

Prevalence of laryngopharyngeal reflux symptoms in divers

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Keywords

DAN – Divers Alert Network; Diving medicine; ENT; Epidemiology; Health surveys; Recreational divers; Technical diving

Abstract

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Introduction: Laryngopharyngeal symptoms (LPS) refer to aerodigestive complaints that may result from the retrograde flow of gastric contents into the upper aerodigestive tract. These symptoms may be under-recognised in populations exposed to mechanical or environmental stressors. Divers may be at increased risk due to factors such as pressure changes and body positioning. This study characterised the prevalence and severity of LPS among divers and identified associated risk factors.

Methods: A cross-sectional, anonymous survey was distributed to members of the Divers Alert Network (DAN). Collected data included demographics, diving-related behaviours, medical history, and LPS burden measured using the Reflux Symptom Index (RSI).

Results: Of the 309 survey responses analysed, 47.2% were male with a median age of 50.0 years (IQR: 40.0–60.0). Among 291 divers with complete RSI data, 26.1% (95% CI, 21.4–31.5%) had abnormal RSI scores, representing a +16.0 percentage-point increase (95% CI, 11.3%–21.4%) over non-diving population estimates ($P < 0.001$). In multivariable analysis, female sex (adjusted prevalence rate [aPR] 1.59, 95% CI 1.07–2.37) and gastroesophageal reflux disease (GERD) history (aPR 1.75, 95% CI 1.16–2.65) were independent predictors. Recreational divers had a lower risk (aPR 0.59, 95% CI 0.39–0.90). Approximately 5% of respondents described their symptoms as life-threatening.

Conclusions: Divers may represent an under-recognised population at elevated risk for LPS. Female sex and GERD history were associated with greater symptom burden, while recreational diving appeared less provocative compared to technical diving. These findings may have implications for risk stratification and symptom management in the diving community.

Introduction

Laryngopharyngeal reflux disease (LPRD) is characterised by the retrograde flow of gastric contents into the upper aerodigestive tract. Unlike gastroesophageal reflux disease (GERD), LPRD often presents without classic heartburn or regurgitation symptoms and is characterised by laryngopharyngeal symptoms (LPS) such as chronic cough, throat clearing, and hoarseness, in conjunction with objective evidence linking these symptoms to gastroesophageal reflux.^{1–3} LPRD remains a challenging condition to manage, as definitive diagnostic and therapeutic gold standards have yet to be established.⁴ Despite increased recognition of LPRD's clinical and economic burden, certain populations may face elevated risk due to mechanical or environmental exposures.

Underwater diving has the potential to exacerbate gastroesophageal reflux through several mechanisms. First, tight wetsuits and increased ambient pressure experienced during underwater descent may increase intra-abdominal pressure through mechanical compression.⁵ Prone or head-down positions during diving can also favor the upward migration of gastric contents. On ascent, expanding gas in the stomach can trigger belching or vomiting in divers with weak lower oesophageal sphincters or full stomachs.⁶ Though limited, prior forensic reports and series have suggested an association between underwater diving and life-threatening reflux-related events.^{6–9} Despite this, there has been no systematic assessment of LPS burden in the diving population to date.

To address this gap, we conducted an international, cross-sectional survey among adult members of the Divers Alert

Network (DAN), a non-profit organisation dedicated to improving the safety of the diving community. The primary objective was to characterise the prevalence and severity of LPS in divers using the validated Reflux Symptom Index (RSI).¹⁰ Secondary objectives included examining associations between abnormal RSI scores and demographic, medical, and diving-related variables to identify predictors for future investigation. This work provides the first population-level estimate of LPS burden in the diving population.

Methods

STUDY DESIGN AND POPULATION

This anonymous, cross-sectional survey study was reviewed and approved by the DAN Institutional Review Board (IRB # 042-25-26), and informed consent was obtained from all participants. An anonymous online questionnaire was distributed to members of the DAN via a public post on DAN's official Facebook page.¹¹ Participation was voluntary, and no incentives to participate were offered. The survey period spanned from July to October 2025. While DAN has a large international membership base, the number of members who viewed the survey post is unknown, and therefore a response rate could not be determined. Participants were required to be adults (over 18 years of age) and included both technical and recreational divers. Incomplete responses, defined as those missing more than 75% of the total questions, were excluded from the final analysis.

