset	25601	74.5 [19063]	25.5 [6538]	

Current cigar or pipe smoking

A higher percentage of the diving sample (7.0%) smoked cigars or pipes than the Smoking Toolkit sample (0.7%) and this difference was significant (*p*<0.001).

Current cigar or pipe smoking:

Independent variables	N	% non smokers [n]	% smokers [n]	Fisher's Exact (p)
Diver dataset	673	93.0 [626]	7.0 [47]	<0.001
Toolkit dataset	25608	99.3 [25440]	0.7 [168]	

Current cannabis smoking

No specific data on cannabis was available from the Smoking Toolkit therefore a comparison was made using non-cigarette tobacco as an alternative. Use of non-cigarette tobacco was significantly higher (p<0.001) in the diving sample (13.3%) compared to the Smoking Toolkit (0.7%).

Current non-cigarette tobacco smoking:

Independent variables	N	% non smokers [n]	% smokers [n]	Fisher's Exact (p)
Diver dataset	698	86.7 [605]	13.3 [93]	<0.001
Toolkit dataset	25608	99.3 [25440]	0.7 [168]	

4.3.2.3.2 Bivariate analysis of nicotine dependence

Nicotine dependence was examined via cigarette consumption, FTND score and salivary cotinine levels.

Daily cigarette consumption

Divers smoked fewer cigarettes per day than non-divers and this difference was significant (p<0.001).

Daily cigarette consumption:

Independent variables	N	Mean cigarettes per day	SD	*t*	DF	*p*
Diver dataset	120	11.58	8.31	-3.57	10431	<0.001
Toolkit dataset	10313	15.10	10.76			

Cigarette dependence

Divers demonstrated a lower dependence on cigarettes than non-divers and this difference was significant (p = 0.007).

Cigarette dependence (FTND score):

Independent variables	N	Mean score	SD	*t*	DF	*p*
Diver dataset Toolkit dataset	120 9781	2.25 2.87	2.30 2.49	-2.72	9899	0.007

Nicotine dependence

Cases were selected as current smokers if the salivary cotinine level was greater or equal to 12ng/ml (Jarvis et al, 2008). Divers who smoked demonstrated a lower dependence on nicotine than non-divers who smoked but this difference was not significant (p=0.247).

Nicotine dependence (salivary cotinine):

Independent variables	N	Mean level ng/ml	SD	*t*	DF	*p*
Diver dataset Toolkit dataset	12 517	202.66 306.62	169.76 309.79	-1.16	527	0.247

4.3.2.3.3 Multivariate analysis of current tobacco use

Logistic regression, employing Wald's backwards elimination technique, was used to investigate whether membership of either the Diving or the Smoking Toolkit datasets could further explain variance in tobacco smoking after controlling for age, gender and social class (the three demographic variables common to both datasets). The final models are presented below.

Final model for current cigarette smoking:

Predictor variables	B	S.E.	Wald	DF	*p*
Dataset	1.78	0.12	223.29	1	<0.001
Age	-0.25	0.00	872.95	1	<0.001
Routine & manual	0.81	0.03	691.41	1	<0.001
Gender	-0.12	0.03	17.44	1	<0.001

The variance explained by the final model was low (Nagelkerke R Square = 0.09) but dataset membership was significantly associated with current cigarette smoking after controlling for age, gender and social class.

<u>Final model for current cigar or pipe smoking:</u>

Predictor variables	B	S.E.	Wald	Df	*p*
Dataset	-2.92	0.29	101.42	1	<0.001
Age	0.21	0.00	26.91	1	<0.001
Routine & manual	-0.49	0.15	10.81	1	0.001
Gender	-2.64	0.28	89.99	1	<0.001

The variance explained by the final model was low (Nagelkerke R Square = 0.15) but dataset membership was significantly associated with current cigar or pipe smoking after controlling for age, gender and social class.

<u>Final model for current non-cigarette smoking:</u>

Predictor variables	B	S.E.	Wald	Df	*p*
Dataset	-3.73	0.26	200.40	1	<0.001
Age	0.02	0.00	17.63	1	<0.001
Routine & manual	-0.53	0.15	13.61	1	<0.001
Gender	-2.30	0.23	99.35	1	<0.001

The variance explained by the final model was low (Nagelkerke R Square = 0.19) but dataset membership was significantly associated with non-cigarette smoking after controlling for age, gender and social class.

4.3.2.3.4 Multivariate analysis of nicotine dependence

Stepwise regression using backwards elimination techniques was used to investigate the effect of dataset membership on cigarette consumption, cigarette dependence (FTND score) and nicotine dependence (salivary cotinine levels) after controlling for age, gender and social class. The final models are presented below.

<u>Final regression model for cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.07	0.07					
Dataset			5.03	1.09	0.05	4.62	<0.001
Age			0.12	0.01	0.20	20.86	<0.001
Routine & manual			1.65	0.21	0.08	7.80	<0.001
Gender			-2.90	0.21	-0.14	-14.09	<0.001

Dataset membership (B = 5.03), age (B = 0.12) and social class (B = 1.65) were positively significantly associated with higher cigarette consumption in this model. Gender (*B* = -2.90) was negatively significantly associated with a higher cigarette consumption.

<u>Final regression model for cigarette dependence (FTND score):</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.03	0.03					
Dataset			1.66	0.26	0.07	6.47	<0.001
Age			<0.01	0.01	0.01	1.41	0.158
Routine & manual			0.83	0.05	0.17	16.20	<0.001
Gender			-0.33	0.05	-0.07	-6.52	<0.001

Dataset membership (B = 1.66) and social class (B = 0.83) were positively significantly associated with higher cigarette dependence in this model. Gender (*B* = -0.33) was negatively significantly associated with a higher cigarette dependence.

For nicotine dependence, cases were selected as current smokers if the salivary cotinine level was greater or equal to 12ng/ml (Jarvis et al, 2008).

<u>Final regression model for nicotine dependence (salivary cotinine>= 12ng/ml):</u>

Predictor variables	R Square	Adjstd. R	*B*	Stand. error *B*	Standrsd. Beta	*t*	*p*

		Square			coefficient		
Final model:	0.01	0.01					
Dataset			89.90	95.15	0.04	0.95	0.345
Age			1.96	0.87	0.10	2.26	0.024
Routine & manual			-10.49	28.93	-0.02	-0.36	0.717
Gender			-12.36	27.40	-0.02	-0.45	0.652

Age (B = 1.96) was positively significantly associated with higher nicotine dependence in this model.

4.4 Discussion

4.4.1 Comparisons with UK demographic data

Compared with national population statistics the diving population is likely to be significantly younger, over-represented by males and those not in Routine and Manual occupations. Although the findings are statistically supported, some residual uncertainty about this demographic profile will persist for the following reasons.

Firstly, the use of both hard copy and internet-based questionnaires to investigate human behaviour will always be beset by questionable representativeness and low response rates (Cook, Heath and Thompson, 2000) which renders findings difficult to verify. As the actual number of divers in the *Dear Fellow Diver* database who were potentially eligible for inclusion in the research is unknown, the best estimates of the internet response rate for this study range from 0.7% – 7.0%, accompanied by a hard copy response rate of 30%. In comparison, the response rate achieved for the internet component of the research conducted by St Leger Dowse et al (2011) was 2.4% with a 26% return rate from hard copy questionnaires.

Moreover, without the full co-operation of the main diver training agencies, then the representativeness of the sample cannot be externally verified.

The discussions held with the British Diving Safety Group in 2005 indicated that sharing of sensitive data between rival agencies is unlikely; however, the demographic similarities between the internet responders in this study and the random sample selected from the central PADI database indicate that the total diving sample is likely to be representative of the total PADI membership. This assertion is supported by the age of the randomly selected group being closer to the median age quoted by PADI for its membership in 2006.

The gender ratio of the PhD diving sample is also similar to that obtained from the Scottish Sub-Aqua Club (SSAC) total audit of its medical records (Glen, White and Douglas, 2000). This study possessed a near total sample design as every new SSAC member was required to undergo a medical examination on entry to the Club. Notably the median age of SSAC members (displayed as a band) appears to be lower than the PhD diving sample and the UK samples obtained by St Leger Dowse et al (2002; 2011) suggesting that age might be a factor in motivating divers to participate in surveys of this kind.

No other diving surveys (UK or worldwide) explored social class as an influencing variable although it appears to be a central characteristic of the UK diving population.

There is a possibility that the detailed information often sought by diver questionnaires (especially with regards to frequency and patterns of diving) introduces a selection bias towards those with a higher education level and socio-economic group. Response rates to health surveys are known to increase with social class and education level (Sonne-Holm et al, 1989; Korkelia et al, 2001) and the questionnaire survey method, in particular, often requires divers to impart detailed accounts of their diving behaviour without the support of an interviewer or peer group. This approach could favour respondents with a degree-level education or those who are used to working independently, which might explain the low representation of Routine and Manual workers in the study, although there is no data to support or refute this supposition. In addition all divers are required to demonstrate an understanding of complex theories, such as the gas laws, to acquire basic certification, which suggests they would already be familiar with answering detailed questions of this kind.

Education level, however, is likely to explain the observed differences in marital status and living arrangements of divers compared to the UK population at all ages, with greater participation in higher education thought responsible for delaying marriage and childbirth (ONS, 2011), although increasing ill-health is also likely to account for the under-representation of divers in older age groups, especially over 55.

4.4.2 Comparisons with UK smoking behaviour

The identification and analysis of demographic differences between divers and the UK general population provides important background context for subsequent discussions regarding divers smoking behaviour.

Cigarette smoking prevalence

The literature review indicated cigarette smoking prevalence levels ranged from 9% to 20% for UK divers and from 13% to 44% worldwide. The figure of 19% obtained by this study is within the high end of the UK range and, on initial observations, could have been regarded as lower than UK population levels (22%) due to a disproportionately small number of divers from Routine and Manual occupations in the study. Indeed the prevalence rate for divers more closely reflects that of UK Professional and Managerial workers (15%) than Routine and Manual workers (29%) in 2006; however, statistical comparisons with the Smoking Toolkit Study revealed cigarette smoking to be significantly lower amongst divers even after controlling for the significant predictors age, gender and social class.

Cigarette consumption

Daily cigarette consumption was significantly lower (mean = 11.58) amongst divers than in the general population (mean = 15.10) after controlling for the significant predictors age, gender and social class.

Cigarette dependence

Cigarette dependence in divers (mean FTND score = 2.25) was also significantly lower than in the general population (mean FTND score = 2.87) after controlling for the significant predictors gender and social class.

Nicotine dependence

Nicotine dependence, as measured by salivary cotinine levels[14], was lower in divers who smoked (mean = 202.65 ng/ml; n = 12) compared to non-divers who smoked (mean = 306.62 ng/ml; n = 517) but this difference was not significant after controlling for age, gender and social class.

Overall, significantly lower levels of cigarette smoking and lower dependence on cigarettes was exhibited by divers compared to the general population in this study.

Cigar or pipe smoking prevalence

No data on cigar or pipe smoking by divers is apparent in the literature. Observational comparison with GHS data indicated that cigar or pipe smoking by divers (7%) was likely to be higher than in the UK general population (4%). This finding was confirmed by statistical comparison with the Smoking Toolkit data, specifically that cigar or pipe smoking is significantly higher in divers even after controlling for the significant predictors age, gender and social class.

[14] Using a cut-off point of 12.0 ng/ml for salivary cotinine.

Insufficient data was available for an analysis of daily consumption of cigar or pipe smoking.

Cannabis smoking prevalence

A recent survey of illegal drug use by UK recreational divers (St Leger Dowse et al, 2011) reported 3.5% of divers having used some form of illegal drug within the last twelve months compared to 9.3% of the UK population, and that cannabis was the most popular choice. Divers in this study appeared equally likely to smoke cannabis (8%) as their national counterparts (8%); however, using the Smoking Toolkit data, non-cigarette smoking was found to be significantly higher in divers than in the general UK population after controlling for the significant predictors age, gender and social class.

It is possible that some divers have switched from cigarette smoking to another form of smoked tobacco to try to reduce their likelihood of harm (Wald and Watt, 1997; Ockene et al, 1987) or are buying cheaper hand-rolled tobacco (The Information Centre, 2009); however, it is not possible to determine the extent to which that might have happened with divers in this study, although the numbers involved are likely to be small.

Insufficient data was available for an analysis of daily consumption of cannabis smoking.

Additional factors likely to affect tobacco consumption in divers

There are a number of other factors, identified by the literature review, which might influence tobacco consumption in divers. These include professional diver training, attitudes to risk and general health and are discussed in subsequent chapters.

CHAPTER 5 - TOBACCO USE AND SMOKING BEHAVIOUR AMONGST UK RECREATIONAL SCUBA DIVERS

5.1 Introduction

This chapter focuses on the prevalence of the different types of tobacco products used by divers and their consumption. It also examines their associations with demographics, professional training and other factors.

5.2 Methods

Univariate, bivariate and multivariate analyses were carried out for each of the three different types of tobacco products used and their consumption. Demographic factors were the primary focus, however, the literature review had identified a number of additional factors that might influence smoking levels amongst extreme sports activists, in particular, the level of participant training or experience within the sport and the predisposition to risk taking. In order to determine the influence of risk taking on smoking over and above those of demographic and professional training factors, two sum variables were created.

5.2.1 Everyday risk taking sum variable

A sum variable was devised to reflect the tendency towards everyday risk taking by totalling the binary variables presented in Table 5.1. These variables were derived from the section on Attitudes to Risk (Appendix 5, Qs 172-180) in the diving questionnaire. It was felt that a sum variable would better reflect the overall predisposition to risk-taking than examining individual variables.

Table 5.1: Variables employed to create 'everyday risk taking' variable

Binary variable	Score = 0	Score = 1
Risks at work	Never or rarely	At least occasionally
Risks outside work	Never or rarely	At least occasionally

Smoke alarm	Yes	No
Seat belt	Yes	No
Travel insurance	Yes	No
Comprehensive car insurance	Yes	No
Fruit machines	Less than once a month	At least once a month
Pools	Less than once a month	At least once a month
National Lottery	Less than once a month	At least once a month
TOTAL EVERYDAY RISK TAKING SCORE =		Sum score

5.2.2 Diving risk taking sum variable

A sum variable was devised to reflect the tendency towards risk taking whilst diving by totalling the binary variables presented in Table 5.2. These variables were derived from the section on Attitudes to Risk (Appendix 5, Qs 141-146 and 181-190) in the diving questionnaire.

Variables were only selected for inclusion where there was a clear indication either theoretically, or from the results, that they constituted more risky behaviour. For example, diving with a pre-existing short-term illness, such as a common cold, was considered much more risky diving behaviour because of the increased likelihood of ear or sinus problems than diving with a long-term condition, such as diabetes or asthma, where divers are much more likely to have consulted a diving physician about their fitness to dive.

Use of a reserve gas supply was not included in the sum variable because it was found to be highly correlated with mixed gas diving in this study (N = 577; r = 0.38; p<0.001) which is regarded as a strategy to reduce the risk of diving-related illness, especially decompression illness, if carried out as per training. Similarly, the variable 'plan decompression stops' was also excluded because it was significantly negatively correlated with mixed gas diving in this study (N = 578; r = -0.09; p = 0.024) even though planned decompression stops are a key safety feature of certain types of mixed gas diving. Instead, as there was no method of determining the type of gas mixture being used, for example the use of Nitrox (oxygen-enriched air) does not have the same decompression requirements as other types of mixed gas diving, it was decided to omit 'plan decompression stops' as a component of the sum variable.

Table 5.2: Variables employed to create 'diving risk taking' variable

Binary variable	**Score = 0**	**Score = 1**
Short-term illness	No	Yes
Ear or sinus problem	No	Yes
Solo diving	No	Yes
Overhead diving	No	Yes
Missed safety stop	Never or rarely	At least occasionally
Unplanned deco stop	Never or rarely	At least occasionally
Risks for fun	Never or rarely	At least occasionally
Dived below 40m	No	Yes
TOTAL DIVING RISK-TAKING SCORE =		Sum score

5.3 Results

5.3.1 Prevalence of cigarette smoking and demographic characteristics

19% of divers (131 out of 698) were current cigarette smokers. Not having been educated to at least degree level was significantly associated with cigarette smoking ($p<0.001$). An analysis of demographic correlates is summarised in Table 5.3.

Table 5.3: Demographic associations with cigarette smoking in UK recreational divers

Independent variables	**Smokers**	**Non-smokers**	**Statistical test**	**DF**	***p***
Age (continuous)	Mean = 39.34 SD = 9.33 N = 101	Mean = 39.80 SD = 10.30 N = 483	t = 0.42	582	P = 0.678
Gender	19% male N = 76 14% female	81% male N = 331 86% female	Fisher's Exact	1	P = 0.193

	N = 25	N = 152			
Three-class NS-SEC	17% Prof & Mngr N = 79 20% Intermdiate N = 14 12% Rtn & Mnl N = 6	83% Prof & Mngr N = 375 80% Intermdiate N = 55 88% Rtn & Mnl N = 44	Chi-square = 1.44	2	P = 0.696
Education level	13% Degree N = 49 27% Non-degree N = 52	87% Degree N = 340 73% Non-degree N = 143	Fisher's Exact	1	P<0.001
Marital status	18% Single N = 27 16% Mrrd/CoH N = 62 21% Prev mrrd N = 12	82% Single N = 120 84% Mrrd/CoH N = 318 79% Prev mrrd N = 45	Chi-square = 0.94	2	P = 0.626
Living arrangements	20% Live alone N = 24 16% Live others N = 75	80% Live alone N = 96 84% Live others N = 381	Fisher's Exact	1	P = 0.345
Ethnicity	17% White N = 92 31% Non-white N = 8	83% White N = 458 69% Non-white N = 18	Fisher's Exact	1	P = 0.106

Logistic regression, employing Wald's backwards elimination technique, confirmed education level as the only demographic variable significantly associated with cigarette smoking by divers, although the total variance explained by the model is low (Nagelkerke R Square = 0.09).

<u>Final model for current cigarette smoking within divers:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Highest qualification	-1.07	0.24	19.88	1	<0.001
Social class	-0.32	0.19	2.92	1	0.087
Ethnicity	0.77	0.46	2.74	1	0.098
Gender	-0.42	0.27	2.31	1	0.129
Age	-0.01	0.01	1.10	1	0.295

Living arrangements	0.28	0.28	0.99	1	0.320
Marital status	-0.02	0.08	0.07	1	0.790

5.3.2 Prevalence of cigar or pipe smoking and demographic characteristics

7% of divers (47 out of 673) were current cigar or pipe smokers. Being older, male and previously married were significantly associated with current cigar or pipe smoking. An analysis of demographic correlates is summarised in Table 5.4.

Table 5.4: Demographic associations with cigar or pipe smoking in UK recreational divers

Independent variables	**Smokers**	**Non-smokers**	**Statistical test**	**DF**	***p***
Age (continuous)	Mean = 44.44 SD = 12.00 N = 39	Mean = 39.40 SD = 9.91 N = 544	t = -3.02	581	P = 0.003
Gender	9% male N = 37 1% female N = 2	91% male N = 369 99% female N = 175	Fisher's Exact	1	P<0.001
Three-class NS-SEC	7% Prof & Mngr N = 30 6% Intermdiate N = 4 10% Rtn & Mnl N = 5	93% Prof & Mngr N = 424 94% Intermdiate N = 64 90% Rtn & Mnl N = 45	Chi-square = 1.30	2	P = 0.730
Education level	6% Degree N = 24 8% Non-degree N = 15	94% Degree N = 364 92% Non-degree N = 180	Fisher's Exact	1	P = 0.487
Marital status	4% Single N = 6 7% Mrrd/CoH N = 25 14% Prev mrrd	96% Single N = 140 93% Mrrd/CoH N = 355 86% Prev mrrd	Chi-square = 6.49	2	P = 0.039

	N = 8	N = 49			
Living arrangements	8% Live alone N = 9 7% Live others N = 30	92% Live alone N = 111 93% Live others N = 425	Fisher's Exact	1	P = 0.687
Ethnicity	7% White N = 36 8% Non-white N = 2	93% White N = 513 92% Non-white N = 24	Fisher's Exact	1	P = 0.687

Logistic regression, employing Wald's backwards elimination technique, confirmed age and gender to be significantly associated with cigar or pipe smoking by divers, although the total variance explained by the model is low (Nagelkerke R Square = 0.11).

<u>Final model for current cigar or pipe smoking within divers:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Gender	-1.93	0.74	6.73	1	0.010
Age	0.05	0.02	6.39	1	0.011
Marital status	0.18	0.11	2.60	1	0.107
Living arrangements	0.28	0.43	0.43	1	0.513
Highest qualification	-0.19	0.37	0.10	1	0.749
Ethnicity	0.16	0.78	0.04	1	0.842
Social class	0.02	0.26	0.01	1	0.937

5.3.3 Prevalence of cannabis smoking and demographic characteristics

8% of divers (56 out of 667) were current cannabis smokers. Being younger, not a professional or managerial worker and never married were significantly associated with current cannabis smoking. An analysis of demographic correlates is summarised in Table 5.5.

<u>Table 5.5: Demographic associations with cannabis smoking in UK recreational divers:</u>

Independent variables	**Smokers**	**Non-smokers**	**Statistical test**	**DF**	***p***

Age (continuous)	Mean = 33.78 SD = 8.76 N = 46	Mean = 40.22 SD = 10.09 N = 538	t = 4.20	582	P <0.001
Gender	9% male N = 38 4% female N = 8	91% male N = 369 96% female N = 169	Fisher's Exact	1	P = 0.065
Three-class NS-SEC	6% Prof & Mngr N = 27 13% Intermdiate N = 9 16% Rtn & Mnl N = 8	94% Prof & Mngr N = 427 87% Intermdiate N = 60 84% Rtn & Mnl N = 42	Chi-square = 16.37	2	P = 0.001
Education level	8% Degree N = 30 8% Non-degree N = 16	92% Degree N = 359 92% Non-degree N = 179	Fisher's Exact	1	P = 0.871
Marital status	15% Single N = 22 5% Mrrd/CoH N = 19 9% Prev mrrd N = 5	85% Single N = 125 95% Mrrd/CoH N = 361 91% Prev mrrd N = 52	Chi-square = 14.58	2	P = 0.001
Living arrangements	8% Live alone N = 10 8% Live others N = 35	92% Live alone N = 110 92% Live others N = 421	Fisher's Exact	1	P = 0.848
Ethnicity	8% White N = 42 11% Non-white N = 3	92% White N = 508 89% Non-white N = 23	Fisher's Exact	1	P = 0.446

Logistic regression, employing Wald's backwards elimination technique, confirmed age, gender and social class to be significantly associated with cannabis smoking by divers, although the total variance explained by the model is low (Nagelkerke R Square = 0.14).

<u>Final model for current cannabis smoking within divers:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Age	-0.08	0.02	18.30	1	<0.001
Social class	0.59	0.21	7.95	1	0.005
Gender	-1.09	0.43	6.34	1	0.012
Ethnicity	0.67	0.67	1.10	1	0.293
Marital status	0.09	0.10	0.95	1	0.329
Highest qualification	0.17	0.38	0.21	1	0.645
Living arrangements	-0.17	0.43	0.15	1	0.700

There were clear demographic differences influencing the type of tobacco smoked by UK recreational divers. These differences are summarised in Table 5.6.

Table 5.6: Summary of significant demographic associations with choice of tobacco product

Demographic variables	**Cigarette smokers vs. non-smokers**	**Cigar or pipe smokers vs. non-smokers**	**Cannabis smokers vs. non-smokers**
Age	No difference	Cigar smokers older	Cannabis smokers younger
Gender	No difference	Cigar smokers male	No difference
Marital status	No difference	Cigar smokers previously married	Cannabis smokers never married
Live alone	No difference	No difference	No difference
Socio-economic status	No difference	No difference	Cannabis smokers not professional or managerial workers
Education level	Cigarette smokers below degree level	No difference	No difference
Ethnicity	No difference	No difference	No difference

5.3.4 Associations between different types of tobacco usage

Current cannabis smokers were significantly more likely to smoke other forms of tobacco than non-cannabis smokers.

Current cigarette & cigar or pipe smoking associations:

	N	% non cigar or pipe smokers [n]	% cigar or pipe smokers [n]	Fisher's Exact (p)
Non cigarette smoker	551	93.5 [515]	6.5 [36]	0.328
Cigarette smoker	122	91.0 [111]	9.0 [11]	

Current cigarette & cannabis smoking associations:

	N	% non cannabis smokers [n]	% cannabis smokers [n]	Fisher's Exact (p)
Non cigarette smoker	547	94.9 [519]	5.1 [28]	<0.001
Cigarette smoker	120	76.7 [92]	23.3 [28]	

Current cigar or pipe & cannabis smoking associations:

	N	% non cannabis smokers [n]	% cannabis smokers [n]	Fisher's Exact (p)
Non cigar or pipe smoker	620	92.6 [574]	7.4 [46]	0.003
Cigar or pipe smoker	46	78.3 [36]	21.7 [10]	

5.3.5 Tobacco consumption and demographic characteristics

The relationships between demographic variables and tobacco consumption were also investigated; however, only cigarette smoking provided enough cases for more complex statistical analysis.

Cigarette consumption

Daily cigarette consumption was normally distributed with a minimum of 0.1 and a maximum of 35 cigarettes smoked per day.

Frequency distribution for daily cigarette consumption:

N	Average score	Dispersion measures
120	Mean = 11.58 Median = 10.00	SD = 8.31 Range = 34.9

Age, social class and education level were significantly correlated with daily cigarette consumption.

Correlation matrix for daily cigarette consumption:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	100	0.32	0.001	0.34	0.001
Gender	100	-0.19	0.062	-0.18	0.070
Social class	99	0.23	0.023	0.28	0.006
Highest qualification	100	-0.33	0.001	-0.31	0.002
Marital status	100	-0.18	0.069	-0.12	0.252
Living arrangements	98	-0.02	0.845	-0.01	0.893
Ethnicity	99	0.10	0.347	0.11	0.299

Stepwise linear regression analysis confirmed age (*B* = 0.28), education level (*B* = -3.60) and social class (*B* = 2.69) to be significantly associated with cigarette consumption. The final model is presented below.

Final model for daily cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	Signif. level (*p*)
Final model:	0.24	0.21					
Age			0.28	0.08	0.32	3.39	0.001
Education level			-3.60	1.58	-0.22	-2.28	0.025
Social class			2.69	1.26	0.21	2.14	0.035

Cigarette dependence

Cigarette dependence was measured using the Fagerstrom Test for Nicotine Dependence (FTND). The distribution was positively skewed.

Frequency distribution for cigarette dependence (FTND score):

N	Average score	Dispersion measures
120	Median = 2.00	25th percentile = 0.00 75th percentile = 4.00

Gender and education level were significantly correlated with cigarette dependence.

Correlation matrix for cigarette dependence (FTND score):

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	100	0.17	0.100	0.21	0.040
Gender	100	-0.26	0.011	-0.25	0.012
Social class	99	0.17	0.097	0.22	0.032
Highest qualification	100	-0.23	0.021	-0.24	0.016
Marital status	100	-0.18	0.077	-0.11	0.293
Living arrangements	98	0.03	0.750	0.05	0.645
Ethnicity	99	0.13	0.210	0.09	0.368

Stepwise linear regression analysis confirmed gender (*B* = -1.10) and education level (*B* = -0.93) to be negatively significantly associated with cigarette dependence although the variance explained is low. The final model is presented below.

Final model for cigarette dependence (FTND score):

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.09	0.07					
Gender			-1.10	0.53	-0.20	-2.07	0.042
Education level			-0.93	0.45	-0.20	-2.04	0.044

Cigar or pipe consumption

Daily cigar or pipe consumption was positively skewed with a minimum of 0.1 and a maximum of 20 cigars or pipes smoked per day.

<u>Frequency distribution for cigar or pipe consumption:</u>

N	Average score	Dispersion measures
47	Median = 0.10	25th percentile = 0.03 75th percentile = 1.00

Age was significantly positively correlated with daily cigar or pipe consumption.

<u>Correlation matrix for cigar or pipe consumption:</u>

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	39	0.45	0.004	0.62	<0.001
Gender	39	-0.12	0.476	-0.30	0.065
Social class	39	0.10	0.557	0.20	0.219
Highest qualification	39	0.09	0.584	0.06	0.720
Marital status	39	-0.07	0.658	-0.08	0.633
Living arrangements	39	0.09	0.591	0.08	0.642
Ethnicity	38	0.41	0.010	0.09	0.581

No further analysis was possible due to a low number of cases.

Cannabis consumption

Daily cannabis consumption was positively skewed with a minimum of 0.1 and a maximum of 5 joints smoked per day.

<u>Frequency distribution for cannabis consumption:</u>

N	Average score	Dispersion measures
52	Median = 0.03	25th percentile = 0.03 75th percentile = 0.29

No demographic variables were significantly correlated with daily cannabis consumption.

Correlation matrix for cannabis consumption:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	45	0.07	0.662	-0.06	0.698
Gender	45	-0.17	0.253	-0.04	0.810
Social class	45	0.12	0.422	0.27	0.072
Highest qualification	45	0.06	0.722	-0.19	0.214
Marital status	45	-0.05	0.722	-0.23	0.123
Living arrangements	44	0.22	0.154	0.14	0.366
Ethnicity	44	-0.11	0.480	-0.10	0.523

No further analysis was possible due to a low number of cases.

5.3.6 Tobacco use and level of diver training

The influence of diver training on the consumption of tobacco was of considerable interest to this study. Diver training was categorised to the internationally recognised standard of Confédération Mondiale des Activités Subaquatiques (CMAS)[15] as either professional (CMAS Level 3) or non-professional (CMAS Level 2) training.

Adding CMAS Level to the previous logistic regression analyses for current tobacco use produced no change in the variance explained or the final model produced for each type of tobacco; however, diver training was found to influence daily cigarette consumption and dependence.

Associations between diver training level and cigarette consumption:

Independent variables	**CMAS Level 3**	**CMAS Level 2**	**Statistical test**	**DF**	***p***
Cigarettes per day	Mean = 19.87 SD = 9.40 N = 11	Mean = 11.09 SD = 7.7 N = 90	t = -3.46	99	P = 0.001
FTND score	Mean = 4.17 SD = 2.41 N = 12	Mean = 2.09 SD = 2.22 N = 88	t = -3.01	98	P = 0.003

15 www.cmas.org/index

CMAS Level was a significant predictor variable for daily cigarette consumption and Fagerstrom score using the previous stepwise regression models for demographic variables. The final models are presented below.

Final model for daily cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.24	0.22					
Age			0.25	0.08	0.28	3.08	0.003
Education level			-4.12	1.51	-0.25	-2.73	0.008
CMAS Level			6.55	2.44	0.25	2.68	0.009

Age (*B* = 0.25), education level (*B* = -4.12) and diver training level (*B* = 6.55) were significantly associated with cigarette consumption in this model.

Final model for cigarette dependence (FTND score):

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.14	0.11					
CMAS Level			1.74	0.70	0.24	2.50	0.014
Gender			-1.11	0.52	-0.21	-2.15	0.034
Education level			-0.77	0.44	-0.17	-1.72	0.088

Gender (*B* = -1.11) and diver training level (*B* = 1.74) were significantly associated with nicotine dependence in this model.

5.3.7 Diver training and factors likely to affect smoking levels

The literature review had identified a number of additional factors that might influence smoking levels amongst extreme sports activists, in particular, the level of participant training or experience in the sport and predisposition to risk taking. Attitudes to smoking at the time of diving were examined and two new variables were created (section 5.2) to investigate the effect of attitudes to risk taking on smoking behaviour.

5.3.7.1 Diver training and attitudes to smoking whilst diving

Attitudes to tobacco use at the time of diving were investigated by CMAS training level although no significant differences were found. The results are presented in Table 5.7.

Table 5.7: Attitudes to tobacco use by diver training level

Independent variable	**CMAS Level 3**	**CMAS Level 2**	**Statistical test**	**DF**	***p***
Ever smoked within 6hrs of diving?	25% Yes N = 21 75% No N =64	26% Yes N = 128 74% No N = 373	Fisher's Exact	1	P = 1.000
How soon do you smoke before diving?	14% 5 mins or < N = 3 86% >5 mins N = 18	9% 5 mins or < N = 12 91% >5 mins N = 115	Fisher's Exact	1	P = 0.449
How soon do you smoke after diving?	14% 5 mins or < N = 3 86% >5 mins N = 18	7% 5 mins or < N = 9 93% >5 mins N = 119	Fisher's Exact	1	P = 0.378
Ever used NRT whilst diving?	10% Yes N = 2 90% No N =19	3% Yes N = 4 97% No N = 123	Fisher's Exact	1	P = 0.202
Noticed any changes to health or fitness?	43% Yes N = 9 57% No N =12	57% Yes N = 72 43% No N = 55	Fisher's Exact	1	P = 0.249
Ever tried to	86% Yes	87% Yes	Fisher's Exact	1	P = 1.000

give up smoking?	N = 18 14% No N =3	N = 110 13% No N = 17			
How many times have you tried?	Mean = 3.12 SD = 2.15 N = 17	Mean = 3.21 SD = 2.59 N = 105	t = 0.14	120	P = 0.890

5.3.7.2 Diver training and attitudes to risk taking

Two new variables were created (section 5.2) to investigate the effect of attitudes to risk on smoking behaviour amongst recreational divers within an everyday and a diving context.

5.3.7.2.1 Univariate analysis of everyday risk taking sum variable

The distributions of individual responses to each component of the sum everyday risk taking variable are described in Table 5.8 below.

Table 5.8: Percentage response to everyday risk taking variables

Binary variable	**N**	**% risk negative**	**% risk positive**
Risks at work	586	62.8	37.2
Risks outside work	586	41.1	58.9
Smoke alarm	585	87.9	12.1
Seat belt	585	97.8	2.2
Travel insurance	585	93.3	6.7
Comprehensive car insurance	579	83.9	16.1
Play fruit machines	581	95.5	4.5
Play Pools	577	98.3	1.7
Play National Lottery	579	64.4	35.6

Taking risks outside of work was the largest positive response to everyday risk taking, followed by taking risks at work and playing the National Lottery at least once a month. Divers were highly unlikely to play the Pools at least once a month and to not to normally wear a seat belt whilst driving.

The distribution of everyday risk taking scores was positively skewed.

Frequency distribution for everyday risk taking:

N	Average score	Dispersion measures
586	Median = 2.00	25th percentile = 1.00 75th percentile = 2.00

5.3.7.2.2 Univariate analysis of diving risk taking sum variable

The distribution of individual responses to each component of the sum diving risk taking variable are described in Table 5.9 below.

Table 5.9: Percentage response to diving risk taking variables

Binary variable	**N**	**% risk negative**	**% risk positive**
Short-term illness	619	62.7	37.3
Ear or sinus problem	618	83.8	16.2
Solo diving	585	88.7	11.3
Overhead diving	586	41.8	58.2
Missed safety stop	584	89.6	10.4
Unplanned deco stop	579	87.2	12.8
Risks for fun	581	92.9	7.1
Dived below 40m	582	67.0	33.0

Diving in overhead environments produced the largest positive response to diving risk taking, followed by diving with a pre-existing short-term illness and having dived below forty metres using compressed air. Divers were highly unlikely to report taking risks for fun whilst diving.

The distribution of diving risk taking scores was positively skewed.

Frequency distribution for diving risk taking:

N	Average score	Dispersion measures
619	Median = 2.00	25th percentile = 1.00 75th percentile = 3.00

5.3.7.2.3 Bivariate analysis of everyday risk taking sum variable

Current cigar or pipe and current cannabis smoking were positively significantly correlated with a propensity towards everyday risk taking. CMAS Level was not significantly correlated with everyday risk taking.

<u>Correlation matrix for everyday risk taking:</u>

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	586	0.02	0.610	0.03	0.535
Current cigar / pipe	585	0.08	0.057	0.09	0.040
Current cannabis	586	0.12	0.003	0.12	0.003
Cigarettes per day	101	0.07	0.517	0.05	0.622
Fagerstrom	101	0.18	0.073	0.17	0.092
CMAS	581	0.03	0.525	0.03	0.432

5.3.7.2.4 Bivariate analysis of diving risk taking sum variable

Current cigarette smoking and CMAS Level were positively significantly correlated with a propensity towards risk taking whilst diving.

