

# Health and wellbeing of recently active United States scuba divers

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## Key words

Demography; Diving; Medical conditions and problems; Population; Surveillance

## Abstract

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**Introduction:** This study aimed to describe recently active adult scuba divers in the United States (US) and compare their characteristics with other active adults. The research question was: do active scuba divers have different health and wellbeing characteristics, compared with adults active in other pursuits?

**Methods:** The Behavioural Risk Factor Surveillance System (BRFSS) is a proportionally representative annual survey of adults in the US. It is the largest continuous population health survey in the world. Since 2011, data on scuba diving is collected biannually. A comparison group were matched on age, sex, being physically active and state of residence.

**Results:** The dataset comprised 103,686,087 person-years of monthly behavioural data, including 14,360 person years of monthly scuba data. The median weekly frequency of recent scuba diving was 1.0 times per week and the median weekly duration was equivalent to two dives each of one hour. Compared with the comparison group, divers more often earned > USD\$50,000 per year, were less frequently married, with fewer children in the house, which they more often owned. They reported being able to afford a doctor if needed within the previous year, but more often reported excellent/good health and excellent/good mental health, despite the divers being 16% more frequently overweight.

**Conclusions:** The results demonstrate a relatively healthy cohort of active scuba divers, confirming previous survey results that active divers are commonly college-educated, unmarried, without children, home owning, often overweight, they often currently drink alcohol, and smoked tobacco in the past, but commonly gave up smoking ten years or more ago.

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## Introduction

Little is known about the health and wellbeing of active scuba divers and, despite numerous long-term prospective birth cohort studies,<sup>1</sup> it remains unknown whether recreational scuba diving adds to one's life expectancy or reduces it. It is estimated around three million United States (US) residents, or 1% of the population, scuba dive each year, collectively making around 30 million recreational dives annually.<sup>2</sup> Regardless of the inherently hazardous environment in which scuba diving takes place, recreational scuba diving morbidity and mortality is relatively low,<sup>2,3</sup> compared with other adventure recreation pursuits.<sup>4</sup> On average an estimated 1,400 divers present at US emergency departments each year,<sup>2</sup> and in recent years around 70 scuba diving fatalities have been recorded annually in US and Canadian recreational divers.<sup>5</sup> The most common injuries/illnesses reported to the Divers Alert Network are barotrauma, decompression sickness and marine envenomation, though medical complaints where fitness may play a role include pulmonary oedema, non-fatal drowning and cardiac arrhythmias.<sup>5</sup>

An analysis of recreational diving fatalities that occurred while supervised by a professional dive guide found 57% had a medical cause of death, (such as a sudden cardiac death), as opposed to a dive related issue, (such as running out of air).<sup>6</sup> After drowning, cardiac events are the most common cause of death in North American diving fatalities, accounting for at least 16%,<sup>7</sup> though cardiac-related disabling injuries may precede drowning and the actual proportion may be higher. Cardiovascular risk factors, (hypercholesterolaemia, body mass index, hypertension, and smoking status) have already been described in active US scuba divers.<sup>8</sup> Furthermore, an analysis of 100 consecutive US scuba diving autopsies found an increased prevalence of left ventricular hypertrophy (LVH) compared with an age-sex matched group of 178 autopsies from vehicle collision deaths (31% vs. 20%,  $P = 0.04$ ).<sup>9</sup> A recent study of active US recreational divers aged  $\geq 40$  y found a prevalence of LVH at 8% which, considering the prevalence was 31% at autopsy, suggests the possibility that LVH may increase the risk of death while scuba diving.<sup>10</sup>

Socioeconomic factors also influence life expectancy. One study demonstrated the direct relationship between

life expectancy and gross domestic product per person in 57 countries, which was interpreted as likely the effect of improved health care, rather than increased income or improved housing.<sup>11</sup> Access to health care, income, and housing status have not previously been described for active scuba divers. A later study of developing countries, concluded that decreased mortality was associated with gains in female autonomy, as evidenced by improved access to education.<sup>12</sup> Education has been shown to influence risk-taking and health behaviors (e.g., smoking status and alcohol consumption), and to be associated with longer life expectancy, especially in the US.<sup>13,14</sup> Marriage is also now well established to increase life expectancy, in both males and females, with 2.2 and 1.5 additional years total life expectancy respectively, and 2.4 and 2.0 years of additional active (or disability free) life expectancy respectively, compared with unmarried males and females.<sup>15</sup>

In recent years, mental wellbeing has diminished in US adults. The prevalence of anxiety increased from 5% in 2008 to 7% in 2018, and was associated with being never married, and having college education, but did not increase in over 50's.<sup>16</sup> Mental wellbeing and its relationship with marriage and college education has not previously been described in a representative sample of active recreational scuba divers. Among military veterans not currently diagnosed with post-traumatic stress disorder, psychological wellbeing has been demonstrated to improve with exposure to outdoor recreation in group settings,<sup>17</sup> such as are commonly experienced in recreational scuba diving, but neither the proportion of active recreational divers who are military veterans nor their psychological wellbeing have previously been described.