DATA COLLECTION

Demographic data, diving experience, relevant medical history, diving-associated symptoms, and behaviors were collected. Demographic data included height, weight, body mass index (BMI), sex, race, ethnicity, educational level, and employment status. Relevant medical history included prior medical conditions, voice-related medical problems, bariatric/laryngeal surgery, and active medication use. Diving-associated symptoms included regurgitation, laryngospasm, heartburn, vomiting, difficulty inhaling, coughing, globus sensation, postnasal drip, throat clearing, dysphagia, and hoarseness. Interruption of regular diet was defined as avoidance, reduction, or modification of a participant's typical food or meal intake due to LPS. Collected diving-related behaviors included eating, consuming alcohol, soda, energy drinks, coffee, or smoking prior to diving. Diving categories were not mutually exclusive, as participants could hold multiple credentials (e.g., recreational and technical certifications).

SURVEY INSTRUMENTS

The primary outcome was LPS burden measured by the RSI, a validated, nine-item questionnaire originally developed to quantify reflux-related complaints.¹⁰ While the RSI was

historically associated with 'laryngopharyngeal reflux', it more accurately captures the presence and severity of LPS rather than diagnosing LPRD, which requires objective evidence linking chronic, troublesome LPS to gastroesophageal reflux. The symptoms covered include hoarseness, throat clearing, excess throat mucus, swallowing difficulties, coughing, choking, globus sensation, and classic GERD symptoms such as heartburn or chest pain. Each item is scored on a Likert scale from 0 (indicating no problem) to 5 (indicating severe problems), with a total possible score of 45 thus higher scores indicate more severe symptoms. The RSI has demonstrated high internal consistency, test-retest reliability, and responsiveness to treatment across several populations.^{10,12,13} A score of 13 or higher has been described as abnormal, as it corresponds to the 95th percentile among healthy controls (without LPRD) in the original validation study.¹⁰

STATISTICAL ANALYSIS

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY). Continuous variables were reported as means with standard deviations (SD) or as medians with interquartile ranges (IQR), contingent on their distribution. Categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro-Wilk test, and equality of variances using Levene's test. The one-sample binomial test was used to compare the observed prevalence of elevated RSI scores (≥ 13) among divers to a previously published non-diving population rate of 10.15%.¹⁴ Between-group comparisons were conducted using chi-square or Fisher's exact tests for categorical variables and Mann Whitney U or Kruskal Wallis tests for non-normally distributed continuous variables. Multivariable Poisson regression with robust standard errors was used to identify independent predictors of $\text{RSI} \geq 13$. Patients with missing clinicodemographic variables were excluded from the corresponding analyses. A *P*-value of < 0.05 was considered statistically significant.

Results

COHORT CHARACTERISTICS

A total of 436 responses were recorded. After eliminating 127 incomplete responses, 309 divers were included in the final analysis. The median age of participants was 50.0 years (IQR: 40.0, 60.0) with a roughly equal sex distribution (47.2% male, 45.3% female). In terms of ethnic/racial distribution, most participants self-identified as non-Hispanic (81.6%) white (85.8%). The majority of participants had a high level of education, with 71.2% having completed a four-year college degree or higher. Table 1 summarises the demographic characteristics of the study cohort.

Table 1

Baseline demographic characteristics of the final study cohort ($n = 309$). IQR – interquartile range; LL – lower limit; SD – standard deviation; UL – upper limit