<u>Correlation matrix for diving risk taking:</u>

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	619	0.12	0.003	0.11	0.008
Current cigar / pipe	618	0.01	0.771	0.02	0.594
Current cannabis	619	0.09	0.033	0.08	0.057
Cigarettes per day	107	0.14	0.158	0.12	0.207
Fagerstrom	106	0.10	0.312	0.09	0.357
CMAS Level	581	0.34	<0.001	0.32	<0.001

5.3.7.2.5 Multivariate analysis of tobacco consumption with respect to diver training and attitudes to risk

A series of logistic and stepwise regression analyses were undertaken to determine the likely influence of both diver training and attitudes to risk on tobacco consumption. The following order of entry of variables was common to all analyses:

Block 1 – Demographics	Age, gender, social class, highest education level, marital status, living arrangements, ethnicity
Block 2 – Diver training	CMAS Level
Block 3 – Risk taking variables (tested separately then together)	Everyday risk taking, diving risk taking

The sum risk taking variables were positively significantly correlated ($r = 0.12$; $p = 0.003$; $n = 586$) and explained a similar amount of variance when tested separately. The inclusion of both variables resulted in a slightly higher level of variance explained and an improved 'model of best fit' for each tobacco variable investigated. The final models are provided below.

Current cigarette use

Logistic regression, employing Wald's backwards elimination technique, reconfirmed education level as the only variable significantly associated with cigarette smoking by divers. There was no change in the total variance explained, over and above demographics, by adding the diver training and risk taking variables (Nagelkerke R Square = 0.08).

<u>Final model for current cigarette smoking:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Highest qualification	-1.10	0.25	19.78	1	<0.001
Social class	-0.31	0.19	2.62	1	0.106
Gender	-0.40	0.28	2.08	1	0.149
Ethnicity	0.65	0.49	1.77	1	0.183
CMAS level	-0.42	0.38	1.24	1	0.266
Living arrangements	0.31	0.28	1.24	1	0.266
Age	-0.01	0.01	1.14	1	0.286
Diving risk taking	0.06	0.08	0.46	1	0.496
Everyday risk taking	-0.04	0.10	0.14	1	0.712
Marital status	-0.02	0.08	0.07	1	0.786

Current cigar or pipe use

Logistic regression, employing Wald's backwards elimination technique, identified age, gender and everyday risk taking as significantly associated with cigar or pipe smoking by divers. The total variance explained by the model was increased with the addition of the risk taking variables (Nagelkerke R Square = 0.13).

<u>Final model for current cigar or pipe smoking:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Age	0.06	0.02	8.21	1	0.004
Gender	-1.86	0.75	6.25	1	0.012
Everyday risk taking	0.31	0.15	4.35	1	0.037
Marital status	0.18	0.11	2.45	1	0.118
CMAS level	0.24	0.52	0.20	1	0.653
Living arrangements	0.18	0.44	0.17	1	0.681
Ethnicity	0.26	0.79	0.12	1	0.734
Diving risk taking	-0.04	0.13	0.11	1	0.741
Social class	-0.04	0.27	0.03	1	0.874
Highest qualification	-0.04	0.38	0.10	1	0.921

Current cannabis use

Logistic regression, employing Wald's backwards elimination technique, reconfirmed age, gender and social class as significantly associated with cannabis smoking by divers, although the total variance explained by the model was increased by the additional of the risk taking variables (Nagelkerke R Square = 0.17).

<u>Final model for current cannabis smoking:</u>

Predictor variables	B	S.E.	Wald	DF	*p*
Age	-0.07	0.02	14.42	1	<0.001
Social class	0.59	0.21	7.70	1	0.006
Gender	-1.00	0.44	5.16	1	0.023
CMAS level	-1.04	0.65	2.53	1	0.112
Diving risk taking	0.13	0.11	1.35	1	0.246
Everyday risk taking	0.15	0.14	1.28	1	0.257
Ethnicity	0.72	0.67	1.14	1	0.287

Marital status	0.08	0.10	0.78	1	0.377
Living arrangements	-0.27	0.44	0.38	1	0.540
Highest qualification	0.16	0.39	0.18	1	0.674

Cigarette consumption

Stepwise linear regression analysis identified age, (B = 0.36), CMAS level (B = 8.21) and attitudes to everyday risk taking (B = 1.53) as positively significantly associated with daily cigarette consumption. The variance explained by the model increased with the addition of the risk taking variables. The final model is presented below.

Final model for daily cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.28	0.24					
Age			0.36	0.09	0.39	4.12	<0.001
CMAS level			8.21	2.40	0.31	-2.28	0.001
Everyday risk			1.53	0.75	0.19	2.03	0.046
Social class			2.18	1.21	0.16	1.80	0.075

Cigarette dependence

Stepwise linear regression analysis identified age, (B = 0.06), CMAS level (B = 2.24) and attitudes to everyday risk taking (B = 1.53) as positively significantly associated with cigarette dependence, measured by Fagerstrom score. Gender (B = -1.13) was negatively significantly associated with cigarette dependence. The variance explained by the model increased with the addition of the risk taking variables. The final model is presented below.

Final model for cigarette dependence:

Predictor	R	Adjstd.	*B*	Stand.	Standrsd.	*t*	*p*

variables	Square	R Square		error *B*	Beta coefficient		
Final model:	0.22	0.18					
CMAS level			2.24	0.66	0.32	3.40	0.001
Everyday risk			0.56	0.22	0.26	2.58	0.011
Gender			-1.13	0.50	-0.21	-2.27	0.026
Age			0.05	0.03	0.22	2.18	0.032

5.4 Discussion

The regression analyses illustrated that demographic factors played a major role in determining the choice of tobacco product by divers, but that other factors such as diver training and attitudes to risk taking also contributed.

5.4.1 Tobacco choice and consumption by divers

Table 5.10 summarises the results of the regression analyses for tobacco use and consumption. It includes only the significant variables in the final models in descending order of significance.

Table 5.10: Final model variables significantly associated with tobacco consumption by divers

Tobacco variable	Demographics only	Diver training added as distal variable	Risk taking added as distal variable
Current cigarette	Highest qualification	No change	No change
Current cigar or pipe	Gender Age	No change	Age Gender Everyday risk
Current cannabis	Age Social class Gender	No change	No change
Cigarette consumption	Age Highest qualification Social class	Age Highest qualification CMAS level	Age CMAS level Everyday risk

Cigarette dependence	Gender Highest qualification	CMAS level Gender	CMAS level Everyday risk Gender Age

Individual tobacco variables are discussed in more detail below.

Current cigarette smoking

The GHS publication *Smoking and drinking amongst adults, 2006* (Goddard, 2008) reports age, gender, marital status, social class, geographical location and economic activity to be the major influences on cigarette smoking prevalence. Although geographical location and economic activity were not included in this study, none of the remaining major determinants were found to significantly influence smoking behaviour within the recreational diving population. Instead, degree-level education was the only variable significantly associated with cigarette smoking amongst divers, with smoking more likely to occur amongst those without a degree.

Diver training and attitudes to risk had no significant influence on cigarette smoking levels amongst divers.

Current cigar or pipe smoking

The GHS publication *Smoking and drinking amongst adults, 2006* (Goddard, 2008) reports age and gender as the major influences on cigar or pipe smoking. In particular that cigar smoking is predominantly a male activity with the numbers of women smoking virtually negligible. The 2006 GHS was the first survey to identify a clear age difference, with almost all pipe smokers being males aged 50 and over and cigar smokers more likely to be men aged 35 and over. These patterns were virtually identical in the diving sample.

Attitudes to everyday risk taking was significantly associated with cigar or pipe smoking amongst divers, with smokers reporting higher risk taking scores.

Current cannabis smoking

The use of illicit drugs is a central topic of the British Crime Survey 2006/7 and cannabis was the most popular illicit drug during that period (Murphy and Roe, 2007). Age, gender and geographical location are recognised as the major determinants of cannabis use. Age-related use follows a similar pattern to cigarette smoking with high levels of use amongst 16-19 year olds, rising to the highest levels of use amongst 20-24 year olds before gradually decreasing to the lowest levels of use amongst those aged 60 and over. Men consistently report higher levels of illegal drug use than females in all age groups. These patterns were similar in the diving sample with the addition of social class. Divers in Routine and Manual occupations were significantly more likely to smoke cannabis than those in other occupations.

Diver training and attitudes to risk had no significant influence on cannabis smoking by divers.

Cigarette consumption

The GHS publication *Smoking and drinking amongst adults, 2006* (Goddard, 2008) reports age, gender and social class as the major influences on cigarette consumption. Males smoke more cigarettes per day than females in all age groups and cigarette consumption generally increases with age (bar women aged 60 and over). Cigarette consumption is also significantly higher in Routine and Manual occupations.

The patterns in the diving sample were slightly different. Cigarette consumption increased with age but was not significantly higher in males than females (t = 1.89; DF = 98; p = 0.062) or significantly higher in divers with Routine and Manual occupations (t = -0.78; DF = 97; p = 0.437). Instead, consumption was significantly lower in divers with Professional and Managerial occupations (t = 3.27; DF = 96; p = 0.001) and also in those educated to at least degree level (t = 3.42; DF = 98; p = 0.001) suggesting that degree-level education has a protective effect against smoking in divers.

Diver training was significantly associated with cigarette consumption, with those having trained to a professional level smoking more cigarettes daily. This finding was in contrast to the protection afforded by degree-level education.

Attitudes to everyday risk taking were significantly associated with cigarette consumption although the two variables were not significantly correlated.

Cigarette dependence

The GHS publication *Smoking and drinking amongst adults, 2006* (Goddard, 2008) reports gender and social class as the major influences on cigarette dependence, measured by time to first cigarette after waking.

Men were more likely to report having their first cigarette within five minutes of waking and Professional and Managerial workers were less likely than other groups to do so.

In the diving sample, women were significantly more likely to have their first cigarette thirty minutes after waking and to have a lower FTND score. No significant differences existed for time to first cigarette by social class or highest qualification; however, degree-level education was significantly associated with a lower FTND score.

Diver training and attitudes to risk were significantly associated with higher FTND scores.

Cigar or pipe consumption

Daily cigar or pipe consumption was significantly positively correlated with age ($r = 0.45$; $p = 0.004$; $n = 39$) but significantly negatively correlated with everyday risk taking scores ($r = -0.38$; $p = 0.017$; $n = 39$). No further analyses could be carried out due to the low number of cases involved.

Cannabis consumption

No demographic, diver training or risk taking variables were significantly correlated with daily cannabis consumption.

5.4.2 The associations between diver training, attitudes to risk and divers' smoking behaviour

Sensation seeking, in particular Thrill and Adventure Seeking (Zuckerman, 1983; Zuckerman and Neeb, 1980), is linked to smoking levels, with a greater proportion of high sensation seekers being regular smokers.

A number of small-scale studies have found recreational divers to score more highly on sensation seeking than non-divers (Guszkowska and Boldak, 2010; Heyman and Rose,1980; Biersner and LaRocco, 1983) but lower on sensation seeking than other types of high adrenaline sports (Guszkowska and Boldak, 2010).

It might therefore be expected for divers to have higher smoking rates than the general population, however, the results of Chapter 4 demonstrated a mixed picture, with divers having a lower cigarette smoking prevalence but higher rates of smoking non-cigarette tobacco compared to the general population, after controlling for age, gender and social class.

Attitudes to everyday risk taking were significantly associated with cigar or pipe smoking amongst divers in this study, but not for any other type of tobacco product. It is possible that cigar or pipe smoking might be regarded as an attractive alternative to cigarette smoking for divers with higher sensation seeking tendencies.

Attitudes to everyday risk taking were also significantly associated with cigarette consumption and dependence. It is possible that higher sensation seeking tendencies in divers are reflected by a greater dependence on cigarettes and by cigar or pipe smoking, rather than by higher cigarette or cannabis smoking levels.

As these findings run counter to accepted knowledge that sensation seeking is typically linked to higher levels of tobacco and recreational drug use, it is possible that other factors are also influencing smoking behaviour amongst divers, for example diver training.

Training is undertaken by all non-divers before they can be certified to dive independently. Basic diver training (CMAS Level 2) focuses on the theory and practice of safe diving, which includes use of compressed gases, diving-related health and illness and potential threats within the marine environment. Professional diver training (CMAS Level 3) focuses on greater management of self and others whilst diving, including rescue techniques and effective teaching methods (www.padi.com).

Smoking is widely discouraged throughout the diving community with advice against smoking routinely given by diver training agencies, during medical examinations and within discussion forums (Appendix 6). Therefore it is highly unlikely that any diver will not be aware of the possible complications of smoking during the certification process. On this basis, it might be expected that the lower cigarette prevalence seen amongst divers compared to the general population is partly a product of the specific anti-tobacco messages delivered as an integral part of training; however, the picture within certified divers is more complex.

Although smoking levels between professional (14%) and non-professional divers (18%) are not significantly different (X_2 = 0.74; DF = 1; p = 0.442) those who have achieved professional status have a higher dependence on cigarettes that is independent of demographic factors and attitudes to risk taking.

Paradoxically it appears that professional-level diver training programmes do not positively affect smoking behaviour and that the most protective action against cigarette smoking by divers is a degree-level education. This finding concurs with the consistently significant associations found between formal education attainment and risky health behaviours and health outcomes (Baker et al, 2011; Eide and Showalkter, 2011). Therefore it appears that further influence through professional diver training and diver networks is likely to be limited.

CHAPTER 6 - THE IMPACT OF SMOKING ON THE GENERAL HEALTH AND 'FITNESS TO DIVE' OF UK RECREATIONAL SCUBA DIVERS

6.1 Introduction

This chapter compares the health of divers to the UK general population and examines the impact of smoking on their self-assessed general health and their medically-assessed 'fitness to dive'.

6.2 Methods

6.2.1 Selection of health self-assessment variables

Questions designed to capture health status via self-report have been a central component of national surveys for many years. The General Household Survey 2006 (Ali et al, 2008) used the following self-assessment tools for this purpose:

1. Gen Hlth
Over the last 12 months would you say your health has on the whole been…
1 good
2 fairly good
3 or not good?

2. Gen Hlth2
How is your health in general? Would you say it was…
1 very good
2 good
3 fair
4 bad
5 very bad?

Both questions were included in the diver survey (Appendix 5, Qs 1-2).

6.2.2 Approach to analyses

Univariate, bivariate and multivariate analyses were carried out for the dependent variables ‘general health’ and ‘fitness to dive’. Demographic factors were the primary focus along with diver experience. To help with the selection of independent variables for analysis, a list of primary variables was drawn up (Appendix 7) from which variables were selected for inclusion by statistical and theoretical considerations. More detail on the selection of variables is provided with the results and discussion where relevant.

Exploratory analyses carried out during the investigation of the relationships between smoking and general health (Chapter 6) and diving-related illness (Chapter 7) identified a systematic approach to variable selection and inclusion that consistently produced the ‘model of best fit’.

The most suitable technique (for numerical dependent variables) was identified as a hierarchical backwards elimination approach with variables being added in blocks in the following order:

Block 1 – Demographics Example variables: gender, age, highest qualification, never married
Block 2 – Health prior to diving Example variables: general health, short-term illness, ear or sinus problem
Block 3 – Attitudes to everyday risk Example variables: smoke alarm, seat belt, National Lottery
Block 4 – Attitudes to diving risk Example variables: missed safety stop, risks for fun, deepest dive on air
Block 5 – Diving experience Example variables: CMAS, overhead diving, worked outside UK
Block 6 – Tobacco use Example variables: Current cigarette smoking, current cannabis smoking
Block 7 – Tobacco dependence Variables: Number of cigarettes per day, Fagerstrom score

The ‘model of best fit’ was decided by a combination of theoretical considerations and comparison of R-Square and Adjusted R-Square figures, when the most variance was explained by the fewest variables and statistically verified by the closest R-square and Adjusted R-square values.

Although a series of multivariate analyses were carried out for each dependent variable, only the final ‘model of best fit’ per analysis is included in the Results, unless stated otherwise.

6.3 Results

6.3.1 Comparison of divers’ general health with the UK population

The 5-part general health self-assessment tool indicates current health whilst the 3-part tool assesses health over the preceding year.

Divers were more likely to report their current health as ‘very good’ or ‘good’ than the general population and much less likely to report their health as being ‘fair’ or ‘bad’ (Table 6.1).

There were also some gender differences, with female divers were more likely to rate their health as ‘good’ or ‘very good’ than male divers and less likely to report it as ‘fair’ or ‘bad’. In the UK population women were less likely to report ‘very good’ health than men.

Table 6.1: ‘Health in general’ by gender

	GHS 2006 dataset			**Diving sample**		
Self-reported health status	% male	% female	% total	% male [N]	% female [N]	% total [N]
Very good	34	31	33	35 [142]	38 [66]	36 [208]
Good	43	44	43	54 [216]	56 [97]	55 [313]

Fair	17	18	17	11 [42]	5 [8]	9 [50]
Bad	6	6	6	0 [1]	1 [1]	0 [2]
Very bad	1	1	1	0 [0]	0 [0]	0 [0]
TOTAL	**100**	**100**	**100**	**100** [401]	**100** [172]	**100** [573]

Divers were more likely to report their health over the last year as being 'good' than the general population and less likely to report it as 'fairly good' or 'not good' (Table 6.2). Although comparable data from the GHS survey was not available, gender differences between divers were small.

Table 6.2: Self-perception of health during last 12 months

	GHS 2006 dataset	**Diving sample**		
Self-reported health status	% total	% male [N]	% female [N]	% total [N]
Good	62	80 [324]	81 [143]	80 [467]
Fairly good	26	18 [74]	16 [28]	18 [102]
Not good	12	2 [9]	3 [6]	3 [15]
TOTAL	**100**	**100** [407]	**100** [177]	**101** [584]

Population differences based on socio-economic group were more marked, with the UK general population showing a clear gradient in self-reported health by occupational group. The proportion of those reporting 'very good' health was highest in Professional and Managerial occupations and lowest in Routine and Manual occupations. The reverse is true for reporting 'bad' or 'very bad' health. In contrast, no equivalent gradient exists within the diving sample (Table 6.3).

Table 6.3: Self-reported health by social class

	GHS 2006 dataset			Diving sample		
Three-class NS-SEC	% Prof & Mngrl	% Intrmdt	% Routine & Mnl	% Prof & Mngrl [N]	% Intrmdt [N]	% Routine & Mnl [N]
Very good	40	33	26	36 [165]	36 [25]	36 [18]
Good	44	44	42	54 [247]	57 [39]	54 [27]
Fair	13	18	22	9 [41]	7 [5]	8 [4]
Bad / very bad	4	5	10	0 [1]	0 [0]	2 [1]
TOTAL	**101**	**100**	**100**	**99** [454]	**100** [69]	**100** [50]

6.3.2 Influence of smoking on self-assessed health of divers

6.3.2.1 Smoking-attributed changes to health

55% of divers who had ever smoked tobacco within six hours of diving (n = 165) reported noticing changes to their health or physical fitness since they started smoking. A summary of open-ended responses (where given) is presented in Table 6.4, multiple answers were permitted:

Table 6.4: Changes noticed to health or physical fitness since started smoking

Health complaint (n = 78)	N	% response	Specific conditions (if any)
Reduced lung function	50	64	None given
Reduced fitness / more tired	39	50	General poor health
More infections	8	10	Colds
Miscellaneous	5	6	Chest pain; taste / smell; headaches, weight gain

Reduced lung function and poorer fitness were the most commonly recorded health complaints attributed to smoking.

6.3.2.2 Self-assessed general health

The primary outcome variable was the 5-part assessment tool for general health with higher scores indicating worse health. The distribution was positively skewed.

Frequency distribution for self-assessed general health:

Ordinal scale for general health:	N	Average score	Dispersion measures
1 – Very good 5 – Very bad	698	Median = 2.00	25th percentile = 1.00 75th percentile = 2.00

Bivariate relationships with the main demographic variables were explored although none were significant.

Correlation matrix for demographic variables with general health:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	584	0.02	0.709	0.01	0.871
Gender	584	-0.07	0.117	-0.06	0.144
Live alone	576	-0.03	0.445	-0.03	0.528
Never married	584	-0.03	0.534	-0.02	0.692
Currently married	584	0.07	0.114	0.06	0.132
Previously married	584	-0.06	0.169	-0.05	0.212
Highest qualificn	584	-0.04	0.321	-0.03	0.490
Prof & Mngrl	573	<0.01	0.998	<0.01	0.956
Intermediate	578	-0.01	0.797	-0.01	0.878
Routine & Manual	578	-<0.01	0.989	-0.01	0.840
Unemployment	577	0.02	0.682	0.03	0.551
Ethnicity	576	0.06	0.181	0.05	0.223

Bivariate relationships with the three main types of tobacco use were explored alongside cigarette dependence, measured by daily consumption and Fagerstrom score.

Correlation matrix for tobacco variables with general health:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	698	0.09	0.017	0.10	0.008
Current cigar / pipe	673	0.08	0.041	0.07	0.068

Current cannabis	667	0.05	0.195	0.06	0.140
Cigarettes per day	120	0.16	0.076	0.16	0.081
Fagerstrom	120	0.10	0.301	0.11	0.244

Current cigarette and cigar or pipe smoking were significantly correlated with poorer health.

A backwards entry regression analysis was performed using the demographic variables alone. The final model is presented below with all variables included.

Final regression model produced using demographic variables:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.01	<0.01					
Currently married			0.10	0.06	0.07	1.71	0.087

A minimum amount of variance was explained by including demographic variables alone and none were significant.

Effect of adding tobacco variables

The effects of the tobacco variables were examined in a hierarchical fashion by inserting the most correlated variables first and then subsequently adding or removing any variables of interest.

Block 1 – Demographics	Age, gender, live alone, marital status, education level, social class, unemployment, ethnicity
Block 2 – Tobacco use variables (tested separately then together)	Current cigarette Current cigar
Block 3 – Tobacco dependence variables (tested separately)	Number of cigarettes per day Fagerstrom

Choice of tobacco type

Both current cigarette and current cigar or pipe smoking produced a rise in the variance explained when added separately to the regression analysis and were significantly associated with self-assessed health in the final models. Maximum variance was explained by including both tobacco variables, although only cigarette smoking was significant.

Final regression model produced with all tobacco use variables added:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.03	0.02					
Current cigarette			0.19	0.07	0.12	2.78	0.006
Current cigar			0.20	0.10	0.08	1.91	0.057
Currently married			0.10	0.06	0.07	1.78	0.076

Current cigarette smoking (*B* = 0.19) was a positive significant predictor for (poorer) general health in this model.

Cigarette dependence

The analysis was repeated substituting current cigarette use with daily cigarette consumption, and then FTND score, as the most distal variable in the hierarchical regression model. The resultant final models produced were very similar but with FTND explaining slightly more variance. Both tobacco variables produced an appreciable rise in variance explained, although neither was significant.

Final regression model with daily cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.10	0.10					
Live alone			-0.42	0.13	-0.32	-3.31	0.001

Final regression model with FTND score substituted:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.14	0.12					
Live alone			-0.67	0.18	-0.53	-3.64	<0.001
Currently married			-0.30	0.16	-0.26	-1.83	0.070

Living alone was the only variable significantly associated with self-assessed health after the inclusion of cigarette dependence variables. Living alone was predictive of better health in this model.

6.3.3 Influence of smoking on medically-assessed fitness to dive

The role of medical examinations in identifying possible health contraindications to diving and treating dive-related illness has been a central tenet of health and safety policy for work-related diving for many years and is statutorily regulated (HSE, 2011).

In contrast, routine medical examinations have been considered of limited value to the recreational sector (Glen, White and Douglas, 2000) which instead relies on self-assessment via a medical checklist that identifies conditions that interfere with safe diving. Potential divers are handed the checklist at entry-level training and a positive response to an item on the checklist prompts referral for medical assessment by a diving physician.

6.3.3.1 Diving medical examinations

Almost half of divers in this study (51%; n = 317) had ever been medically assessed for diving. 19% (n = 119) had been assessed for work purposes and 39% (n = 241) for recreational diving. 8% of all divers (n = 47) had received both assessments.

Ever having attended a non-work related medical was significantly correlated with self-assessed poorer health, whilst ever attending a work related medical was not.

Correlation matrix between diving medicals and general health:

Type of medical	N	Pearson (r)	*p*	Spearman (rho)	*p*
Work related	623	-0.03	0.446	-0.03	0.502
Non-work related	623	0.11	0.008	0.11	0.006

Of those that had received any type of medical, 11% (33 out of 314 cases) had been assessed as unfit to dive or had been advised to restrict their diving for health reasons.

Tobacco use and diving medicals

No significant correlations were found between tobacco use and ever having attended a work related medical.

Correlation matrix between work related medicals and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	623	-0.03	0.450	-0.03	0.450
Current cigar / pipe	622	-<0.01	0.989	-<0.01	0.989
Current cannabis	622	-0.02	0.558	-0.02	0.558
Cigarettes per day	108	0.08	0.408	0.07	0.485
Fagerstrom	107	0.03	0.732	0.06	0.565

Daily cigarette consumption and FTND score were positively significantly correlated with having a non-work related diving medical.   Current cannabis smoking was negatively significantly correlated with non-work related diving medicals.

Correlation matrix between non-work related medicals and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	p
Current cigarette	623	-<0.01	0.972	-<0.01	0.972
Current cigar / pipe	622	0.02	0.572	0.02	0.572

Current cannabis	622	-0.09	0.026	-0.09	0.026
Cigarettes per day	108	0.23	0.015	0.23	0.015
Fagerstrom	107	0.31	0.001	0.29	0.002

6.3.3.2 Fitness to dive status

A diving physician has three outcomes to consider when deciding to issue a certificate of medical fitness to dive (HSE, 2011). Firstly, to declare a diver medically fit to undertake all diving operations likely to be required of them; secondly, to restrict diving in some way, for example requiring diabetes patients to train under medical supervision; or finally, to declare a diver medically unfit to dive, such as those taking short or long-term psychotropic medication. The distribution was positively skewed.

Frequency distribution for medically-assessed fitness to dive:

Ordinal scale:	N	Average score	Dispersion measures
1 – Fit to dive 2 – Fit with restrictions 3 – Not fit to dive	315	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00

Bivariate relationships between 'fitness to dive' status and the main demographic variables were explored; however, none were significant.

Correlation matrix between fitness to dive status and demographics:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	295	0.08	0.156	0.07	0.225
Gender	295	-0.03	0.561	-0.02	0.699
Live alone	294	-0.05	0.445	-0.04	0.533
Never married	295	-0.09	0.135	-0.08	0.175
Currently married	295	0.08	0.149	0.08	0.193
Previously married	295	-0.05	0.446	-0.04	0.473
Highest qualification	295	-0.01	0.901	-0.03	0.653
Prof & managerial	290	0.01	0.921	0.03	0.668
Intermediate	292	0.06	0.332	0.036	0.542
Routine & manual	292	-0.08	0.186	-0.08	0.168
Current employment	293	-0.11	0.064	-0.07	0.221

Ethnicity	292	0.01	0.929	0.01	0.836

A backwards entry regression analysis was performed using the demographic variables alone. Current employment was significantly negatively associated with fitness to dive in this model (B = -0.19) indicating that unemployment was significantly associated with being assessed as medically unfit to dive.

Final regression model produced using demographic variables:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model: Current employment	0.02	0.02	-0.19	0.08	-0.14	-2.39	0.018

Other primary factors affecting medical fitness to dive were considered to be diving experience, pre-existing health problems and tobacco use. Relationships with general health and tobacco use were investigated in detail.

Self-assessed general health

The 5-part health self-assessment tool is regarded as a reliable indicator of poor health. Diving fitness status at last medical and ever having been advised not to dive for health reasons were significantly correlated with self-assessed poorer health. Current diving fitness was negatively significantly correlated with poorer health.

Correlation matrix between fitness to dive status and general health:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Fitness at last medical	315	0.14	0.017	0.16	0.005
Ever not fit to dive	315	0.13	0.018	0.13	0.022
Ever had to limit diving	314	0.10	0.081	0.09	0.122
Currently fit to dive	615	-0.14	<0.001	-0.13	0.001

Tobacco use and fitness to dive status

There were no significant correlations between tobacco use and fitness to dive as per the most recent medical assessment.

Correlation matrix between fitness to dive status and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	315	-0.04	0.495	-0.03	0.562
Current cigar / pipe	315	0.07	0.239	0.09	0.133
Current cannabis	315	-0.01	0.857	-0.01	0.930
Cigarettes per day	52	0.14	0.330	0.18	0.215
Fagerstrom	53	-0.04	0.803	-0.03	0.634

There were no significant correlations between tobacco use and ever having been advised not to dive for health reasons.

Correlation matrix between not diving for health reasons and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	315	-0.03	0.616	-0.03	0.616
Current cigar / pipe	315	0.05	0.348	0.05	0.348
Current cannabis	315	0.08	0.173	0.08	0.173
Cigarettes per day	52	0.14	0.338	0.09	0.506
Fagerstrom	53	0.08	0.589	0.09	0.525

There were no significant correlations between tobacco use and ever having been advised to limit diving for health reasons.

Correlation matrix between limit diving for health reasons and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	314	-0.02	0.708	-0.02	0.708
Current cigar / pipe	314	0.04	0.433	0.04	0.433
Current cannabis	314	-0.06	0.302	-0.06	0.302
Cigarettes per day	52	0.14	0.330	0.16	0.273
Fagerstrom	53	0.21	0.126	0.21	0.131

There were no significant correlations between tobacco use and current fitness to dive.

Correlation matrix between current fitness to dive and tobacco use:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	615	0.07	0.079	0.07	0.079
Current cigar / pipe	614	-0.05	0.263	-0.05	0.263
Current cannabis	615	0.03	0.484	0.03	0.484
Cigarettes per day	107	-0.09	0.346	-0.11	0.277
Fagerstrom	106	-0.15	0.117	-0.14	0.154

Further investigations were carried out using groups of variables selected by statistical and theoretical considerations from Appendix 7, such as pre-existing health problems and diving experience, with fitness to dive status at last medical. Parametric and non-parametric correlations revealed the following significant associations:

Correlation matrix for fitness to dive status at last medical:

Independent variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
General health	315	0.14	0.017	0.16	0.005
Long-term illness	313	0.21	<0.001	0.26	<0.001
Rec. drugs 6 hrs diving	313	-0.12	0.038	-0.12	0.030
Dived below 40m	294	-0.14	0.018	-0.14	0.021
CMAS Level	297	-0.12	0.047	-0.12	0.044

Variables were selected for backwards entry into the regression analysis according to the model previously described in Section 6.2.2.

Block 1 – Demographics	Current employment
Block 2 – Diver health	General health, long-term illness, recreational drug use
Block 3 – Diving risk	Dived below 40m
Block 4 – Diving experience	CMAS Level
Block 5 – Tobacco variables	*Excluded for this analysis*

The final model increased the variance explained from demographic variables alone and pre-existing long-term illness (B = 0.17) was positively significantly associated with being assessed as medically unfit to dive.

Final model produced for fitness to dive (excluding tobacco variables):

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.09	0.08					
Long-term illness			0.17	0.04	0.22	3.83	<0.001
Current employment			-0.19	0.08	-0.14	-2.39	0.018
Dived below 40m			-0.07	0.03	-0.13	-2.25	0.025

Current employment (B = -0.19) and having dived below 40m using compressed air (B = -0.07) were negative predictors of being unfit to dive.

Effect of adding tobacco variables

The effects of the tobacco variables were examined in a hierarchical fashion by inserting the most correlated variables first and then subsequently adding or removing any variables of interest.

Block 1 – Demographics	Current employment
Block 2 – Diver health	General health, long-term illness, recreational drug use
Block 3 – Diving risk	Dived below 40m
Block 4 – Diving experience	CMAS Level
Block 5 – Tobacco use variables (tested separately then together)	Current cigarette Current cigar Current cannabis
Block 3 – Tobacco dependence variables	Number of cigarettes per day

(tested separately)	Fagerstrom

None of the tobacco use variables had an effect on the variance explained or the final model produced either separately or together.

The analysis was repeated adding the variable 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model and then run again, substituted by FTND score. The resultant models produced were very similar except that FTND score explained slightly less variance. Both variables produced an appreciable rise in variance explained from previous models although neither was significant.

<u>Final regression model produced with daily cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.68	0.67					
Long-term illness			0.68	0.07	0.82	9.26	<0.001
CMAS Level			-0.09	0.04	-0.17	-1.97	0.055

<u>Final regression model produced with FTND score substituted:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.65	0.64					
Long-term illness			0.67	0.07	0.82	9.33	<0.001
CMAS Level			-0.08	0.04	-0.17	-1.92	0.062

Pre-existing long-term illness remained the sole variable significantly associated with ever being assessed as medically unfit to dive.

6.4 Discussion

Over the period during which self-assessed health has been measured nationally using the 3-part assessment tool (1977-2007) the response percentages have remained largely unchanged (ONS, 2008),[16] however, the limits to which self-assessed health can be used as an indicator of well-being and future need for medical services are well known (Sturgis, 2001; Bajekal et al, 2006).

Self-assessed health is recognised as encompassing a range of factors affecting an individual's well-being at any point, with the response invoked likely to emphasise the positive rather than negative aspects of their health. There are also systematic variations in reporting amongst different social groups, for example, older people are more likely to report better levels of wellbeing for similar symptoms or illness to younger people and people with disabilities are more likely to rate their health as 'good' whilst discounting any limitations imposed by the disability (Kaplan and Baron-Epel, 2003).

Rates of reporting 'very good' and 'good' health decrease with age, whilst reporting of poorer health increases. Age-related subgroups place greater emphasis on different dimensions of health, for example older people value function highly, whereas younger people are more likely to emphasise fitness. Women, more educated respondents and adults of working age tend to emphasise the psycho-social aspects of well-being whilst females consistently report higher rates of 'fairly good' and 'not good' health than males. Nevertheless, despite responses encompassing a range of concepts, a self-assessment of 'poor' health is a powerful predictor of admission to hospital, disability and subsequent mortality (Idler and Benyamini, 1997; Burstrom and Fredlund, 2001).

Comparisons with the UK general population indicate that divers are more likely to report better health (using both assessment tools) and less likely to report poorer health. This might be expected given the significant

[16] In 2008, the 3-part assessment tool (good, fairly good, not good) was replaced with the 5-part tool (very good, good, fair, bad, very bad) to harmonise findings with that of other European countries (Dunstan, 2012). From 2005 to 2007 both questions were used in the GHS.

demographic differences between the two groups (the diving sample being younger and over-represented by males and Professional and Managerial workers); however, the occupational health gradient that exists in the general population is not replicated in the diving sample. Instead divers from Routine and Manual occupations share similar levels of health to those in Professional and Managerial occupations, although the significance of these findings cannot be verified without statistical analysis.

Both current cigarette and cigar or pipe smoking were significantly correlated with poorer self-reported health amongst divers. Cigarette smoking remained significantly associated with poorer health after controlling for demographic variables, raising the possibility that smoking-related ill health is aggravated by diving, although (as per lung function) the physiological effects may not yet be clinically or consistently measurable. No other tobacco variables were significantly associated with poorer health after accounting for demographics.

In contrast to the above findings, tobacco use had no bearing on whether divers were likely to be medically assessed as ‘fit to dive’. These findings might be explained by a number of factors. Firstly those who take up the sport are significantly younger than the general population and, even if current smokers, are unlikely to be experiencing tobacco-related health effects, which generally manifest at aged 35 and over (The Information Centre, 2011).

Secondly, in contrast to those who dive for work, recreational divers are not required to have diving medicals, which might indicate that divers who attend non-work related medicals already have concerns about their health or a pre-existing health condition. Potential divers are issued a medical checklist at entry-level training to help them identify any health complications that might affect their safety and are encouraged to seek a medical assessment from a diving physician if they need further advice. The self-assessment policy appears to be at least partially effective as attending non-work related medicals was significantly correlated with self-assessed poorer health ($p = 0.006$) in this study.

