

# Original articles

## The demographics and diving behaviour of DAN Asia-Pacific members with and without pre-existing medical conditions

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### Abstract

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**Introduction:** This report examines Diver Alert Network Asia-Pacific (DAN AP) members with and without cardiac or respiratory conditions, diabetes or hypertension and compares their demographics, health and diving activities.

**Methodology:** Two online cross-sectional surveys of DAN AP members were conducted. The first sought information from 833 divers who applied for membership between July 2009 and August 2013 and who had declared the targeted medical conditions. The second, conducted between December 2014 and April 2015, was sent to 9,927 current members with known email addresses. The groups were compared for age, gender, body mass index, fitness, smoking and diving qualifications, history, currency and practices.

**Results:** Of 343 (41%) respondents to the first survey, 267 (32%) provided sufficient information for inclusion. Of 1,786 (18%) respondents to the second survey, 1,437 (15%) had no targeted medical condition and were included in the analysis. Those with medical conditions were on average 4.7 years older ( $P < 0.001$ ); more overweight or obese (68% versus 57%,  $P = 0.001$ ); took more medications (57% vs. 29%,  $P < 0.001$ ), smoked less (4% vs. 7%,  $P = 0.02$ ) and did less repetitive diving (median 75 vs 90,  $P < 0.001$ ). Other diving demographics were similar.

**Conclusions:** A substantial number of people are diving with medical conditions and there is a need to better understand the associated risks. Divers need to be well-educated about the potential impact such conditions may have on diving safety and should monitor their health status, especially as they age.

### Key words

Survey; Fitness to dive; Health surveillance; Cardiovascular; Scuba divers; Recreational divers

### Introduction

It is generally accepted that scuba divers need to have an appropriate level of physical and medical fitness in order to facilitate safe diving. Historically, conditions such as asthma, diabetes and many cardiac conditions were considered absolute contraindications.<sup>1-3</sup> Traditionally, scuba diving was the realm of the relatively healthy, fit and young although, as the sport evolved, individuals with a variety of medical conditions began to participate.<sup>4,5</sup> Data from the United Kingdom (UK) indicate that the average age of divers has increased over time, rising from 10% being over 50 years old in 1998 to 30% in 2015.<sup>6</sup> Long-time divers are ageing and the sport has become increasingly available to a broader-aged cohort of the population.

Associated with increasing age is an increase in co-existing disease, both known and occult.<sup>7-10</sup> Diving fatality reports reflect a rise in the ages of victims and this is likely a result of the combination of increased participation and increased risk imposed by co-morbidities.<sup>11,12</sup> Up to one third of cohorts of active Australian and USA divers continued to dive even with traditional medical contraindications.<sup>5,13</sup> Some divers had never sought diving medical advice about their conditions.

Diving medical organisations have progressively modified their advisories on diving with conditions such as asthma

and diabetes. The Divers Alert Network Asia-Pacific (DAN AP) is a non-profit membership-based association with a mission to improve recreational diving safety, and provides its members with access to diving injury insurance. Although membership applicants are required to declare pre-existing medical conditions, in most cases, no evidence of a fitness-to-dive assessment is required. DAN AP membership data reflect a growing representation from divers with asthma, diabetes, hypertension and a variety of cardiac-related conditions. As a result, there is an increasing need to learn more about the medical conditions of active divers and the impact, if any, that these conditions have on their diving practices and experiences.

The aim of this project was to examine the health status of a cohort of active recreational divers and determine the impact of co-existing disease on their diving practices. We surveyed DAN AP members with and without significant pre-existing medical conditions. We aimed to clarify the prevalence of significant medical conditions in active divers and identify any impact of certain predefined conditions on diving frequency, practice and outcome.

### Methodology

An anonymous, online, cross-sectional medical conditions survey (MCS) was conducted on a cohort of DAN AP

members who had declared that they suffered from a significant medical condition, including hypertension, diabetes, respiratory and cardiac conditions. A second similar cross-sectional general DAN members survey (GDMS) was conducted with the general DAN AP membership. The latter survey was conducted in order to obtain a control group for comparison (footnote). Ethics approvals were received from the Human Research Ethics Committees of Austin Health and Deakin University, both in Victoria, Australia.