Characteristics		n (%)	Mean (SD)	Median [IQR]	Range: LL–UL
Age (years)		286 (92.6)	49.8 (13.8)	50.0 [40.0–60.0]	18–81
Height (cm)		288 (93.2)	172.8 (9.5)	173.0 [167.5–178.5]	150–204
Weight (kg)		289 (93.5)	81.6 (17.5)	79.7 [69.6–89.8]	43.0–158.8
Body mass index ($\text{kg}\cdot\text{m}^{-2}$)		288 (93.2)	27.3 (5.2)	26.5 [23.4–29.7]	14.1–48.8
Sex	Male	146 (47.2)	-----	-----	-----
	Female	140 (45.3)	-----	-----	-----
	Prefer not to answer	1 (0.3)	-----	-----	-----
Race	White	265 (85.8)	-----	-----	-----
	Other/prefer not to answer	17 (5.5)	-----	-----	-----
	Asian	4 (1.3)	-----	-----	-----
	American Indian or Alaska native	2 (0.7)	-----	-----	-----
	Native Hawaiian or other Pacific Island	1 (0.3)	-----	-----	-----
	Black or African American	1 (0.3)	-----	-----	-----
Ethnicity	Not Hispanic or Latino	252 (81.6)	-----	-----	-----
	Hispanic or Latino	25 (8.1)	-----	-----	-----
	Unsure/Prefer not to answer	7 (2.3)	-----	-----	-----
Education	More than 4-year college degree	155 (50.2)	-----	-----	-----
	4-year college graduate	65 (21.0)	-----	-----	-----
	Some college or 2-year degree	54 (17.5)	-----	-----	-----
	High school or GED	13 (4.2)	-----	-----	-----
	Some high school, did not graduate	1 (0.3)	-----	-----	-----
Diving	Recreational	217 (70.2)	-----	-----	-----
	Technical	43 (13.9)	-----	-----	-----
	Recreational instructor	90 (29.1)	-----	-----	-----
	Technical instructor	15 (4.9)	-----	-----	-----
	Open Water	87 (28.2)	-----	-----	-----
	Advanced	151 (48.9)	-----	-----	-----
	Freediver	17 (5.5)	-----	-----	-----
	Other	31 (10.0)	-----	-----	-----

A range of scuba-diving backgrounds were represented in our cohort. Most (70.2%) of the participants consisted of recreational divers, followed by advanced divers (48.9%), recreational instructors (29.1%), technical divers (13.9%), and freedivers (5.5%). The majority of participants (82.5%) reported eating prior to diving, with a mean interval of 1.5 (SD 0.7) hours between eating and dive initiation. Alcohol consumption the night before diving was also reported by 50.5% of divers, with an average intake of 1.8 (1.0) standard drinks. A smaller subset (7.4%) reported consuming alcohol immediately before or between dives. Additional pre-/inter-dive behaviors included cigarette use (11.7%), electronic cigarette use (5.5%), marijuana use (1.6%), and consumption of coffee (56.0%), soda (43.7%), and energy drinks (15.9%).

Common medical comorbidities included GERD (26.2%), allergies (24.3%), hypertension (14.9%), and asthma (7.4%). A small subset of respondents reported prior laryngeal or upper airway conditions including chronic cough (6.8%), vocal cord paresis/paralysis (1.6%), uncorrected upper airway obstruction (0.6%), or swallowing disorders (0.3%). Few had undergone prior laryngeal surgery (2.3%). In terms of medication use, 13.6% were actively taking proton pump inhibitors (PPIs), 7.4% were on glucagon-like peptide-1 (GLP-1) agonists, and 4.9% reported histamine-2 (H2) antagonist use. Few participants had undergone formal reflux testing, including pH impedance (4.5%) or wireless capsule testing (1.3%). Table 2 summarises the baseline clinical characteristics of the final study cohort.

Table 2

Baseline clinical characteristics of the final study cohort ($n = 309$).
GLP-1 – glucagon-like peptide-1

Characteristics ($n = 309$)	n (%)
Prior medical conditions	
Hypertension	46 (14.9)
Diabetes	16 (5.2)
Allergies	75 (24.3)
Asthma	23 (7.4)
Patent foramen ovale	8 (2.6)
Other lung/heart condition	12 (3.9)
Gastroesophageal reflux disease	81 (26.2)
Hiatal hernia	27 (8.7)
Gastric ulcer	7 (2.3)
Fundoplication	5 (1.6)
Bariatric surgery	9 (2.9)
Other	38 (12.3)
Prior voice-related medical problems	
Inflammatory conditions	5 (1.6)
Vocal cord paresis/paralysis	5 (1.6)
Uncorrected upper airway obstruction	2 (0.6)
Laryngocele	1 (0.3)
Inducible laryngeal obstruction/vocal cord dysfunction	2 (0.6)
Chronic cough	21 (6.8)
Swallowing disorder	1 (0.3)
Other	13 (4.2)
Prior laryngeal/upper airway surgery?	7 (2.3)
Are you actively taking any of the following medications?	
Anticholinergics	1 (0.3)
Calcium channel blockers	7 (2.3)
Progesterone	17 (5.5)
Tricyclic antidepressants	5 (1.6)
GLP-1 agonist	23 (7.4)
Proton pump inhibitor	42 (13.6)
Histamine-2 receptor antagonist	15 (4.9)
Other	34 (11.0)

SYMPTOM BURDEN DURING DIVES

LPS were commonly reported during dives. The most frequently endorsed symptoms included coughing (60.5%), regurgitation (49.5%), and heartburn (49.2%). Less commonly reported symptoms included throat clearing (38.5%), postnasal drip (36.6%), globus sensation (24.6%), hoarseness after surfacing (23.6%), and vomiting (17.8%). Laryngospasm during dives was reported by 23 divers (7.4%). Table 3 provides a summary of the LPS of the final study cohort.