The aim of this study was to describe the demography, health and wellbeing of recently active adult scuba divers in the US and compare these characteristics with other recently active adults. The research question was: do active scuba divers have different health and wellbeing characteristics, compared with adults active in other pursuits?

## Methods

The Behavioural Risk Factor Surveillance System (BRFSS) is a random-number mobile and landline telephone-based proportionally representative annual survey of non-institutionalised adults in all US states and territories. This system is the largest continuously conducted population health survey system in the world. Every other year since 2011 a module collects data on types, frequency and duration of physical activities. Scuba diving was included in the list of physical activities in 2011, 2013, 2015, 2017 and 2019 surveys.<sup>18–22</sup> The relevant BRFSS survey questions were:

- During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?
- What type of physical activity or exercise did you spend the most time doing during the past month?

- What other type of physical activity gave you the next most exercise during the past month?

BRFSS data were weighted using an iterative ranking method involving up to 16 variables and with trimming of outliers. These weightings were then used to generate person-level weights to reflect Nielsen Company intercensal population estimates. The data were de-identified and made freely available by the Centers for Disease Control and Prevention. SAS version 9.4 (Statistical Analysis System, Cary, NC) was used for the analysis. Before combining the years of data, individual weights ( $w$ ) were adjusted ( $w'$ ) for each year ( $i$ ), relative to each year's ( $n = 5$ ) proportion of the combined dataset,<sup>23</sup> as shown in Equation 1.

$$w'_i = \frac{n \cdot w_i}{\sum_{i=1}^n w_i} \quad (\text{Eq. 1})$$

All reported data in this study are national estimates, generated by summing the adjusted annual weights ( $w'_i$ ).<sup>24</sup> This is appropriate where:

- The sample is as small as it is for divers;
- the divers were proportionally distributed across the US;
- the minimum cell size for all reported variables  $\geq 50$ ;
- the relative standard error of ordinal/linear variables is  $< 30\%$ .

A comparison group of active participants with a ratio of three per diver (actual participants, not weighted estimates) was compiled. This group were also physically active, (in activities other than diving), and were matched with the divers on survey year, sex, age (5 year bin), and state of residence. Frequency of scuba diving was leptokurtic and weekly duration of scuba diving positively skewed, therefore medians and interquartile ranges (IQR) are reported. National estimates and proportions for demography, health and wellbeing factors among divers and the comparison group are presented. Relative risks and 95% confidence intervals (Table 1) were also calculated. Both the Institutional Review Board (IRB) of the Divers Alert Network and the Curtin University Human Research Ethics Committee (HREC) classed this study exempt from requiring ethical approval, (letters available on request).

## Results

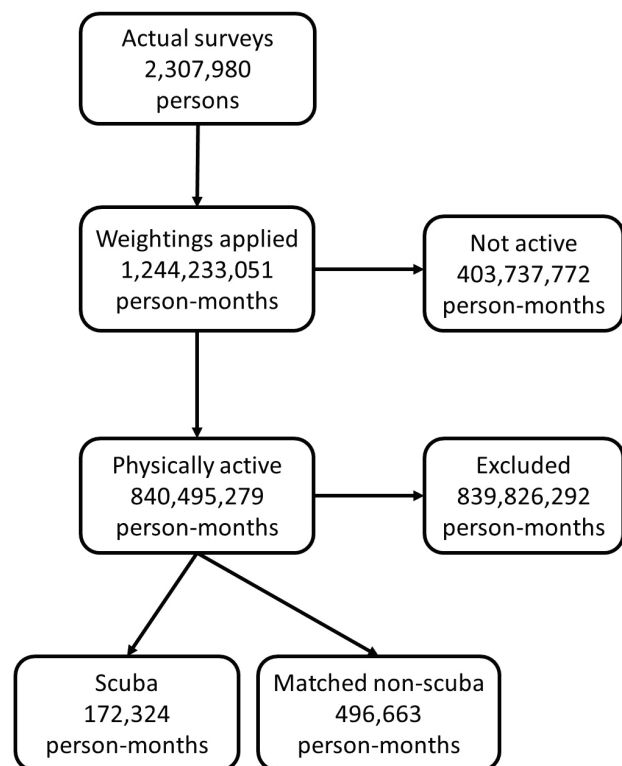
The dataset comprised a total of 2,307,980 telephone survey responses. Combined 2011–2019 BRFSS surveys with the physical activity module included ( $n = 5$  years) yielded an estimate of 1,244,233,051 person-months (103,686,087 person-years) of nationally representative behavioral data. Of those, being active was self-reported for 840,495,279 (68%) previous months, and 172,324 (0.01%) identified the physical activity they had been most, or next most, active in during the previous month was scuba diving (14,360 person years of data), 137,266 months from males (80%) and 35,058 from females (20%). The comparison group, matched on age, sex, being physically active and