At medical examination, 8% of those ever having a work-related assessment had health-related restrictions placed on their diving compared to 12% of those undertaking non-work related assessments, although these differences were not significant ($X_2 = 1.78$; DF = 1; $p = 0.255$) and the only variable significantly associated with medically-advised diving restrictions was the presence of a long-term illness ($p<0.001$).

CHAPTER 7 - WHETHER UK RECREATIONAL SCUBA DIVERS WHO SMOKE, OR HAVE A HIGHER CIGARETTE CONSUMPTION, ARE MORE LIKELY TO EXPERIENCE ANY TYPE OF DIVING-RELATED HEALTH INCIDENT THAN NON-SMOKER DIVERS

7.1 Introduction

This chapter explores relationships between tobacco use and the frequency of diving-related illness. In this study diving-related illness refers to any injury or illness occurring during, or as a result of, the practice of SCUBA diving, and is not limited to injuries incurred by breathing compressed gases underwater.

7.2 Methods

7.2.1 Overall approach

A comprehensive list of the principal injuries likely to occur in recreational diving was drawn up and finalised during the piloting phase of the questionnaire (see section 3.3.2 for more details). The survey tool collected information about the frequency, severity and duration of specific dive-related illnesses (Appendix 5, Qs 35-121) and also contained an open response ‘any other illness or injury’ item designed to capture any unforeseen health-related events (Appendix 5, Q122).

Responses to the question ‘have you ever had any other illness or injury from sub-aqua diving activities?’ were either assigned to another category of illness (for example, ear damage) or included in the ‘any other illness category’.

Two sum variables were created to capture the total frequency and severity of diving-related illness experienced per diver. Total number of episodes of illness was created by adding up the number of episodes of each illness per case. Total severity of illness was determined by the number of days reported absent from work, or everyday activities, per case.

Univariate, bivariate and multivariate analyses were carried out (wherever possible) for each specific diving-related illness and the two sum variables. The findings are reported per dependent variable together with a summary of the specific aetiology of each diving-related illness and a brief description of the likely interaction with tobacco smoking.

7.2.2 Overview of analysis procedures

The same exploratory approach (described below) was adopted for all analyses, unless stated otherwise.

Relationships between independent and outcome variables

Prevalence and frequency distributions were determined per specific diving illness and the sum variables. Where binary variables were utilised, ‘No’ and ‘Not sure’ responses were combined to form one category (coded ‘0’) and ‘Yes’ responses were coded as ‘1’.

Each diving illness variable was investigated for relationships with tobacco consumption and the independent variables identified in Appendix 7 using statistical and theoretical considerations. Relevant medical information to assist the choice of variables used in the analyses was obtained from literature reviews and seminal texts on hyperbaric medicine (Edmonds et al, 2002; Edmonds, Lowry and Pennefather, 1992).

Parametric and non-parametric correlations were carried out to asses the relationships between independent predictor and diving-related illness variables. Where any appreciable discrepancies occurred between test results, scatterplot diagrams were used to examine for outliers.

The primary route for inclusion into any regression analyses was a significant correlation between the predictor and the dependent variable (where p =<0.050); however, theoretical considerations, such as known aetiological factors, were taken into account when deciding which variables to select and also in determining the order of entry of variables.

Independent variables that were known, or strongly suspected, to have a link with a particular diving illness were included if p=<0.10 and a brief explanation of the rationale for inclusion provided.

Relationships between independent predictor variables:

Additional correlations were conducted to examine the relationships between independent predictor variables. Where predictor variables were significantly associated at the level of p=<0.05, then principal components analysis was used to help identify variables for inclusion in the analysis.

The final models produced from using variables selected by principal components analysis were compared to those produced by including all significantly correlated variables in the analysis, so that the 'model of best fit' could be chosen.

Deciding which regression approach to adopt & the 'model of best fit'

Logistic regression, using Wald's backward elimination model, was used to investigate binary outcome variables, such as having a history of a particular illness. Multiple linear regression was used to investigate the frequency of occurrence of illness.

During the exploratory analyses, many different regression techniques (including simultaneous, forwards and stepwise entry of variables) were employed to determine how to produce the 'model of best fit'.

The exploration led to the final model being decided by a combination of theoretical considerations and comparing R-Square and Adjusted R-Square figures, where the most variance was explained by the fewest variables and statistically verified by the closest R-square and Adjusted R-square values.

The most effective approach was determined to be a hierarchical backwards elimination technique with frequency of illness as the numeric dependent variable and predictor variables being added in blocks in the following order:

Block 1 – Demographics: Example variables: gender, age, highest qualification, never married
Block 2 – Health prior to diving: Example variables: general health, short-term illness, ear or sinus problem
Block 3 – Attitudes to everyday risk: Example variables: smoke alarm, seat belt, National Lottery
Block 4 – Attitudes to diving risk: Example variables: missed safety stop, risks for fun, deepest dive on air
Block 5 – Diving experience: Example variables: CMAS, overhead diving, dived for work
Block 6 – Tobacco smoking: Example variables: Current cigarette smoking, current cannabis smoking
Block 7 – Tobacco dependence: Variables: Number of cigarettes per day, FTND score

Only the ‘model of best fit’ is included in the results, except where relevant information can be obtained from additional analyses, such as logistic regression or alternative linear regression models.

7.3 Results

7.3.1 Descriptive analyses

Table 7.1 illustrates the overall prevalence rates for self-reported dive-related illness or injury. Marine life injuries (40%) followed by panic attacks (25%) and infections (23%) were the most commonly reported dive-related injuries.

Some of the most serious injuries that can occur in diving such as suspected cardiac problems, loss of consciousness and dysbaric osteonecrosis were reported, but occurred in only one or two cases and therefore do not generally feature in the results.

Table 7.1:Self-reported experience of diving-related illness in descending order of prevalence by gender

Diving-related illness or injury	% male [N]	% female [N]	% total [N]
Marine life injuries	37 [152]	47 [83]	40 [235]
Panic attack	22 [89]	33 [59]	25 [148]
Infection	23 [92]	24 [42]	23 [134]
Musculoskeletal	13 [52]	18 [32]	14 [84]
Dehydration	13 [54]	10 [18]	12 [72]
Dysbaric ear damage	10 [39]	9 [15]	10 [64]
Dysbaric sinus damage	4 [17]	6 [11]	5 [28]
Hypothermia	4 [17]	3 [6]	4 [23]
Any other illness	2 [9]	2 [4]	2 [13]
Decompression illness	2 [7]	2 [4]	3 [11]
Nervous system effects	0 [0]	3 [6]	1 [6]
Hyperthermia	1 [3]	0 [0]	1 [3]
Lung problems	0 [1]	1 [1]	0 [2]
Cardiac problems	0 [1]	0 [0]	0 [1]
Dysbaric bone disease	0 [1]	0 [0]	0 [1]
Loss of consciousness	0 [1]	0 [0]	0 [1]

Females were significantly more likely to report nervous system effects ($X_2 = 13.91$; DF = 1; $p = 0.001$), marine life injuries ($X_2 = 4.68$; DF = 1; $p = 0.035$) and panic attacks ($X_2 = 8.57$; DF = 1; $p = 0.005$).

Examination of the ‘any other illness or injury’ category revealed three cases that were reassigned to ‘decompression sickness’, three cases that were reassigned as ‘musculoskeletal problems, three cases that were reassigned as 'dysbaric ear damage', two cases that were reassigned as 'dysbaric sinus damage' and one case reassigned to 'infection'. The remainder of cases were grouped as follows:

Distribution of non-reassigned responses to 'any other illness':

Any other illness:	% [N]	Frequency distribution	Central tendency
Cuts & grazes	1 [8]	Unimodal	Median = 1.00
Motion sickness	0 [3]	Unimodal	Median = 1.00
Dental barotrauma	0 [1]	Unimodal	Median = 1.00
Sunburn	0 [1]	Unimodal	Median = 1.00

Table 7.2 summarises the frequency experience of each diving illness.

Table 7.2: Summary of frequency experience of diving-related illness

Diving-related illness	N	Total no. of episodes	Average no. of episodes per case	Dispersion measures
Lung problems	2	2	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00
Decompression illness	15	16	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00
Nervous system effects	6	12	Median = 1.00	25th percentile = 1.00 75th percentile = 3.00
Dysbaric bone disease	1	1	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00
Musculoskeletal	90	312	Median = 2.00	25th percentile = 1.00 75th percentile = 4.00
Dysbaric ear damage	63	111	Median = 1.00	25th percentile = 1.00 75th percentile = 2.00
Dysbaric sinus damage	28	78	Median = 1.00	25th percentile = 1.00 75th percentile = 3.25
Infection	146	309	Median = 2.00	25th percentile = 1.00 75th percentile = 2.00
Marine life injuries	252	600	Median = 2.00	25th percentile = 1.00 75th percentile = 2.00
Dehydration	78	226	Median = 2.00	25th percentile = 1.00 75th percentile = 3.00
Hypothermia	23	48	Median = 2.00	25th percentile = 1.00 75th percentile = 3.00

Hyperthermia	3	5	Median = 1.00	25th percentile = 1.00
Panic attack	159	234	Median = 1.00	25th percentile = 1.00 75th percentile = 2.00
Loss of consciousness	1	1	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00
Cardiac problems	1	1	Median = 1.00	25th percentile = 1.00 75th percentile = 1.00
Any other illness	13	24	Median = 1.00	25th percentile = 1.00 75th percentile = 2.50

Table 7.3 summarises the frequency distribution of the specific diving illnesses and the sum variable 'total number of episodes of illness'.

<u>Table 7.3: Summary of frequency distribution of diving-related illness</u>

Diving-related illness	N	Total no. of episodes	Average no. of episodes per diver	Dispersion measures
Lung problems	647	2	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Decompression illness	645	16	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Nervous system effects	640	12	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Dysbaric bone disease	641	1	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Musculoskeletal	636	312	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Dysbaric ear damage	633	111	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Dysbaric sinus damage	633	78	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Infection	630	311	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Marine life injuries	628	600	Median = 0.00	25th percentile = 0.00 75th percentile = 1.00
Dehydration	625	226	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00
Hypothermia	628	48	Median = 0.00	25th percentile = 0.00 75th percentile = 0.00

Hyperthermia	628	5	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Panic attack	628	234	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 1.00
Loss of consciousness	627	1	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Cardiac problems	626	1	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Any other illness	625	24	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Total number of episodes of illness	654	1983	Median = 2.00	25^{th} percentile = 0.00 75^{th} percentile = 4.00

Table 7.4 summarises the frequency distribution of the severity of each diving illness and the sum variable 'total severity of illness'. Severity of illness was measured by the number of days reported as being taken off work or everyday activities due to the diving-related illness.

Table 7.4: Summary of distribution of severity of diving-related illness

Diving-related illness	% taking time off work [n]	Total no. of days off work	Average no. of days off work	Dispersion measures
Lung problems	0 [0]	0	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Decompression illness	67 [12]	427	Median = 14.00	25^{th} percentile = 1.25 75^{th} percentile = 55.5
Nervous system effects	20 [2]	61	Median = 30.50	25^{th} percentile = 1.00
Dysbaric bone disease	0 [0]	0	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00
Musculoskeletal	10 [10]	243.2	Median = 17.50	25^{th} percentile = 2.50 75^{th} percentile = 57.00
Dysbaric ear damage	30 [27]	390	Median = 5.00	25^{th} percentile = 2.00 75^{th} percentile = 11.00
Dysbaric sinus damage	22 [11]	44.6	Median = 3.00	25^{th} percentile = 0.88 75^{th} percentile = 7.75
Infection	38 [65]	607.3	Median = 6.00	25^{th} percentile = 2.00 75^{th} percentile = 14.00

Marine life injuries	2 [4]	21	Median = 3.00	25^{th} percentile = 1.25 75^{th} percentile = 11.50
Dehydration	10 [10]	17.8	Median = 1.00	25^{th} percentile = 0.75 75^{th} percentile = 3.00
Hypothermia	3 [1]	0.2	Median = 0.20	25^{th} percentile = 0.20 75^{th} percentile = 0.20
Hyperthermia	20 [1]	3	Median = 3.00	25^{th} percentile = 3.00 75^{th} percentile = 3.00
Panic attack	4 [6]	10.5	Median = 1.50	25^{th} percentile = 0.63 75^{th} percentile = 5.75
Loss of consciousness	50 [1]	1	Median = 1.00	25^{th} percentile = 1.00 75^{th} percentile = 1.00
Cardiac problems	20 [1]	14	Median = 14.00	25^{th} percentile = 14.00 75^{th} percentile = 14.00
Any other illness	14 [2]	28	Median = 14.00	25^{th} percentile = 14.00 75^{th} percentile = 14.00
Total severity of illness	11 [112]	1868.6	Median = 5.00	25^{th} percentile = 2.00 75^{th} percentile = 16.75

7.3.2 Multivariate analyses

The relationships between each of the diving-related illnesses and the two sum variables were examined separately with each of the main tobacco variables. The daily consumption levels of cannabis and cigars or pipes contained too few cases for further analyses to be conducted and are not included in the results.

All bivariate analyses were examined for evidence of linear and non-linear relationships using the appropriate statistical tests and graphical inspection before entry into the regression analyses, as previously described. Any unexpected or relevant findings are reported below the test results per specific diving illness.

Due to the relationship between tobacco dependence and diving-related illness being a central aim of the study, each regression analysis was repeated adding the variables ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression model.

Although numerous approaches, including principal components analysis, were employed during the regression analyses, only the final ‘model of best fit’ is presented per dependent variable, unless alternative models provide additional relevant information.

The most salient findings are reported below.

7.3.2.1 Lung problems

Aetiological summary

Predisposing pathology includes local pathophysiology for gas trapping and airways obstruction, such as asthma, pleural adhesions, previous spontaneous pneumothorax, intrapulmonary fibrosis, infection and inflammation. Precipitating factors include inadequate air exhalation during ascent caused by panic, faulty apparatus or water inhalation (p56, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Tobacco smokers are more likely to show evidence of airway hyper-responsiveness, increased mucous production, upper and lower respiratory tract infections and chronic airway disease which would predispose them to ‘burst lung’ and therefore air embolism (p451-2, Edmonds et al, 2002).

Main findings from analyses

Correlations of history of lung problems with tobacco variables:

Lung history	N	Pearson (r)	*p*	Spearman (rho)	*p*

Current cigarette	647	-0.03	0.520	-0.03	0.520
Current cigar or pipe	646	-0.02	0.706	-0.02	0.706
Current cannabis	647	-0.02	0.676	-0.02	0.676
Cigarettes per day	110	n/a	n/a	n/a	n/a
FTND score	109	n/a	n/a	n/a	n/a

n/a - signifies that not enough cases existed for analysis

No significant associations were found.

<u>Correlations of frequency of lung problems with tobacco variables:</u>

Lung frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	647	-0.03	0.520	-0.03	0.520
Current cigar or pipe	646	-0.02	0.706	-0.02	0.706
Current cannabis	647	-0.02	0.676	-0.02	0.676
Cigarettes per day	110	n/a	n/a	n/a	n/a
FTND score	109	n/a	n/a	n/a	n/a

n/a - signifies that not enough cases existed for analysis

No significant associations were found.

<u>Predictor variables significantly correlated with frequency lung problems:</u>

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Panic attack	624	0.10	0.014	0.10	0.014
Travel insurance	581	0.10	0.014	0.10	0.014
Fruit machine	577	0.13	0.002	0.13	0.002

Ever having had a panic attack, not normally purchasing travel insurance and playing fruit machines at least once a month were all positively significantly correlated with frequency of lung problems.

The frequency of panic attacks was also positively significantly correlated with the frequency of lung problems, but not as strongly as ever having had a panic attack.

<u>Correlation matrix of panic attack and lung problem frequencies:</u>

	N	Pearson (r)	*p*	Spearman (rho)	*p*

Freq. panic attack; Freq. lung problems	628	0.08	0.037	0.10	0.011

Predictor variables with known influence and borderline significance at p=<0.100:

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Missed safety stop	580	0.08	0.065	0.08	0.065

Missing a safety stop was of interest to the analysis because breath-holding and rapid ascent to the surface (without performing a safety stop) is a predisposing factor for burst lung. Panic is one of the main causes of sudden or rapid ascent and ever having a panic attack was significantly positively correlated with ever having missed a safety stop in this study.

Correlation matrix of history of panic attack and missed safety stop:

	N	Pearson (r)	*p*	Spearman (rho)	*p*
Panic attack; Missed safety stop	584	0.11	0.008	0.11	0.008

A regression analysis using the methods previously described was conducted to examine the influence of 'missed safety stop' on the frequency of lung problems.

Block 1 – Demographics	N/A
Block 2 – Diver health	Panic attack
Block 3 – Everyday risk	Travel insurance, fruit machine
Block 4 – Diving risk	N/A
Block 5 – Diving experience	N/A
Block 6 – Tobacco smoking	N/A
TEST VARIABLE:	Missed safety stop

Without missed safety stop, the following final model was produced:

Final model for frequency of lung problems without missed safety stop:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.04	0.03					
Fruit machine			0.04	0.01	0.13	3.17	0.002
Panic attack			0.02	0.01	0.11	2.61	0.009
Travel insurance			0.02	0.01	0.09	2.28	0.023

Playing fruit machines at least once a month (B = 0.04), experiencing a panic attack (B = 0.02) and not having travel insurance (B = 0.02) were all positively significantly associated with lung problems.

Including missed safety stop, the following final model was produced:

Final model for frequency of lung problems with missed safety stop:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.04	0.04					
Fruit machine			0.04	0.01	0.13	3.10	0.002
Panic attack			0.01	0.01	0.10	2.43	0.016
Travel insurance			0.02	0.01	0.10	2.40	0.017
Missed safety stop			0.01	0.01	0.07	1.68	0.093

A slight improvement to the model of best fit (with a small increase in Adjusted R-Square) was achieved by adding missed safety stop into the analysis, although the variable itself was not significant.

No further analyses could be carried out with cigarette consumption because of a lack of cases available who smoked.

7.3.2.2 Decompression illness

Aetiological summary

Predisposing pathology includes increasing age, low physical fitness and overweight / obesity. Precipitating factors include exercise at depth, mild hypothermia during a dive, rapid heat gain soon after a dive, dehydration, increased carbon dioxide retention, presence of alcohol, physical injury, diving to greater depths, undertaking dives with long decompression requirements, repetitive diving, diving at altitude and the use of mixed gases whilst diving (p137-140, Edmonds et al, 2002).

Possible interaction with tobacco smoking

The medical diving community strongly suspects a link between tobacco smoking and decompression illness although no causal link has been demonstrated (p451-2, Edmonds et al, 2002). There is evidence that smoking may increase the severity of DCI symptoms where they occur (Buch et al, 2003).

Main findings from analyses

Correlations of history of decompression illness with tobacco variables:

DCI history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	646	-0.02	0.595	-0.02	0.595
Current cigar or pipe	645	0.04	0.362	0.04	0.362
Current cannabis	646	0.03	0.508	0.03	0.508
Cigarettes per day	112	0.05	0.600	0.07	0.495
FTND score	111	0.13	0.191	0.14	0.151

No significant associations were found.

Correlations of frequency of decompression illness with tobacco variables:

DCI frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	645	-0.02	0.615	-0.02	0.665
Current cigar or pipe	644	0.03	0.392	0.04	0.315
Current cannabis	645	0.02	0.535	0.03	0.451

Cigarettes per day	112	0.05	0.600	0.07	0.495
FTND score	111	0.13	0.191	0.14	0.151

No significant associations were found.

<u>Predictor variables significantly correlated with DCI frequency:</u>

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Short-term illness	618	0.09	0.026	0.09	0.035
Travel insurance	584	0.11	0.006	0.11	0.006
Overhead diving	585	0.09	0.027	0.09	0.027
Risks for fun	580	0.21	<0.001	0.21	<0.001
Deepest dive on air	581	0.13	0.001	0.10	0.013
Number years dived	583	0.12	0.004	0.10	0.019
Total number of dives	584	0.46	<0.001	0.12	0.005
CMAS	585	0.16	<0.001	0.15	<0.001
Ever dived for work	585	0.10	0.017	0.10	0.017
No. mixed gas dives	219	0.30	<0.001	0.19	0.004
Ever worked outside UK	575	0.10	0.014	0.10	0.014

Ever having a short-term illness, not taking out travel insurance, ever having dived in overhead environments, taking risks for fun whilst diving, diving more deeply, diving for a greater total number of years, having a greater total number of dives, being qualified to at least CMAS Level 3, ever having dived for work, having carried out a greater number of mixed gas dives and ever having worked outside the UK were all positively significantly correlated with the frequency of decompression illness.

Principal components analysis was used to try and reduce the number of variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded two factors: Diving experience (explaining 31% of variance) and Risky diving (explaining 21% of variance) as per the matrix below:

<u>Orthogonal factor loading matrix for decompression illness:</u>

Predictor variable	Factor 1 – Diving experience	Factor 2 – Risky diving
Total number of dives	0.87	0.14
Number of years dived	0.74	-0.08
Total mixed gas dives	0.69	0.16
Deepest dive on air	0.61	0.46
Worked outside UK	0.59	0.29
Risks for fun	-0.14	0.69
CMAS	0.27	0.69
Ever dived for work	0.42	0.65
Overhead diving	0.10	0.43

A regression analysis was carried out selecting ‘total number of dives’ for Factor 1 and ‘risks for fun’ as Factor 2; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	N/A
Block 2 – Diver health	Short-term illness
Block 3 – Everyday risk	Travel insurance
Block 4 – Diving risk	Risks for fun, overhead diving, deepest dive on air
Block 5 – Diving experience	Total number of dives, number of years dived, CMAS, ever dived for work, ever worked outside UK, total number mixed gas dives
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for frequency of decompression illness:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.06	0.05					
Total number dives			<0.01	<0.01	0.24	3.48	0.001

Total number of dives (*B* <0.01) was positively significantly associated with decompression illness in this model.

Daily cigarette consumption

The analysis was then repeated adding ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression model:

<u>Final model for frequency of decompression illness with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	B	Stand. error B	Standrsd. Beta coefficient	t	p
Final model:	0.85	0.80					
Worked outside UK			0.96	0.13	1.98	7.68	<0.001
Total number dives			-<0.01	<0.01	-0.93	-4.13	0.001
Travel insurance			-0.42	0.11	-0.42	-3.85	0.001
Short-term illness			0.18	0.04	0.46	4.46	<0.001
Total no. mxd gas			-<0.01	<0.01	-0.90	-6.39	<0.001
Risks for fun			0.23	0.05	0.38	4.24	<0.001
Cigarettes per day			-0.01	<0.01	-0.23	-2.45	0.023

Having worked in the diving industry outside of the UK (B = 0.96), diving with a pre-existing short-term illness (B = 0.18) and taking risks for fun (B = 0.23) were all positively significantly associated with the frequency of decompression illness in this model.

The greater the number of dives undertaken (B -<0.01), not having travel insurance (B = -0.42), the greater the number of mixed gas dives performed (B = -<0.01) and the greater the number of cigarettes smoked per day (B = -0.01) were all negatively significantly associated with the frequency of decompression illness in this model.

Adding ‘number of cigarettes’ to the analysis resulted in a marked rise in the variance explained and interacted with other predictor variables to produce a more complex ‘model of best fit’ to previously. The variable itself was negatively significantly associated with the frequency of decompression illness in this model.

Further investigation of the relationships between daily cigarette consumption and other variables relevant to the analysis was undertaken.

Correlations between 'number of cigarettes per day' and likely correlates of frequency of decompression illness:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
CMAS level	101	0.33	0.001	0.28	0.005
Ever dived mixed gases	101	0.20	0.044	0.21	0.038
Total no. dives	101	0.12	0.222	0.27	0.006
Ever dived for work	101	0.18	0.075	0.13	0.191
Deepest dive on air	100	0.18	0.071	0.12	0.224
Number of years dived	101	0.17	0.083	0.17	0.096
Short-term illness	107	0.12	0.219	0.12	0.205
Ever worked outside UK	99	0.10	0.321	0.10	0.323
Overhead diving	101	0.07	0.511	0.07	0.492
Risks for fun	100	0.07	0.505	0.08	0.408
Number mixed gas dives	29	-0.08	0.672	0.12	0.544
Travel insurance	101	-0.08	0.453	-0.07	0.521

CMAS Level 3 and 'ever having dived with mixed gases' were positively significantly correlated with daily cigarette consumption. There was a significant non-linear correlation with total number of dives.

Independent variable	N	Mean cigarettes per day	SD	*t*	*DF*	*p*
CMAS Level 2 CMAS Level 3	90 11	11.09 19.87	7.77 9.38	-3.46	99	0.001
Never mixed gas Ever mixed gas use	71 30	10.96 14.62	8.25 8.23	-2.04	99	0.044

Not having travel insurance and the total number of mixed gas dives were negatively correlated with daily cigarette consumption; however, these relationships were not significant.

The regression analysis was run again, substituting ‘ever used mixed gases’ for ‘total number of mixed gas dives’. The final model is reproduced below:

Final model for frequency of decompression illness with cigarette consumption and ever used mixed gases:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.28	0.26					
Risks for fun			0.18	0.04	0.38	4.22	<0.001
Travel insurance			0.12	0.05	0.22	2.50	0.014
Deepest dive on air			<0.01	<0.01	0.22	2.44	0.017

Taking risks for fun (B = 0.18), not having travel insurance (B = 0.12) and diving more deeply using compressed air (B <0.01) were all positively significantly associated with the frequency of decompression illness in this model.

The variance explained was much lower than that explained by using ‘total number of mixed gases’, however, the predictors identified were a better theoretical fit with the known aetiological factors for decompression illness. Daily cigarette consumption was not significantly associated with the frequency of decompression illness in this model.

7.3.2.3 Nervous system effects

Aetiological summary

There are a number of factors inherent to diving, especially the combination of high pressure environments and the sensitivity of the nervous system to ischaemia, that predispose all divers to clinical neurological effects under various conditions (p409, Edmonds et al, 2002).

Possible interaction with tobacco smoking

A combination of reduced pulmonary and cardiovascular function, especially with physical exertion at depth, is expected to increase the likelihood of tissue hypoxia in smokers, thereby predisposing them to neurological sequelae from diving (p451-2, Edmonds et al, 2002). No evidence exists to confirm or refute this effect although there is some evidence that neurological symptoms from DCI are more common in smokers (Wilmshurst et al, 1994).

Main findings from analyses

Correlations of history of nervous effects with tobacco variables:

Nervous history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	640	-0.03	0.402	-0.05	0.255
Current cigar or pipe	639	-0.02	0.623	-0.03	0.504
Current cannabis	640	-0.02	0.594	-0.03	0.470
Cigarettes per day	112	n/a	n/a	n/a	n/a
FTND score	111	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant associations were found.

Correlations of frequency of nervous effects with tobacco variables:

Nervous frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	640	-0.03	0.402	-0.05	0.255
Current cigar or pipe	639	-0.02	0.623	-0.03	0.504
Current cannabis	640	-0.02	0.594	-0.03	0.470
Cigarettes per day	112	n/a	n/a	n/a	n/a
FTND score	111	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant associations were found.

Predictor variables significantly correlated with frequency nervous effects:

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*

Gender	583	0.11	0.006	0.15	<0.001

No other potential predictors were significantly correlated with the dependent variable and no further analyses with cigarette consumption could be carried out due to a lack of cases available.

A regression analysis was carried out using gender as the only predictor. The final model is presented below.

<u>Final model for frequency of nervous system effects:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.01	0.01					
Gender			0.07	0.03	0.11	2.76	0.006

Being female (*B* = 0.07) is positively significantly associated with reporting nervous system effects in this study.

7.3.2.4 Dysbaric bone disease

Aetiological summary

Dysbaric osteonecrosis is characterised by (aseptic) infarction of areas of bone from exposure to high pressures of air or water. It is observed principally in commercial divers and submariners. Cases in recreational divers are extremely rare (p167-9, Edmonds et al, 2002).

Possible interaction with tobacco smoking

There is some evidence that cigarette smoking is positively associated with the development of osteonecrosis (Hirota et al, 1993) although the link between dysbaric osteonecrosis and smoking has not been investigated. It is possible that the increased risk of ischaemia in smokers could be a contributory factor (p451-2, Edmonds et al, 2002).

Main findings from analyses

Correlations of history of dysbaric bone disease and tobacco variables:

Bone disease history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	641	-0.02	0.644	-0.02	0.644
Current cigar or pipe	640	-0.01	0.786	-0.01	0.786
Current cannabis	641	-0.01	0.769	-0.01	0.769
Cigarettes per day	112	n/a	n/a	n/a	n/a
FTND score	111	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant associations were found.

Correlations of frequency of dysbaric bone disease and tobacco variables:

Bone disease freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	641	-0.02	0.644	-0.02	0.644
Current cigar or pipe	640	-0.01	0.786	-0.01	0.786
Current cannabis	641	-0.01	0.769	-0.01	0.769
Cigarettes per day	112	n/a	n/a	n/a	n/a
FTND score	111	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant variables were identified either from tobacco or from any other potential predictors, therefore no further analyses were carried out.

7.3.2.5 Musculoskeletal problems

Aetiological summary

Musculoskeletal problems are a common complaint amongst recreational and commercial divers. Muscle spasms occur frequently underwater with ill-fitting equipment or exertion. Cramps principally occur in the calves, feet, thighs, abdomen and upper body and can result in temporary severe pain and disability (p435-437, Edmonds et al, 2002).

Possible interaction with tobacco smoking

There is some evidence that cigarette smoking is positively associated with the development of musculoskeletal problems (Palmer et al, 2003) although this has not been investigated in divers. It is possible that the greater risk of ischaemia in smokers could be a contributory factor to increased reports of pain at peripheral sites (p451-2, Edmonds et al, 2002) and could also result in cramp.

Main findings from the analyses

Correlations of history of musculoskeletal injuries with tobacco variables:

Muscloskeletal history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	636	-0.04	0.328	-0.04	0.328
Current cigar or pipe	635	-0.06	0.135	-0.06	0.135
Current cannabis	636	-0.09	0.026	-0.09	0.026
Cigarettes per day	112	<0.01	0.987	<0.01	0.982
FTND score	111	-0.02	0.832	-0.04	0.669

Current cannabis use was negatively significantly correlated with the occurrence of musculoskeletal injuries.

Correlations of musculoskeletal frequency with tobacco variables:

Muscloskeletal freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	636	-0.06	0.141	-0.04	0.345
Current cigar or pipe	635	0.01	0.908	-0.05	0.179
Current cannabis	636	-0.05	0.209	-0.08	0.034
Cigarettes per day	112	0.08	0.421	0.01	0.893
FTND score	111	0.03	0.783	-0.03	0.742

There was a non-linear significant negative association between current cannabis smoking and the frequency of musculoskeletal problems reported.

<u>Predictor variables significantly correlated with musculoskeletal frequency:</u>

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	583	-0.13	0.002	-0.19	0.001
Never married	583	-0.07	0.078	-0.12	0.003
Highest qualification	583	0.09	0.033	0.13	0.002
Prof. & managerial	572	-0.09	0.003	-0.11	0.007
Short-term illness	618	0.15	<0.001	0.17	<0.001
National Lottery	578	-0.09	0.039	-0.14	0.001
Overhead diving	585	0.13	0.002	0.13	0.001
Missed safety stop	583	0.09	0.024	0.04	0.031
Risks for fun	580	0.13	0.002	0.10	0.016
Dived below 40m	581	0.10	0.014	0.12	0.004
Deepest dive on air	581	0.09	0.030	0.16	<0.001
CMAS	585	0.12	0.005	0.13	0.002
Dived for work	585	0.15	<0.001	0.16	<0.001
Ever worked outside UK	575	0.16	<0.001	0.15	<0.001

Being qualified to at least degree-level, ever having dived with a short-term illness, ever having dived in overhead environments, ever having missed a safety stop, taking risks for fun whilst diving, ever having dived below 40m using compressed air, diving more deeply, being qualified to CMAS Level 3 or above and ever having dived for work were all positively significantly correlated with the frequency of musculoskeletal problems.

Being older, never having married, being a Professional or Managerial worker and playing the National Lottery at least once a month were negatively significantly correlated with musculoskeletal problems.

Principal components analysis was used to try and reduce the number of variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded two factors: Diving for work (29% of variance) and Risky diving (24% of variance) as per the matrix below:

Orthogonal factor loading matrix for musculoskeletal problems:

Predictor variables	Factor 1 – Diving for work	Factor 2 – Risky diving
Ever dived for work	0.82	0.22
Worked outside UK	0.74	0.04
CMAS	0.74	0.18
Deepest dive on air	0.49	0.71
Dived below 40m	0.42	0.67
Overhead diving	0.16	0.67
Missed safety stop	-0.33	0.54
Risks for fun	0.07	0.37

A regression analysis was carried out selecting ‘ever dived for work’ for Factor 1 and ‘deepest dive on air’ as Factor 2; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Age, never married, highest qualification, professional & managerial
Block 2 – Diver health	Short-term illness
Block 3 – Everyday risk	National Lottery
Block 4 – Diving risk	Overhead diving, missed safety stop, risks for fun, dived below 40m, deepest dive on air
Block 5 – Diving experience	Ever dived for work, CMAS, worked outside UK
Block 6 – Tobacco smoking	Current cannabis smoker

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for musculoskeletal frequency:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*

Final model:	0.08	0.07					
Worked outside UK			0.97	0.30	0.14	3.28	0.001
Risks for fun			0.78	0.33	0.10	2.29	0.022
Age			-0.02	0.01	-0.09	-2.24	0.026
Prof. & managerial			0.46	0.21	0.09	2.21	0.027
Overhead diving			0.36	0.17	0.09	2.09	0.037
Missed safety stop			0.47	0.27	0.07	1.76	0.079

Having worked in the dive industry outside of the UK (*B* = 0.97), taking risks for fun whilst diving (*B* = 0.78), having a professional or managerial occupation (*B* = 0.46) and having dived in overhead environments (*B* = 0.36) were positively significantly associated with having experienced musculoskeletal problems in this model. Age (B = -0.02) was negatively significantly associated with musculoskeletal problems.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included:

<u>Final model for musculoskeletal frequency with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.12	0.09					
Risks for fun			0.66	0.27	0.25	2.48	0.015
Dived for work			0.42	0.20	0.21	2.15	0.034
Missed safety stop			-0.44	0.26	-0.17	-1.72	0.089

Taking risks for fun (*B* = 0.66) and diving for work (B = 0.42) were positively significantly associated with having experienced musculoskeletal problems in this model.

Adding ‘number of cigarettes’ to the analysis resulted in a small rise in the variance explained, but the variable itself was not significant.

7.3.2.6 Dysbaric ear damage

Aetiological summary

Predisposing pathology includes any condition which tends to block the eustachian tube, especially morphological factors such as mucosal polyps, and local inflammation produced by upper respiratory tract infections and allergies (p75-76, Edmonds et al, 2002). Precipitating factors include failure to voluntarily equalise the pressure in the middle ear sufficiently on descent or ascent, alcohol ingestion, tobacco or marijuana smoking, certain drugs (such as beta-blockers, cocaine and parasympathomimetics).

Possible interaction with tobacco smoking

The increased risk of upper respiratory tract infections and mucosal congestion in the nasopharyngeal region of smokers is thought to predispose them to a greater risk of ear damage whilst diving (p451-2, Edmonds et al, 2002).

Main findings from analyses

<u>Correlations between history of ear damage and tobacco variables:</u>

Ear damage history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	633	0.05	0.200	0.04	0.376
Current cigar or pipe	631	0.04	0.316	0.01	0.718
Current cannabis	632	<0.01	0.993	-<0.01	0.940
Cigarettes per day	112	0.01	0.955	-<0.01	0.972
FTND score	111	0.06	0.513	-0.03	0.771

No significant associations were found.