Among divers who reported the number of episodes experienced in the past year, throat clearing occurred most frequently (mean 18.6 episodes per year), followed by globus sensation (mean 16.1 episodes per year), hoarseness (mean 15.2 episodes per year), postnasal drip (mean 15.0 episodes per year), and heartburn (mean 14.5 episodes per year). Laryngospasm (5.8 episodes per year), regurgitation (5.0 episodes per year), and vomiting (5.0 episodes per year) occurred less frequently. Notably, symptom distributions were wide, with several participants reporting up to 200 episodes per year for some items (Table 3).

Symptoms were described as life-threatening by 13 divers (4.2%) and severe enough to interrupt diet in 63 (20.4%). Of 216 respondents, the average depth at which symptoms occurred was 17.8 (13.2) m. Symptoms occurred most commonly underwater (37.2%) or both underwater and at the surface (37.2%).

REFLUX SYMPTOM INDEX (RSI)

Ninety-four percent of participants ($n = 291$) completed the RSI section of the survey. The mean total RSI score was 8.9 (8.3) (range 0–41). Among 291 divers with complete RSI data, 26.1% (95% CI, 21.4–31.5%) met the RSI ≥ 13 threshold. Compared to a non-diving population prevalence of 10.15%,¹⁴ this was significantly higher ($P < 0.001$), representing a +16.0 percentage-point increase (95% CI, +11.3%–21.4%).

Among individual RSI items, the most frequently reported symptoms (score ≥ 2) were related to upper throat irritation: excess throat mucus/postnasal drip (42.9%), heartburn or indigestion (49.5%), and frequent throat clearing (36.1%). Globus sensation (27.5%), coughing (24.8%), and hoarseness (19.9%) were also common. In contrast, more severe symptoms such as difficulty swallowing (15.1%) or breathing/choking episodes (6.8%) were less frequently reported. Mean item scores were highest for heartburn-related complaints (mean 1.8 [SD 1.6]) and excess mucus/postnasal drip (mean 1.6 [1.6]), reflecting the most burdensome symptoms among the cohort. Table 4 provides a summary of the RSI responses for the final study cohort.

BETWEEN-GROUP COMPARISONS AND PREDICTORS OF ABNORMAL RSI

Abnormal RSI scores (≥ 13) were more frequently observed in females (30.9%) compared to males (21.2%; $P = 0.043$), although total RSI scores did not significantly differ by sex (median 7 [IQR 11] vs 6.5 [IQR 8]; $P = 0.225$). Divers with a history of GERD had higher rates of RSI ≥ 13 (38.3%) compared to those without GERD (21.4%; $P = 0.003$), and their total RSI scores were also significantly elevated (median 10 [IQR 9] vs 5 [IQR 9]; $P < 0.001$).

Table 3Baseline upper aerodigestive symptoms of the final study cohort ($n = 309$); LL – lower limit; SD – standard deviation; UL – upper limit