#### MEDICAL CONDITIONS SURVEY

The survey targeted adults (>18 years old) who had joined DAN AP between 01 July 2009 and 01 August 2013. At the time of joining, DAN AP applicants for dive injury insurance are required to declare significant pre-existing medical conditions and, during the period under study, these were recorded in a database for research purposes. Those reporting an existing condition were surveyed using a two-part questionnaire. The first part sought details about the responders' demographics (e.g., age, gender, physical characteristics, general health and perceived fitness) and details of their diving history and activity, e.g., years of diving, total number of dives, dives per year, frequency of diving and the type of diving undertaken: depths, technical (self- and certification-defined) and repetitive diving. The second part sought details about certain 'targeted conditions' including cardiac (septal defects, myocardial infarction, arrhythmias, angina) and respiratory (asthma, pneumothorax, lung surgery) conditions, diabetes and hypertension. There were also specific questions about any impact these conditions had had on the responders' diving practices and any adverse incidents that had occurred.

In August 2013, an invitation to participate in the survey was sent to DAN AP members who had previously declared the conditions of interest. A reminder was sent in October 2013 and the survey was closed in December 2013. No inducements to participation were offered, and invitees were assured of their anonymity and that responding or otherwise would have no impact on their insurance status. All invitees had access to Part 1 of the questionnaire, as well as the set of questions relating to their declared condition(s). Participants were invited to enter their responses directly into an online, dedicated MYSQL database (Oracle, Redwood CA). Responses were then downloaded into an MS Excel database (Microsoft Corporation, Redmond WA) for collation and pre-analysis.

#### GENERAL DAN AP MEMBERS SURVEY

A separate survey containing similar demographic, diving history and activity questions was designed for all DAN AP members. This GDMS, which used the *Survey Monkey*

**Table 1**

Age and gender of invitees, responders and non-responders to a medical conditions survey (MCS) and a general DAN members survey (GDMS) (gender not known in GDMS invitees and hence non-responders); \* comparison of responders and non-responders

	Age (y) Mean (SD)	Gender (%F)
<b>MCS</b>		
Invitees	50.0 (12.0)	27
Responders (n = 267)	52.1 (12.2)	31
Non-responders (n = 566)	49.6 (12.4)	24
P-value *	< 0.01	0.02
<b>GDMS</b>		
Invitees	42.9 (11.9)	–
Responders (n = 1437)	47.6 (11.7)	30
Non-responders (n = 7961)	42.1 (11.8)	–
P-value *	< 0.001	–

platform, included some filtering questions about whether or not the responders had any of the 'targeted' or other significant medical conditions, and if they had participated in the MCS. Those with a positive response to either of these questions were excluded from the subsequent comparative analysis.

An invitation to participate was emailed to all current members (which would have included some who had participated in the MCS) using the email address known to DAN in December 2014. A reminder was sent in March 2015 and the survey was closed in April 2015.

The variables of interest for the divers with and without targeted medical conditions were compared. No *a priori* sample size calculation was undertaken as all DAN AP members were invited to participate. Statistical analysis was conducted using SPSS Version 22 (IBM, Armonk, NY; 2013). Groups were compared using the Student's *t*-test,  $\chi^2$ -test, z-test and Median Test for independent samples. The level of significance was set as  $\leq 0.05$ .

#### Results

##### MEDICAL CONDITIONS SURVEY

Eight-hundred-and-thirty-three DAN AP members with previously disclosed medical conditions were invited to participate. Age and gender were known and are shown in Table 1. Three-hundred-and-forty-three responses were received (41%) of which 267 (32%) contained sufficient information for inclusion. The medical conditions of interest included cardiac conditions (92 cases), hypertension (127), diabetes (24) and respiratory conditions, predominantly asthma (47). Some responders had multiple conditions.

**Footnote:** The general and disease-specific questionnaires are available at <[www.danap.org/research/med\\_conditions/](http://www.danap.org/research/med_conditions/)>.

