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# Oral Health in the Naval Armed Forces: A Scoping Review

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## ABSTRACT

Naval armed forces are commonly prone to stressors during military activities which are associated with their working environment. This can adversely impact the oral health of these personnel. This scoping review aimed to explore the literature concerning oral health among naval personnel. Relevant articles that reported oral health among naval armed forces published from 1990 to December 2022 were retrieved from five main databases. Of the 641 articles searched, 15 met the inclusion and exclusion criteria. Occurrences of caries, periodontal disease and barodontalgia were high among the naval armed forces, with a significant number of dental emergencies during deployment and training operations. The dental diseases and emergencies experienced by the naval personnel on duty may influence their performance during missions. Given the far-reaching effects of dental diseases among personnel in the naval armed forces, further prospective studies with standardised report investigating oral health and dental diseases are recommended. Oral health services in the naval armed forces can also be improved by increasing the dentist-to-navy personnel ratio both at the military bases and on board the vessels during missions, as well as designing preventive strategies to improve oral health among the naval personnel.

**Keywords:** *Dental disease; marine; military dentistry; navy; oral health*

## INTRODUCTION

Defence dentistry in the armed forces aims to ensure that the personnel is deployable and able to meet the demands of security and national safety (Armstrong & Dermont, 2021). Part of these armed forces are the naval personnel in the naval armed forces. They are exposed to a unique set of stressors related to their work environment

specifically during naval operations. These stressors include physically closed, socially intense and potentially dangerous working environment, constrained space, monotonous routine, typical 4 hours on/8 hours off watch schedule leading to fatigue and disruption of circadian rhythm and sleep-wake cycle and constant exposure to noise and vibrations (Khanna *et al.*, 2019). Intensive field training that mimics the

conditions seen in battle and during natural disasters can also have an impact on the oral health of the military personnel. Yamashita *et al.* (2017) reported periodontal deterioration in the Japanese army personnel after a 7-day training. They attributed it to behavioural changes specifically the discontinuation of regular toothbrushing that resulted in the accumulation of dental biofilm as the factor influencing inflammatory responses in the periodontium.

Training conditions while navigating can be challenging to the oral health of the naval personnel with consequences on both local and systemic factors. These include local factors such as dental biofilm accumulation and caries development from poor oral hygiene (Singh, 2009), crack formation and propagation from extreme cold or hot food and environment (Yamashita *et al.*, 2017), parafunction such as tooth grinding because of stress, dietary habits restricted to those offered by the galley leading to development of caries and periodontal diseases (Schlagenhauf *et al.*, 2020) and psychological stressors which increase the inflammatory mediators contributing to periodontal diseases (Khanna *et al.*, 2019).

Oral diseases can lead to considerable disruption to naval personnel, resulting in anything from a reduced effectiveness during naval operations to catastrophic outcomes such as debilitation from dental abscesses and toothache. This can lead to the need to be recalled while being deployed on naval operations. It has been estimated from a retrospective cohort study of United States of America Marine Corps recruits that 58.4% to 70.3% of dental diseases or conditions in dental emergencies were nonpreventable where the condition causing the dental emergency was not indicated for urgent treatment at the previous periodic dental examination, hence cannot be prevented earlier (Simecek, 2008). These figures indicate that 29.7% to 41.6% of the dental emergencies in the United States of America Marine Corps can be prevented. This underlies the importance of oral health

in navy personnel due to their specific work conditions.

The naval personnel are exposed to specific stressors related to their work environment as well as unique conditions while being deployed on naval operations. Despite the importance of oral health in this specific group of the population, there is limited information available in the literature on dentistry and oral health of the naval armed forces. Hence, this review aims to explore the literature regarding oral health in the naval armed forces, to determine how data pertinent to oral health in the naval armed forces are reported in primary studies worldwide, and to identify the knowledge gaps regarding the prevalence and severity of oral diseases in the naval armed forces. This information can later be utilised by clinicians, researchers and policymakers when allocating resources and planning strategies to continuously maintain the oral health of the navy personnel.