Characteristics:	<i>n</i> (%)	Mean (SD)	Range: LL–UL
Experienced the following symptoms while diving:			
Regurgitation	153 (49.5)	-----	-----
Laryngospasm	23 (7.4)	-----	-----
Heartburn	152 (49.2)	-----	-----
Vomiting	55 (17.8)	-----	-----
Difficulty taking a breath “in”	42 (13.6)	-----	-----
Coughing	187 (60.5)	-----	-----
“Lump” in the throat	76 (24.6)	-----	-----
Excess mucus in the throat/postnasal drip	113 (36.6)	-----	-----
Frequent urge to throat-clear	119 (38.5)	-----	-----
Trouble swallowing	45 (14.6)	-----	-----
Hoarseness (after surfacing)	73 (23.6)	-----	-----
How many times have you experienced the following symptoms during the last year?			
Regurgitation	104 (33.7)	5.0 (7.9)	0–50
Laryngospasm	19 (6.1)	5.8 (8.6)	0–30
Heartburn	103 (33.3)	14.5 (26.2)	0–200
Vomiting	42 (13.6)	5.0 (14.8)	0–80
Difficulty taking a breath “in”	28 (9.1)	6.6 (11.7)	0–50
Coughing	113 (36.6)	12.0 (22.8)	0–200
“Lump” in the throat	67 (21.7)	16.1 (28.7)	0–200
Excess mucus in the throat	43 (13.9)	15.0 (33.0)	0–200
Frequent urge to throat-clear	66 (21.4)	18.6 (29.3)	0–200
Trouble swallowing	25 (8.1)	20.0 (41.3)	0–200
Hoarseness (after surfacing)	42 (13.6)	15.2 (21.2)	0–100
Regular diet was interrupted by symptoms	63 (20.4)	-----	-----
Considered symptoms to be life-threatening	13 (4.2)	-----	-----
Depth when last experienced symptoms (m)?	216 (69.9)	17.8 (13.2)	0–140
Location where symptoms occurred:			
Underwater	115 (37.2)	-----	-----
Surface	40 (12.9)	-----	-----
Both	115 (37.2)	-----	-----
Neither	29 (9.4)	-----	-----
Do you tend to eat prior to diving?			
Yes	255 (82.5)	-----	-----
No	53 (17.2)	-----	-----
How long before diving do you typically eat? (h)	237 (76.7)	1.5 (0.7)	0–4
Do you ever drink alcohol the night before diving?			
Yes	156 (50.5)	-----	-----
No	151 (48.9)	-----	-----
How much alcohol do you typically drink (servings)?	142 (46.0)	1.8 (1.0)	1–5
Have you done any of the following before or between dives?			
Consumed alcohol	23 (7.4)	-----	-----
Smoked cigarettes	36 (11.7)	-----	-----
Smoked marijuana	5 (1.6)	-----	-----
Used an e-cigarette or vaporiser	17 (5.5)	-----	-----
Drink soda	135 (43.7)	-----	-----
Drink energy drinks	49 (15.9)	-----	-----
Drink coffee	173 (56.0)	-----	-----
Have you ever had one of the following reflux tests?			
pH impedance test	14 (4.5)	-----	-----
Wireless capsule test	4 (1.3)	-----	-----

Table 4
Reflux Symptom Index responses for the final study cohort ($n = 291$); SD – standard deviation

Reflux symptom index item	n (%)						Mean (SD)
	0	1	2	3	4	5	
Hoarseness or a problem with your voice	212 (72.9)	18 (6.2)	19 (6.5)	27 (9.3)	8 (2.7)	4 (1.4)	0.7 (1.2)
Clearing your throat	127 (43.6)	58 (19.9)	38 (13.1)	27 (9.3)	28 (9.6)	12 (4.1)	1.3 (1.5)
Excess throat mucus or postnasal drip	114 (39.2)	50 (17.2)	33 (11.3)	42 (14.4)	34 (11.7)	16 (5.5)	1.6 (1.6)
Difficulty swallowing foods, liquids, or pills	214 (73.5)	31 (10.7)	17 (5.8)	16 (5.5)	4 (1.4)	7 (2.4)	0.6 (1.2)
Coughing after you ate or after lying down	169 (58.1)	49 (16.8)	29 (10.0)	20 (6.9)	14 (4.8)	9 (3.1)	0.9 (1.4)
Breathing difficulties or choking episodes	242 (83.2)	26 (8.9)	14 (4.8)	5 (1.7)	1 (0.3)	-----	0.3 (0.7)
Troublesome or annoying cough	178 (61.2)	54 (18.6)	17 (5.8)	17 (5.8)	13 (4.5)	11 (3.8)	0.9 (1.4)
Sensation of something sticking in your throat or a lump in your throat	158 (54.3)	51 (17.5)	32 (11.0)	23 (7.9)	13 (4.5)	12 (4.1)	1.0 (1.4)
Heartburn, chest pain, indigestion, or stomach acid coming up	97 (33.3)	50 (17.2)	47 (16.2)	43 (14.8)	35 (12.0)	19 (6.5)	1.8 (1.6)
Reflux symptom index total score							8.9 (8.3)

Diving-related symptoms showed strong associations with elevated RSI scores. Abnormal RSI scores were significantly more common among divers who experienced laryngospasm (52.4% vs 23.0%; $P = 0.008$), vomiting (41.2% vs 22.3%; $P = 0.005$), coughing (33.3% vs 13.3%; $P < 0.001$), and hoarseness after surfacing (49.3% vs 17.9%; $P < 0.001$), though the latter two associations may be partially influenced by the fact that coughing and hoarseness are included as RSI scoring items. Active PPI use (vs. non-use) was also associated with elevated RSI scores (median 9 [IQR 10] vs 6 [IQR 10]; $P < 0.04$).