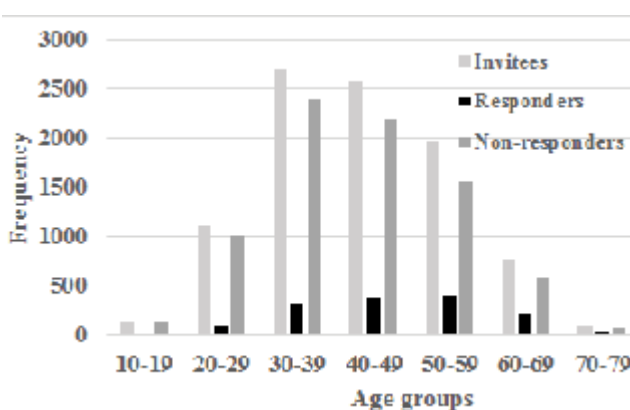
**Table 2**

Demographic and health information of 267 divers with declared targeted conditions and 1,437 without targeted medical conditions; \* not reported; † comparison excludes not reported; BMI – body mass index; ‡ 25 < BMI < 30 kg·m<sup>-2</sup>; § BMI ≥ 30 kg·m<sup>-2</sup>

	Group		<i>P</i> -value <sup>†</sup>
	No condition ( <i>n</i> = 1,437)	Medical condition ( <i>n</i> = 268)	
<b>Sex <i>n</i> (%)</b>			
Male	1,007 (70)	182 (68)	0.90
Female	430 (30)	81 (30)	
NR*	4 (2)		
<b>Age (y), mean (SD)</b>	47.3 (11.7)	52.4 (12.1)	< 0.001
<b>BMI (kg·m<sup>-2</sup>), mean (SD)</b>	26 (4.2)	27 (4.2)	0.001
Overweight <i>n</i> (%) <sup>‡</sup>	582 (41)	103 (42)	0.06
Obese <i>n</i> (%) <sup>§</sup>	233 (16)	63 (26)	< 0.01
<b>Fitness <i>n</i> (%)</b>			
very fit	97 (7)	18 (7)	0.19
fit	533 (37)	80 (30)	
moderately fit	719 (50)	146 (54)	
unfit	88 (6)	20 (8)	
not reported		3 (1)	
<b>Medications <i>n</i> (%)</b>			
Yes	414 (29)	151 (57)	< 0.001
No	1023 (71)	110 (41)	
not reported		6 (2)	
<b>Current smoker <i>n</i> (%)</b>	105 (7)	11 (4)	0.02

**Figure 1**

Proportions of invitees, responders and non-responders to a general DAN members survey (GDMS) according to 10-year age groups



#### GENERAL DAN AP MEMBERS SURVEY

Nine-thousand-nine-hundred-and-twenty-seven DAN AP members were invited to participate. Although the genders of these invitees were unavailable, the ages of 9,398 were known (Table 1 and Figure 1).

Of 1,786 respondents (18%), 1,086 (61%) reported that they were free from any medical conditions, and 1,437 (81%) reported being free from the targeted medical conditions. Data from respondents without the targeted medical conditions were analysed in this survey. The remaining 349 subjects were excluded (including 265 who indicated that they had participated in the MCS).

Figure 1 shows the age breakdowns of invitees, responders and non-responders to the GDMS. There were two invitees over 80 years old but neither responded and are not included in Figure 1. Responders were significantly older than non-responders ( $P < 0.001$ ). Table 2 shows the demographic and medical information of the 267 responders with adequate information in the MCS and of the 1,437 responders to the GDMS without targeted medical conditions.

The sex distributions of MCS and GDMS responders were similar, with approximately 30% female and 70% males in each group. However, the divers with the medical conditions were significantly older than those without, with a difference in the means of 4.7 years. Sixty-three percent of the medical condition group were aged 50 years or older, compared with 45% of the group without the medical conditions. The mean body mass index (BMI) of divers with medical conditions was significantly higher than those without. Sixty-eight percent of the medical condition group were overweight or obese compared to 57% of the GDMS respondents ( $P = 0.001$ ).

The self-reported fitness levels of the two groups were similar with over 90% of each group assessing themselves as moderately fit or fitter. The proportion of the medical condition group who took medications was almost twice that of those without. Although the proportion of smokers was low in both groups, the proportion of smokers in the group without the medical conditions was almost twice that of those with conditions.