## MATERIALS AND METHODS

### Search Criteria

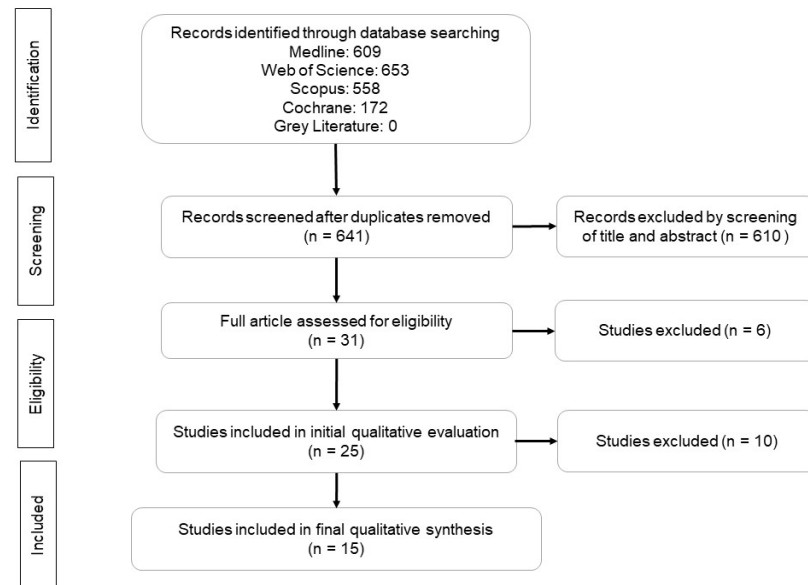
Before conducting this review, a search using PubMed ascertained that there were no published reviews on this topic. The scoping review was conducted following the Preferred Reporting Items for Systematic Review and Meta-Analysis extensions for Scoping Reviews (PRISMA-ScR) guidelines (Tricco *et al.*, 2018). The population, concept, and context strategy was used, where articles investigating oral health in the naval armed forces were considered eligible.

Studies were included if they: (i) were cross-sectional, case-control, cohort, or interventional studies; (ii) reported on oral health using any combination of clinical parameters; (iii) involved participants from the naval armed forces; (iv) were published in the English language. The articles were excluded if: (i) they were editorials, case reports or case studies, letters to editors and

reviews; (ii) the participants were navy new recruits that have yet to undergo any training or missions; (iii) they had insufficient or overlapping data. Limits to the publication years from the year 1990 onwards were applied to access more recent data in this field.

Two reviewers (i.e. NMNA and RNRA) independently searched for relevant articles on Medline, Scopus, Web of Science and The Cochrane Library databases up to 30 December 2022. The grey literature

was searched using Google Scholar. A third reviewer (BB) was consulted in the case of disagreements. The keywords “naval dentistry”, “oral health”, “dental health services” and “military dentistry” were chosen from the Medical Subjects Headings (MeSH) for the search. Other keywords used were “naval” OR “navy” OR “marine” AND “oral health” OR “dental” OR “periodontal disease” OR “caries” OR “oral disease” OR “dentistry”. The flow diagram of the database searches is shown in Fig. 1.



**Fig. 1** PRISMA flow diagram depicting the results of the search strategy.

## Data Extraction and Analysis

Data extraction was done with the following parameters: primary author, year of publication, location/country of study, type of study, sample size, study parameters and conclusions/findings. A predefined data extraction table was utilised and tested before use.

## RESULTS

### Study Selection and Characteristics

A total of 15 studies were found to report on oral health parameters in the naval

armed forces. Table 1 summarises the characteristics of the included studies. Out of 15 included studies, five of them were from the United States of America Naval Armed Forces. Most of the studies were either cross-sectional ( $n = 5$ ) or retrospective ( $n = 5$ ) in design while the rest were longitudinal ( $n = 3$ ) and randomised controlled trials ( $n = 2$ ).

The oral health parameters including the clinical parameters used in the studies, prevalence of dental emergencies, caries, and periodontal disease as well as other parameters are shown in Table 2.