Correlations between frequency of ear damage and tobacco variables:

Ear damage frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	633	0.05	0.200	0.04	0.329
Current cigar or pipe	631	0.04	0.316	0.01	0.784
Current cannabis	632	<0.01	0.993	<0.01	0.966
Cigarettes per day	112	0.10	0.320	<0.01	0.982
FTND score	111	0.06	0.513	-0.02	0.845

No significant associations were found.

Predictor variables significantly correlated with frequency of ear damage:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	583	-0.13	0.002	-0.19	0.001
Short-term illness	617	0.12	0.003	0.13	0.001
Solo diving	583	0.11	0.007	0.09	0.024
Overhead diving	584	0.10	0.014	0.104	0.012
Dived below 40m	581	0.12	0.005	0.10	0.012
Deepest dive on air	581	0.15	<0.001	0.10	0.020
Number of dives	583	0.11	0.007	0.07	0.110
CMAS	584	0.11	0.008	0.08	0.042
Dived for work	584	0.13	0.002	0.11	0.009
Mixed gas diving	584	0.10	0.016	0.08	0.059
Worked outside UK	574	0.16	<0.001	0.10	0.017

Ever having dived with a short-term illness, ever having dived solo, ever having dived in overhead environments, diving below 40m on compressed air, diving more deeply, having a greater total number of dives, being qualified to CMAS Level 3 or above, diving for work, mixed gas diving and ever having worked in the diving industry outside the UK were all significantly positively correlated with frequency of ear damage.

Age was significantly negatively correlated with ear damage.

Principal components analysis was used to try and reduce the number of variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded two factors: Diving for work (30% of variance) and Risky diving (27% of variance) as per the matrix below:

<u>Orthogonal factor loading matrix for ear problems:</u>

Predictor variable	Factor 1 – Diving for work	Factor 2 – Risky diving
Worked outside UK	0.80	0.05
Ever dived for work	0.74	0.34
Total number of dives	0.74	0.15
CMAS	0.68	0.26
Solo diving	0.46	0.35
Deepest dive on air	0.35	0.81
Dived below 40m	0.25	0.78
Overhead diving	<-0.01	0.73
Mixed gas diving	0.32	0.57

A regression analysis was carried out selecting 'worked outside the UK' for Factor 1 and 'deepest dive on air' as Factor 2; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Age
Block 2 – Diver health	Short-term illness
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Solo diving, overhead diving, dived below 40m, deepest dive on air
Block 5 – Diving experience	Ever dived for work, CMAS, ever worked outside UK, mixed gas diving, total number of dives
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for ear damage frequency:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.04	0.03					
Worked outside UK			0.23	0.09	0.12	2.68	0.008
Deepest dive on air			0.01	<0.01	0.11	2.47	0.014

Having worked in the diving industry outside of the UK (*B* = 0.23) and diving to greater depths on air (*B* = 0.01) were positively significantly associated with having experienced ear problems in this model.

Daily cigarette consumption

The analysis was then repeated adding ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included:

<u>Final model for ear damage frequency with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.13	0.11					
Deepest dive on air			0.02	0.01	0.25	2.49	0.015
Total number dives			<0.01	<0.01	0.20	2.01	0.047

Diving to greater depths on air (*B* = 0.02) and having performed a greater number of dives (*B*<0.01) were positively significantly associated with having experienced ear problems in this model.

Adding ‘number of cigarettes’ to the analysis resulted in a modest rise in the variance explained but the variable itself was not significant.

7.3.2.7 Dysbaric sinus damage

Aetiological summary

Predisposing pathology includes any condition which occludes the sinus openings, particularly mucosal congestion produced by local infections and inflammatory reactions, but also morphological factors, such as mucosal folds or sinus polyps (p99-100, Edmonds et al, 2002). Precipitating factors include failure to voluntarily equalise the pressure in the sinuses sufficiently on descent or ascent, failure to keep the head upright whilst 'equalising', use of local irritants such as tobacco or marijuana smoking and certain drugs (such as topical and systemic vasoconstrictors, used before a dive to reduce nasopharyngeal congestion but which may cause a rebound effect by the end of a dive).

Possible interaction with tobacco smoking

The increased risk of upper respiratory tract infections and mucosal congestion in the nasopharyngeal region of smokers is thought to predispose them to a greater risk of sinus damage whilst diving (p451-2, Edmonds et al, 2002).

Main findings from analyses

Correlations between history of sinus damage and tobacco variables:

Sinus damage history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	633	-0.02	0.617	0.04	0.366
Current cigar or pipe	632	-0.01	0.761	-<0.01	0.989
Current cannabis	632	0.07	0.063	0.07	0.063
Cigarettes per day	111	-0.21	0.025	-0.21	0.024
FTND score	110	-0.17	0.083	-0.15	0.126

A significant negative correlation was found between daily cigarette consumption and a history of sinus damage.

Correlations between frequency of sinus damage and tobacco variables:

Sinus damage freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	633	-0.02	0.617	0.02	0.624
Current cigar or pipe	632	-0.01	0.761	<0.01	0.991
Current cannabis	632	0.02	0.618	0.08	0.056
Cigarettes per day	111	-0.21	0.030	-0.25	0.009
FTND score	110	-0.17	0.083	-0.20	0.041

Significant negative correlations were found for daily cigarette consumption and FTND score with the frequency of sinus damage.

<u>Predictor variables significantly correlated with frequency of sinus damage:</u>

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Previously married	584	0.14	0.001	0.12	0.004
Health over last year	698	0.11	0.008	0.10	0.009
Seat belt	585	0.12	0.005	0.08	0.058
Freq. overhead dives	584	0.10	0.021	0.05	0.231
Worked outside UK	576	0.09	0.040	0.08	0.067

Currently being separated, widowed or divorced, having poorer health in the last year, not usually wearing a seat belt when travelling by car, diving more frequently in overhead environments and ever having worked in the diving industry outside of the UK were all positively significantly correlated with frequency of sinus damage.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Previously married
Block 2 – Diver health	Health over last year
Block 3 – Everyday risk	Seat belt
Block 4 – Diving risk	Frequency overhead dives
Block 5 – Diving experience	Ever worked in diving industry outside UK
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for sinus damage frequency:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.07	0.06					
Frq. dive overhead			<0.01	<0.01	0.15	3.74	<0.001
Previously married			0.34	0.11	0.12	3.04	0.002
Seat belt			0.63	0.23	0.11	2.80	0.005
Health last year			0.18	0.07	0.11	2.58	0.010

Diving more frequently in overhead environments (B <0.01), currently being widowed, separated or divorced (*B* = 0.34), not normally wearing a seat belt when travelling by car (*B* = 0.63) and having poorer health in the preceding year (*B* = 0.18) were all positively significantly associated with the frequency of sinus problems in this model.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

Final model for sinus damage frequency with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.38	0.36					
Seat belt			1.78	0.28	0.52	6.28	<0.001
Cigarettes per day			-0.01	0.01	-0.17	-2.14	0.035
Previously married			0.25	0.13	0.17	2.01	0.048

Not normally wearing a seat belt when travelling by car (*B* = 1.78) and currently being widowed, separated or divorced (*B* = 0.25) were positively significantly associated with experiencing sinus problems in this model.

Adding 'number of cigarettes per day' to the analysis resulted in an appreciable rise in the variance explained and was negatively significantly associated (*B* = -0.01) with sinus damage, but had the effect of removing all the diving variables from the final model.

Further investigation was undertaken to determine any relationships between daily cigarette consumption and the major variables for diving risk and diving experience (Appendix 7). Each variable was tested in the analysis separately.

Missed safety stop was the only variable to have a positive effect on the variance explained in the final model, although the variable itself was not significant.

<u>Final model for sinus damage frequency with cigarette consumption and missed safety stop:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.41	0.39					
Seat belt			1.91	0.27	0.56	7.03	<0.001
Missed safety stop			0.36	0.12	0.24	3.03	0.003
Cigarettes per day			-0.01	0.01	-0.21	-2.63	0.010

Not normally wearing a seat belt when travelling by car (*B* = 1.91) and ever having missed a safety stop (*B* = 0.36) were positively significantly associated with the frequency of sinus problems in this model.

Daily cigarette consumption remained negatively significantly associated (B = -0.01) with the frequency of sinus problems reported.

Combined dysbaric ear and sinus damage

Dysbaric ear and sinus damage share common aetiological factors as well as physical proximity in the body and the presence of one often indicates that the other is likely to co-exist (Uzun, 2009).

In this study, the history and frequency of dysbaric ear and sinus damage were significantly associated with each other.

<u>Associations between history of dysbaric ear and sinus damage:</u>

Binary variables	No sinus damage	Sinus damage	DF	Fisher's Exact
No ear damage	97% N = 554	3% N = 15	1	P <0.001
Ear damage	79% N = 49	21% N = 13		

13% of divers (n = 80) had a history of dysbaric ear or sinus problems.

<u>Associations between frequency of dysbaric ear and sinus damage:</u>

Frequency variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Frequency ear damage; Frequency sinus damage	630	0.22	<0.001	0.25	<0.001

An average of 0.28 episodes of dysbaric ear or sinus damage had occurred per diver in this study. The distribution was positively skewed.

<u>Frequency distribution of combined dysbaric ear and sinus damage:</u>

N	Average frequency	Dispersion measures
630	Median = 0.00	25^{th} percentile = 0.00 75^{th} percentile = 0.00

Further analyses were undertaken to compare the characteristics and predictors of a combined ear or sinus barotrauma variable with their individual counterparts.

Correlations between history of barotrauma and tobacco variables:

Dysbaric history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	634	0.06	0.139	0.06	0.139
Current cigar or pipe	633	0.01	0.837	0.01	0.837
Current cannabis	634	0.03	0.492	0.03	0.492
Cigarettes per day	112	-0.14	0.156	-0.15	0.121
FTND score	111	-0.10	0.304	-0.11	0.253

No significant associations were found.

Correlations between frequency of barotrauma and tobacco variables:

Dysbaric frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	630	0.01	0.719	0.05	0.173
Current cigar or pipe	629	0.02	0.592	0.01	0.742
Current cannabis	630	0.02	0.611	0.04	0.375
Cigarettes per day	111	-0.03	0.792	-0.15	0.108
FTND score	110	-0.05	0.584	-0.13	0.180

No significant associations were found.

Predictor variables significantly correlated with frequency of barotrauma:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Previously married	582	0.14	0.001	0.07	0.119
Short-term illness	616	0.12	0.003	0.14	0.001
Seat belt	583	0.11	0.011	0.09	0.023
Solo diving	583	0.07	0.096	0.09	0.003
Overhead diving	584	0.08	0.050	0.10	0.020
No. of overhead dives	583	0.26	<0.001	0.13	0.002
Dived below 40m	581	0.11	0.006	0.09	0.025
Deepest dive on air	581	0.11	0.009	0.09	0.037
CMAS	584	0.09	0.029	0.07	0.085
Dived for work	584	0.08	0.047	0.08	0.068
Mixed gas diving	584	0.09	0.038	0.05	0.202
Worked outside UK	574	0.15	<0.001	0.09	0.039

Being widowed, separated or divorced, diving with a pre-existing illness, not normally wearing a seat belt when travelling by car, having ever dived solo or in overhead environments, diving more frequently in overhead environments, having dived below 40m using compressed air, diving more deeply on air, having dived for work or using mixed gases and ever having worked in the diving industry outside of the UK were all positively significantly correlated with the frequency of ear or sinus barotraumas.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Previously married
Block 2 – Diver health	Short-term illness
Block 3 – Everyday risk	Seat belt
Block 4 – Diving risk	Solo diving, overhead diving, frequency overhead dives, dived below 40m, deepest dive on air
Block 5 – Diving experience	CMAS level, work-related diving, mixed gas use, worked in diving industry outside UK
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model of frequency of combined ear and sinus problems:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.11	0.10					
No. overhead dives			<0.01	<0.01	0.26	5.66	<0.001
Previously married			0.47	0.15	0.13	3.22	0.001
Seat belt			0.81	0.28	0.16	2.87	0.004
Worked outside UK			0.38	0.19	0.10	2.07	0.039
Dived for work			-0.24	0.12	-0.10	-1.96	0.050

Diving more frequently in overhead environments (B <0.01), currently being widowed, separated or divorced (*B* = 0.47), not normally wearing a seat belt when travelling by car (*B* = 0.81) and having ever worked in the diving industry outside of the UK (*B* = 0.38) were all positively significantly associated with frequency of dysbaric ear or sinus problems in this model.

Ever having dived for work was negatively significantly associated with the frequency of dysbaric ear or sinus problems (B = -0.24).

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

<u>Final model of frequency of combined ear and sinus problems with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.27	0.25					
No. overhead dives			0.01	<0.01	0.44	4.98	<0.001
Seat belt			1.88	0.55	0.30	3.42	0.001

Diving more frequently in overhead environments (B = 0.01) and not normally wearing a seat belt when travelling by car (*B* = 1.88) were positively significantly associated with experiencing dysbaric ear or sinus problems in this model.

Adding 'number of cigarettes per day' to the analysis resulted in an appreciable rise in the variance explained but the variable itself was not significant.

7.3.2.8 Infections acquired from aquatic environments

Aetiological summary

Divers are exposed to a variety of pathogenic organisms in the marine environment. Infections are acquired via passage through intact or damaged skin and via the mucous membranes of the eyes, ears, nose, throat, lungs, gastrointestinal or genitourinary systems. Infections may remain localised or become systemic (p305, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Smokers are known to be at an increased risk of contracting infections through damaged skin (for example, postoperative wounds) or mucosal membranes (for example, respiratory tract infections). It is possible that divers who smoke are at a greater risk of acquiring infections from the marine environment or from shared diving equipment (such as hired regulators) but no studies were found on this topic.

Main findings from analyses

Correlations between history of infections and tobacco variables:

Infections history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	630	0.02	0.631	0.04	0.297
Current cigar or pipe	629	0.05	0.196	-0.02	0.958
Current cannabis	630	-0.02	0.541	0.03	0.439
Cigarettes per day	111	0.07	0.479	0.06	0.552
FTND score	110	0.04	0.671	-0.04	0.658

No significant correlations were found.

Correlations between frequency of infections and tobacco variables:

Infections frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	630	0.02	0.631	0.03	0.443

Current cigar or pipe	629	0.05	0.196	0.02	0.668
Current cannabis	630	-0.02	0.541	0.02	0.673
Cigarettes per day	111	0.20	0.034	0.09	0.363
FTND score	110	0.04	0.671	-0.03	0.781

A significant positive linear correlation existed between daily cigarette consumption and frequency of infections.

<u>Predictor variables significantly correlated with frequency of infections:</u>

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Intermediate occupation	577	-0.12	0.005	-0.13	0.001
Short-term illness	617	0.19	<0.001	0.19	<0.001
Ear or sinus problems	616	0.23	<0.001	0.21	<0.001
Solo diving	583	0.30	<0.001	0.22	<0.001
Overhead diving	584	0.16	<0.001	0.17	<0.001
No. of overhead dives	582	0.26	<0.001	0.22	<0.001
Reserve gas supply	580	0.17	0.002	0.09	0.029
Dived below 40m	580	0.26	<0.001	0.24	<0.001
Deepest dive on air	580	0.30	<0.001	0.25	<0.001
Number of years dived	582	0.26	<0.001	0.17	<0.001
Total number of dives	583	0.31	<0.001	0.26	<0.001
CMAS	584	0.29	<0.001	0.23	<0.001
Dived for work	584	0.32	<0.001	0.27	<0.001
Mixed gas diving	584	0.21	<0.001	0.16	<0.001
Worked outside UK	575	0.26	<0.001	0.21	<0.001

Diving with a pre-existing short-term illness or ear or sinus problems, diving solo, diving in overhead environments and the number of overhead dives carried out, ever carrying a reserve supply of gas, having dived below 40m using compressed air, diving more deeply, diving for a greater number of years, having made a greater total number of dives, being qualified to CMAS Level 3 or above, having dived for work, ever having used mixed gases and having worked in the diving industry outside of the UK were all positively significantly correlated with frequency of infections.

Being an Intermediate worker was negatively significantly correlated with the frequency of infections.

Principal components analysis was used to try and reduce the number of variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded three factors: Diving experience (23% of variance), Risky diving (21% of variance) and Technical diving (13% of variance) as per the matrix below:

<u>Orthogonal factor loading matrix for marine acquired infections:</u>

Predictor variable	Factor 1 – Diving experience	Factor 2 – Risky diving	Factor 2 – Technical diving
Worked outside UK	0.82	0.06	-0.01
Total number of dives	0.76	0.35	-0.08
Ever dived for work	0.63	0.19	0.50
Number overhead dives	0.62	0.34	0.17
CMAS	0.55	0.14	0.54
Deepest dive on air	0.32	0.82	0.15
Dived below 40m	0.06	0.82	0.24
Number of years dived	0.41	0.55	-0.35
Solo diving	0.26	0.53	0.12
Mixed gas diving	0.17	0.27	0.69
Reserve air	0.04	0.43	0.54
Overhead diving	-0.02	-0.02	0.23

A regression analysis was carried out selecting ‘ever worked outside the UK’ for Factor 1, ‘deepest dive on air’ as Factor 2 and ‘mixed gas diving’ for Factor 3; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Intermediate occupation
Block 2 – Diver health	Short-term illness, pre-existing ear or sinus problems
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Solo diving, overhead diving, number of overhead dives,

	reserve gas supply, dived below 40m, deepest dive on air
Block 5 – Diving experience	Ever dived for work, CMAS, worked outside UK, mixed gas diving, total number of dives, number of years dived
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for aquatic infections frequency:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.25	0.24					
Ear or sinus problem			0.72	0.17	0.21	4.30	<0.001
Total no. of dives			<0.01	<0.01	0.24	4.10	<0.001
Years spent diving			0.03	0.01	0.15	2.69	0.008
Solo diving			0.49	0.19	0.13	2.55	0.011
Mixed gas diving			0.26	0.14	0.10	1.91	0.057

Having dived with a pre-existing ear or sinus problem (*B* = 0.72), having performed a greater number of dives (*B*<0.01), having spent more years diving (*B* = 0.03) and having ever dived solo (*B* = 0.49) were all positively significantly associated with having acquired infections from aquatic environments in this model.

Daily cigarette consumption

The analysis was then repeated adding ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression analysis. All significant and non-significant variables in the final model are included.

Final model for aquatic infections frequency with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*

Final model:	0.62	0.60					
Total overhead dives			0.02	0.01	0.55	3.74	<0.001
Total no. of dives			<0.01	<0.01	0.37	2.26	0.028
Diving for work			-0.64	0.38	-0.18	-1.67	0.101

Having performed a greater number of overhead dives ($B = 0.02$) and having undertaken a greater number of dives overall ($B<0.01$) were positively significantly associated with having acquired infections from aquatic environments in this model.

Adding 'number of cigarettes' to the analysis resulted in an appreciable rise in the variance explained but the variable itself was not significant.

7.3.2.9 Marine life injuries

Aetiological summary

There is a wide variety of marine life that may cause injury to divers. Most injuries are minor, such as accidental coral scrapes, or follow from diver-initiated interactions, for example hand-feeding, but can also arise simply by the presence of divers in a specific environment, for example when large numbers of schooling fish are present. Serious injuries can result from contact with venomous species, such as sting rays, and as a result of defensive territorial behaviour by certain species, such as reef sharks. In rare instances, divers may be viewed as potential prey by apex predators (p325-351, Edmonds et al, 2002).

Possible interaction with tobacco smoking

It is widely believed that a considerable proportion of injuries from diver-marine life interactions are caused by risky or careless behaviour on behalf of the divers concerned, although no evidence exists to confirm or refute this hypothesis. Smoking is also known to be more prevalent amongst individuals with high impulsiveness and sensation-seeking personality traits. One of the aims of this research was to investigate the possibility that divers who smoke take more risks whilst diving and that this would be reflected in the proportion of marine life injuries reported.

Main findings from analyses

Correlations between history of marine life injuries and tobacco variables:

Marine life history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	-0.02	0.599	<0.01	0.944
Current cigar or pipe	627	0.05	0.179	-0.04	0.372
Current cannabis	628	0.02	0.695	-0.03	0.438
Cigarettes per day	112	0.04	0.703	0.04	0.703
FTND score	111	-0.08	0.382	-0.10	0.307

No significant correlations were found.

Correlations between frequency marine life injuries and tobacco variables:

Marine life frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	-0.02	0.599	0.01	0.896
Current cigar or pipe	627	0.05	0.179	-0.01	0.816
Current cannabis	628	0.02	0.695	-0.02	0.627
Cigarettes per day	112	0.04	0.703	0.04	0.648
FTND score	111	-0.08	0.382	-0.09	0.337

No significant correlations were found.

Predictor variables significantly correlated with frequency marine life:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Never married	582	-0.12	0.003	-0.14	0.001
Highest qualification	582	0.10	0.012	0.10	0.013
Short-term illness	617	0.17	<0.001	0.22	<0.001
Rec. drugs 6hrs diving	615	0.09	0.021	0.09	0.027
Risks outside work	584	0.09	0.033	0.08	0.058
Smoke alarm	583	0.11	0.011	0.05	0.242
Travel insurance	583	0.12	0.003	0.07	0.085
National Lottery	577	-0.11	0.011	-0.11	0.007

Solo diving	583	0.22	<0.001	0.17	<0.001
Overhead diving	584	0.12	0.005	0.14	0.001
Unplanned deco stop	577	0.19	0.004	0.10	0.016
Dived below 40m	580	0.22	<0.001	0.20	<0.001
Deepest dive on air	580	0.29	<0.001	0.27	<0.001
Years spent diving	582	0.22	<0.001	0.24	<0.001
Total dives	583	0.31	<0.001	0.30	<0.001
CMAS	564	0.17	<0.001	0.14	0.001
Dived for work	584	0.19	<0.001	0.18	<0.001
Worked outside UK	574	0.29	<0.001	0.24	<0.001

Being educated to at least degree-level, having dived with a pre-existing short-term illness or taken any type of recreational drugs within six hours of diving, taking risks outside work, not having a smoke alarm at home, not having travel insurance, diving solo, diving in overhead environments, having had to carry out an unplanned decompression stop, diving below 40m using compressed air, diving more deeply, having dived for a greater number of years and having undertaken a greater number of dives, being qualified to CMAS Level 3 or above, ever having dived for work and having worked in the diving industry outside the UK were all positively significantly correlated with the frequency of marine life injuries.

Never having married and playing the National Lottery at least once a month were significantly negatively correlated with marine life injuries.

Principal components analysis was used to try and reduce the number of diving variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded two factors: Diving experience (31% of variance) and Risky diving (20% of variance) as per the matrix below:

Orthogonal factor loading matrix for marine life injuries:

Predictor variable	Factor 1 – Diving experience	Factor 2 – Risky diving
Total number of dives	0.79	0.05
Worked outside UK	0.76	-0.04

Ever dived for work	0.74	0.23
CMAS	0.67	0.17
No. of years dived	0.52	0.16
Solo diving	0.47	0.34
Deepest dive on air	0.50	0.72
Dived below 40m	0.41	0.68
Overhead diving	0.14	0.67
Unplanned deco stop	-0.12	0.58

A regression analysis was carried out selecting 'total number of dives' for Factor 1 and 'deepest dive on air' as Factor 2; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Never married, highest qualification
Block 2 – Diver health	Short-term illness, recreational drug use 6hrs diving
Block 3 – Everyday risk	Risks outside work, smoke alarm, travel insurance, National Lottery
Block 4 – Diving risk	Solo diving, overhead diving, unplanned decompression stop, dived below 40m, deepest dive on air
Block 5 – Diving experience	Ever dived for work, CMAS, ever worked outside UK, total number of dives, number of years dived
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for marine life injuries frequency:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.18	0.17					
Total number dives			<0.01	<0.01	0.16	3.25	0.001
Worked outside UK			1.15	0.32	0.18	3.56	<0.001
Deepest dive on air			0.02	0.01	0.14	2.99	0.003

Smoke alarm			0.53	0.22	0.09	2.38	0.018
Travel insurance			0.72	0.30	0.10	2.41	0.016
Unplanned d. stop			0.42	0.22	0.08	1.93	0.054
Solo diving			0.45	0.26	0.08	1.77	0.077
Ever dived for work			-0.35	0.21	-0.08	-1.67	0.096

Having performed a greater total number of dives (*B*<0.01), ever having worked in the dive industry outside of the UK (*B* = 1.15), diving to greater depths using compressed air (*B* = 0.02), not having a smoke alarm (*B* = 0.53) or travel insurance (*B* = 0.72) were all positively significantly associated with frequency of marine life injuries in this model.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

<u>Final model for marine life injuries frequency with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.30	0.28					
Total number dives			<0.01	<0.01	0.40	4.49	<0.001
Highest qualification			0.63	0.23	0.25	2.76	0.007
Unplanned decompression stop			0.73	0.28	0.23	2.56	0.012

Having performed a greater total number of dives (*B*<0.01), being qualified to degree-level or above (*B* = 0.63) and having had to carry out an unplanned decompression stop (*B* = 0.73) were all positively significantly associated with frequency of marine life injuries in this model.

Adding 'number of cigarettes' to the analysis resulted in an appreciable rise in the variance explained but the variable itself was not significant.

7.3.2.10 Dehydration

Aetiological summary

Divers are prone to mild dehydration for a number of reasons. Firstly that the air breathed from a SCUBA tank has been compressed and dried before use, leading to water loss through respiration. Secondly that water loss occurs more readily in a marine environment, due to conditions such as increased temperature and exertion. Thirdly, that the opportunities for ingesting replacement water are often limited by practicalities. Severe dehydration is relatively rare, but milder forms are a predisposing factor for decompression illness (p138 & 233, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Dehydration is known to reduce the efficiency of tissue perfusion in divers and it is possible that this effect could be compounded in divers by the greater risk of tissue ischaemia associated with smoking (p451-2, Edmonds et al, 2002).

Correlations between history of dehydration and tobacco variables:

Dehydration history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	625	-0.03	0.406	-0.06	0.169
Current cigar or pipe	624	0.01	0.812	0.01	0.812
Current cannabis	625	-0.04	0.316	0.01	0.784
Cigarettes per day	111	0.04	0.715	0.03	0.787
FTND score	110	0.01	0.951	0.06	0.536

No significant correlations were found.

Correlations between frequency of dehydration and tobacco variables:

Dehydration freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	625	-0.03	0.406	-0.06	0.118

Current cigar or pipe	624	0.12	0.004	0.02	0.647
Current cannabis	625	-0.04	0.316	-0.01	0.851
Cigarettes per day	111	0.04	0.715	0.02	0.837
FTND score	110	0.01	0.951	0.06	0.539

A positive significant linear correlation was found between current cigar or pipe smoking and the frequency of dehydration. This relationship did not persist with the removal of outliers.

Predictor variables significantly correlated with dehydration frequency:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	581	-0.12	0.004	-0.15	<0.001
Never married	581	-0.16	<0.001	-0.16	<0.001
Highest qualification	581	0.07	0.095	0.11	0.011
Short-term illness	616	0.16	<0.001	0.18	<0.001
Risks outside work	583	0.09	0.037	0.10	0.015
Smoke alarm	582	0.07	0.105	0.09	0.029
Solo diving	582	0.08	0.048	0.07	0.079
No. of overhead dives	337	0.17	0.002	0.15	0.007
Missed safety stop	581	0.13	0.003	0.09	0.037
Unplanned deco stop	576	0.08	0.066	0.09	0.038
Dived below 40m	579	0.11	0.009	0.08	0.048
Deepest dive on air	579	0.12	0.005	0.14	0.001
Dived for work	583	0.16	<0.001	0.16	<0.001
Mixed gas diving	583	0.11	0.009	0.14	0.001

Being educated to at least degree level, having dived with a pre-existing short-term illness, taking risks outside work, not having a smoke alarm at home, diving solo, having performed a greater number of overhead dives, ever having missed a safety stop or having carried out an unplanned decompression stop, diving below 40m using compressed air, diving more deeply, having dived for work and mixed gas diving were all positively significantly correlated with the frequency of dehydration.

Being older and never having married were negatively significantly correlated with the frequency of dehydration.

Principal components analysis was used to try and reduce the number of diving variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00. Orthogonal rotation yielded three factors: Diving experience (30% of variance), Risky diving (13% of variance) and Everyday risk (11% of variance) as per the matrix below:

Orthogonal factor loading matrix for dehydration:

Predictor variable	Factor 1 – Diving experience	Factor 2 – Risky diving	Factor 3 – Everyday risk
Deepest dive on air	0.83	0.19	-0.17
Dived below 40m	0.73	0.22	-0.18
Ever dived for work	0.72	-0.11	0.19
No. of overhead dives	0.68	-0.06	0.13
Mixed gas diving	0.62	-0.07	0.16
Solo diving	0.60	0.13	-0.13
Missed safety stop	-0.08	0.70	0.13
Unplanned deco stop	0.16	0.60	-0.23
Risks outside work	0.05	0.57	0.32
Smoke alarm	0.05	0.13	0.87

A regression analysis was carried out selecting 'deepest dive on air' for Factor 1 and 'missed safety stop' as Factor 2 and 'smoke alarm' as Factor 3; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Age, never married, highest qualification
Block 2 – Diver health	Short-term illness
Block 3 – Everyday risk	Risks outside work, smoke alarm
Block 4 – Diving risk	Solo diving, number of overhead dives, missed safety stop, unplanned decompression stop, dived below 40m, deepest dive on air
Block 5 – Diving experience	Ever dived for work, mixed gas diving
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for dehydration frequency:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.07	0.06					
No. overhead dives			0.01	<0.01	0.17	3.21	0.001
Missed safety stop			0.77	0.28	0.15	2.76	0.006
Never married			0.49	0.19	0.14	2.64	0.009

Having performed a greater number of overhead dives (*B* = 0.01), ever having missed a safety or decompression stop (*B* = 0.77) and having never married (*B* = 0.49) were positively significantly associated with the frequency of dehydration in this model.

Daily cigarette consumption

The analysis was then repeated adding ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

Final model for dehydration frequency with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.13	0.10					
Solo diving			0.87	0.36	0.32	2.45	0.018
Never married			0.34	0.29	0.15	1.18	0.245

Having performed solo dives (*B* = 0.87) was positively significantly associated with the frequency of dehydration in this model.

Adding 'number of cigarettes' to the analysis resulted in a small rise in the variance explained but the variable itself was not significant.

7.3.2.11 Hypothermia

Aetiological summary

Heat loss (at a rate faster than the body's metabolism can replace it) remains a risk for most divers and is often a limiting factor in length of dives performed. Most divers have experienced mild hypothermia and the use of insulating clothing is generally considered a requirement of diving, except in very warm seas. Increased body fat and cold adaptation are protective against hypothermia, whilst lower water temperatures, higher flow rates, increased exercise and the use of drugs (which are vasodilators or prevent vasoconstriction) are factors which promote the onset of hypothermia. Moderate to severe hypothermia is likely to accompany diving accidents (p297, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Hypothermia is known to reduce the efficiency of tissue perfusion in divers and it is possible that this effect could be compounded in divers who smoke by the greater risk of tissue ischaemia associated with smoking (p451-2, Edmonds et al, 2002).

Main findings from analyses

<u>Correlations between history of hypothermia and tobacco variables:</u>

Hypothermia history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	-0.03	0.430	0.01	0.784
Current cigar or pipe	626	-0.02	0.663	0.01	0.843
Current cannabis	627	-0.05	0.225	-0.06	0.130
Cigarettes per day	111	0.01	0.944	0.02	0.849
FTND score	110	0.01	0.952	0.04	0.700

No significant correlations were found.

Correlations between frequency of hypothermia and tobacco variables:

Hypothermia freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	-0.03	0.430	-<0.01	0.933
Current cigar or pipe	626	-0.02	0.663	-0.02	0.631
Current cannabis	627	-0.05	0.225	-0.06	0.147
Cigarettes per day	111	0.01	0.944	-0.03	0.763
FTND score	110	0.01	0.952	-0.02	0.808

No significant correlations were found.

Predictor variables significantly correlated with hypothermia frequency:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Live alone	574	0.08	0.046	0.10	0.016
Routine & manual	576	-0.11	0.007	-0.07	0.099
Long-term illness	616	0.09	0.028	0.13	0.001
Overhead diving	584	0.10	0.017	0.11	0.009
Dived below 40m	580	0.11	0.012	0.08	0.053
Deepest dive on air	580	0.12	0.003	0.08	0.044
Total number dives	584	0.06	0.184	0.09	0.031
Mixed gas diving	585	0.09	0.037	0.10	0.019

Living alone, having a long-term condition, diving in overhead environments, diving below 40m using compressed air, diving more deeply, having performed a greater total number of dives and mixed gas diving were all positively significantly correlated with the frequency of hypothermia.

Being in a Routine or Manual occupation was significantly negatively correlated with the frequency of hypothermia.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Live alone, routine & manual occupation
Block 2 – Diver health	Long-term illness
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Overhead diving, dived below 40m, deepest dive on air
Block 5 – Diving experience	Total number of dives, mixed gas diving
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for hypothermia frequency:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.05	0.04					
Deepest dive on air			0.01	<0.01	0.14	3.39	0.001
Routine & manual			0.21	0.07	0.13	3.12	0.002
Long-term illness			0.15	0.06	0.09	2.27	0.023
Live alone			-0.10	0.05	-0.09	-2.09	0.037

Diving to greater depths on air (*B* = 0.01), being in a Routine or Manual occupation (*B* = 0.21) and diving with a pre-existing long-term illness (B = 0.15) were all positively significantly associated with the frequency of hypothermia in this model.

Living alone was negatively significantly associated (*B* = -0.10) with the frequency of hypothermia.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

Final model for hypothermia frequency with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.06	0.04					
Deepest dive on air			<0.01	<0.01	0.24	2.24	0.027
Mixed gas diving			-0.09	0.05	-0.18	-1.66	0.100

Diving to greater depths on air (*B* <0.01) was positively significantly associated with the frequency of hypothermia in this model.

Adding 'number of cigarettes' to the analysis resulted in a very small rise in the variance explained but the variable itself was not significant.

7.3.2.12 Hyperthermia

Aetiological summary

Hyperthermia is a far less common condition than hypothermia, although it is responsible for a number of deaths. Divers are particularly at risk of hyperthermia when waiting around on the surface in protective or insulating clothing, especially in temperate to warm conditions (p435, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Hyperthermia is known to reduce the efficiency of tissue perfusion in divers and it is possible that this effect could be compounded in divers who smoke by the greater risk of tissue ischaemia associated with smoking (p451-2, Edmonds et al, 2002).

Main findings from analyses

Correlations between history of hyperthermia and tobacco variables:

Hyperthermia history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	0.09	0.027	0.09	0.027
Current cigar or pipe	626	-0.02	0.679	-0.02	0.634
Current cannabis	627	0.03	0.512	0.06	0.109
Cigarettes per day	111	0.17	0.072	0.10	0.281
FTND score	110	0.07	0.496	0.08	0.410

There was a significant relationship between current cigarette smoking and having a history of hyperthermia.

<u>Correlations between hyperthermia frequency and tobacco variables:</u>

Hyperthermia freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	0.04	0.383	0.09	0.027
Current cigar or pipe	627	-0.02	0.679	-0.02	0.634
Current cannabis	628	0.03	0.512	0.06	0.110
Cigarettes per day	111	0.17	0.072	0.10	0.281
FTND score	110	0.07	0.496	0.08	0.410

There was a significant non-linear relationship between current cigarette smoking and the frequency of hyperthermia.

<u>Predictor variables significantly correlated with hyperthermia frequency:</u>

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Intermediate occupation	578	-0.13	0.001	-0.122	0.003
Dived for work	586	0.008	0.048	0.07	0.083

There was a significant negative correlation between having an Intermediate occupation and the frequency of hyperthermia.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Intermediate occupation
Block 2 – Diver health	N/A
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	N/A

Block 5 – Diving experience	Ever dived for work
Block 6 – Tobacco smoking	Current cigarette smoking

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for hyperthermia frequency:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.02	0.02					
Intermediate occpn			0.05	0.02	0.12	2.97	0.003
Dived for work			0.02	0.01	0.07	1.64	0.102

Being in an Intermediate occupation was positively significantly associated (B = 0.05) with the frequency of hyperthermia.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

<u>Final model for hyperthermia frequency with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.03	0.02					
Cigarettes per day			<0.01	<0.01	0.18	1.78	0.078

There were no variables significantly associated with the frequency of hyperthermia in this model.