**Table 1**

Demography, personal circumstances and health status of recently active US adult scuba divers and comparison group, 2011–2019; BMI – body mass index, normal 18.5–25.0 kg.m<sup>-2</sup>, overweight 25.0–30.0 kg.m<sup>-2</sup>, obese ≥ 30.0 kg.m<sup>-2</sup>; N/A – too much data missing for a reliable estimate of relative risk

Parameter	Divers %	Controls %	Relative Risk (95% CI)
Males	79.7	73.9	1.28 (1.27, 1.29)
Age < 40 years	32.3	35.8	0.95 (0.95, 0.95)
Age 40–49 years	23.9	26.4	0.97 (0.96, 0.97)
Age 50–59 years	25.8	26.1	0.89 (0.89, 0.90)
Age ≥ 60 years	17.9	14.8	1.04 (1.04, 1.04)
Married (vs. divorced, widowed, separated, never)	49.9	56.8	0.86 (0.86, 0.87)
Do children live in the household?	29.7	40.4	0.85 (0.84, 0.85)
High school graduate?	18.9	19.9	0.99 (0.99, 0.99)
College one to three years?	27.8	33.8	0.92 (0.91, 0.92)
College four years or more?	41.5	34.8	1.11 (1.11, 1.12)
Annual household income < \$50,000	31.1	47.7	0.76 (0.76, 0.76)
≥ \$50,000	68.9	52.2	1.53 (1.52, 1.55)
Own home?	76.9	69.6	1.31 (1.30, 1.33)
Rent home?	21.4	26.7	0.93 (0.93, 0.94)
Active duty veteran?	17.8	13.7	1.05 (1.05, 1.05)
Health is excellent/very good?	63.5	52.9	1.29 (1.28, 1.30)
Physical health good every day last 30 days?	68.4	65.9	1.08 (1.07, 1.09)
Mental health good every day last 30 days?	71.6	61.9	1.34 (1.33, 1.35)
Have a health care coverage plan?	84.8	85.2	0.97 (0.96, 0.99)
Have a personal doctor?	79.1	78.4	0.99 (0.99, 0.99)
Could afford a doctor if needed in last year?	91.1	85.1	1.68 (1.65, 1.70)
Doctor routine check-up within last 1 year?	66.9	69.7	0.92 (0.91, 0.92)
Doctor routine check-up within last 5 years?	82.3	90.7	0.52 (0.52, 0.53)
BMI classification: Obese	24.6	34.6	0.87 (0.87, 0.87)
Overweight	40.0	30.6	1.16 (1.15, 1.16)
Normal/under	33.2	29.5	1.05 (1.05, 1.06)
Ever been diagnosed with high blood pressure?	23.7	30.1	0.92 (0.91, 0.92)
Currently taking blood pressure medication?	15.0	22.4	N/A
Ever been diagnosed with high cholesterol?	30.0	29.3	1.01 (1.01, 1.01)
Not had a heart attack?	97.2	97.1	1.00 (1.00, 1.00)
Not had angina or coronary heart disease?	98.8	97.4	2.15 (2.05, 2.25)
Not had a stroke?	99.6	95.2	10.60 (9.82, 11.44)
Not diagnosed with asthma?	86.1	81.9	1.30 (1.28, 1.32)
Not diagnosed with skin cancer?	95.3	94.0	1.23 (1.20, 1.26)
Not diagnosed with other types of cancer?	98.0	93.1	3.36 (3.25, 3.48)
Alcoholic drinks in last week or 30 days? Yes	70.4	62.3	1.30 (1.29, 1.31)
No	28.1	36.7	0.88 (0.88, 0.88)
Drink to excess in last 30 days? 1–30 times	24.2	22.8	N/A
No	46.2	39.5	N/A
Missing/Do not know	29.6	37.7	N/A
Most drinks on one occasion recently? 1–2	28.5	24.1	N/A
3–4	17.3	15.6	N/A
≥ 5	23.1	18.9	N/A
Missing/Do not know	31.1	41.4	N/A
Ever smoked at least 100 cigarettes?	49.3	42.1	1.14 (1.13, 1.15)
Currently smoke cigarettes?	11.6	19.2	0.91 (0.91, 0.91)
Do not currently use any other tobacco products?	97.6	94.7	2.37 (2.29, 2.45)
Gave up smoking ten years ago or more?	22.1	12.2	N/A