In a multivariable Poisson regression model, GERD history (adjusted prevalence ratio [aPR] 1.75, 95% CI 1.16–2.65; $P = 0.008$) and female sex (aPR 1.59, 95% CI 1.07–2.37; $P = 0.022$) emerged as independent predictors of RSI ≥ 13 . Recreational divers had a significantly lower likelihood of elevated RSI (aPR 0.59, 95% CI 0.39–0.90; $P = 0.014$), while technical divers showed a non-significant trend toward higher prevalence (aPR 1.54, 95% CI 0.95–2.49; $P = 0.08$). Other diver types, including scuba instructors and freedivers, did not show measurable associations. No significant associations were observed for age, PPI use, asthma, allergy, alcohol use, or eating before diving.

Discussion

In this cross-sectional survey study, over a quarter (26.1%) of divers had abnormal RSI scores. This prevalence is significantly higher than the 10.15% reported in the non-

diving population using the same diagnostic tool and cutoff threshold.¹⁴ Additional factors associated with an increased rate of abnormal RSI scores included a history of GERD (aPR 1.75, 95% CI 1.16–2.65, $P = 0.008$) and female sex (aPR 1.59, 95% CI 1.07–2.37, $P = 0.022$). On the other hand, recreational diving was associated with a significantly lower prevalence of abnormal RSI scores (aPR 0.59, 95% CI 0.39–0.90, $P = 0.014$), suggesting that exposure intensity and diving technique may influence the risk of experiencing LPS.

In the absence of a diagnostic gold standard, general population estimates of LPRD prevalence vary depending on the diagnostic tool, cutoff threshold, and population studied. Additionally, this heterogeneity can also be attributed to the nonspecific nature of LPR symptoms, which can be mimicked by other inflammatory and functional conditions.¹⁵ The RSI is commonly used to quantify LPS in the general population because it is validated, reliable, and easy to administer.¹⁰ Existing studies on LPS prevalence have exclusively focused on non-diving populations, ranging from otolaryngology outpatient clinics to general practices. Xiao and colleagues conducted a large-scale multicenter survey study across otolaryngology clinics in China where approximately 10% of the study population had an RSI score > 13 .¹⁴ In contrast, Kamani and colleagues employed pseudo-random sampling of 2,000 adults from four general practices in England and found that 34.4% of respondents had LPS. Notably, their study used a lower threshold (RSI > 10) which may overestimate the prevalence of LPS in this particular population.¹⁶

We also found that LPS were common during dives, with approximately 60% reporting coughing, 50% regurgitation, and 40% frequent throat clearing. Laryngospasm was reported by approximately 8% of participants and almost 5% described their symptoms as life-threatening. While laryngospasm was included as a self-reported symptom in the questionnaire, we acknowledge that the term may have been interpreted variably by respondents and may not necessarily reflect clinically confirmed laryngospasm. These findings align with prior reports of reflux-associated incidents in divers, which, though not specific to LPRD, highlight potential safety concerns of reflux-like symptoms underwater. Petri et al. described a self-contained underwater breathing apparatus (scuba) diving fatality in a previously healthy, properly trained, and fairly experienced diver.⁹ Forensic analysis and postmortem findings suggested that an episode of vomiting followed by panic and removal of the breathing regulator resulted in death by drowning. Similarly, Novomesky and colleagues reported two diving-related incidents with vomiting and aspiration of gastric contents, with one of the cases resulting in fatality.⁶ Finally, a series of scuba-related fatalities in military personnel revealed that almost 12% (4/34) of divers had evidence of gastric content aspiration, suggesting that acute reflux-related events may be an underdiagnosed cause of mortality in the diving population.⁷