Adding 'number of cigarettes' to the analysis resulted in a very small rise in the variance explained but the variable itself was not significant (*p* = 0.078).

7.3.2.13 Panic attacks

Aetiological summary

Panic is defined as a psychological response to stress that can lead to life-threatening behaviour. It is widely cited as the single most common cause of death in diving (p468, Edmonds et al, 2002). Stress is commonly experienced by divers due to the complexity of managing equipment (some of which may be dangerous, such as propulsion devices), self and other personnel in the dynamic, unpredictable and sometimes arduous nature of the marine environment.

Possible interaction with tobacco smoking

Smoking is strongly associated with stress-related personality traits and psychopathology (McClernon and Gilbert, 2007, p214) but also commonly cited as a tool used to reduce stress and control negative emotional states. It is possible that divers who smoke may experience additional stress whilst diving due to the lack of availability of nicotine via the usual methods to control anxiety.

Main findings from analyses

<u>Correlations between history of panic attacks and tobacco variables:</u>

Panic attack history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	0.09	0.021	0.09	0.021
Current cigar or pipe	627	-0.02	0.615	-0.02	0.678
Current cannabis	628	-<0.01	0.987	-0.01	0.760
Cigarettes per day	111	0.08	0.411	0.08	0.420
FTND score	110	<0.01	0.967	0.01	0.918

There was a significant relationship between current cigarette smoking and the history of panic attacks.

Predictor variables significantly correlated with a history of panic attacks:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Gender	584	0.12	0.003	0.12	0.003
Ear or sinus problem	618	0.12	0.003	0.12	0.003
Comp. car insurance	579	-0.09	0.025	-0.09	0.025
Missed safety stop	584	0.11	0.008	0.11	0.008

Being female, having dived with a pre-existing ear or sinus problem and having missed a safety stop were all positively correlated with a history of panic attacks. Not having comprehensive car insurance was negatively correlated with a history of panic attacks.

Theoretically-speaking panic attacks precede a missed safety stop, however, the latter was included in the analyses to examine its relationship with other variables in predicting a history of panic attacks. A separate logistic regression analysis of predictors of missed safety stop produced the following final model:

Final model for ever having missed a safety stop:

Predictor variables	B	S.E.	Wald	Df	Sig. (*p*)
Risks outside work	1.01	0.35	8.32	1	0.004
Smoke alarm	0.89	0.37	5.86	1	0.016
Unplanned deco. stop	0.84	0.35	5.72	1	0.017
History of ear damage	1.01	0.43	5.45	1	0.020
History of panic attacks	0.62	0.31	4.09	1	0.043

The variance explained by the final model was relatively low (Nagelkerke R Square = 0.19) but taking risks outside work more frequently (B = 1.01), not having a smoke alarm at home (B = 0.89), ever having carried out an unplanned decompression stop (B = 0.84), having a history of dysbaric ear damage (B = 1.01) and a history of panic attacks (B = 0.62) were all positively significantly associated with having ever missed a safety stop.

The logistic regression analysis for a history of panic attacks was performed using Wald's backwards elimination technique with the variables entered as follows:

Block 1 – Demographics	Gender
Block 2 – Diver health	Ear or sinus problems
Block 3 – Everyday risk	Comprehensive car insurance
Block 4 – Diving risk	Missed safety stop
Block 5 – Diving experience	N/A
Block 6 – Tobacco smoking	Current cigarette smoking

The final model is presented below.

<u>Final model for history of panic attacks:</u>

Predictor variables	B	S.E.	Wald	Df	Sig. (*p*)
Gender	0.62	0.21	8.95	1	0.003
Ear or sinus problem	0.70	0.25	8.03	1	0.005
Comp. car insurance	-0.77	0.31	6.20	1	0.013
Current cigarette smoking	0.60	0.25	6.03	1	0.014
Missed safety stop	0.61	0.30	4.17	1	0.041

The variance explained by the final model was low (Nagelkerke R Square = 0.08) but being female (B = 0.62), diving with a pre-existing ear or sinus problem (B = 0.70), current cigarette smoking (B = 0.60) and ever having missed a safety stop (B = 0.61) were all significantly positively associated with a history of panic attacks.

Not having comprehensive car insurance was negatively significantly associated (B = -0.77) with a history of panic attacks.

<u>Correlations between panic attack frequency and tobacco variables:</u>

Panic attack freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*

Current cigarette	628	0.04	0.276	0.09	0.033
Current cigar or pipe	627	-0.02	0.615	-0.02	0.667
Current cannabis	628	-<0.01	0.987	-<0.01	0.925
Cigarettes per day	111	0.14	0.140	0.10	0.288
FTND score	110	0.13	0.187	0.05	0.629

There was a non-linear significant relationship between frequency of panic attacks and current cigarette smoking.

<u>Predictor variables significantly correlated with frequency of panic attacks:</u>

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Gender	584	0.13	0.001	0.13	0.002
Short-term illness	619	0.09	0.031	0.07	0.075
Ear or sinus problem	618	0.11	0.007	0.12	0.002
Missed safety stop	584	0.08	0.054	0.11	0.010

Being female, having dived with a short-term illness or a pre-existing ear or sinus problem and missing a safety stop were all positively significantly correlated with the frequency of panic attacks.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Gender
Block 2 – Diver health	Short-term illness, ear or sinus problems
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Missed safety stop
Block 5 – Diving experience	N/A
Block 6 – Tobacco smoking	Current cigarette smoking

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for panic attacks frequency:</u>

Predictor variables	R Square	Adjstd. R	*B*	Stand. error *B*	Standrsd. Beta	*t*	*p*

		Square			coefficient		
Final model:	0.04	0.03					
Gender			0.21	0.07	0.12	3.00	0.003
Ear / sinus problem			0.24	0.09	0.11	2.74	0.006
Missed safety stop			0.16	0.11	0.06	1.53	0.126

Being female (*B* = 0.21) and diving with a pre-existing ear or sinus problem (*B* = 0.24) were positively significantly associated with the frequency of panic attacks.

Daily cigarette consumption

The analysis was then repeated substituting current cigarette smoking with 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model. All significant and non-significant variables in the final model are included.

Final model for panic attacks frequency with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.22	0.18					
Gender			0.41	0.15	0.25	2.68	0.009
Short-term illness			0.35	0.15	0.23	2.32	0.022
Cigarettes per day			0.02	0.01	0.18	1.92	0.057
Ear / sinus problem			0.33	0.19	0.17	1.72	0.088
Missed safety stop			0.06	0.21	0.03	0.30	0.764

Being female, (B = 0.41) and diving with a pre-existing short-term illness (*B* = 0.35) were positively significantly associated with the frequency of panic attacks.

Adding 'number of cigarettes' to the analysis resulted in an appreciable rise in the variance explained and the variable itself was at borderline significance (p = 0.057).

7.3.2.14 Loss of consciousness

Aetiological summary

Loss of consciousness during diving has a wide variety of possible aetiologies, ranging from difficulties with breathing equipment (usually resulting in oxygen or carbon monoxide toxicity) to internal physiological causes (for example, arduous physical exertion at depth may result in hyperventilation or even cardiac arrest) and external causes (such as toxins absorbed from contact with marine life). Loss of consciousness either at depth or at the surface is likely to result in drowning unless the victim can be given life-support assistance in a timely manner (p491-494, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Smokers might be a greater risk of loss of consciousness for a variety of reasons, for example they are known to be at a greater risk of ischaemic heart disease and have increased carboxyhaemoglobin levels which can compromise their physiological response to exertion and predispose to cardiac arrest. There may also be additional complications between raised carboxyhaemoglobin levels and the body's response to increasing levels of gaseous toxicity (p451-2, Edmonds et al, 2002).

Main findings from analyses

Correlations between history of unconsciousness and tobacco variables:

Unconscious history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	628	-0.02	0.641	-0.02	0.641
Current cigar or pipe	627	-0.01	0.786	-0.01	0.786
Current cannabis	628	-0.01	0.766	-0.01	0.766
Cigarettes per day	111	n/a	n/a	n/a	n/a
FTND score	110	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant correlations were found.

Correlations between frequency unconsciousness and tobacco variables:

Unconscious freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	627	-0.02	0.641	-0.02	0.641
Current cigar or pipe	626	-0.01	0.786	-0.01	0.786
Current cannabis	627	-0.01	0.766	-0.01	0.766
Cigarettes per day	111	n/a	n/a	n/a	n/a
FTND score	110	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant correlations were found.

Predictor variables correlated with frequency of lost consciousness:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Live alone	576	0.08	0.050	0.08	0.050
Ear or sinus problem	618	0.09	0.023	0.09	0.023
Rec. drugs 6hrs diving	617	0.08	0.054	0.08	0.054
Solo diving	585	0.12	0.005	0.12	0.005
Reserve air supply	582	0.08	0.047	0.08	0.047
Deepest dive on air	582	0.14	0.001	0.07	0.085
Years spent diving	584	0.17	<0.001	0.07	0.088
Total number of dives	585	0.15	<0.001	0.07	0.093
Worked outside UK	576	0.14	0.001	0.14	0.001

Living alone, having ever dived with a pre-existing ear or sinus problem or having used any recreational drugs within six hours of diving, solo diving, diving with a reserve gas supply, diving more deeply, having spent a greater number of years diving, having made a greater total number of dives and ever working in the diving industry outside of the UK were all positively significantly correlated with the frequency of lost consciousness.

Principal components analysis was used to try and reduce the number of diving variables entered into the regression analysis with factors being extracted where eigenvalues were equal to or greater than 1.00.

Orthogonal rotation yielded two factors: Diving experience (34% of variance) and Risky diving (26% of variance) as per the matrix below:

Orthogonal factor loading matrix for lost consciousness:

Predictor variable	Factor 1 – Diving experience	Factor 2 – Risky diving
Total number of dives	0.82	0.17
Worked outside UK	0.75	0.06
Years spent diving	0.67	0.17
Reserve gas supply	-0.05	0.88
Solo diving	0.34	0.64
Deepest dive on air	0.52	0.57

A regression analysis was carried out selecting 'total number of dives' for Factor 1 and 'solo diving' as Factor 2; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Live alone
Block 2 – Diver health	Ear or sinus problem, recreational drug use 6hrs diving
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Solo diving, reserve gas supply, deepest dive on air
Block 5 – Diving experience	Total number of dives, number of years spent diving, worked outside UK
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for lost consciousness frequency:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.05	0.05					
Total number dives			<0.01	<0.01	0.13	2.78	0.007
Years spent diving			<0.01	<0.01	0.11	2.37	0.018
Ear / sinus problem			0.01	0.01	0.08	1.92	0.055

Having performed a greater number of dives (*B* <0.01) and having dived for a greater number of years (*B* <0.01) were positively significantly associated with losing consciousness whilst diving in this model.

No analyses with daily cigarette consumption could be carried out due to a lack of cases.

7.3.2.15 Cardiac problems

Aetiological summary

Up to 21% of SCUBA diving deaths have been attributed to ‘cardiac disease’ (Edmonds and Walker, 1989) although this percentage has gradually increased over recent years to 28% in 2006 (DAN, 2008). Diving is known to create physiological stress which may impact on cardiac function through the autonomic regulation system, the coronary blood supply or altered muscular contraction. Immersion in water and other environmental factors, such as temperature, affect the flow rate and distribution of blood volume which also increases cardiac work. Predisposing pathophysiology includes hypertension, dysrhythmias, coronary artery stenosis and previous cardiac surgery. Precipitating factors include cold water, physical exertion stress and the presence of certain drugs, such as nicotine, alcohol, caffeine, sympathomimetics, beta-blockers, calcium channel blockers, pro-arrhythmic drugs and cocaine (p399, Edmonds et al, 2002).

Possible interaction with tobacco smoking

Smokers are known to be at a greater risk of ischaemic heart disease (Meade, Imeson, Stirling, 1987) and have increased carboxyhaemoglobin levels which can compromise their physiological response to exertion and predispose them to cardiac arrest.

Main findings from analyses

Correlations between history of cardiac problems and tobacco variables:

Cardiac history	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	626	-0.02	0.643	-0.02	0.643
Current cigar or pipe	625	-0.01	0.786	-0.01	0.786
Current cannabis	626	-0.01	0.769	-0.01	0.769
Cigarettes per day	110	n/a	n/a	n/a	n/a
FTND score	109	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant correlations were found.

Correlations between frequency cardiac problems and tobacco variables:

Cardiac frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	626	-0.02	0.643	-0.02	0.643
Current cigar or pipe	625	-0.01	0.786	-0.01	0.786
Current cannabis	626	-0.01	0.769	-0.01	0.796
Cigarettes per day	110	n/a	n/a	n/a	n/a
FTND score	109	n/a	n/a	n/a	n/a

n/a signifies that not enough cases existed for analysis

No significant correlations were found.

Predictor variables correlated with frequency of cardiac problems:

Predictor variables	N	Pearson (r)	*p*	Spearman (rho)	*p*
Comp. car insurance	579	0.10	0.022	0.10	0.022
Risks for fun	581	0.15	<0.001	0.15	<0.001

Not having comprehensive car insurance and taking risks for fun whilst diving were positively significantly correlated with the frequency of cardiac problems.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	N/A

Block 2 – Diver health	N/A
Block 3 – Everyday risk	Comprehensive car insurance
Block 4 – Diving risk	Risks for fun
Block 5 – Diving experience	N/A
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for heart problems frequency:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.03	0.03					
Risks for fun			0.02	0.01	0.14	3.45	0.001
Car insurance			0.01	0.01	0.08	1.87	0.062

Taking risks for fun whilst diving (*B* = 0.02) was positively significantly associated with the frequency of heart problems in this model.

No analyses with daily cigarette consumption could be carried out due to a lack of cases available.

7.3.2.16 Total number of episodes of diving-related illness

Further investigations were undertaken to determine whether tobacco smoking affected the total amount of diving-related illness experienced.

Main findings from analyses

Relationships were examined with the main tobacco variables.

<u>Correlations between total episodes of illness and tobacco variables:</u>

Total illness freq.	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	654	-0.02	0.577	0.01	0.737

Current cigar or pipe	651	0.07	0.059	-0.01	0.747
Current cannabis	651	-0.03	0.440	-0.02	0.545
Cigarettes per day	112	0.17	0.073	0.14	0.134
FTND score	111	0.02	0.854	0.02	0.872

No significant correlations were found.

The relationships between the primary variables for analysis (Appendix 7) and the sum variable 'total number of episodes of illness' were investigated using parametric and non-parametric correlations.

<u>Correlations between 'total episodes of illness' and primary variables:</u>

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Age	584	-0.08	0.053	-0.08	0.049
Never married	584	0.13	0.002	0.13	0.001
Highest qualification	584	0.10	0.016	0.12	0.003
Short-term illness	619	0.27	<0.001	0.34	<0.001
Ear or sinus problem	618	0.19	<0.001	0.21	<0.001
Risks at work	586	0.08	0.065	0.11	0.010
Risks outside work	586	0.08	0.064	0.10	0.018
Smoke alarm	585	0.10	0.014	0.09	0.024
National Lottery	579	-0.12	0.003	-0.13	0.001
Solo diving	585	0.22	<0.001	0.23	<0.001
Overhead diving	586	0.22	<0.001	0.26	<0.001
No. of overhead dives	340	0.33	<0.001	0.28	<0.001
Missed safety stop	584	0.12	0.005	0.09	0.032
Unplanned deco stop	579	0.09	0.029	0.09	0.025
Risks for fun	581	0.14	0.001	0.13	0.002
Dive below 40m	582	0.28	<0.001	0.28	<0.001
Deepest dive on air	582	0.32	<0.001	0.37	<0.001
Number of years dived	584	0.21	<0.001	0.22	<0.001
Total number of dives	585	0.25	<0.001	0.39	<0.001
CMAS	586	0.25	<0.001	0.24	<0.001
Ever dived for work	586	0.31	<0.001	0.33	<0.001
Worked outside UK	576	0.33	<0.001	0.29	<0.001
Mixed gas diving	586	0.20	<0.001	0.24	<0.001

Never having married, being educated to at least degree level, having dived with a pre-existing short-term illness or ear or sinus problems, taking risks at and outside work at least occasionally, not having a smoke alarm, diving solo or in overhead environments, having carried out more dives in overhead environments, missing a safety stop, having to carry out an unplanned decompression stop, taking risks for fun whilst diving, diving below 40m using compressed air, diving more deeply, diving for a greater number of years and for a greater total number of dives, having qualified to CMAS Level 3 or above, diving for work, having worked in the diving industry outside of the UK and having ever dived with mixed gases were all positively significantly correlated with total number of episodes of diving-related illness.

Being older and playing the National Lottery at least once a month were significantly negatively correlated with total number of episodes of diving illness.

Principal components analysis was used to try and reduce the number of variables entered into the regression analysis with predictor variables being categorised as either diving or non-diving variables and factors being extracted where eigenvalues were equal to or greater than 1.00.

Orthogonal rotation of the non-diving variables yielded three factors: Attitudes to risk (explaining 24% of variance), Pre-existing illness (explaining 21% of variance) and Everyday risk taking (explaining 17% of variance) as per the matrix below:

<u>Orthogonal factor loading matrix for non-diving variables:</u>

Predictor variable	Factor 1 – Attitudes to risk	Factor 2 – Pre-existing illness	Factor 3 – Everyday risk taking
Risks outside work	0.85	0.08	0.01
Risks at work	0.84	-0.05	-0.01
Ear or sinus problem	-0.05	0.75	0.23
Short-term illness	0.06	0.72	-0.29

National Lottery	-0.08	-0.16	0.81
Smoke alarm	0.12	0.36	0.50

Orthogonal rotation of the diving variables yielded another three factors: Diving experience (explaining 24% of variance), Technical diving (explaining 15% of variance) and Risky diving (explaining 10% of variance) as per the matrix below:

<u>Orthogonal factor loading matrix for diving variables:</u>

Predictor variable	Factor 4 – Diving experience	Factor 5 – Technical diving	Factor 6 – Risky diving
Total number of dives	0.81	0.13	-0.12
Number years dived	0.75	-0.13	0.09
Deepest dive on air	0.69	0.35	0.41
Worked outside UK	0.64	0.19	-0.29
No. of overhead dives	0.63	0.28	-0.03
Solo diving	0.49	0.21	0.23
Mixed gas diving	0.14	0.76	0.09
Dived for work	0.46	0.64	-0.11
CMAS	0.36	0.62	-0.19
Overhead diving	-0.15	0.41	0.12
Missed safety stop	-0.05	-0.08	0.61
Unplanned deco stop	0.02	0.06	0.57
Dived below 40m	0.47	0.41	0.48
Risks for fun	-0.13	0.07	0.14

A regression analysis was carried out selecting ‘risks outside work’ for Factor 1, ‘dived with pre-existing ear or sinus problems’ for Factor 2, ‘play National Lottery’ for Factor 3, ‘total number of dives’ for Factor 4, ‘mixed gas diving’ for Factor 5 and ‘missed safety stop as Factor 6; however, the resultant model produced was not more effective at explaining variance than an analysis utilising all significantly correlated variables entered in the following order:

Block 1 – Demographics	Age, never married, highest qualification
Block 2 – Diver health	Short-term illness, pre-existing ear or sinus problem

Block 3 – Everyday risk	Risks at work, risks outside work, smoke alarm, National Lottery
Block 4 – Diving risk	Missed safety stop, solo diving, overhead diving, number of overhead dives, unplanned deco stop, risks for fun, dived below 40m, deepest dive on air,
Block 5 – Diving experience	Total number of dives, mixed gas diving, number of years dived, CMAS, dived for work, worked outside UK
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

<u>Final model for frequency of total diving-related illness:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.24	0.23					
No. overhead dives			0.03	<0.01	0.22	4.00	<0.001
Short-term illness			1.60	0.55	0.15	2.91	0.004
Worked outside UK			2.56	0.93	0.16	2.77	0.006
Highest qualification			1.38	0.57	0.12	2.41	0.017
Ear or sinus problem			1.48	0.69	0.11	2.15	0.032
Smoke alarm			1.76	0.84	0.11	2.11	0.036
Missed safety stop			1.67	0.80	0.10	2.09	0.037
No. of years dived			0.09	0.05	0.11	2.03	0.043

Performing a greater number of overhead dives (B = 0.03), diving with a pre-existing short-term illness (B = 1.60), having worked in the diving industry outside of the UK (B = 2.56), being qualified to degree level or above (B = 1.38), diving with a pre-existing ear or sinus problem (B = 1.48), not having a smoke alarm (B = 1.76), ever having missed a safety stop (B = 1.67) and having dived for a greater number of years (B = 0.09) were all positively significantly associated with total illness frequency in this model.

Daily cigarette consumption

The analysis was then repeated adding 'number of cigarettes smoked per day' as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

<u>Final model for frequency of total diving-related illness with cigarette consumption:</u>

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.74	0.68					
Risks for fun			5.26	1.03	0.46	5.09	<0.001
Solo diving			4.24	0.92	0.48	4.62	<0.001
Dived for work			2.49	0.78	0.32	3.18	0.003
Age			0.14	0.05	0.35	3.08	0.004
Dived below 40m			-2.26	0.75	-0.31	-3.00	0.005
Short-term illness			1.78	0.62	0.24	2.87	0.006
Highest qualification			1.79	0.67	0.25	2.69	0.010
Unplanned d. stop			-1.84	0.76	-0.23	-2.43	0.020
Cigarettes per day			0.10	0.04	0.22	2.15	0.037
Never married			1.85	0.87	0.26	2.12	0.040
No. overhead dives			0.01	0.01	0.17	1.71	0.095

Taking risks for fun whilst diving (B = 5.26), undertaking solo dives (B = 4.24), diving for work purposes (B = 2.49), being older (B = 0.14), diving with a pre-existing short-term illness (B = 1.78), being qualified to degree level or above (B = 1.79), the number of cigarettes smoked per day (B = 0.10) and never having married (B = 1.85) were all positively significantly associated with total illness frequency in this model.

Having dived below 40m (B = -2.26) and carrying out an unplanned decompression stop (B = -1.84) were negatively significantly associated with total illness frequency.

Adding ‘number of cigarettes’ to the analysis resulted in an appreciable rise in the variance explained and the variable itself was significant (p = 0.037).

7.3.2.17 Total severity of diving-related illnesses

Further investigations were undertaken to determine whether tobacco smoking affected the total severity of diving-related illness experienced. Illness severity was measured by the number of days reported absent from work or everyday activities; however, the number of cases available for analysis was relatively low as not all divers required time off work.

Main findings from analyses

Relationships were examined with the main tobacco variables.

Correlations between total severity of illness and tobacco variables:

Severity frequency	N	Pearson (r)	*p*	Spearman (rho)	*p*
Current cigarette	112	-0.03	0.734	0.08	0.415
Current cigar or pipe	112	-0.11	0.260	-0.08	0.397
Current cannabis	112	-0.11	0.255	-<0.01	0.992
Cigarettes per day	22	0.24	0.283	0.46	0.032
FTND score	20	0.07	0.767	0.40	0.079

A non-linear significant relationship existed between total illness severity and daily cigarette consumption.

Relationships between the primary variables for analysis (Appendix 7) were investigated using parametric and non-parametric correlations.

Correlations between total severity of illness and primary variables:

Predictor variable	N	Pearson (r)	*p*	Spearman (rho)	*p*
Gender	102	0.20	0.042	0.13	0.190
Long-term illness	109	0.28	0.003	0.31	0.001
Reserve gas supply	102	0.18	0.073	0.20	0.047

Deepest dive on air	101	0.15	0.140	0.24	0.014
Ever dived for work	102	0.20	0.039	0.25	0.013

Being female, having a long-term medical condition, carrying a reserve gas supply, diving more deeply using compressed air and ever diving for work were all positively significantly correlated with total illness severity.

The following variables were entered into a backwards elimination hierarchical multiple regression analysis in the order described below:

Block 1 – Demographics	Gender
Block 2 – Diver health	Pre-existing long-term illness
Block 3 – Everyday risk	N/A
Block 4 – Diving risk	Deepest dive on air, reserve gas supply
Block 5 – Diving experience	Dived for work
Block 6 – Tobacco smoking	N/A

The final model produced (with all significant and non-significant variables included) was as follows:

Final model for total severity of diving-related illness:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.19	0.17					
Long-term illness			25.98	7.03	0.34	3.70	<0.001
Dived for work			9.55	4.85	0.18	1.97	0.052
Gender			8.34	5.10	0.15	1.63	0.105

Diving with a pre-existing long-term illness (B = 25.98) and having dived for work purposes (B = 9.55) were positively significantly associated with total illness severity in this model.

Daily cigarette consumption

The analysis was then repeated adding ‘number of cigarettes smoked per day’ as the most distal variable in the hierarchical regression model described earlier. All significant and non-significant variables in the final model are included.

Final model for total severity of diving-related illness with cigarette consumption:

Predictor variables	R Square	Adjstd. R Square	*B*	Stand. error *B*	Standrsd. Beta coefficient	*t*	*p*
Final model:	0.31	0.27					
Long-term illness			40.44	14.20	0.56	2.85	0.011

Diving with a pre-existing long-term illness (B = 24.38) was the only variable to be positively significantly associated with total illness severity in this model.

The variance explained increased appreciably with the introduction of ‘number of cigarettes per day’ but the variable itself was not significant.

7.4 Discussion

Prevalence of diving-related illness

The range of illnesses or injuries that either predispose to, or can be contracted whilst undertaking recreational SCUBA diving is very broad; however, obtaining an accurate picture of pre-existing illness or rates of occurrence of injury within the diving population is problematic.

Firstly, reliable estimates of illness prevalence are almost impossible to obtain due to difficulties ascertaining the precise numbers of active divers or the number of dives undertaken at any point in the year. Secondly, the pre-diving medical has been abandoned in favour of a system in which the prospective diver bears the responsibility for identifying health problems which might be contraindicated, and voluntarily having them assessed by a diving physician, thus leading to a loss of large-scale medical record-keeping for research into the recreational diving population. Thirdly, if serious diving accidents occur, a voluntary reporting system exists unless the authorities are involved. Finally, due to the difficulties of accessing the total diver population, opportunities to obtain random samples are limited thus leading to the use of diver networks, which tends to produce self-selecting samples and convenience samples for research.

To try and address some of these issues, DAN initiated Project Dive Exploration (PDE) in 1997. Its purpose is to recruit volunteers to submit information regarding their health and diving practices in order to produce a control group of healthy divers that can be compared with the sub-group who experience serious incidents (DAN, 2000).

Relevant information from PDE is published alongside the analyses of diving incidents in the DAN Annual Report, although classification and reporting of pre-existing health problems varies from year to year. Comparable data from PDE is reported in this discussion where it exists.

Influence of tobacco smoking on the development of diving-related illness

Although the range of diving-related illness is very broad, some injuries are very similar in aetiology, such as those unique to those using compressed gases to breathe underwater (whether surface-supplied or via SCUBA equipment) where changes in gas volume with depth create soft tissue trauma, for example, ruptured ear drum or burst lung.

Other injuries are not primarily pressure-related and have a wide variety of aetiological factors such as marine life injuries, hypothermia, physical trauma and infections.

Regardless of the primary aetiology of any diving illness, the risk of barotraumas or other pressure-related changes will always exist whenever compressed gas is used. Similarly, when present, the gaseous and particulate matter produced from the combustion of tobacco might be expected to interact with compressed gas utilised by the body and also with any pre-existing pathophysiology to affect clinical outcomes.

Despite predictions, however, there are very few studies that demonstrate a specific contribution from tobacco smoking to the development of pathophysiology in divers. The effects of tobacco smoking on divers' lung function are mixed (Dembert et al, 1984; Chong, Tan and Lim, 2008; Suzuki, 1997; Skogstad et al, 2002; Sekulic and Tocilj, 2006; Tetzlaff et al, 2006; Cirillo et al, 2003; Tetzlaff et al, 1998) and any influence of smoking on the development of decompression illness has yet to be conclusively demonstrated (Wilmshurst et al, 1994; Buch et al, 2003).

Given the broad range of diving illnesses potentially affected by tobacco smoking and the wide variety of aetiological factors involved, the impact of smoking on divers in this study is discussed per specific diving illness and subsequently on sum frequency and severity of diving illness.

7.4.1 Lung problems

Diving-related pulmonary barotrauma is one of the most serious injuries that can occur whilst diving, especially if it results in arterial gas embolism. It is typically caused by breath-holding during rapid ascent in healthy subjects and is more likely to occur if predisposing pathology, such as lung bullae, are also present.

A high proportion (85%) of incidents involving rapid ascents reported to DAN are fatal. One-third of the diver fatalities investigated in 2006 were attributed to arterial gas embolism (DAN, 2008).

Ascent-related incidents were the second largest category (n = 99) of diving accidents reported to the BSAC in 2006 (Cumming, 2006). Typically they involve a rapid ascent with missed safety stops, however, if the ascent results in decompression illness, then the event would be recorded in the latter category.

The frequency of lung problems in this study, including burst lung leading to arterial gas embolism, was very low (n = 2) and predicted by two variables associated with attitudes to everyday risk taking: playing fruit machines more frequently (p = 0.002) and not taking out travel insurance for holidays (p = 0.017).

It was also predicted by ever having had a panic attack (p = 0.016) which was significantly positively correlated with ever missing a safety stop; however, missing a safety stop was not significant in predicting lung problems in this study (p = 0.093).

No significant relationships were found with any of the tobacco variables, however, the relationship between panic attacks and cigarette smoking is discussed later in the chapter.

7.4.2 Decompression illness

Apart from fatality, decompression illness (DCI) is regarded as the most serious incident in recreational diving.

It results from gases absorbed by bodily tissue coming out of solution on ascent. The more rapid the ascent, the greater the likelihood of bubble formation and therefore DCI, although other factors also play a role (see section 7.3.2.2 for more details).

One hundred and five diving incidents recorded by the BSAC in 2006 had resulted in decompression illness, the largest category of accidents reported (Cumming, 2006). Approximately 120 cases of DCI are thought to occur in the UK each year, although not all cases will be diagnosed.

The annual incidence of DCI recorded by DAN in 2006 was 2.0 cases per 10,000 dives (DAN, 2008). Prevalence estimates typically range from 2-5% amongst global recreational diving populations.

11 cases of DCI (7 male; 4 female) were reported by divers in this study reflecting a prevalence of 2%, which is consistent with other estimates.

No tobacco variables were significantly correlated with either a history or a frequency of DCI, but the regression analyses yielded some mixed findings when daily cigarette consumption was introduced.

Without the inclusion of daily cigarette consumption, the original model explained very little variance and the sole predictor of frequency of decompression illness was the total number of dives performed ($p = 0.001$) which is theoretically consistent with increased exposure to risk.

The addition of daily cigarette consumption resulted in a marked rise in the variance explained but the variable became negatively significantly associated with the frequency of DCI ($p = 0.023$), alongside other variables that would normally be expected to be positively associated with DCI due to increased exposure, for example the total number of dives.

Having worked in the diving industry outside of the UK ($p<0.001$), diving with a pre-existing short-term illness ($p<0.001$) and taking risks for fun whilst diving ($p<0.001$) were all positively significantly associated with DCI frequency, as expected, due to the increased exposure to risk. In contrast, not having travel insurance ($p = 0.001$) would be expected to be positively significantly associated with DCI as a reflection of everyday risk taking attitudes, but in this study was negatively significantly associated with DCI.

Further examination led to the identification of mixed gas diving as a possible source of interactions.

Ever having dived with mixed gases was not significantly correlated with the frequency of decompression illness ($r = 0.05$; $p = 0.257$; $n = 585$); however, it was significantly correlated with daily cigarette consumption ($r = 0.20$; $p = 0.044$; $n = 101$) whereas the opposite was true for 'total number of mixed gas dives'.

This led to the consideration that there may be distinct differences between these two groups of divers that affect the variables identified in the final models. For example, ever having dived with mixed gases is more likely to be associated with those with sensation-seeking traits who are attracted to novelty value.

By contrast, continuing to dive using mixed gases as an ongoing replacement for compressed air is viewed as a risk-reducing measure, as its purpose is to prolong diving times and lower the risk of decompression illness by reducing the nitrogen loading of the body.

In addition, diving with mixed gases requires specific training and the adoption of new behaviours which might be viewed as a more complex and demanding way to dive, for example by having to pay greater attention to diving equipment during dives, than by using compressed air. It is therefore possible that divers have to be more committed to reducing their risk of decompression illness in order to regularly dive with mixed gases.

Finally, there is also the effect of the gas mixture itself on the likely occurrence of decompression illness. The most common type of mixed gas utilized for recreational diving is oxygen-enriched air (Nitrox) which, by virtue of its lower nitrogen content, reduces the nitrogen loading on the body and therefore the risk of decompression illness.

Collectively these factors could theoretically account for why a different set of variables might predict decompression illness in divers regularly using mixed gases to those predominantly using compressed air.

The final model produced for divers using compressed air contained a set of variables (taking risks for fun whilst diving, $p < 0.001$; not having travel insurance, $p = 0.014$; diving more deeply, $p = 0.017$) that were expected to be positively significantly associated with a higher frequency of decompression illness.

Cigarette smoking was not significantly associated with the frequency of decompression illness for divers using compressed air; however, it was negatively significantly associated with frequency of decompression illness in those using mixed gases.

It is conceivable that the complexity of the gaseous interactions taking place with mixed gas diving, and the possibility of interactions with the gaseous and particulate matter inhaled through cigarette smoking, might explain why there have been no studies definitively linking tobacco smoking with decompression illness.

7.4.3 Nervous system effects

Commercial divers using technical gas mixtures, for example helium, are known to be at risk of specific neurological symptoms, especially tremor, nausea, vomiting, dizziness and vertigo (Vaernes, Bergan and Warncke, 1988). In contrast, neurological effects reported by recreational divers are typically non-specific and tend to be either headaches, for example caused by stress, cold or dehydration, or neurological symptoms of DCI (Newton, 2001; p410-413, Edmonds et al, 2002).

Approximately 1% of PDE divers reported ‘nervous system effects’ in the 2001 DAN Annual Report. A similar percentage of divers (1%, n = 6), who were all female, reported nervous effects in this study.

Being female was the only variable positively significantly associated with the frequency of nervous system effects. No significant associations were found with any of the tobacco variables and no further analyses were carried out.

7.4.4 Dysbaric bone disease

Dysbaric osteonecrosis is regarded as relatively rare in recreational SCUBA divers who typically breathe compressed air at depths of less than 50m, although isolated cases have always occurred (Gorman and Sandow, 1992; Wilmhurst and Ross, 1998; Laden and Grout, 2004). It can arise from cumulative exposure to hyperbaric conditions or from a single mega-exposure and although the incidence rates of the disease vary considerably between populations, for example, from very low rates in the military (4% in Royal Navy divers, Elliott and Harrison, 1970) to much higher rates in commercial operations (65% in Hawaiian fishermen, Wade et al, 1978) there have always been suspicions within the medical diving community that it may simply be under-reported in recreational divers (p169, Edmonds et al, 2002).

Recent research seems to confirm these fears with a study (Cimsit et al, 2007) recording a prevalence of 25% amongst dive masters and instructors (CMAS Level 3) who had never performed industrial or commercial dives, had performed over 500 recreational dives as a professional and did not have a prior diagnosis.

One male diver reported dysbaric osteonecrosis in this study. There were no significant associations found with the development of the disease and no further analyses could be carried out.

7.4.5 Musculoskeletal problems

Pain and dysfunction affecting the musculoskeletal system is a relatively common complaint amongst healthy divers. Ten percent of those engaged in Project Dive Exploration in 2006 (DAN, 2008) reported an acute orthopaedic episode (joint, muscle or back pain) prior to diving and levels have fluctuated around this average since PDE data were first reported (6% DAN 2000; 11% DAN 2001; 8% DAN 2002; 12% DAN 2003; 5% DAN 2004; 7% DAN 2005; 16% DAN 2006; 9% DAN 2007).