**Figure 1**  
Enrolment flow diagram



state of residence, equated to an estimated national sample of 496,663 people who were physically active during the previous month (41,388 person years of data), mostly (and next mostly) in activities other than scuba diving (Figure 1).

Diving activity (matched by state in the control group) mostly occurred in residents of Florida and California, (55,508 person-months, 32%), followed by residents of Georgia, New York, Washington and Michigan respectively (41,977 person months, 24%). The median weekly frequency of recent scuba diving was 1.0 times per week (IQR 0.7–2.0) and the median total number of minutes spent scuba diving per week were 120 (IQR 60–150), equivalent to two dives each of one hour duration in a single outing.

Demography, personal circumstances and health status of both the divers and the matched comparison group are presented in Table 1. In summary, compared with the matched comparison group, the divers were more likely to have completed at least four years of college education, and were more likely to earn > USD\$50,000 per year. They were less likely to be married with children in the house, which they were more likely to own. Divers were more likely to report being able to afford to see a doctor if needed within the previous year, but they were more likely to report excellent/good health in the previous 30 days, excellent/good mental health, and they were half as likely to have had a routine medical examination within the previous five years. They

were 13% less likely to report being obese but 16% more likely overweight, fewer had ever been diagnosed with high blood pressure and, therefore, fewer reported currently taking blood pressure medication. The divers were twice as likely to report never having suffered angina or coronary heart disease and ten times as likely to report never having had a stroke. A history free of cancers was more commonly reported by the divers but, conversely, they were more likely to report having drunk alcohol within the previous 30 days, more commonly reported alcohol intake to excess, more commonly drank  $\geq 5$  standard drinks in one sitting, and were more likely to report having ever smoked more than 100 cigarettes. Lastly, more divers than the comparison group reported having given up smoking at least ten years before taking the survey and the divers were less likely than the comparison group to report using any other tobacco products, e.g., chewing tobacco.

## Discussion

Certain health and wellbeing factors not previously described in active US scuba divers were self-reported for the previous month between 2011 and 2019 by a representative sample of US divers and matched controls. The divers reported a lower proportion of obesity but a higher proportion were overweight. Compared with the matched comparison group, the divers less frequently reported high blood pressure, stroke, asthma, skin cancer or other cancers, which is a similar finding to that of a previous survey of Divers Alert Network (DAN) members, which found lower prevalence of asthma, heart attack, stroke, hypercholesterolaemia, and hypertension among scuba divers, compared with the wider US population.<sup>25</sup> These are risk factors associated with cardiovascular and respiratory morbidity and mortality in the general population but the present study also found that the active scuba divers had better college education, higher household income and higher percentage of owning a home, all suggestive of a selection bias, possibly due to a combination of various factors such as costs associated with participation, the physical effort associated with handling the equipment, and others. Despite the lower reported prevalence of risk factors, and perhaps because of the stresses scuba diving places upon the cardiovascular system, cardiovascular events are nonetheless a leading cause of fatalities in recreational divers.<sup>7</sup>

Our analysis of the BRFSS data identified that recently active scuba divers self-reported good physical and mental health, excellent or very good health in general, being able to afford a doctor if needed but less frequently to have had a routine medical assessment within either the previous year or five years, in comparison with other age-sex-matched recently active adults. Given the proportion (> 40%) of divers in this study who were older than 50 years, and the prevalence of other cardiovascular risk factors, it would appear important for active divers to regularly have their fitness for diving reassessed, e.g., annually. The divers reported more frequent excessive alcohol consumption, compared with



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