Our findings are concordant with known LPRD risk factors, including female sex and GERD history, likely reflecting hormonal influences and compromised esophageal sphincter function.^{12,17} The association between abnormal RSI scores and a history of GERD is consistent with existing literature, which estimates that approximately 50% of patients with LPR have concomitant GERD.^{15,18} However, it is important to note that LPR is not merely an extension of GERD; it involves distinct pathophysiological mechanisms, primarily linked to upper esophageal sphincter dysfunction and a significantly higher mucosal sensitivity in the laryngopharynx compared to the esophagus.^{1,18} Mechanical factors intrinsic to diving (e.g., compressive wetsuits, and head-down positioning) may facilitate retrograde flow of gastric contents.⁵ Additionally, pressure fluctuations during descent and ascent may promote aerophagia, belching, or regurgitation, particularly in divers with pre-existing anatomical or comorbid risk factors.⁶ This mechanical facilitation is especially concerning given the unique fragility of the laryngopharyngeal mucosa; while the oesophageal mucosa can resist up to 50 potential episodes of reflux per day without tissue damage, the laryngopharyngeal tissues can be damaged by as few as four episodes.^{1,18} This vulnerability suggests that the physiological stressors of diving could exacerbate even minor, sub-clinical reflux into LPS. Finally, the high prevalence of symptoms in the diving population may be explained by the reflex theory of LPR, which posits that the stimulation of oesophageal nerve receptors by gastric contents can trigger vagally mediated laryngeal reflexes, such as chronic coughing and throat clearing.^{15,18} In the high-pressure and physically demanding

environment of diving, these reflexes may be more easily triggered, leading to the chronic persistent symptoms observed in this cohort. As a result, divers should remain especially cognisant of the modifiable risk factors associated with a potentially increased risk of reflux-related events. Avoiding large, slowly digesting meals at least two hours before a dive, as well as avoiding substances that may reduce esophageal sphincter pressures including ethanol, tobacco, coffee, carbonated beverages and certain medications (e.g., anticholinergics, calcium channel blockers, progesterone, among others) should be encouraged for those concerned among the diving community.^{6,9,19}

While this work provides the first quantitative, population-level data on LPS burden in the diving population, it is not free of limitations. The self-reported nature of this study may be subject to recall or reporting bias, especially for symptoms that have non-reflux related causes such as cough, throat clearing, and hoarseness. To standardise symptom assessment, we utilised the RSI, a widely validated patient-reported outcome measure with strong psychometric properties. Because objective reflux testing was not feasible in this cross-sectional survey, the RSI was used to quantify LPS burden; however, it should be acknowledged that it does not establish a clinical diagnosis of GERD or LPRD. Selection bias is another potential limitation of this study, given the low response rate and older age distribution of respondents, which may not fully reflect the broader diving population. However, this demographic profile is consistent with the membership of the DAN and includes a broad range of certification levels, contributing to generalisability. We also acknowledge that the 10.15% prevalence reported by Xiao et al., was drawn from an otolaryngology clinic-based sample and may reflect a population with a higher baseline risk for LPS. Nevertheless, our finding of a 26.1% prevalence (95% CI, 21.4–31.5%) using the same RSI threshold highlights the need for increased awareness in the diving population. Finally, causality cannot be inferred. It remains unclear whether diving exacerbates LPS or whether those with more severe LPS are more aware of their symptoms during dives. Nevertheless, this limitation is inherent to the cross-sectional study design and given the potential for mortality, the association remains noteworthy.

Our findings suggest that divers may have an increased prevalence and severity of LPS, with potential implications for both safety and quality of life. While current guidelines have adequately covered cardiovascular, pulmonary, neurologic, otologic and rhinologic conditions, there is scant literature on the risk of upper aerodigestive conditions during diving.^{20–22} Interventional studies or prospective tracking of LPS onset relative to dive exposure may help inform future diving fitness recommendations or practice guidelines. Finally, multidisciplinary collaboration between gastroenterology, otolaryngology, speech language pathology, and dive medicine may be an essential component to optimise health and safety in the constantly growing diving population.

Conclusions

In this international survey of divers, we identified a substantially higher prevalence of abnormal (≥ 13) RSI scores compared to the non-diving population. Female sex and GERD history were associated with an increased rate of abnormal RSI scores, while recreational diving appeared less provocative compared to other scuba diving categories. Increased awareness and preventive strategies may improve both safety and quality of life in the diving population.

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