In addition, 6% of divers reporting a pre-existing medical condition in a US survey of 770 recreational divers (Beckett and Kordick, 2007) cited musculoskeletal problems. A Finnish study (Knaepen, 2009) found a lifetime prevalence of 56% lower back pain sufferers amongst recreational divers. Symptomatic cases were significantly more likely to be highly qualified divers and carry additional weight on their weight belts during indoor and outdoor training.

14% of divers reporting musculoskeletal problems in this study with women (18%; n = 32) reporting slightly higher levels than men (13%; n = 52) although gender differences were not significant.

Current cannabis use was negatively significantly correlated with both history and frequency of musculoskeletal problems, but regression analyses identified taking risks for fun ($p = 0.015$) and diving for work ($p = 0.034$) as being positively significantly associated with musculoskeletal injuries. These findings are consistent with increased exposure to risk, for example repetitive carrying of heavy diving equipment and purposefully taking risks whilst diving would be expected to result in greater injury.

The impact of tobacco smoking was minimal although daily cigarette consumption contributed to an increase in variance explained.

7.4.6 Dysbaric ear and sinus damage

Dysbaric ear damage has been cited as the most frequently diagnosed form of barotrauma experienced by recreational divers (Clenney and Lassen, 1996); however, its prevalence is often reported as a joint figure with other related conditions, for example middle ear infection or dysbaric sinus damage. This is partly due to overlapping symptoms such as hearing loss, pain and tinnitus, making distinct diagnoses more difficult (Mawle and Jackson, 2002) and partly because the shared aetiology means that the conditions often co-exist, for example one study (Uzun, 2009) found paranasal sinus barotrauma to be significantly associated with a history of sinusitis and middle-ear barotrauma. For these reasons, the prevalence of both ear and sinus barotrauma are discussed here.

DAN lists ‘ear / sinus problems’ as a category of common chronic conditions reported by divers in the PDE, however, it does not distinguish whether the primary cause was diving-related. Available data from DAN reports is presented below:

DAN Annual report: PDE data (n)	% divers reporting ENT problems	% divers reporting ear / sinus surgery	% total ear / sinus problems & surgery
2000 (n not available)	5	0	5
2001 (n not available)	7	2	9
2002 (n = 1048)	Not recorded		
2003 (n = 1291)	4	2	6
2004 (n = 1573)	2	7	9
2005 (n = 1903)	5	2	7
2006 (n = 1521)	8	3	11
2007 (n = 1181)	6	2	8
2008 (n = 1081)	5	3	8

A British postal survey of 142 recreational divers found that 71% of divers had experienced problems equalising middle ear pressure during diving. 64% reported symptoms of current barotrauma, 11% had been diagnosed with ear barotrauma and 38% had suffered middle ear infection (Mawle and Jackson, 2002).

A Japanese study of 3078 divers over a period of six years (Nakayama et al, 2012) detected ear barotrauma in 11% and paranasal sinus barotrauma in 6% of respondents.

In this study 10% of divers reported ear barotrauma (10% male, n = 39; 9% female, n = 15) and 5% paranasal sinus barotrauma (4% male, n = 17; 6% female, n = 11) which is consistent with the levels of reporting in the British and Japanese studies above. There were no significant gender differences.

Dysbaric ear damage

None of the tobacco variables were significantly correlated with dysbaric ear damage in this study.

Diving to greater depths using compressed air (p = 0.015) and having performed a greater total number of dives (p = 0.047) were positively significantly associated with dysbaric ear damage. These findings are consistent with the greater exposure to risk of barotrauma.

The impact of tobacco smoking was minimal although daily cigarette consumption contributed to an increase in variance explained.

Dysbaric sinus damage

The final model for dysbaric sinus damage originally produced some unexpected findings.

Being divorced, separated or widowed (p = 0.048) and not usually wearing a seat belt when travelling by car (p<0.001) were positively significantly associated with frequency of sinus damage in the initial model, whilst daily cigarette consumption was negatively significantly associated (p = 0.035) with frequency of sinus damage.

The introduction of ‘ever having missed a safety stop’ into the equation (p = 0.003) resulted in an improved model of fit with ‘not usually wearing a seat belt’ (p<0.001) also positively significantly associated with the frequency of sinus damage. Daily cigarette consumption remained negatively significantly associated with frequency of sinus damage in this model (p = 0.010).

'Not usually wearing a seat belt' is a more extreme example of everyday risk taking, whereas missing a safety stop is an indicator of diving risk. Missing a safety stop would also reduce the amount of time available for air in the paranasal sinuses to equalize gradually on ascent, thus increasing the likelihood of mucosal damage.

The finding of daily cigarette consumption as negatively significantly associated with frequency of sinus damage runs counter to accepted knowledge that increased inflammation of the mucosal lining of smokers' paranasal sinuses (Hadar et al, 2009) will predispose to further tissue damage. It is possible that chronic, low-grade inflammation in the oropharyngeal region of smokers prevents them from noticing further mucosal damage during a typical dive and that non-smokers are more sensitive to changes. It may also be that smokers become habituated to a degree of mucosal inflammation and do not regard this as problematic, for example, smokers were no more likely to report diving with a pre-existing ear or sinus problem than non-smokers in this study ($X_2 = 0.02$; DF = 1; p = 1.000). These speculations might be validated by a histological examination of sinus mucosal tissue from divers; however, without the benefit of further research any findings should be interpreted with caution.

Combined dysbaric ear or sinus problems

Investigation of the combined frequency of dysbaric ear or sinus problems explained less variance than that produced for sinus damage alone, but more variance than ear damage alone.

A greater frequency of dives in overhead environments ($p<0.001$) and not normally wearing a seat belt when travelling by car (p = 0.001) were both positively significantly associated with a greater frequency of combined ear or sinus barotrauma.

Daily cigarette consumption was not significantly associated with the frequency of combined ear or sinus damage, although it did contribute to a rise in variance explained.

The individual analyses for dysbaric ear and sinus damage provided more details of the factors likely to influence their development than the combined dependent variable.

7.4.7 Infections acquired from aquatic environments

Divers are at risk of infection from a wide range of bacteria, viruses, protozoa and parasites via aquatic environments, especially when known infectious organisms are present, as in coastal sewage-contaminated areas (Jones et al, 1985; Joseph et al, 1979). Other pathways for acquiring infections include via shared SCUBA diving equipment (Potasman and Pick, 1997) and secondary infections following marine life injuries (Ho et al, 1998).

The diving literature tends to focus on detailed accounts of serious or unusual cases of infection and, as a result, information relating to the incidence of infections at a population level is limited. One Dutch study attempted to estimate the risk of infection from diving in polluted water and found it to be extremely broad, ranging from a few per cent to tens of percent (Schijven and de Roda Husman, 2006) depending on factors such as the volume of water ingested and the concentration and type of pathogens present.

Some members of the diving medical community regard the risks of diving with pre-existing infections, such as sinusitis and upper respiratory tract infections, to be much greater than those acquired from the marine environment (p305, Edmonds et al, 2002; Bellini, 1987).

DAN's Project Dive Exploration (PDE) records upper respiratory tract infections, and sometimes other infections, as acute health conditions present at the time of diving. Other acute conditions reported were seasickness (range 3 -16%) and orthopaedic injury (range 3 - 16%). Over the period 2000-2008 the percentage of acute infections fluctuated between one and eight percent, although data collection or categorisation is not consistently reported:

DAN Annual report: PDE data (n)	% divers reporting cold / flu symptoms	% divers reporting 'infections'	total % acute health conditions reported
2000 (not available)	7	Not recorded	Not recorded
2001 (not available)	6	Not recorded	Not recorded
2002 (n = 1048)	7	2	Not recorded
2003 (n = 1291)	8 (flu / infections reported combined)		Not recorded
2004 (n = 1573)	7	1	Not recorded
2005 (n = 1903)	8 (flu / infections reported combined)		Not recorded
2006 (n = 1521)	5	Not recorded	Not recorded
2007 (n = 1181)	1	Not recorded	Not recorded
2008 (n = 1081)	1	Not recorded	30

The question 'have you ever dived with a short-term illness?' provided the closest equivalent for comparison with the PDE data. A higher percentage of divers in this study (37%, n = 231) reported diving with a short-term illness, which included colds, seasickness, food poisoning and migraine, than the DAN 2006 data (30%).

Divers in this study recorded high levels of infections acquired from aquatic environments (23%, n = 134). There were no significant gender differences (23% male, n = 92; 24% female, n = 42).

Having performed a greater number of recreational dives (p = 0.028) and a greater number of overhead dives (p<0.001) were positively significantly associated with frequency of infections, as expected, due to the increased exposure to risk.

The impact of tobacco smoking was considerable although daily cigarette consumption was not significantly associated with frequency of infections, despite contributing to an appreciable rise in the variance explained.

7.4.8 Marine life injuries

The variety of plant or animal life capable of causing injury to divers is very broad and outcomes range from minor cuts and scrapes requiring very little attention, to life-threatening infections, poisoning or trauma.

Population-level data on the incidence of negative diver-marine life interactions is limited, although general reporting of incidents such as jellyfish stings or shark attacks may be carried out in high-risk or densely populated areas. Information regarding these incidents tends to be presented as either annual statistical reporting, such as the International Shark Attack File[17], or from detailed case studies or regional reports (Hazin, Burgess and Carvalho, 2008). An analysis of 205 marine animal injuries presenting at the emergency departments in Victoria, Australia (Taylor, Ashby and Winkel, 2002) found that nearly 70% of injuries occurred during recreational activity and that 72% of victims were male, most likely reflecting their greater participation in these activities and higher tendencies for sensation seeking. Penetrating injuries from spikes, spines or barbs were the most common (40%, n = 82) followed by stings (26%, n = 54) and that bites were uncommon. Only 8% of patients required admission to hospital.

A high proportion of divers (40%, n = 235) reported marine life injuries in this study. Females were significantly more likely to report a history of injury (47%, n = 83) than males (37%, n = 152); however, no significant differences were found for severity of injuries with males and females equally likely to have received first aid or medical treatment (X_2 = 0.01; DF

[17] The International Shark Attack File is maintained at the Florida Museum of Natural History by the University of Florida. http://www.flmnh.ufl.edu/fish/sharks/isaf/isaf.htm

= 1; p = 1.000) or have taken time off to recover (X_2 = 0.20; DF = 1; p = 1.000).

Divers who reported marine life injuries had performed a greater total number of recreational dives (p<0.001) and were more likely to be educated to degree-level or above (p = 0.007). They were also more likely to have carried out an unplanned decompression stop (p = 0.012) which is an additional safety measure required when diving time exceeds safe levels for risk of decompression illness. Having to carry out an unplanned decompression stop usually signifies that the diver spent longer at depth than intentioned and is more likely to occur when undertaking more complicated dives, such as diving in overhead environments, for example exploring shipwrecks.

Having conducted a greater number of recreational dives and having had to carry out an unplanned decompression stop were both positively significantly associated with frequency of marine life injuries, as expected, due to the extra exposure to risk. It is not clear what role education plays in the occurrence of marine life injuries, although it might be inferred that graduate divers feel more confident reporting these incidents.

Daily cigarette consumption resulted in an appreciable rise in the variance explained by the final model, but the variable itself was not significant.

7.4.9 Dehydration

No figures pertaining to the incidence of dehydration amongst SCUBA divers could be found in the literature, although it is a commonly cited predisposing factor for decompression illness (Newton, 2001; Clenney and Lasson, 1996; Edmonds et al, 2002).

12% of divers (n = 72) reported dehydration in this study with males (13%, n = 54) being slightly more likely to report than females (10%, n = 18) although these differences were not significant.

Solo diving was the only variable to be positively significantly associated with the frequency of dehydration in this study (p = 0.018).

Diving solo is considered to be more risky diving because there is no additional support available from a diving buddy, or boat, should an incident occur. To dive solo safely requires extra equipment, high levels of physical fitness and a rigorous approach to risk management for all aspects of diving. Dehydration might be more frequently reported by solo divers due to the additional stress of diving alone or a lack of shared facilities available.

Daily cigarette consumption resulted in a small rise in the variance explained by the model but the variable itself was not significant.

7.4.10 Hypothermia

No figures pertaining to the incidence of hypothermia amongst SCUBA divers could be found in the literature. Although mild hypothermia (reductions of 1-2 degrees centigrade in core body temperature) is frequently experienced by divers, more severe heat loss is acknowledged as a common cause of death for victims of marine accidents (Edmonds and Walker, 1989; Edmonds et al, 2002) and a predisposing factor for decompression illness (Newton, 2001).

4% of divers (n = 23) reported hypothermia in this study with males (4%, n = 17) more likely to report than females (3%, n = 6) although these differences were not significant.

Diving to greater depths using compressed air was positively significantly associated with the frequency of hypothermia (p = 0.027) and is consistent with expectations, as marine ambient temperatures generally decrease with depth and the total dive length would likely increase, especially if lengthy decompression stops are required.

Daily cigarette consumption resulted in a small rise in the variance explained by the model but the variable itself was not significant.

7.4.11 Hyperthermia

A degree of hyperthermia (increases of 1-2 degrees centigrade in core body temperature) is frequently experienced by divers who wear insulating suits in warm environments. Prolonged hyperthermia places extreme stress on the body and there are isolated cases of fatalities, especially where exercise is involved (Pendergast and Lundgren, 2009; Edmonds et al, 2002).

1% of divers (n = 3) reported hyperthermia in this study. All were male.

Having an Intermediate occupation was the only variable positively significantly associated with the frequency of hyperthermia (p = 0.003) before daily cigarette consumption was added to the analysis.

There were no significant predictors found for hyperthermia after daily cigarette consumption was included in the analysis. The latter resulted in a slight rise in the variance explained but the variable itself was not significant (p = 0.078).

7.4.12 Panic attacks

The role of panic in SCUBA diving fatalities

Panic attacks are regarded as a serious event in diving due to the high levels of associated mortality and morbidity, such as breath-hold air embolism (burst lung) and decompression illness.

Two studies of panic in recreational divers were identified in the literature. Morgan (1995) found that 54% of 254 divers surveyed had experienced a ‘panic or near-panic’ episode on at least one occasion whilst diving. This was twice the level (27%; n = 3,278) reported by Colvard and Colvard (2003) in a large-scale survey (n = 12,087) conducted through SCUBA diving magazine and PADI networks. Both studies found females to be significantly more likely to report a panic response.

Direct evidence linking panic attacks to fatalities is difficult to acquire, however, indirect evidence from Project Dive Exploration (PDE) suggests that rapid ascent is linked to both morbidity and mortality (DAN, 2000). A study of PDE dives resulting in injury or death reported rapid ascent in 38% of fatal dives, 23% of dives resulting in injury and in 1% of safe dives. These observations were based on 26 fatalities, 431 injuries and 5,908 dives collected during PDE.

A quantitative risk assessment commissioned by the Health and Safety Executive (HSE) found that rapid ascents were the most frequent cause of recorded diving incidents and that the majority of fatalities resulted from two or more sequential events or ‘contributory causes’ (Paras, 1997).

A series of reviews of diving accident reports for Australia and New Zealand (Edmonds and Walker, 1989; Edmonds and Walker, 1990; Edmonds and Walker, 1991; Elliott D, 1999) placed panic as the single most common contributory factor for fatalities, being implicated in 39% of recorded deaths (Edmonds and Walker, 1989). This view has been reiterated by many other members of the diving community:

“Most researchers in diving accidents implicate panic, as a response to stress, as the major cause of diving fatalities.” (Bachrach and Egstrom, 1987)

“Panic, or ineffective behaviour in the emergency situation when fear is present, is the single biggest killer of sport divers.” (Bove, 1998)

An investigation into SCUBA diver training practices by the HSE (Hicks, 1994) concluded that anxiety and panic reduce the capability of individuals to cope flexibly in an emergency and that a set of psychological phenomena were responsible for performance reduction in these situations, such as perceptual narrowing. The likely sequence of events preceding an incident has been described as “over-exertion, fatigue, exhaustion, respiratory embarrassment, panic and resultant accident” (Shilling et al, 1984).

This sequence was revised by participants at the 2010 DAN Diving Fatalities Workshop to become Root Cause, Triggering Event, Disabling or Harmful Event, Disabling Injury, Cause of Death (Vann and Lang, 2011).

<u>2010 DAN workshop revised fatality-sequence model:</u>

Root Cause	**Triggering Event**	**Disabling Event**	**Disabling Injury**	**Recorded cause of death**
Examples: Pre-existing pathology; Poor buoyancy control; Gas-supply difficulties; Equipment problems.	*Examples:* Free-flow or out-of-air scenario; Strong currents; Entanglement; Increased exertion.	*Examples:* Breath-hold ascent.	*Examples:* Arterial gas embolism; Loss of consciousness.	*Examples:* Drowning.

A report commissioned by the HSE to examine ways to reduce risk in professional SCUBA diving (HSE, 2006) determined that “there is no way to completely avoid or prevent stress during diving. The question is how the diver will react when stressful situations do occur”. In the recent DAN model, diver training and avoidance of Root Causes are regarded as the most effective approach to preventing fatalities.

The relationship between cigarette smoking and panic attacks

The percentage of recreational divers reporting a history of panic attacks was lower in this study than in any preceding research:

Recreational diver panic research	% male [N]	% female [N]	% total [N]
Morgan, 1995	50 [87]	64 [45]	54 [132]
Colvard & Colvard, 2003	24 [2205]	37 [1074]	27 [3278]
PhD study, 2012	22 [89]	33 [59]	25 [148]

This finding may be partly because the surveys conducted through diver networks by Morgan (1995) and Colvard and Colvard (2003) were promoted as specifically investigating panic attacks, which may have prompted a more favourable response from those with a history of panic.

As in previous studies, women were significantly more likely to report a history of panic attacks than men ($X_2 = 8.57$; DF = 1; $p = 0.005$).

Two final models of best fit were produced for panic attacks in this study.

The first was produced by logistic regression and examined the relationship of current cigarette smoking to panic attacks.

Being female ($p = 0.003$), diving with a pre-existing ear or sinus problem ($p = 0.005$), having comprehensive car insurance ($p = 0.013$), current cigarette smoking ($p = 0.014$) and ever having missed a safety stop ($p = 0.041$) were all positively significantly associated with a history of panic attacks.

The predictor variables fit well with the characteristics of panic attacks and the fatality sequence model described in the diving literature. In particular that divers were predominantly female, were diving with pre-existing medical pathology and had ever missed a safety stop, which is likely to indicate a rapid ascent.

There were two additional significant predictors identified by this model. Having comprehensive car insurance is an indicator of attitude to everyday risk, suggesting that divers with a history of panic attacks are more cautious in their everyday lives, and current cigarette smoking raises the possibility that nicotine plays a modulating role in the onset of panic attacks in smokers who dive.

There is a wealth of literature documenting higher rates of smoking amongst people diagnosed with anxiety (Morissette et al, 2007) and panic disorders (Zvolensky and Schmidt, 2006; Breslau and Klein, 1999) although the role that nicotine plays in affecting stress and emotional states is complex and not yet fully understood.

Although the diagnosis of an anxiety disorder is listed by the HSE as a medical contraindication to diving that requires specialist assessment (HSE, 2011) evidence suggests that general vulnerability to negative emotional states increases the chance of smoking (Patton et al, 1998) and that those affected also experience worse nicotine withdrawal symptoms (Breslau, Kilbey and Andreski, 1992).

The nature of nicotine withdrawal symptoms, which include anxiety, difficulty concentrating, impatience and irritability (Hughes, Higgins and Bickel, 1994), experienced by divers might influence the development of a panic attack, especially as few respondents in this study (4%; n = 6) had ever used nicotine replacement therapy (NRT) to help deal with cravings. No significant gender differences in divers' use of NRT ($X_2 = 0.49$; DF = 1; $p = 0.671$) were found.

The second model for panic attacks was produced by multiple linear regression and examined the role of daily cigarette consumption in predicting the frequency of attacks.

Being female (p = 0.009) and diving with a pre-existing short-term illness (p = 0.022) were both positively significantly associated with the frequency of panic attacks.

Daily cigarette consumption resulted in an appreciable rise in the variance explained by the model but the variable itself was just above the pre-determined significance level (p = 0.057).

The role that nicotine dependence might play in predisposing to panic attacks during diving has not been discussed in the literature; however, the findings of this study suggest that it might play a role in accordance with the sequence of events preceding a diving incident described by Vann and Lang (2011).

In accordance with this sequence, it is possible that enforced nicotine withdrawal whilst diving may contribute to a rise in general anxiety levels or negative affect (Root Causes) that predispose a diver to take ineffective action (Disabling Event) such as a rapid ascent, in response to stress. This sequence would help explain the study findings (previously described in section 7.4.1) that 'missed safety stop' was positively significantly associated with a history of panic attacks (p = 0.041) and also 'having ever had a panic attack' being positively significantly associated with lung problems (p = 0.016).

The fatality-sequence models described by DAN and HSE emphasise that more than one contributory factor generally needs to be present before an incident develops. In this study, increased anxiety due to nicotine withdrawal might be regarded as one Root Cause and a second would be diving with a pre-existing short-term illness, or ear or sinus problem, which concurs with the already identified DAN category of 'pre-existing pathology'.

Removing a potential Root Cause such as nicotine withdrawal symptoms, perhaps through greater use of NRT whilst diving, might be a method of reducing the overall risk that divers who smoke are exposed to and therefore reduce the likelihood of an incident occurring.

More research is required to determine whether this is likely to be the case and if there are any other factors to consider regarding the use of NRT in diving, or at depth (especially in cases with heavy dependence).

7.4.13 Loss of consciousness

Without rescue and life-support interventions, loss of consciousness typically precedes saltwater aspiration and subsequently drowning in marine accidents.

Loss of consciousness is rarely recorded as an event in itself, unless associated with another incident such as pulmonary barotrauma, but drowning is the most commonly recorded cause of death in autopsy reports of SCUBA diving fatalities, accounting for 52-86% of cases (Edmonds et al, 2002), and is cited when no other medical or physiological disorder related to death can be identified (Laurence and Cooke, 2006: Edmonds and Walker, 1989).

One male reported ever having lost consciousness whilst diving in this study and there were no significant associations with tobacco use.

Having performed a greater number of dives ($p = 0.007$) and having spent more years diving ($p = 0.018$) were positively significantly associated with losing consciousness and are consistent with increased exposure to risk.

No further analyses could be conducted.

7.4.14 Cardiac problems

The proportion of divers with chronic cardiovascular conditions is thought to be steadily increasing together with the proportion of divers classified as overweight or obese represented in fatalities (DAN, 2008).

Project Dive Exploration (PDE) records pre-existing cardiovascular disease, which includes chronic cardiac conditions and hypertension, although data collection or categorisation is not consistently reported.

DAN Annual report: PDE data (n)	% divers with chronic cardiac conditions	% divers with hypertension	total % cardiovascular
2000 (n not available)	Reported as cardiovascular		3
2001 (n not available)	Reported as cardiovascular		2
2002 (n = 1048)	Reported as cardiovascular		12
2003 (n = 1291)	2	4	6
2004 (n = 1573)	1	5	6
2005 (n = 1903)	2	6	8
2006 (n = 1521)	2	9	11
2007 (n = 1181)	2	8	10
2008 (n = 1081)	2	6	8

DAN also records cardiovascular events as a percentage of fatalities.

DAN fatality data (% history available; n)	% known history of heart disease	% known history of hypertension	total % cardiovascular –related fatalities
2000 (n = 83)	Not recorded	Not recorded	10
2001 (81%; n = 63)	Not recorded	Not recorded	9
2002 (n = 91)	Not recorded	Not recorded	17
2003 (n = 77)	Not recorded	Not recorded	15
2004 (n = 89)	Not recorded	Not recorded	15
2005 (64%; n = 57)	16	9	Not recorded
2006 (40%; n = 35)	15	9	Not recorded
2007 (40%; n = 35)	14	15	Not recorded
2008 (49%; n = 37)	38	11	28

One male reported ever having cardiac problems whilst diving in this study and there were no significant associations with tobacco use.

Taking risks for fun whilst diving (p = 0.001) was the only variable to be positively significantly associated with frequency of cardiac problems, although no data relating to body mass index was recorded in this study.

No further analyses could be conducted.

7.4.15 Total number of episodes of diving-related illness

The analysis of total frequency of episodes of diving-related illness identified ten separate predictors which are discussed according to their grouping at entry.

Demographics

Being older (p = 0.004), having qualified to degree level or above (p = 0.010) and never having married (p = 0.040) were all positively significantly associated with total frequency of illness.

Ageing is associated with an increase in diving-related injuries, and more serious dive-related injuries (DAN, 2008). Being educated to degree level or above is associated with a higher response rate in health surveys (Sonne-Holm et al, 1989; Korkelia et al, 2001) and it might be that more-educated respondents feel more confident in reporting relevant diving incidents. Never having married can reflect a stage of the life course where respondents have fewer responsibilities, such as dependents, and therefore risk-taking is more likely. Never having married was significantly associated with higher everyday and diving risk taking scores in this study:

<u>Associations between risk taking and marital status:</u>

	Currently or previously married	**Never married**	**Statistical test**	**DF**	***p***
Everyday risk taking	Mean = 1.57 SD = 1.23 N = 359	Mean = 2.00 SD = 1.22 N = 225	t = -4.17	582	P<0.001

Diving risk taking	Mean = 1.68 SD = 1.41 N = 359	Mean = 2.12 SD = 1.62 N = 225	t = -3.52	582	P<0.001

Pre-existing pathology

Diving with a short-term illness was positively significantly associated with total dive-related illness (p = 0.006) and is suspected to contribute to higher rates of diving-related illness through increased stimulation of an inflammatory response that has already been activated by SCUBA diving.

The hyperoxia associated with SCUBA diving is known to cause oxidative stress within the body (Ferrer et al, 2007) which is thought to result in endothelial dysfunction (Madden and Laden, 2009). Bubbles and tissue injury are also known to affect the endothelial lining (Bove, 2002) resulting in acute inflammation and increased vascular permeability, which leads to diminished perfusion of local tissue.

The presence of an inflammatory response prior to SCUBA diving is likely to enhance the inflammatory response associated with diving-related hyperoxia, further reduce tissue perfusion and consequently lead to a greater risk of pathology and subsequently illness. Diving with a pre-existing short-term illness was significantly associated with both panic attacks and decompression illness in this study, which are two of the most serious medical events in recreational SCUBA diving.

Everyday risk taking

No everyday risk taking variables were significantly associated with total frequency of diving-related illness.

Diving risk taking

Taking risks for fun whilst diving ($p<0.001$) and diving solo ($p<0.001$) were positively significantly associated with total dive-related illness, as expected, due to the increased exposure to risk whilst diving. Diving below 40m using compressed air ($p = 0.005$) and having ever undertaken an unplanned decompression stop ($p = 0.020$) were negatively significantly associated with total diving-related illness. This is a more surprising finding as both variables indicate a greater degree of risk-taking.

In theory, diving to greater depths than 40m using compressed air exceeds the safe depth threshold recommended by PADI due to the increased risk of nitrogen narcosis and the short time period available at depth before a lengthy decompression stop is required. In practice, having to undertake an unplanned decompression stop might directly follow from having exceeded the safe depth limits for diving and the two variables were significantly associated ($X_2 = 9.73$; DF = 1; $p = 0.003$) in this study. Therefore in contrast to the perception of increased risk, having carried out an unplanned decompression stop would alleviate some, or all, of the risk of decompression illness in this scenario and it is possible that the negative associations result from effective risk-reducing actions by divers, whereas those who did not take the appropriate action would have experienced a more deleterious outcome, such as a panic, rapid ascent or decompression illness, as a result of deviating from their original dive plan.

Diving experience

Having ever dived for work purposes was positively significantly associated ($p = 0.003$) with total diving-related illness. This outcome is expected as professional divers will be required to undertake more dives and to expose themselves to greater risk in the process of carrying out their work activities, for example, using dangerous equipment such as mobile vehicles, or by trying to ensure the safety of novice divers by assisting with buoyancy control.

Tobacco smoking

The analyses of individual diving illnesses yielded some mixed results with daily cigarette consumption being negatively significantly associated with frequency of sinus damage (p = 0.010) and also decompression illness (p = 0.023) when frequency of mixed gas use was taken into account.

Daily cigarette consumption was also nearly positively significantly associated with the frequency of panic attacks (p = 0.057) and hyperthermia (p = 0.078) and resulted in an appreciable rise in the variance explained (more than 0.10 increase) when added to the regression analyses for decompression illness for compressed air divers, infections acquired from aquatic environments and marine life injuries, and a very modest rise in variance explained for ear damage and dehydration (less than 0.10 increase).

Overall, daily cigarette consumption was positively significantly associated with total frequency of dive-related illness (p = 0.037); however, the picture appears to be more complicated than one might expect from the general medical literature relating to tobacco-caused illness.

In particular, the role of cigarette smoking in the development of decompression illness may be masked, or rendered more labyrinthine, by the hyperoxic environment created by SCUBA diving and the particular gas mixture that is present.

It is possible that the gaseous interactions taking place at a cellular level have mixed effects in relation to the development of diving-related illness, especially decompression sickness and lung function as identified in the literature review, but a substantial amount of further research will be required to determine the precise mechanisms involved.

In contrast, the role of nicotine dependence (and subsequent withdrawal symptoms) in the development of panic attacks would be relatively easy for the diving community to investigate further and consider the action that might be taken to further reduce risks.

7.4.16 Total severity of diving-related illnesses

The only variable to be positively significantly associated with total severity of diving-related illness was the pre-existence of a long-term health condition, such as diabetes or asthma ($p = 0.011$). It is possible that the chronic presence of inflammatory factors or vascular changes induced by metabolic processes could predispose to diving-related illness in a similar manner to that described above for pre-existing acute conditions. Further investigation is warranted, particularly as the number of divers with hypertension and other conditions associated with metabolic syndrome continues to rise (DAN, 2008).

CHAPTER 8 - GENERAL DISCUSSION AND CONCLUSIONS

The study yielded a large number of findings from areas as diverse as population-level statistics to the possible clinical implications of tobacco smoking for divers.

For ease of navigation, a summary of the main findings has been presented at the beginning of the chapter. The broad range of findings requires some elaboration of the relevant policy context before the limitations and implications of the research can be discussed. This is provided in the sections below the summary.

8.1 Summary of main findings

Recreational SCUBA divers are a distinct sub-group of the wider UK population, being significantly younger and over-represented by males and those not in Routine and Manual occupations. Significant differences in tobacco use between UK recreational divers and the general population, which persisted after controlling for age, gender and social class, were found in this study although the low response rate obtained precludes any certainty with these findings.

After adjusting for demographic factors, divers were significantly less likely to smoke cigarettes ($p<0.001$) and their cigarette consumption ($p<0.001$) was also lower than the UK population, however the latter was not biochemically supported by salivary cotinine levels ($p = 0.345$) which requires the findings to be treated with caution. Divers, however, were more likely to smoke cigars or pipes ($p<0.001$) or non-cigarette tobacco, including cannabis ($p<0.001$), than the UK population.

Demographics were a major determinant of the tobacco products used by divers. Cigarette smoking was associated with a non-degree-level education ($p<0.001$) whereas cigar or pipe smokers were significantly more likely to be older ($p = 0.011$) and male ($p = 0.010$) than non-smoker divers. Cannabis smokers were significantly more likely to be younger ($p<0.001$), male ($p = 0.012$) and not in Professional or Managerial occupations ($p = 0.005$) than non-smoker divers. Cigarette consumption was also strongly linked to demographic variables with fewer cigarettes being smoked by younger divers ($p = 0.001$), those educated to degree-level or above ($p = 0.025$) or in a Professional or Managerial occupation ($p = 0.035$).

Non-demographic variables associated with tobacco use included attitudes to everyday risk taking and being a professionally-qualified recreational diver. After adjusting for demographic factors, everyday risk taking was significantly associated with current cigar or pipe use ($p = 0.037$) and higher everyday risk taking scores were significantly associated with higher cigarette consumption ($p = 0.046$) and increased cigarette dependence ($p = 0.011$). Being professionally qualified in the recreational diving sector was also significantly associated with a higher cigarette consumption ($p = 0.001$) and cigarette dependence ($p = 0.001$).

Recreational SCUBA divers were much less likely to report poor general health than the UK population, probably reflecting their relative youth, greater prevalence of males and higher socio-economic group. Despite these potential advantages, however, current cigarette smoking was significantly associated with poorer self-assessed health within the diving population after controlling for demographic variables ($p = 0.006$) raising the possibility that smoking-related ill health might be aggravated by SCUBA diving. Divers with the poorest self-assessed health were most likely to seek input from a diving physician and, after adjusting for confounding variables, the presence of a long-term condition was the sole predictor of ever being medically assessed as ‘unfit to dive’ ($p<0.001$).

Current cigarette smoking was also significantly associated with panic attacks ($p = 0.014$) after adjustment for confounding variables, which in turn was significantly associated with lung problems ($p = 0.016$), leading to the possibility that the experience of nicotine withdrawal during a dive might predispose the smoker to panic and subsequent serious injury.

Daily cigarette consumption was also significantly associated with the total frequency of diving-related illness experienced ($p = 0.037$) after adjustment for confounding factors.

8.2 Overview of the health risks of diving

SCUBA diving is an inherently risky activity. The health risks of using compressed air to breathe whilst diving are well documented and research, conducted principally in the commercial and military diving sectors, has helped identify a range of measures to try to reduce the morbidity and mortality experienced by divers. These measures include the use of computers in dive planning, regulations to cover 'diving at work' and medical standards to assess 'fitness to dive' (HSE, 2010).

In contrast, the recreational sector is relatively poorly researched but the main health issues affecting divers, such as decompression illness, are very similar with a few notable exceptions, such as dysbaric osteonecrosis or 'high pressure neurological syndrome'. Technological developments, however, which allow recreational divers to undertake more complex and physically demanding dives are thought to be partly responsible for a rise in medical conditions that were previously only seen in the commercial or military sectors (Cimsit et al, 2007).

Tobacco smoking is widely regarded as a potential, but as yet undefined, additional risk to health by the diving community. No causal link between tobacco use and diving-related illness has yet been established (Wilmshurst et al, 1994; Buch et al, 2003) although there are suspicions that the severity of DCI experienced might be linked to the consumption of cigarettes (Buch et al, 2003) and that pulmonary function might decline faster in divers with heavy smoking histories (Dembert et al, 1984).

Despite the recent rise in recreational diver deaths attributed to cardiovascular disease (DAN, 2008) there are no studies examining either the long-term effects of diving on the cardiovascular system or the role that smoking might play in the development of cardiovascular pathology in divers (Walker, 2001).

The enforcement of workplace regulations, setting training standards and identifying medical conditions that might be contraindicated in SCUBA diving, are key tenets of the current HSE Diving Health and Safety Strategy (HSE, 2010) and where not enforceable, they are regarded as good practice in the recreational sector. Anti-tobacco messages are widespread and likely to be specifically addressed during basic diver training and medical assessments, therefore it is highly unlikely that either novice or veteran divers will be unaware of the potential additional risks posed by smoking although, despite these warnings, in this study many had smoked within six hours of diving for recreation (26%; n = 171) and professionally-trained divers (CMAS Level 3 or above) consumed more cigarettes daily ($p = 0.001$) and had a higher dependence on cigarettes ($p = 0.001$) after controlling for demographic factors and attitudes to everyday risk taking.

8.3 Overview of tobacco use within the recreational diving sector

Recreational SCUBA divers are a distinct sub-group of the wider UK population, being significantly younger and over-represented by males and those not in Routine and Manual occupations. There are significant differences in tobacco use between UK recreational divers and the general population, which persist after controlling for age, gender and social class.

After adjustment for demographic factors, divers were significantly less likely to be current cigarette smokers ($p<0.001$) and smoked fewer cigarettes per day ($p<0.001$) than the UK population. Instead they were more likely to smoke cigars or pipes ($p<0.001$) or non-cigarette tobacco, including cannabis ($p<0.001$), raising the possibility that some may have switched from regular cigarette smoking to the occasional use of other forms of tobacco, in the belief it may mitigate the health risks (Ockene et al, 1987). Unfortunately no further information on whether this was likely to be the case could be found.