Table 3 describes the diving history and characteristics of the

**Table 3**

Diving history and characteristics of survey participants; OW – open water diver; Tech – technical diver; DM – divemaster; Inst – instructor; Comm – commercial diver; > 30 m – dives deeper than 30 metres; \* hold commercial qualifications but still dive recreationally

	Group		P-value
	No condition (n = 1,437)	Medical condition (n = 268)	
<b>Years diving</b> , median (IQR)	11 (5, 21)	12 (6, 22)	0.79
<b>Qualifications</b> n (%)			
OW only	304 (21)	71 (27)	0.05
OW+	420 (29)	89 (33)	
Tech	174 (12)	30 (11)	
DM	237 (17)	42 (16)	
Inst	254 (18)	32 (12)	
Comm	48 (3)*	4 (1)*	
<b>Total dives</b> , median (IQR)	300 (120, 800)	350 (150, 850)	0.37
<b>Dives in past year</b> , median (IQR)	30 (20, 60)	30 (20, 50)	0.82
<b>Time since last dive</b> (months, %)			
< 1	58	54	< 0.001
1–6	34	22	
6–12	6	17	
> 12	2	7	
<b>Depth &gt; 30 m</b> (%), median (IQR)	10 (3, 25)	10 (3, 25)	0.77
<b>Decompression</b> (%), median (IQR)	1 (0, 5)	1 (0, 5)	0.93
<b>Technical</b> (%), median (IQR)	0 (0, 5)	0 (0, 5)	0.17
<b>Repetitive</b> (%), median (IQR)	90 (50, 100)	75 (25, 95)	< 0.001

responders to the MCS and the GDMS. The groups did not differ in the numbers of years that they had been diving or their reported total dives. However, more responders without targeted medical conditions were qualified as divemaster or higher (38% vs 29%). The data for decompression dives and technical diving are especially skewed. For example, in the group without conditions, 735 divers reported doing some percentage of decompression dives - some claimed 100% and some only 1% – with many doing no-decompression dives only, giving a median for decompression diving of 1% as shown in Table 3. Similarly 435 divers reported doing some technical diving but the median percentage for this type of diving was zero.

The groups did not differ in the numbers of dives conducted over the previous year, although the divers without medical conditions reported having dived more recently or in the proportion of dives deeper than 30 metres, decompression dives or technical dives. However, those with medical conditions had done significantly less repetitive diving.

Twenty-eight (10%) responders with medical conditions reported having had decompression illness (DCI) compared with 62 (4%) of those without ( $P < 0.0001$ ). Twenty-five of the 28 MCS divers who reported DCI were diagnosed with an intra-cardiac right-to-left shunt, predominantly a persistent foramen ovale. The most common diving-related injury reported by those with medical conditions was ear or sinus barotrauma (46, 17%). Two of the cases of ear barotrauma led to significant inner ear damage but both divers continue to dive.

## Discussion

The 70:30 male to female gender distribution between the groups is similar to the 2:1 male:female ratio currently reported by the Professional Association of Diving Instructors (PADI) for its certifications for 2009–2014.<sup>15</sup> Hence, the gender breakdowns appear to be similar to the general diving population. The significantly higher age of the responders with medical conditions is consistent with the increased incidence of co-existing disease with age.<sup>7–10</sup>

Although the mean BMI of respondents with conditions was higher, the absolute difference between the groups was small and not clinically significant. However, there was a significantly higher proportion of obese divers in the cohort with medical conditions. This is consistent with data from the general population that indicate an association between the presence of significant health conditions and being overweight or obese.<sup>15–18</sup> The older age of the respondents with conditions may contribute to the higher proportion of obese divers in this group. The proportions of those with medical conditions who were overweight or obese are very similar to those in a cohort of divers from the United Kingdom (66%).<sup>19</sup> However, the UK cohort (median age 46) were not specifically known to have medical conditions. This could indicate that UK divers are more likely to be overweight or obese than our responders without conditions; or could reflect a reporting bias. Alternatively, the cohort of 346 divers reported in an earlier study had lower BMIs than all of the above-mentioned groups with 46.8% overweight or obese. This was likely due to the substantially lower

age of the cohort, of which 83% were aged 50 years or less; compared to 40% in the MCS group and 58% of the GDMS group.

Both groups rated their fitness similarly. However, this must be interpreted with caution as self-reported fitness, especially without further questions about specific activities, does not always correlate well with that measured objectively.<sup>20–22</sup> The higher incidence of medication use among those with medical conditions was expected, given the type of conditions examined, such as hypertension and cardiac disease,<sup>23,24</sup> whereas in the 2002 study of a younger cohort only 13% reported taking regular medication.<sup>5</sup> The types of medications used will be discussed in a subsequent report that will detail the various conditions. However, given the rarity of testing medications under hyperbaric conditions and the effect of certain medications on circulation and cardiac function, medication usage in divers is an area deserving more scrutiny.