Despite the inherent difficulties of establishing a representative sample of respondents through recreational diver networks, a relatively low prevalence of cigarette smoking (19%) is a finding that is common to other UK studies using a similar methodology (10%, St Leger Dowse et al, 2011; 15%, Glen, White and Douglas, 2000; 17%, Wilmshurst et al, 1994). This survey found the highest prevalence of smoking of all the UK studies conducted; however, the result is supported by biochemical verification (93% percentage agreement between self-reported cigarette smoking status and salivary cotinine levels) that was not utilised in other studies. Therefore the prevalence figure identified by this study might be expected to be robust, although the study sample is likely to be influenced by the same selection biases as other UK surveys.

Demographic factors associated with divers' smoking behaviour

Demographic factors were a major determinant of the tobacco choices of divers in this study, although these did not always concur with the equivalent variables identified by the 2006 General Household Survey (GHS) for the wider UK population.

The only major determinant significantly influencing cigarette smoking amongst divers was being educated to degree-level or above ($p<0.001$) with graduates being less likely to smoke. In contrast, the 2006 GHS identified age, gender, marital status and social class as major determinants of cigarette smoking. These observed differences are likely to reflect the already unique demographic characteristics of the diving sample and also the established relationships between higher educational attainment and reduced participation in risky health behaviours and better health outcomes (Baker et al, 2011; Eide and Showalkter, 2011).

Cigar or pipe smokers were significantly more likely to be older (p = 0.011) and male (p = 0.010) than non-smoker divers. These demographic characteristics reflect those in the 2006 GHS.

Cannabis smokers were significantly more likely to be younger (p<0.001), male (p = 0.012) and in an Intermediate or a Routine or Manual occupation (p = 0.005) than non-smoker divers. These demographic characteristics reflect those in the 2006/7 British Crime Survey. Current cannabis smokers were significantly more likely to be concurrent cigarette (p<0.001) and cigar or pipe smokers (p = 0.003).

Cigarette consumption was also strongly linked to demographic variables with fewer cigarettes being smoked by younger divers (p = 0.001), those educated to degree-level or above (p = 0.025) or in a Professional or Managerial occupation (p = 0.035). These demographic characteristics are similar to those identified in the 2006 GHS with the exception of gender. Although male divers were more likely to have a higher daily cigarette consumption than females, this difference was not significant (p = 0.062).

Cigarette dependence, as measured by the FTND score, was significantly greater in males (p = 0.042) and those not educated to degree-level (p = 0.044) in the diving sample. These demographic characteristics reflect those in the 2006 GHS with the exception that social class, specifically being in a Professional or Managerial occupation, was a determinant of lower dependence in the 2006 GHS.

Non-demographic factors associated with divers' smoking behaviour

The systematic review of the literature identified the possibility that divers were more likely to be sensation seekers than non-divers (Heyman and Rose, 1980; Guszkowska and Boldak, 2010; Biersner and LaRocco, 1983) and that a higher proportion of tobacco users (Roberti, 2004; Zuckerman, 1979; Zuckerman, Ball and Black, 1990; Zuckerman and Neeb, 1980; Carton, Jouvent and Widlocher, 1994; Gurpegui et al, 2007; Spillane, Smith and Kahler, 2010) and recreational drug users (Roberti, 2004) were more likely to be sensation seekers than non-users.

In addition, that highly qualified extreme sports enthusiasts were more likely to be sensation seekers (Zuckerman, 1992) but less likely to have accidents than novices (Bouter et al, 1988; Cherpitel et al, 1998) whilst novice sensation seekers were more likely to have accidents than their more conservative peers (Bonnet et al, 2003).

In accordance with these findings, divers who smoke might be expected to be greater risk takers than non-smoker divers and that professionally-qualified divers might be expected to be greater risk takers, but have fewer diving accidents, than novices.

Both the variables 'having trained to a professional-level within recreational SCUBA diving' (CMAS Level 3) and 'attitudes to everyday risk taking' were added sequentially to the regression analyses for tobacco use and consumption to examine their effect on divers' smoking behaviour.

Whilst neither variable influenced the final models produced for current cigarette or cannabis smoking, everyday risk taking was an independent significant predictor for current cigar or pipe use ($p = 0.037$).

Both variables, added separately and together, significantly influenced the variance explained and final models produced for cigarette consumption.

After controlling for demographic variables, having qualified to at least CMAS Level 3 or above was positively significantly associated with higher cigarette consumption ($p = 0.001$) and cigarette dependence ($p = 0.001$) and higher everyday risk taking scores was positively significantly associated with higher cigarette consumption ($p = 0.046$) and cigarette dependence ($p = 0.011$).

These findings differ slightly from those expected from the literature in that sensation seeking (represented in this study by attitudes to everyday risk taking) appears to be better reflected by cigarette consumption and dependence rather than current tobacco or recreational drug use, with the exception of cigar or pipe smoking. Further research, preferably using similar tools to those having previously investigated sensation seeking in recreational SCUBA divers, would be required to validate these findings.

In addition no previous studies have reported a greater cigarette dependence amongst professionally-qualified divers compared to their non-professionally qualified peers, although anecdotal observations of increased smoking activity amongst instructors have been noted (p17). The Health and Safety Executive requires an annual diving medical examination for those diving for work purposes, which includes professional recreational diving instructors, and might prove to be a productive area of research into the smoking behaviour, beliefs and related health effects of this potentially ‘at risk’ group.

8.4 Relationship between tobacco use and self-reported general health and medically-assessed ‘fitness to dive’

In comparison to the UK population, recreational SCUBA divers are much less likely to report poor general health. This finding is to be expected given the significant demographic differences between the two populations, although it could not be statistically verified.

In contrast, there were significant differences in self-reported health within the diving sample with regards to tobacco use. Current cigarette smoking was positively significantly associated with poorer self-assessed general health after controlling for demographic variables ($p = 0.006$) raising the possibility that smoking-related ill health might be aggravated by diving.

Regularly breathing compressed air is known to have an effect on both lung function (Tetzlaff et al, 1998; Skogstad, Thorsen and Haldorsen, 2000; Skogstad et al, 2002) and airway hyper-responsiveness in divers (Cirillo et al, 2003; Tetzlaff et al, 1998) which may be further aggravated by smoking (Dembert et al, 1984; Sekulic and Tocilj, 2006; Tetzlaff et al, 2006; Dillard and Ewald, 2003) although research findings have been mixed (Chong, Tan and Lim, 2008; Suzuki; 1997) and are not regarded as conclusive. It is feasible that these changes are noticed by divers themselves before they become clinically detectable. Unfortunately only a small amount of information detailing how smokers' health was affected was recorded by this study (section 6.3.2.1) with the two most common health complaints being reduced lung function (n = 50) and lower fitness (n = 39) and further research is needed to investigate these possibilities.

Another area of ambiguity is the role of medical assessments in determining a diver's 'fitness to dive'. In this study there were no significant relationships found between tobacco use and whether a diver had ever been classified as either 'unfit to dive' or advised to limit their diving for medical reasons, even though divers who smoked reported significantly poorer general health than non-smokers (p = 0.006) after adjustment for confounding variables.

It is possible that the signs of smoking-related disease, which normally manifest at 35 years of age and over (The Information Centre, 2011), are less easy to detect in the relatively youthful, and possibly more healthy, recreational diver population. It is difficult to interpret these findings further, however, as only half of divers in this study (51%; n = 317) had ever had any type of medical assessment. This development is the result of a national policy change to replace compulsory pre-training medical screening, deemed to have little value as a routine exercise (Glen, White and Douglas, 2000), with a self-assessment checklist whereby the individual bears responsibility for identifying any possible medical contraindications and for seeking input from a diving physician where necessary.

This study provided some indications that the self-assessment policy is at least partially achieving its aims as attending a non-work related medical was significantly correlated with poorer self-assessed general health ($p = 0.008$) and that the only variable positively significantly associated with having any restrictions placed on them for medical reasons was the presence of a long-term condition ($p<0.001$). Some suspicions remain, however, that a sizeable proportion of divers are avoiding medical assessments because they prefer potential contraindications not to be identified (Taylor, O'Toole and Ryan, 2002) in order to continue diving. It is possible that this latter development might be reflected in the growing proportion of diver mortality attributed to pre-existing cardiovascular disease and hypertension in recent years (DAN, 2008; Denoble et al, 2008) as divers in the earlier stages of systemic disorders, such as pre-diabetes, might not consider themselves in poor enough health to seek medical advice, although the matter requires further research.

8.5 Prevalence of diving-related illness

The diving-related illnesses are typically characterised by barotraumas of ascent or descent (associated with breathing compressed gas at depth) in combination with factors present in the marine environment that interact with individual personality, behavioural and biological or genetic factors to produce specific clinical and non-clinical outcomes.

Divers in this study reported a broad range of illnesses or injuries that had occurred during, or as a result of, the practice of diving. Unfortunately with the exception of decompression illness, the prevalence of diving-related illness is not well documented in the diving literature and shared definitions or classification of illnesses are not commonly used, resulting in a wider range of prevalence estimates than might otherwise be the case.

Data from DAN's Project Dive Exploration (PDE) together with relevant literature review articles provided comparator figures to this study, summarised in Table 8.1.

Table 8.1: Prevalence comparisons of diving-related illness

DIVING-RELATED ILLNESS	% PhD study	% DAN 2008 / PDE data [notes]
Lung problems	0	0 [suspected in 33% of fatalities]
Decompression illness	3	2 - 5
Nervous system effects	1	1
Dysbaric bone disease	0	0 [suspected higher]
Musculoskeletal	14	10
Dysbaric ear damage	10	11 [Nakayama et al, 2012]
Dysbaric sinus damage	5	6 [Nakayama et al, 2012]
Infection	23	1 – 8 [flu / infections combined]
Pre-existing short-term illness	37	30 [total acute health conditions]
Marine life injuries	40	Unknown
Dehydration	12	Unknown
Hypothermia	4	Unknown
Hyperthermia	1	Unknown
Panic attack	25	27 – 54 [Colvards, 2003; Morgan, 1995]
Loss of consciousness	0	Unknown [suspected in 48% of fatalities]
Cardiac problems	0	2 [suspected in 38% of fatalities]

Prevalence levels for this study were broadly in line with those identified elsewhere, although like-for-like comparisons could not always be made.

Reporting of marine life injuries and infections acquired from aquatic environments was much higher than expected in this study, although no directly comparable data could be found. 38% of those reporting an infection had to take time off work (median = 6.0 days) suggesting that infections were a significant problem for some, whilst only 2% reported needing time off for marine life injuries (median = 3.0 days) suggesting that these incidents reported by divers were generally minor.

The proportion of divers choosing to dive with a pre-existing short-term illness was surprisingly high given the additional hazards posed whilst diving, which could range from localised difficulties such as equalising the pressure in the middle ear or sinus cavities, to more systemic conditions such as fatigue, vomiting and fever.

The role that diving with a pre-existing short-term illness poses to the development of more serious diving conditions, such as panic attack, is discussed in the next section.

8.6 Relationship between diving-related illness and tobacco smoking

The development of diving-related illness is a complex process with a multitude of factors affecting outcomes. This study focused on the influence of variables within six principal domains: demographics; underlying health status prior to diving; attitudes to everyday risk taking; attitudes to risk taking whilst diving; diving experience and tobacco use.

A short description of the role of the main variables predicting diving-related illness is provided below and a summary of the final models produced for frequency of diving-related illness is provided in Table 8.2.

<u>Table 8.2: Final model predictors for frequency of diving-related illness:</u>

DIVING-RELATED ILLNESS	**Predictor variables**	*p*
Lung problems	Play fruit machines more frequently	0.002
	Panic attack history	0.016
	Not having travel insurance	0.017
	Ever missed safety stop	*0.093*
Decompression illness (compressed air users)	Take risks for fun whilst diving	<0.001
	Not having travel insurance	0.014
	Deepest dive on air	0.017
Nervous system effects	Being female	0.006
Musculoskeletal	Take risks for fun whilst diving	0.015
	Ever dived for work	0.034
	Ever missed safety stop	*0.089*
Dysbaric ear damage	Deepest dive on air	0.015
	Greater total number of dives	0.047
Dysbaric sinus damage	Not normally wear seat belt whilst driving	<0.001

	Ever missed safety stop	0.003
	Smoke fewer cigarettes per day	0.010
Infection	Greater total number of overhead dives	<0.001
	Greater total number of dives	0.028
	Diving for work	*0.101*
Marine life injuries	Greater total number of dives	<0.001
	Degree-level qualification	0.007
	Unplanned decompression stop	0.012
Dehydration	Solo diving	0.018
	Never married	*0.245*
Hypothermia	Deepest dive on air	0.027
	Mixed gas diving	*0.100*
Hyperthermia	*Smoke more cigarettes per day*	*0.078*
Panic attack	Being female	0.009
	Dived with pre-existing short-term illness	0.022
	Smoke more cigarettes per day	*0.057*
	Dived pre-existing ear or sinus problem	*0.088*
	Ever missed safety stop	*0.764*
Loss of consciousness	Greater total number of dives	0.007
	More years spent diving	0.018
	Dived pre-existing ear or sinus problem	*0.055*
Cardiac problems	Take risks for fun whilst diving	0.001
	No comprehensive car insurance	*0.062*
Total number of episodes of illness	Take risks for fun whilst diving	<0.001
	Solo diving	<0.001
	Ever dived for work	0.003
	Increasing age	0.004
	Dived below 40m using compressed air	0.005
	Dived with pre-existing short-term illness	0.006
	Degree-level qualification	0.010
	Unplanned decompression stop	0.020
	Smoke more cigarettes per day	0.037
	Never married	0.040
	Number of overhead dives	*0.095*
Total severity of illness	Dived with pre-existing long-term illness	0.011

Demographics

Gender, specifically being female, and being educated to at least degree-level were the most commonly identified demographic variables in the final models. Gender was the only variable significantly associated with the frequency of nervous system effects and the most highly significantly associated variable with the frequency of panic attacks. Being educated to degree-level or above was significantly associated with reporting marine life injuries (although these were relatively minor injuries for the majority of divers) and total frequency of diving-related illness, which also included increasing age and never having married as significantly associated variables.

Underlying health status prior to diving

The Health and Safety Executive (HSE) regard diving medical assessments as an essential measure to reduce the risk of injury whilst diving for work purposes (HSE, 2011). Although pre-diving medical assessments are no longer compulsory for those entering the recreational sector, their potential role in preventing dive-related illness is not disputed (except as a routine screening exercise) but the emphasis is instead placed on the diver to recognise their own potential medical risks from a pre-diving checklist and to seek input from a diving physician.

Long-term conditions, such as asthma, diabetes and epilepsy, are listed potential contraindications to diving, as are anxiety disorders and taking any form of psychotropic medication (HSE, 2011). All of these conditions require specialist assessment before a subject can be deemed ‘fit to dive’. This study provided some evidence of the effectiveness of this self-determined medical assessment policy with divers in the poorest health being most likely to seek medical input (the presence of a long-term condition was the only variable to be significantly associated with having ever being medically assessed as ‘unfit to dive’) and of the importance of detecting certain risk factors, such as a history of panic attacks, which was also significantly associated with lung problems (and most likely rapid ascent) in this study.

The responsibility for self-assessed health, however, is an ongoing one and not solely limited to entry-level training. The role that short-term illness plays in the development of diving-related illness has not been overtly studied in the literature, although its influence is recognised by DAN with its inclusion in PDE data and also referred to as a Root Cause in the 2010 DAN Diving Fatalities Workshop (Vann and Lang, 2011).

Diving with a pre-existing short-term illness was found to be significantly associated with the frequency of panic attacks and total frequency of diving-related illness. Due to the role that pre-existing pathology is thought to play in the sequence of events that precedes diving incidents (Vann and Lang, 2011) the risks should be investigated further, especially as that the practice seems common with 37% of divers admitted to diving with a pre-existing short-term illness in this study and 30% in the most recent DAN report (DAN, 2008).

Attitudes to everyday risk taking

Not usually taking out travel insurance for holidays was the variable most commonly reflecting attitudes to everyday risk taking and was significantly associated with the development of lung problems and decompression illness, which are two of the most serious diving-related illnesses. Other significant variables included playing fruit machines more frequently (for lung problems) and not normally wearing a seat belt whilst driving (for sinus problems) but it is impossible to elaborate on any further relationships other than being indicators of a propensity to greater everyday risk taking.

Attitudes to risk taking whilst diving

It is perhaps unsurprising that voluntarily engaging in more risky activities should lead to a higher incidence of diving-related illnesses, although in some cases the risky diving practice may result from the presence of other factors, for example, having to carry out an unplanned decompression stop was significantly associated with marine life injuries (p = 0.034).

In other circumstances it is likely that the risk precedes the injury, for example taking risks for fun was significantly associated with decompression illness, musculoskeletal problems, cardiac disease and the total frequency of diving-related illness. Diving more deeply using compressed air was also significantly associated with decompression illness, dysbaric ear damage and hypothermia. Ever having missed a safety stop was significantly associated with dysbaric sinus damage and solo diving was significantly associated with dehydration and total frequency of diving related illness.

In contrast, diving below 40m using compressed air and having to carry out unplanned decompression stops were both negatively significantly associated with the total frequency of diving-related illness; however, in this scenario is it likely that the two events are sequential, being significantly correlated (p = 0.002), and that carrying out an unplanned decompression stop is a risk-reducing measure, designed to prevent the onset of DCI.

As suspected, engaging in risky diving activities was the most common set of variables significantly associated with total frequency of diving-related illness. More severe diving incidents, especially those that warrant official reporting, typically result from a series of mishaps or unfortunate events that lead to a serious outcome, such as decompression illness or death, as a consequence of no effective interventions being undertaken earlier in the sequence (Paras, 1997). Risky diving practices would be expected to contribute to both the series of mishaps and a failure to undertake effective remedial action within this sequence of events.

Diving experience

Diving experience was suspected to be associated with a higher incidence of diving-related illness due to the increased exposure to risk.

This expectation was fulfilled by a greater total number of dives being significantly associated with a range of illnesses, including dysbaric ear damage, infections acquired from aquatic environments, marine life injuries and loss of consciousness whilst diving.

Ever dived for work was significantly associated with musculoskeletal injuries and total frequency of diving-related illness. Carrying out a greater total of dives in overhead environments was significantly associated with acquiring infections from aquatic environments, and diving for a greater number of years was significantly associated with having lost consciousness whilst diving.

Tobacco use

The only tobacco variables that were significantly associated with diving-related illness were current cigarette smoking and daily cigarette consumption, although the findings were not always as expected.

Current cigarette smoking was significantly associated with a history of panic attacks ($p = 0.014$), which in turn was significantly associated with lung problems ($p = 0.016$), leading to the possibility that the symptoms of nicotine withdrawal experienced during a dive might predispose the smoker to panic and subsequent serious injury. Another interpretation might be that those who are predisposed to anxiety are more likely to smoke (McClernon and Gilbert, 2007) and therefore predisposed to panic episodes during diving. In this instance, the HSE medical examination specifications for identifying those who might be predisposed to panic might need to be revised to take into account a wider range of anxiety indicators than at present. Further research, particularly during diving medical assessments, is warranted in this area as a matter of priority.

Another unexpected finding was that smoking fewer cigarettes per day was significantly associated with sinus damage frequency, whilst greater cigarette consumption did not play the suspected role in the development of other diving-related illnesses, such as decompression illness, dysbaric ear damage or the occurrence of infections, although it did result in an increase in the variance explained in the final models.

Overall, however, increasing daily cigarette consumption was significantly associated with a higher frequency of total dive-related illness, as suspected, although the possible mechanisms underlying these observations are far from clear or well understood.

It is feasible that the complexity of gaseous interactions taking place at a cellular level (as a result of breathing compressed air or other gases) is sensitive to the introduction of additional products from the combustion of tobacco, resulting in yet further complex interactions with the physiological processes underlying the development of diving-related illness. These additional factors provide one plausible explanation why no consistent links have yet been identified between smoking, lung function and decompression illness in divers, despite being widely predicted.

On the other hand, current cigarette smokers reported significantly poorer self-assessed general health than non-smokers in this study, leading to the possibility that although pathophysiological changes are occurring, they are not yet clinically detectable. Further research is required by the medical diving community to determine if this is likely to be the case.

8.7 Conclusions

Although divers' overall cigarette smoking prevalence is lower than that of the general UK population after adjustment for demographic factors, cigarette smoking and especially daily cigarette consumption, plays an important role in the development of poor general health and total frequency of diving-related illness, although the underlying mechanisms are currently not well understood.

In particular that current cigarette smoking is associated with the occurrence of panic attacks alongside the presence of a pre-existing pathology, such as a short-term illness, but further research is needed to confirm these findings and to determine appropriate prevention measures.

Finally, the choice of tobacco by divers and degree of dependence reflect attitudes to risk taking and professional diver status as well as demographic factors.

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APPENDIX 1 - UK MAIN RECREATIONAL DIVER TRAINING AND SAFETY ORGANISATIONS

British Diving Safety Group (BDSG)

The BDSG performs the over-arching role of informal regulator of safety in recreational diving practices in the UK. It consists of the Health & Safety Executive, Royal Navy, Maritime and Coastguard Agency together with the major UK diver training agencies. The Group was formed in 2002 to promote safe diving practices amongst the British sport diving community and exerts an influence through sharing and analysing incident data, devising safety initiatives and subsequently promoting them to the recreational diving community. www.bdsg.org/

British Sub-Aqua Club (BSAC)

BSAC describes itself as the largest diving Club in the world and the Governing Body of the sport in the UK. It runs a local-club based infrastructure and also provides training programmes at all levels of diving experience. In addition, it hosts the UK Sport Diving Medical Committee which recently introduced a system of self-assessment for all BSAC members. All BSAC members are required to complete a declaration form of their fitness to dive and the original is kept by the local Branch Diving Officer. BSAC also provides third party/public liability insurance for its members; however, if members have not completed their medical self-declaration form accurately then they may be uninsured. www.bsac.org.uk

Divers Alert Network (DAN)

DAN is a non-profit organisation that promotes itself as the world's leading organisation for dive safety. It receives more than 14,000 requests for medical and safety information each year through the DAN Dive Safety & Medical Information Line and via e-mails. It also receives between 5-6,000 visits to its medical webpage each month and produces a yearly report and analysis of diving-related injuries and deaths. Even though its members are mainly from North America, it works closely with the UK diver training organisations to produce a comprehensive picture of dive accident statistics. www.diversalertnetwork.org

Diving Diseases Research Centre (DDRC)

The DDRC is a charity which aims to promote and take part in the medical treatment, training and research associated with the treatment of diving diseases. www.ddrc.org

Health and Safety Executive (HSE)

The HSE is the national independent watchdog for work-related health, safety and illness. It is an independent regulator that acts in the public interest to reduce work-related death and serious injury in workplaces across Great Britain. www.hse.gov.uk

Maritime and Coastguard Agency (MCA)

The MCA is responsible for the implementation of the Government's maritime safety policies throughout the UK. www.mca.gov.uk

Professional Association of Diving Instructors (PADI)

PADI is one of a number of dive training organisations worldwide but is probably the most influential. According to its own reports, it trains the largest number of recreational divers, issuing around 950,000 certifications a year of which approximately half are at entry level. Nearly 70% of all divers in the US are PADI certified and approximately 55% of divers worldwide. PADI International Limited (the UK organisation) trained 16% of all PADI entry-level certifications in 2008 (nearly 80,000). PADI is a member of the World Recreational Scuba Training Council and its training programmes conform to those standards. www.padi.com

Royal National Lifeboat Institution (RNLI)

The RNLI is a charity that provides 24-hour lifeboat search and rescue around the coasts of the UK and the Republic of Ireland. It also works to promote beach and sea safety and provides a seasonal lifeguard service at the busiest beaches in England and Wales. www.rnli.org.uk

APPENDIX 2 – COVER LETTER FOR PHASE 1 OF THE RESEARCH

[UCL letterhead]

10 April 2006

Dear Fellow Diver,

RESEARCH INTO HEALTH, RISK-TAKING AND DIVING EXPERIENCE

We are conducting research with UK recreational sub-aqua divers with the support of the British Diving Safety Group (www.bdsg.org) and PADI International Limited. The research will require divers to answer a questionnaire about their health, attitudes to risk and diving experience.

PADI are helping us with the distribution of the questionnaire and a link to an online version of the questionnaire will shortly be sent via PADI e-mail networks. In addition, we need a small sub-sample of PADI divers (chosen at random by computer) to complete a paper version of the questionnaire and return it to UCL together with a saliva sample. The saliva sample is important because it allows us to check our results for smoking. This is done by testing the saliva for *cotinine* which is produced in the body when nicotine breaks down. All questionnaires and saliva samples returned to UCL are completely anonymous and the researchers do not know which PADI divers have been asked for a saliva sample.

As a diver who has been selected by computer to be part of our sub-sample we urge you to take part in the research and return both the completed questionnaire and the saliva sample together to UCL in the pre-paid envelope provided. *Please complete the enclosed questionnaire instead of the online version.* Your participation is very important to the scientific credibility of the results as well as contributing to research within the recreational diving community. Most research with divers is conducted for commercial or work purposes and we are hoping to gain greater understanding of health issues affecting the recreational sector.

Information about how to complete the survey and collect the saliva sample is on the first page of the questionnaire so please take a few minutes to read this through before you start. Any further questions about the research can be e-mailed to: tuyet.nguyen@ucl.ac.uk or a message left on 020 7679 6643. Tuyet is an administrator at UCL and she will arrange a response to your query without your identity being known to the researchers.

Finally, we would like to thank you for your participation in the research. We expect the findings to be publicised through diver networks in 2007.

Yours faithfully,

On behalf of the UCL research team:
Professor Robert West , Dr Amanda Williams, Miriam Armstrong

APPENDIX 3 – EMAIL TEXT FOR PHASE 2 OF THE RESEARCH

RESEARCH INTO HEALTH, RISK-TAKING AND DIVING EXPERIENCE

University College London is conducting research with UK recreational sub-aqua divers with the support of the British Diving Safety Group and PADI International Limited. The research will require divers to answer a questionnaire about their health, attitudes to risk and diving experience.

PADI are helping with the distribution of the questionnaire via this newsletter. If you would like to take part in the survey online, just follow the following link: http://www.surveymonkey.com/s.asp?u=274591742095.

Your participation is very important to the scientific credibility of the results as well as contributing to the overall picture of health issues for recreational divers. Most research with divers is conducted for commercial or work purposes and the researchers are hoping to gain greater understanding of the recreational sector.

The questionnaire is only open to divers who currently live in the UK and is completely anonymous. Any queries can be e-mailed to: tuyet.nguyen@ucl.ac.uk or a message left on 020 7679 6643. Tuyet is an administrator at UCL and she will arrange a response to your query without your identity being known to the researchers.

Finally, we would like to thank you for your participation in the research. The University College London expects that the findings to be publicised through diver networks in 2007.

The University College London research team consists of: Professor Robert West, Dr Amanda Williams, Miriam Armstrong

APPENDIX 4 – QUESTIONNAIRE TO MEASURE SMOKING AND RISK-TAKING BEHAVIOUR AMONGST UK RECREATIONAL SCUBA DIVERS

[UCL Letterhead]

HEALTH, RISK-TAKING AND DIVING EXPERIENCE IN RECREATIONAL SCUBA DIVERS

Introduction

Thank you for helping us with this research. There are three tasks involved:

1) completing a questionnaire;
2) collecting a saliva sample;
3) sending the questionnaire and saliva sample back to UCL.

THE QUESTIONNAIRE AND SALIVA TESTING ARE COMPLETELY ANONYMOUS AND RESPONSES WILL BE SENT DIRECTLY TO UNIVERSITY COLLEGE LONDON. THEREFORE IT WILL NOT BE POSSIBLE TO IDENTIFY ANY INDIVIDUAL TAKING PART.

1. Questionnaire

The questionnaire takes about 20 minutes to complete and covers the following topics:

1. Health and Diving – estimate 10 -15 minutes;
2. Diving Experience – estimate 5 -10 minutes;
3. About You – estimate 3 minutes.

Your contribution is valuable so please complete every question as accurately as you can. Not all questions are relevant to everyone so follow the instructions given to the next question. If no instructions are given, just go straight to the next question.

EXAMPLE:

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149. Have you ever carried out dives which were purely for recreation?

☐ 1 No – go to Q159

☐ 2 Yes – go to Q150

150. What year was your FIRST recreational dive? = _________

(include dives made during training, but not 'try dives')

You will be asked to mark one or more boxes, e.g. ☐ 1, or write an answer. Please mark the box clearly (with an **X**) in biro or pen and ensure that your answers are readable. The small numbers next to the boxes are for recording and should be ignored.

2. Saliva sample

The saliva sample is used to test for nicotine and help with the results for smoking. To collect the sample - put the cotton wool roll inside your cheek whilst you answer the questionnaire. Leave it there for a minimum of 5 minutes. After that take it out and put it inside the plastic tube. The cotton wool roll needs to be soaked with saliva so put it back in your mouth or spit in the tube if the level needs 'topping up'. Put the lid back on firmly and place the tube in the padded mail-bag.

3. Returning the questionnaire and saliva sample

Put your completed questionnaire and saliva sample (which should be inside the padded mail-bag) into the pre-paid 'FREEPOST' envelope, seal the envelope firmly and post back to UCL.

Any queries about this research can be e-mailed to tuyet.nguyen@ucl.ac.uk.

SECTION 1 – HEALTH AND DIVING

This section covers four topics:
- *i) General health;*
- *ii) Smoking;*
- *iii) Injuries from diving;*
- *iv) Fitness to dive.*

GENERAL HEALTH

1. How is your health in general? *(select one response)*
☐ **1** Very good
☐ **2** Good
☐ **3** Fair
☐ **4** Bad
☐ **5** Very bad

2. Over the last 12 months has your health generally been: *(select one response)*
☐ **1** Good?
☐ **2** Fairly good?
☐ **3** Not good?

SMOKING

3. Do you smoke any type of cigarettes at all (this includes cigarillos and hand rolled cigarettes)?
☐ **1** No – go to Q10
☐ **2** Yes – go to Q4

4. How many cigarettes on average do you usually smoke? *(choose one option)*
______ per **day** $_1$ **OR**
______ per **week** $_2$ **OR**
______ per **month** $_3$

5. How soon after waking do you usually smoke your first cigarette? *(select one response)*
☐ **1** Within 5 minutes
☐ **2** 6-30 minutes
☐ **3** 31-60 minutes
☐ **4** After 60 minutes

6. Do you find it difficult to stop smoking in no-smoking areas? (i.e. you cannot smoke when you want to)
☐ **1** No
☐ **2** Yes

7. Which cigarette would you hate most to give up - if you had to give up one?

(select one response)
☐ 1 The first of the morning
☐ 2 Other

8. Do you smoke cigarettes more frequently in the first hours after waking than during the rest of the day?
☐ 1 No
☐ 2 Yes

9. Do you smoke when you are so ill that you are in bed most of the day?
☐ 1 No
☐ 2 Yes

GO TO Q13

10. Have you ever smoked cigarettes?
☐ 1 No – go to Q14
☐ 2 Yes – go to Q11

11. How many cigarettes did you smoke? *(choose one option)*
_____ per **day$_1$ OR**
_____ per **week$_2$ OR**
_____ per **month$_3$**

12. How many years ago did you smoke your LAST cigarette? = ___________

13. How many years IN TOTAL have you smoked cigarettes for? = ___________

---

14. Do you smoke cigars or pipes at all?
☐ 1 No – go to Q16
☐ 2 Yes – go to Q15

15. How many cigars or pipes on average do you usually smoke? *(choose one option)*
______ per **day$_1$ OR**
______ per **week$_2$ OR**
______ per **month$_3$**

GO TO Q19

16. Have you ever smoked cigars or pipes?
☐ 1 No - go to Q20
☐ 2 Yes – go to Q17

17. How many cigars or pipes did you smoke? *(choose one option)*
______ per **day$_1$ OR**

______ per **week$_2$ OR**
______ per **month$_3$**

18. How many years ago did you smoke your LAST pipe or cigar? = ___________

19. How many years IN TOTAL have you smoked pipes or cigars for? = ___________

---

20. Do you smoke cannabis with tobacco at all?
☐$_1$ No – go to Q22
☐$_2$ Yes – go to Q21

21. On average how often do you usually smoke cannabis with tobacco? *(choose one option)*
______ number of times per **day$_1$ OR**
______ number of times per **week$_2$ OR**
______ number of times per **month$_3$**

GO TO Q25

22. Have you ever smoked cannabis with tobacco?
☐$_1$ No – go to Q26
☐$_2$ Yes – go to Q23

23. How often did you smoke cannabis with tobacco? *(choose one option)*
______ number of times per **day$_1$ OR**
______ number of times per **week$_2$ OR**
______ number of times per **month$_3$**

24. How many years ago did you LAST smoke cannabis with tobacco? = ___________

25. How many years IN TOTAL did you smoke cannabis with tobacco for? = ___________

---

26. Have you ever smoked ANY TYPE OF TOBACCO (e.g. hand-rolled cigarettes, pipes etc) less than 6 hours before or after a dive?
☐$_1$ No – go to Q35
☐$_2$ Yes – go to Q27

27. How much time do (or did) you usually leave after smoking before getting in the water? *(select one answer)*
☐$_1$ Less than 5 minutes
☐$_2$ 6-30 minutes
☐$_3$ More than 30 minutes

28. When do (or did) you usually first smoke after a dive? *(select one answer)*
☐**1** Less than 5 minutes after surfacing
☐**2** 6 - 30 minutes after surfacing
☐**3** More than 30 minutes after surfacing

29. Do (or did) you ever use nicotine products (e.g. gum, patch, inhalator) to help you deal with cravings whilst diving?
☐**1** No
☐**2** Yes

30. Have (or did) you notice(d) any changes to your health or physical fitness since you started smoking?
☐**1** No – go to Q32
☐**2** Yes – go to Q31

31. What changes have (or did) you notice to your health or physical fitness since you started smoking?

……………………………………………………………………………………

……………………………………………………………………………………

32. How often do (or did) you think about the effects of smoking on your health?
(select one answer)
☐**1** Never / rarely
☐**2** Quite often
☐**3** A lot

33. Have you ever tried to give up smoking?
☐**1** No – go to Q35
☐**2** Yes – go to Q34

34. How many times have you tried to give up smoking? = _________

DIVING-RELATED ILLNESS OR INJURY – These questions ask how often divers experience illness or injury from diving and whether these problems are mild or serious. Please report any health problems that interfered with your diving or any diving-related activity on the surface.

---

35. Have you ever had any type of lung problems (e.g. breathing difficulties, infection from inhaled water) from diving activities INCLUDING air embolism? Air embolism, also known as 'burst lung', occurs when pressure changes rupture the lung and air enters the bloodstream.
☐**1** No – go to Q41
☐**2** Yes – go to Q36
☐**3** Not sure – go to Q37

36. How many times have you had lung problems from diving activities?
(separate incidents) = _________

37. Have you ever had to finish a dive early due to lung problems from diving activities?
☐1 No
☐2 Yes
☐3 Not sure

38. Have you ever had first aid or medical treatment for lung problems from diving activities?
☐1 No
☐2 Yes

39. Have you ever had to take any time off from diving, or your normal routine or work, due to lung problems from diving activities?
☐1 No – go to Q41
☐2 Yes – go to Q40

40. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or = _______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

41. Have you ever had any type of decompression illness EXCLUDING air embolism?
Air embolism occurs when pressure changes rupture the lung and air enters the bloodstream.
☐1 No – go to Q47
☐2 Yes – go to Q42
☐3 Not sure – go to Q43

42. How many times have you had decompression illness? (separate incidents) = _________

43. Have you ever had to finish a dive early due to decompression illness?
☐1 No
☐2 Yes
☐3 Not sure

44. Have you ever had first aid or medical treatment for decompression illness from diving?
☐1 No
☐2 Yes

45. Have you ever had to take any time off from diving, or your normal routine or work, due to decompression illness from diving?