Only 4% of those with conditions were current smokers, compared to 7% of those without. This is consistent with data from UK divers<sup>19</sup>, and lower than the 11.3% reported in 2002.<sup>5</sup> It compares favourably with the percentage of smokers in the general population (approximately 13% in 2013 in both Australia and Singapore, the main bases of DAN AP membership at the time of the surveys).<sup>25,26</sup> This is likely the result of the increased awareness in recent years of the adverse effects of smoking on cardiovascular and pulmonary health, especially in those with existing health conditions. The smoking rate in the general population in Australia has steadily declined in the past decade and this is likely reflected in the data from the diver surveys.<sup>25</sup>

The groups did not differ in the number of years of diving; 30% of each group had dived for 20 years or more, which is consistent with both the relatively high responder ages and recent PADI data which indicate a median certification age of 29 years.<sup>14</sup> The median number of years of diving is also very similar to the 11 years reported in the previously-mentioned UK survey.<sup>19</sup>

The generally higher level of certifications in the divers without medical conditions suggests that the presence of a medical condition could be a disincentive or barrier to the pursuit of leadership-level diving qualifications. With these qualifications, there is a greater focus on fitness-to-dive issues. The reason why those without medical conditions participated in more repetitive diving is unclear, especially given that there was little difference in the proportions of deeper (> 30 metres), technical or decompression diving, or in the reported level of diving activity. Although speculative, this may reflect the older age of those with medical conditions and an acceptance of their potential vulnerability due to the condition and the desire not to push their physical limits.

The presence of a persistent foramen ovale (PFO) is known to increase the risk of neurological, cutaneous and vestibular DCI.<sup>27,28</sup> The higher incidence of DCI among those with medical conditions is likely due to the relatively high proportion of subjects with a diagnosed septal defect, predominantly PFO. Fatality data from both Australia and the USA point to an increase in the proportion of cardiac-related disabling injuries in divers.<sup>11,12,29</sup> Some of the victims were aware of their medical condition and were under treatment at the time. However, in many victims, the condition was undiagnosed and only became apparent at autopsy. There is a need for further research into the medical and diving histories of diving fatality victims for comparison with survivor groups, such as those in this study, in order to better evaluate the risk of diving with such medical conditions.

This study has several limitations:

- DAN AP members are probably not typical of the diving population at large. They are likely older with the associated increased likelihood of co-existing disease, have more available funds, may travel more, and may better understand their potential vulnerability and the need and benefits of having appropriate insurance.
- Some applicants for DAN membership may have been reluctant to declare medical conditions for fear of it affecting their ability to obtain or retain insurance coverage, although it was made clear that failure to declare a relevant condition may nullify coverage. As a result, there were likely to have been more than the 833 members invited to join the MCS who were suffering from the targeted health conditions. This is supported by the fact that around 20% of respondents to the anonymous GDMS reported having such a condition.
- Respondents to both surveys were older than non-respondents and some selection bias may have been introduced. Therefore, some results may not be representative of the entire DAN AP membership.
- The nature of some of the more historical questions may have introduced a recall bias.
- Many responses were excluded in the MCS survey due to missing replies to certain questions. This would have been improved if the survey had been designed requiring responses to certain key questions. *SurveyMonkey*, used for the GDMS, was more user-friendly and reliable and there were consequently fewer lost responses.

## Conclusions

A large proportion of DAN AP members are diving with potentially significant medical conditions. These members appear to be older, more obese, take more medication and smoke less than other members. There were few major differences in the nature or pattern of diving between divers with and without medical conditions, excepting that those with medical conditions did less repetitive diving. Also, a

greater proportion of divers with a history of intracardiac shunts had suffered DCI. The increased proportion of older divers, the higher likelihood of co-existing disease with age, and the fact that older divers with co-existing health conditions (particularly cardiac conditions) are increasingly represented in diving fatality reports indicate a need for further research into the impact of various medical conditions on divers in order to better determine the level of risk associated with these. Future reports from this project will examine the cohorts with particular conditions and what actions they take, if any, to accommodate these.

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### Conflicts of interest

John Lippmann is the Founder and Chairman of DAN AP. DAN is involved in the collection and reporting of dive accident data and provides evacuation cover and dive injury insurance to recreational divers. This study is funded by DAN AP.

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