☐1 No – go to Q47
☐2 Yes – go to Q46

46. How much time *in total* did you need to take off? *(choose one option)*

Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

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47. Have you ever had any nervous system effects whilst diving (e.g. oxygen toxicity, high pressure neurological syndrome) BUT NOT NITROGEN NARCOSIS? Nitrogen narcosis typically causes drowsiness and impaired judgement around 30m depth. The symptoms usually wear off on ascent from 30m.

☐1 No – go to Q53
☐2 Yes – go to Q48
☐3 Not sure – go to Q49

48. How many times have you had nervous system effects? (separate incidents) = _________

49. Have you ever had to finish a dive early due to nervous system effects from diving?

☐1 No
☐2 Yes
☐3 Not sure

50. Have you ever had first aid or medical treatment for nervous system effects from diving?

☐1 No
☐2 Yes

51. Have you ever had to take any time off from diving, or your normal routine or work, due to nervous system effects from diving?

☐1 No – go to Q53
☐2 Yes – go to Q52

52. How much time *in total* did you need to take off? *(choose one option)*

Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

53. Have you ever had bone disease caused by diving? Bone disease from diving (also known as dysbaric osteonecrosis) is related to exposure to high pressures over time.
☐ 1 No – go to Q57
☐ 2 Yes – go to Q54
☐ 3 Not sure – go to Q54

54. Have you ever had first aid or medical treatment for bone disease from diving?
☐ 1 No
☐ 2 Yes

55. Have you ever had to take any time off from diving, or your normal routine or work, due to bone disease from diving?
☐ 1 No – go to Q57
☐ 2 Yes – go to Q56

56. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or = _______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

57. Have you ever had any damage to bone (e.g. broken bones), muscle (e.g. cramp) or joints (e.g. from lifting equipment) due to diving activities BUT EXCLUDING bone disease from diving? Bone disease from diving (also known as dysbaric osteonecrosis) is related to exposure to high pressures over time.
☐ 1 No – go to Q63
☐ 2 Yes – go to Q58
☐ 3 Not sure – go to Q59

58. How many times have you had any damage to bone, muscle or joints from diving activities? (separate incidents) = _________

59. Have you ever had to finish a dive early due to damage to bone, muscle or joints from diving activities?
☐ 1 No
☐ 2 Yes
☐ 3 Not sure

60. Have you ever had first aid or medical treatment for any damage to bone, muscle or joints from diving activities?
☐ 1 No
☐ 2 Yes

61. Have you ever had to take any time off from diving, or your normal routine or work, due to damage to bone, muscle or joints from diving activities?
☐1 No – go to Q63
☐2 Yes – go to Q62

62. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

---

63. Have you ever had any ear damage from pressure changes whilst diving?
☐1 No – go to Q69
☐2 Yes – go Q64
☐3 Not sure – go to Q65

64. How many times have you had ear damage? (separate incidents) = __________

65. Have you ever had to finish a dive early due to ear damage whilst diving?
☐1 No
☐2 Yes
☐3 Not sure

66. Have you ever had first aid or medical treatment for ear damage from diving?
☐1 No
☐2 Yes

67. Have you ever had to take any time off from diving, or your normal routine or work, due to ear damage from diving?
☐1 No – go to Q69
☐2 Yes – go to Q68

68. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

---

69. Have you ever had any sinus damage from pressure changes whilst diving?
☐1 No – go to Q75

☐2 Yes – go to Q70
☐3 Not sure – go to Q71

70. How many times have you had sinus damage? (separate incidents) = _________

71. Have you ever had to finish a dive early due to sinus damage whilst diving?
☐1 No
☐2 Yes
☐3 Not sure

72. Have you ever had first aid or medical treatment for sinus damage from diving?
☐1 No
☐2 Yes

73. Have you ever had to take any time off from diving, or your normal routine or work, due to sinus damage from diving?
☐1 No – go to Q75
☐2 Yes – go to Q74

74. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or = _______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

75. Have you ever had an infection caught by exposure to an aquatic environment whilst diving? (e.g. stomach upsets, ear or eye infections from the sea or swimming pool BUT NOT LUNG INFECTIONS)
☐1 No – go to Q81
☐2 Yes – go to Q76
☐3 Not sure – go to Q77

76. How many times have you caught an infection from the aquatic environment whilst diving? (separate incidents) = _________

77. Have you ever had to finish a dive early due to an infection caught from the aquatic environment whilst diving?
☐1 No
☐2 Yes
☐3 Not sure

78. Have you ever had first aid or medical treatment for an infection caught from the aquatic environment whilst diving?
☐1 No
☐2 Yes

79. Have you ever had to take any time off from diving, or your normal routine or work, due to an infection caught whilst diving?
□$_1$ No – go to Q81
□$_2$ Yes – go to Q80

80. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS$_1$ or = ________
Number of DAYS$_2$ or = ________
Number of WEEKS$_3$ or = ________
Number of MONTHS$_4$ = ________
Number of YEARS$_5$ = ________

---

81. Have you ever had any stings, bites or other injuries involving aquatic plants (e.g. kelp) or animals (e.g. jellyfish, coral) whilst diving?
□$_1$ No – go to Q87
□$_2$ Yes – go to Q82
□$_3$ Not sure – go to Q83

82. How many times have you had a sting, bite or other injury from aquatic plants or animals? (separate incidents) = __________

83. Have you ever had to finish a dive early due to a sting, bite or other injury from aquatic plants or animals whilst diving?
□$_1$ No
□$_2$ Yes
□$_3$ Not sure

84. Have you ever had first aid or medical treatment for any injuries from aquatic plants or animals whilst diving?
□$_1$ No
□$_2$ Yes

85. Have you ever had to take any time off from diving, or your normal routine or work, due to injuries from aquatic plants or animals whilst diving?
□$_1$ No – go to Q87
□$_2$ Yes – go to Q86

86. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS$_1$ or = ________
Number of DAYS$_2$ or = ________
Number of WEEKS$_3$ or = ________
Number of MONTHS$_4$ = ________
Number of YEARS$_5$ = ________

87. Have you ever had dehydration from diving activities?
Dehydration occurs when the body is lacking enough water and mineral salts to function normally. Early symptoms include dry mouth and low urine output. Later it causes sunken eyes, lethargy and coma.
☐ **1** No – go to Q93
☐ **2** Yes – go to Q88
☐ **3** Not sure – go to Q89

88. How many times have you had dehydration from diving activities?
(separate incidents) = _________

89. Have you ever had to finish a dive early due to dehydration from diving activities?
☐ **1** No
☐ **2** Yes
☐ **3** Not sure

90. Have you ever had first aid or medical treatment for dehydration from diving activities?
☐ **1** No
☐ **2** Yes

91. Have you ever had to take any time off from diving, or your normal routine or work, due to dehydration from diving activities?
☐ **1** No – go to Q93
☐ **2** Yes – go to Q92

92. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS**1** or = _______
Number of DAYS**2** or = _______
Number of WEEKS**3** or = _______
Number of MONTHS**4** = _______
Number of YEARS**5** = _______

---

93. Have you ever had hypothermia from diving activities?
Hypothermia occurs when the body's core temperature drops beyond its ability to cope with the heat loss. Symptoms include drowsiness, loss of co-ordination, pale skin and uncontrollable shivering.
☐ **1** No – go to Q99
☐ **2** Yes – go to Q94
☐ **3** Not sure – go to Q95

94. How many times have you had hypothermia from diving activities?
(separate incidents) = _________

95. Have you ever had to finish a dive early due to hypothermia from diving activities?

☐1 No
☐2 Yes
☐3 Not sure

96. Have you ever had first aid or medical treatment for hypothermia from diving activities?
☐1 No
☐2 Yes

97. Have you ever had to take any time off from diving, or your normal routine or work, due to hypothermia from diving activities?
☐1 No – go to Q99
☐2 Yes – go to Q98

98. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or = _______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

99. Have you ever had hyperthermia from diving activities?
Hyperthermia, also known as heat exhaustion or heatstroke, occurs when the body's core temperature rises above its capacity to cool itself. Early symptoms include extreme thirst and sweating. Later it causes confusion, lack of sweating and hot, red skin.
☐1 No – go to Q105
☐2 Yes – go to Q100
☐3 Not sure – go to Q101

100. How many times have you had hyperthermia from diving activities?
(separate incidents) = _________

101. Have you ever had to finish a dive early due to hyperthermia from diving activities?
☐1 No
☐2 Yes
☐3 Not sure

102. Have you ever had first aid or medical treatment for hyperthermia from diving activities?
☐1 No
☐2 Yes

103. Have you ever had to take any time off from diving, or your normal routine or work, due to hyperthermia from diving activities?
☐1 No – go to Q105
☐2 Yes – go to Q104

104. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or = _______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

105. Have you ever had a panic attack or serious fear or stress whilst diving? A panic attack is a brief period of intense anxiety often accompanied by a fear of dying or loss of control.
☐1 No – go to Q111
☐2 Yes – go to Q106
☐3 Not sure – go to Q107

106. How many times have you had a panic attack or serious fear or stress whilst diving? (separate incidents) = _________

107. Have you ever had to finish a dive early due to a panic attack or serious fear or stress whilst diving?
☐1 No
☐2 Yes
☐3 Not sure

108. Have you ever had first aid or medical treatment for a panic attack or serious fear or stress whilst diving?
☐1 No
☐2 Yes

109. Have you ever had to take any time off from diving, or your normal routine or work, due to panic attack(s), serious fear or stress whilst diving?
☐1 No – go to Q111
☐2 Yes – go to Q110

110. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = _______
Number of DAYS2 or =_______
Number of WEEKS3 or = _______
Number of MONTHS4 = _______
Number of YEARS5 = _______

---

111. Have you ever lost consciousness during diving activities?
☐1 No – go to Q116
☐2 Yes – go to Q112
☐3 Not sure – go to Q113

112. How many times have you lost consciousness during diving activities?
(separate incidents) = _________

113. Have you ever had first aid or medical treatment for loss of consciousness from diving activities?
☐ 1 No
☐ 2 Yes

114. Have you ever had to take any time off from diving, or your normal routine or work, due to a loss of consciousness from diving activities?
☐ 1 No – go to Q116
☐ 2 Yes – go to Q115

115. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS 1 or = _______
Number of DAYS 2 or = _______
Number of WEEKS 3 or = _______
Number of MONTHS 4 = _______
Number of YEARS 5 = _______

---

116. Have you ever had any suspected heart problems (e.g. chest pain, irregular heartbeat) during diving activities?
☐ 1 No – go to Q122
☐ 2 Yes – go to Q117
☐ 3 Not sure – go to Q118

117. How many times have you had suspected heart problems during diving activities?
(separate incidents) = _________

118. Have you ever had to finish a dive early due to suspected heart problems?
☐ 1 No
☐ 2 Yes
☐ 3 Not sure

119. Have you ever had first aid or medical treatment for suspected heart problems that occurred during diving activities?
☐ 1 No
☐ 2 Yes

120. Have you ever had to take any time off from diving, or your normal routine or work, due to suspected heart problems that occurred during diving activities?
☐ 1 No – go to Q122
☐ 2 Yes – go to Q121

121. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

---

122. Have you ever had any other illness or injury from sub-aqua diving activities?
☐1 No – go to Q129
☐2 Yes – go to Q123
☐3 Not sure – go to Q124

123. How many times have you had any other illness or injury from diving activities?
(separate incidents) = __________

124. Please say briefly what other type of illnesses or injuries you have had from diving:
(separate incidents)

……………………………………………………………………………………

……………………………………………………………………………………

125. Have you ever had to finish a dive early due to these illnesses or injuries from diving activities?
☐1 No
☐2 Yes
☐3 Not sure

126. Have you ever had first aid or medical treatment for these illnesses or injuries?
☐1 No
☐2 Yes

127. Have you ever had to take any time off from diving, or your normal routine or work, due to these illnesses or injuries?
☐1 No – go to Q129
☐2 Yes – go to Q128

128. How much time *in total* did you need to take off? *(choose one option)*
Number of HOURS1 or = ________
Number of DAYS2 or = ________
Number of WEEKS3 or = ________
Number of MONTHS4 = ________
Number of YEARS5 = ________

FITNESS TO DIVE – These questions check if you have ever had a health problem that might influence your 'fitness to dive'.

---

129. Have you ever had a diving medical examination, e.g. for work or recreational diving?
☐ **1** No – go to Q139
☐ **2** Yes – go to Q130

130. Which of the following medical examinations have you had for diving: *(mark all that apply)*
☐ **1** Work-related medical? (required by an employer, the Health & Safety Executive or other agency)
☐ **2** Follow-up medical? (after a dive injury or illness)
☐ **3** Check-up medical? (to test your fitness to dive for recreation)
☐ **4** Other, please specify: **5**
……………………………………………………………………………………..

131. What year was your last medical? = ________

132. At the end of your last medical were you considered to be:
(choose one response)
☐ **1** Fit to dive with no health restrictions?
☐ **2** Fit to dive with certain restrictions for health reasons?
☐ **3** Not fit to dive?
☐ **4** Other

133. Has a doctor ever advised you NOT TO DIVE for health reasons?
☐ **1** No – go to Q136
☐ **2** Yes – go to Q134
☐ **3** Not sure – go to Q136

134. How many times has a doctor advised you not to dive for health reasons?
(separate incidents) = _________

135. Please say briefly why for each incident:

………………………………………………………………………………………

136. Has a doctor ever advised you to LIMIT YOUR DIVING for health reasons?
☐ **1** No – go to Q139
☐ **2** Yes – go to Q137
☐ **3** Not sure – go to Q139

137. How many times has a doctor advised you to limit your diving for health reasons?
(separate incidents) = _________

138. Please say briefly why for each incident:

………………………………………………………………………………………

---

139. Would you say you are currently fit to dive?
☐1 No – go to Q140
☐2 Yes – go to Q141
☐3 Not sure – go to Q140

140. Please say briefly why you think you are not currently fit to dive?
………………………………………………………………………………………
………………………………………………………………………………………

141. Have you ever dived with a short-term illness, e.g. colds, sea sickness, food poisoning, migraine? (This does not include diabetes, asthma or other long-term conditions)
☐1 No – go to Q143
☐2 Yes – go to Q142
☐3 Not sure – go to Q142

142. Have you ever had to finish a dive early due to a short-term illness?
☐1 No
☐2 Yes
☐3 Not sure

143. Have you ever dived with a long-term health problem or condition? (e.g. diabetes, asthma)
☐1 No – go to Q145
☐2 Yes – go to Q144
☐3 Not sure – go to Q144

144. Have you ever had to finish a dive early due to a long-term health problem or condition?
☐1 No
☐2 Yes
☐3 Not sure

145. Have you ever dived with pre-existing ear or sinus problems?
☐1 No – go to Q147
☐2 Yes – go to Q146
☐3 Not sure – go to Q146

146. Have you ever had to finish a dive early due to a pre-existing ear or sinus problem?
☐1 No
☐2 Yes
☐3 Not sure

147. Have you ever taken recreational drugs, e.g. alcohol, tobacco, cannabis, less than 6 hours before diving?

☐ **1** No – go to SECTION 2
☐ **2** Yes – go to Q148
☐ **3** Not sure – go to Q148

148. Have you ever had to finish a dive early due to the effects of recreational drugs?

☐ **1** No
☐ **2** Yes
☐ **3** Not sure

END OF SECTION ONE

SECTION 2 – DIVING EXPERIENCE

Congratulations – you are over half-way through the questionnaire!

This section covers three topics:

i) Recreational diving;
ii) Work-related diving;
iii) Attitudes to risk.

Please read the definitions of recreational and work-related diving carefully.

RECREATIONAL DIVING – This refers to all diving done for fun, hobby or personal interest only*. If there is any work-related element to the dive then it should be classified as 'work-related diving' and included in that section.*

---

149. Have you ever carried out dives which were purely for recreation?
☐ **1** No – go to Q159
☐ **2** Yes – go to Q150

150. What year was your FIRST recreational dive? = _________
(include dives made during training, but not 'try dives')

151. What year was your LAST recreational dive? = __________
(include dives made during training)

152. How many recreational dives have you made IN TOTAL? = ________
(include dives made during training, but not 'try dives')

153. What is the HIGHEST recreational diving qualification you have?

Please write: ………………………………………………………………………………

154. Which organisation awarded this qualification? (e.g. PADI, BSAC, SAA etc)

Name of organisation: ………………………………………………………………………….

155. What year were you awarded this qualification? = ________

156. Have you ever dived for recreation using *gases other than ordinary compressed air*? (e.g. nitrox, heliox, trimix)
☐ **1** No – go to Q158
☐ **2** Yes – go to Q157

157. How many dives for recreation IN TOTAL have you made using *gases other than ordinary compressed air*? = ______________

158. How many HOURS A YEAR IN TOTAL do you usually spend diving for recreation?
(all gas mixtures) = ___________________

WORK-RELATED DIVING – This refers to **all diving done for work purposes** whether you are an employee, self-employed or an occasional worker. *Any recreational dives that had a work-element to them, such as formally training or assisting the training of other divers, should be included here*.

---

159. Have you ever dived for work purposes? (this includes unpaid work)
☐ **1** No – go to Q172
☐ **2** Yes – go to Q160

160. What type of diving are you trained to do for work purposes?
(mark all that apply)
☐ **1** Offshore
☐ **2** Inland / Inshore
☐ **3** Shellfish
☐ **4** Scientific (includes Archaeological)
☐ **5** Media
☐ **6** Police
☐ **7** Military
☐ **8** Other

161. Are you qualified to train, or assist in training, students to dive recreationally?
☐ **1** No – go to Q165
☐ **2** Yes – go to Q162

162. What is your highest TRAINING qualification in recreational diving?

Please write:
………………………………………………………………………………………

163. Which organisation awarded this training qualification? (e.g. PADI, BSAC etc)

Name of organisation:
……………………………………………………………………………………..

164. What year were you awarded this training qualification? =
____

165. What year was your FIRST dive for work purposes? = _______
(include dives made during training for work)

166. What year was your LAST dive for work purposes? = _______
(include dives made during training for work)

167. How many hours a year in total do you CURRENTLY spend diving for work purposes?
= __________

168. How many dives in total have you made for work purposes? = ______
(include dives made during training for work)

169. What type of diving have you done for work purposes? *(mark all that apply)*
☐ **1** SCUBA
☐ **2** Surface-supplied
☐ **3** Saturation diving
☐ **4** Other

170. Have you ever dived for work using *gases other than ordinary compressed air*?
☐ **1** No – go to Q172
☐ **2** Yes – go to Q171

171. How many dives IN TOTAL have you made for work purposes using *gases other than ordinary compressed air?* *(include dives made during training for work)* = _______________

ATTITUDES TO RISK – We are interested in your attitudes to risk generally and whilst diving.

---

172. How frequently do you take risks at work? (in your main job if you have more than one)
☐ **1** Not at all
☐ **2** Rarely
☐ **3** Occasionally
☐ **4** Quite frequently
☐ **5** Very frequently
☐ **6** Not applicable

173. How frequently do you take risks outside work?
☐ **1** Not at all
☐ **2** Rarely
☐ **3** Occasionally
☐ **4** Quite frequently
☐ **5** Very frequently

174. Do you have a smoke alarm in your home?

☐1 No
☐2 Yes
☐3 Not applicable

175. Do you usually wear a seat-belt when you travel by car?
☐1 No
☐2 Yes
☐3 Not applicable

176. Do you usually take out travel insurance when you go on holiday?
☐1 No
☐2 Yes
☐3 Not applicable

177. Do you have fully comprehensive car insurance?
☐1 No
☐2 Yes
☐3 Not applicable

178. How often do you play fruit or other games machines?
☐1 At least once a week
☐2 At least once a month
☐3 Less than once a month
☐4 Rarely or never

179. How often do you do the Pools?
☐1 At least once a week
☐2 At least once a month
☐3 Less than once a month
☐4 Rarely or never

180. How often do you play the National Lottery?
☐1 At least once a week
☐2 Less than once a week but at least once a month
☐3 Less than once a month but sometimes
☐4 Less than five times in total

---

181. Have you ever dived solo for recreation? (This does not include becoming separated from your buddy or group during a dive.)
☐1 No – go to Q183
☐2 Yes – go to Q182

182. How many times in total have you dived solo for recreation? = ________

183. Have you ever dived in overhead environments for recreation? (e.g. caves or wrecks where direct access to the surface is blocked)
☐1 No – go to Q185
☐2 Yes – go to Q184

184. How many times in total have you dived in overhead environments for recreation?
= ________

185. Do you carry a separate 'reserve' supply of gas (e.g. a pony bottle) whilst diving for recreation?
☐ 3 Never or rarely
☐ 2 Occasionally
☐ 1 Frequently

186. Do you ever plan dives which require decompression stops?
☐ 1 Never or rarely
☐ 2 Occasionally
☐ 3 Frequently

187. Have you ever missed a decompression stop or a safety stop?
☐ 1 Never or rarely
☐ 2 Occasionally
☐ 3 Frequently

188. Have you ever had to carry out an unplanned 'decompression stop'?
☐ 1 Never or rarely
☐ 2 Occasionally
☐ 3 Frequently

189. Do you ever take risks for fun whilst diving?
☐ 1 Never or rarely
☐ 2 Occasionally
☐ 3 Frequently

190. What is the deepest dive IN METRES you have ever made on compressed air? = ______

END OF SECTION TWO

SECTION 3 – ABOUT YOU

The final section asks for general background information which helps us analyse the research.

---

191. What is your age? (in years) = ________

192. Are you male or female?
□ **1** Male
□ **2** Female

193. Do you live: *(select one category)*
□ **1** On your own?
□ **2** With a partner?
□ **3** Other?

194. What is your marital status? *(select one category)*
□ **1** Never married
□ **2** Married (first marriage)
□ **3** Re-married
□ **4** Separated (but still legally married)
□ **5** Divorced
□ **6** Widowed

195. What is the HIGHEST educational qualification you have? *(Select the one category which best fits your highest qualification)*
□ **1** CSEs, GCSEs, School Certificate, Standard Grades, O Levels
□ **2** Higher School Certificate, A Levels, AS Levels, Scottish Highers
□ **3** HNC, HND, NVQs
□ **4** University degree or higher (e.g. BA, BSc, MA, PhD, PGCE, Postgraduate Diplomas / Certificates)
□ **5** Other qualifications (e.g. City and Guilds, RSA / OCR, BTEC / Edexcel)
□ **6** None of the above

EMPLOYMENT – We are interested the type of work you do for your **main job** whether this is paid or unpaid. *Your main job is the job you spend most hours a week doing.*

---

196. What is the title of the MAIN JOB YOU ARE CURRENTLY WORKING IN? If you are not working now, write the title of the main job you last worked in.

TITLE OF YOUR MAIN JOB (OR LAST JOB)

………………………………………………………………………………………

197. Which category best describes your MAIN JOB (or your last job)? *(select only one)*

☐1 ***Modern professional*** – for example, teacher, nurse, physiotherapist, social worker, welfare officer, artist, musician, police officer (sergeant or above), software designer, diving instructor
Go to Q199

☐2 ***Clerical or intermediate occupations*** – for example, secretary, personal assistant, clerical worker, office clerk, call centre agent, nursing auxiliary, nursery nurse
Go to Q199

☐3 ***Senior manager or administrator*** – for example, chief executive, managing director or other director of an organisation
Go to Q199

☐4 ***Technical or craft*** – for example, motor mechanic, inspector, plumber, printer, tool maker, electrician, train driver, commercial diver, diving support staff
Go to Q199

☐5 ***Semi-routine manual*** – for example, postal worker, machine operative, security guard, caretaker, farm worker, catering assistant, receptionist
Go to Q199

☐6 ***Routine manual*** – for example, HGV driver, van driver, cleaner, porter, packer, sewing machinist, messenger, labourer, bar staff, waiter
Go to Q199

☐7 ***Middle or junior manager*** – for example, office, retail or bank manager, restaurant or warehouse manager, publican, diving superintendent, manager of a dive shop, dive supervisor
Go to Q199

☐8 ***Traditional professional*** – for example, accountant, solicitor, doctor, scientist, civil, mechanical or chemical engineer
Go to Q199

☐9 ***Never worked*** – <u>you have never had a job of any type</u> (including unpaid or voluntary work)
Go to Q203

☐10 ***Not sure*** – go to Q198

198. Please say briefly what your job involves:

……………………………………………………………………………………

199. Are you self-employed?
☐1 No

☐2 Yes

200. How many people work at the place where you work (or last worked)? *(select only one)*
☐1 1 to 24
☐2 25 or more

201. Do (or did) you supervise any employees at work (or your last place of work)? (i.e. you were responsible for overseeing the work of other employees)
☐1 No
☐2 Yes

202. Are you CURRENTLY in paid employment? (this includes being self-employed)
☐1 No – go to Q203
☐2 Yes – go to Q204

203. Which category best describes your current situation?
☐1 ***Student*** – you are in formal study or education
☐2 ***Not working*** – e.g. retired, unemployed, looking after home / family
☐3 ***Other***

---

204. Which of the following best describes your ethnic group / cultural background?
(select only one category)
☐1 White
☐2 Mixed race
☐3 Asian or Asian British
☐4 Black or Black British
☐5 Other ethnic group

205. What is your country of birth?
☐1 UK
☐2 Outside the UK

206. Is the UK currently your main place of residence? (i.e. where you usually live now)
☐1 No
☐2 Yes

207. How many years in total have you lived in the United Kingdom for? = ___________

208. Have you ever worked in the dive industry outside the UK?
☐1 No – go to Q210
☐2 Yes – go to Q209

209. How many years in total have you worked in the dive industry outside the UK for? = _________

210. How do you keep in touch with developments in diving? *(mark all that apply)*
☐ **1** Friends
☐ **2** Local club or group
☐ **3** Internet
☐ **4** Dive shows
☐ **5** Dive magazines
☐ **6** Dive organisation news
☐ **7** Other, please specify
8 ……………………………………………………………………………………

211. What date did you complete this survey on? (dd/mm/yy) = ______

212. How did you FIRST find out about this survey?
☐ **1** PADI e-mail
☐ **2** Letter
☐ **3** Word of mouth
☐ **4** Other, please specify
……………………………………………………………………………………

213. We are looking for people to take part in some further research. Would you be willing to help?
☐ **1** No – go to Q215
☐ **2** Yes – go to Q214

214. Thank you for offering to help with further research. Please write your e-mail or other address here so we can contact you:

……………………………………………………………………………………

215. THIS IS THE END OF THE QUESTIONNAIRE – THANK YOU FOR TAKING PART.

If you would like to make any comments please do so here:

……………………………………………………………………………………

216. Notes:
……………………………………………………………………………………

……………………………………………………………………………………

APPENDIX 5 – ATTITUDES AND APPROACHES TO TOBACCO SMOKING WITHIN THE DIVING COMMUNITY: EXAMPLES OF ADVICE GIVEN BY THE MAIN DIVER TRAINING ORGANISATIONS AND DIVING PHYSICIANS

British Sub-Aqua Club (BSAC)

Safety and Rescue for Divers, p17, The British Sub-Aqua Club, Ebury Press, revised edition 1998.

"Tobacco smoke contains a number of substances which produce drug effects, including carbon monoxide, nicotine and tar. These affect the function of the cells lining the air passages, so that mucus collects in the lungs, air passages are narrowed and air trapping occurs. There is evidence that burst lung and air embolism are more common in smokers than non-smokers.

Carbon monoxide binds with haemoglobin and consequently reduces the oxygen-carrying capacity of the blood. About 1% of the haemoglobin of non-smokers is bound to carbon monoxide, mainly from motor car exhausts. Smokers of 10-15 cigarettes a day have about 5% of their haemoglobin put out of action by carbon monoxide, whereas smokers of 20-30 cigarettes a day have effectively lost 10% of the oxygen-carrying capacity of their blood. This is the equivalent to losing a pint of blood. Clearly, the exercise capacity of heavy smokers will be impaired as a result, quite apart from the effects due to lung damage resulting from smoking.

Carbon monoxide from tobacco smoke has two additional adverse effects. Firstly, it makes the haemoglobin which is carrying oxygen (not carbon monoxide) reluctant to give up its oxygen to the tissues, which increases tissue hypoxia. Secondly, divers who start the dive with a significant amount of their haemoglobin bound to carbon monoxide will be more susceptible than non-smokers to the risk of carbon monoxide poisoning if there is a low level of carbon monoxide contamination of their air supply. Nicotine can cause spasm or narrowing of air passages as well as the coronary arteries, which supply blood to the heart muscle itself. The narrowing of air passages will increase the difficulty of respiration, which occurs at depth because of the increased density of the air breathed. A raised partial pressure of oxygen can also cause significant narrowing of coronary arteries. This effect may potentiate in the presence of nicotine."

Professional Association of Diving Instructors (PADI)

The Encyclopedia of Recreational Diving, Professional Association of Diving Instructors (PADI), 2nd edition reprinted 1996.

"Divers should be aware that smoking and lung congestion can create obstructions within the lung that cause conditions identical to holding the breath. Diving should be avoided until any condition causing congestion is completely healed, and divers should not smoke for several hours before a dive. Smokers should consult a pulmonary physician before engaging in diving." (p2-59)

"Following forced expiration, a percentage of the lung bronchioles may collapse, causing a momentary internal lung blockage. The inner surfaces of the bronchioles and alveoli are coated with surfactant, which keeps the collapsed air passages from adhering shut. Smoking destroys lung surfactant, inhibiting reopening of the bronchioles, which can lead to sectional conditions in the lung identical to breath holding." (p2-55)

Divers Alert Network (DAN)

The DAN Guide to Dive Medical Frequently Asked Questions (FAQs), Divers Alert Network, first published 2003.

"Smoking can cause chronic bronchitis, emphysema and atherosclerosis. In addition, it exacerbates asthma. Whilst smoking is not recommended, there is currently little evidence that smoking by itself predisposes anyone to diving-related illness, unless it has produced or exacerbated lung disease". (p196)

Reports from diving physicians:

Diving and Subaquatic Medicine, Edmonds C, Lowry C and Pennefather J, 4th edition reprinted 2002. Butterworth-Heinemann.

"The acute effects of nicotine include increased blood pressure and heart rate, and coronary vasoconstriction. The inhalation of tobacco smoke containing nicotine and tar causes increased bronchospasm, depressed cilial activity and increased mucous production in bronchial mucosa. This may lead to intrapulmonary air trapping and increased pulmonary infection, and there is therefore an increased possibility of ascent pulmonary barotrauma.

Carboxyhaemoglobin levels in smokers range from 5 per cent to 9 per cent. Significant psychomotor effects from exposure to this level of carbon monoxide have been reported.

Many studies of smoking and physical fitness show detrimental effects. Increased heart rate and decreased stroke volume are the opposite of the changes with aerobic training. Oxygen debt accumulation after exercise is greater amongst smokers.

The long-term use of tobacco may lead to chronic bronchitis and emphysema, with decreased exercise tolerance and eventually marked hypoxaemia. It may also lead to coronary artery disease and peripheral vascular disease. Reduced blood volume and decreased haematocrit also develop with long exposure to increased carboxyhaemoglobin.

Nasopharyngeal mucosal congestion may predispose to sinus and middle-ear barotraumas." (p451-2)

www.mtsinai.org/pulmonary/books/scuba/medical.htm [Accessed Sep 2007]

"Based on a half-life of excess CO in the blood (about 6 hours), and typical CO-haemoglobin levels of smokers (5-10%), scuba divers who cannot break the smoking habit should abstain at least 12 hours before any dive. However, many divers do smoke, and sometimes just before a dive. Sadly, it is not uncommon to see dive professionals, divemasters and instructors, smoke during the surface interval between a two-tank dive."
www.spc.int/coastfish/News/Fish_News/104/Scuba_Safety_104.pdf [Accessed Sep 2007]

"Smoking increases risk of lung over-expansion, due to general weakening of the lungs and coating of alveoli, which prevents proper gas exchange. Gas poisoning can occur as the partial pressures of the surface-inhaled carbon monoxide increase on descent. The possibility of a heart attack (the number one killer of divers) is increased with smoking. Divers should refrain from these activities before diving and for about four hours afterwards".

"Most smokers also have nasal and sinus drainage problems. This markedly increases their chances of middle ear and sinus blocks and squeezes. There have been studies that have shown that stopping smoking prior to surgery actually increased the amount of mucous production for about a week. Taking this information to diving – one would have to say that if you are going to gain any benefit from stopping – then you need to have stopped at least one week in advance. If you can do this – then why not just stop forever."
www.scuba-doc.com/smkndvng.htm [Accessed Sep 2007]

APPENDIX 6 – LIST OF PRIMARY VARIABLES USED IN ANALYSIS

Independent variable	Numerical	Categorical (recorded as binary values: 0,1)
Demographics:		
Age	Yes	
Gender		Male or female
Marital status		GHS legal marital status (3 class)
		Live with others vs. live alone
		Currently or previously married vs. never married
		Not currently married vs. currently married
		Never or currently married vs. previously married
Highest qualification		Below degree-level vs. degree-level & above
Social class		3-class NS-SEC
		Other vs. professional & managerial occupation
		Other vs. intermediate occupation
		Other vs. routine & manual occupation
Employment		Unemployed vs. paid employment
Ethnicity		White vs. non-white
Tobacco smoking:		
Current cigarette		No / Yes
Current cigar		No / Yes
Current cannabis		No / Yes
Smoked within 6 hrs diving		No / Yes
Number of cigarettes	Yes	
Fagerstrom score	Yes	
Number of cigars	Yes	
Number of joints	Yes	
Pre-existing health:		
General health	Yes	Good / very good vs. fair / bad
Health over last year	Yes	
Short-term illness		No / Yes
Long-term illness		No / Yes
Ear or sinus damage		No / Yes
Recreational drugs		No / Yes
Diving illness:		
Lung problems		No / Yes
Freq. lung	Yes	
DCI		No / Yes

Freq. DCI	Yes	
Nervous system		No / Yes
Freq. nervous	Yes	
Osteonecrosis		No / Yes
Muscle, bone, joint		No / Yes
Freq. cramp	Yes	
Ear damage		No / Yes
Freq. ear	Yes	
Sinus damage		No / Yes
Freq. sinus	Yes	
Infection		No / Yes
Freq. infection	Yes	
Marine life injuries		No / Yes
Freq. marine life	Yes	
Dehydration		No / Yes
Freq. dehydration	Yes	
Hypothermia		No / Yes
Freq. hypothermia	Yes	
Hyperthermia		No / Yes
Freq. hyperthermia	Yes	
Panic attack		No / Yes
Freq. panic attack	Yes	
Lost consciousness		No / Yes
Freq. unconscious	Yes	
Heart problems		No / Yes
Freq. heart	Yes	
Total freq. illness	Yes	
Total severity illness	Yes	
Everyday risk:		
Risks at work		Never or rarely vs. at least occasionally
Risks outside work		Never or rarely vs. at least occasionally
Smoke alarm		Yes / No
Seat belt		Yes / No
Travel insurance		Yes / No
Car insurance		Yes / No
Fruit machines		Less than once a month vs. at least once a month
Pools		Less than once a month vs. at least once a month
National Lottery		Less than once a month vs. at least once a month
Diving risk:		
Solo diving		No / Yes

No. of solo dives	Yes	
Overhead diving		No / Yes
No. of overhead	Yes	
Reserve gas supply		Never or rarely vs. at least occasionally
Plan deco stops		Never or rarely vs. at least occasionally
Missed safety stop		Never or rarely vs. at least occasionally
Unplanned stop		Never or rarely vs. at least occasionally
Risks for fun		Never or rarely vs. at least occasionally
Deepest dive on air	Yes	Less than 40m vs. 40m or more
Diving experience:		
Number of years	Yes	
Total number dives	Yes	
CMAS qualification		CMAS 2* vs. 3* Level qualified
Dived for work		No / Yes
Mixed gas diving		No / Yes
Total number of mixed gas dives	Yes	
Worked outside UK		No / Yes