**Table 1** Characteristics of the studies included in the review

Authors, year of publication	Publication	Type of study	Aim(s)	Location	Sample size	Type of subjects
da Silva et al., 2022	<i>Research, Society and Development</i>	Longitudinal	To evaluate the gingival condition and stress level of the navy corps during field training.	Brazil	30	Marine Corps personnel
Schlagenhauf et al., 2020	<i>Journal of Periodontology</i>	Randomised controlled trial	To evaluate whether the regular consumption of probiotics may improve the known deterioration of periodontal health in navy sailors during deployments at sea. The two arms were: Group consuming lozenges containing either the probiotic strains <i>Lactobacillus reuteri</i> and <i>L. reuteri</i> or no probiotics.	Germany	72 (Test = 36, Placebo = 36)	Crew members of the German Navy
Alwohaibi et al., 2020	<i>Journal of International Society of Preventive and Community Dentistry</i>	Cross-sectional	To assess dental as well as orofacial pain under atmospheric pressure in military divers.	Jubail, Saudi Arabia	216	Saudi military divers
Veiga et al., 2018	<i>European Journal of Public Health</i>	Cross-sectional	To characterise the oral health of a Portuguese navy sample from the Naval Base of Lisbon, Portugal.	Lisbon, Portugal	278	Naval personnel
Rohani et al., 2016	<i>Journal of Archives in Military Medicine</i>	Cross-sectional	To evaluate the prevalence of oral and maxillofacial diseases among submarine personnel.	Tehran, Iran	102 (Group 1 = 74, Group 2 = 28)	Submarine crew and marine personnel
Wang et al., 2016	<i>International Journal of Clinical and Experimental Medicine</i>	Prospective randomised control study	To investigate the efficacy of dental health education or dental health education plus a novel mouthwash on the periodontal health of the navy personnel. The three arms were: no intervention, pre-seafaring education booklet and seminars, or dental health education plus mouth rinse twice per day.	China	154 (Group I = 49, Group II = 51, Group 3 = 54)	Naval personnel
Gunepin et al., 2016	<i>Aerospace Medicine and Human Performance</i>	Cross-sectional	To investigate the experience of barodontalgia among western military divers.	France	1,317	Armed Forces diving personnel
Nor Azman et al., 2015	<i>Malaysian Dental Journal</i>	Cross-sectional	To compare the oral health experiences and practices while underwater and on land.	Malaysia	86	Naval submariners

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Table 1 (continued)

Authors, year of publication	Publication	Type of study	Aim(s)	Location	Sample size	Type of subjects
Zhao <i>et al.</i> , 2015	<i>Journal of Oral Hygiene and Health</i>	Longitudinal	To investigate the changes in periodontal status among naval personnel during convoy and analyse possible causes.	China	186	Naval personnel
von Wilimowsky <i>et al.</i> , 2014	<i>Journal of the Royal Army Medical Corps</i>	Retrospective	To evaluate the dental service during a three-month deployment on a German warship.	German Warship	650	Servicemen
Simecek <i>et al.</i> , 2011	<i>Journal of Trauma Injury Infection and Critical Care</i>	Retrospective	To describe the severity of oral/facial problems occurring in Navy and Marine Corps personnel deployed to Iraq.	United States of America personnel in Iraq	13,933	Navy and marine corps members with dental visits to naval dental officers
Deutsch, 2008	<i>Military Medicine</i>	Retrospective	To investigate dental events during periods of isolation in the United States of America Submarine Force on 240 submarine patrols from 1 January 1997 to 30 September 2000.	United States of America	240 submarine patrols	Submarine crew members
Simecek, 2008	<i>Military Medicine</i>	Retrospective	To estimate the percentage of nonpreventable dental emergencies and to estimate the rate of dental emergencies that can be expected if all urgent treatment is completed.	United States of America	906	Marine Corps personnel
Diefenderfer <i>et al.</i> , 2007	<i>Journal of Public Health Dentistry</i>	Longitudinal	To assess the prevalence and severity of periodontal disease, characterise changes in periodontal health, and determine the associations of age, race, gender, and tobacco use with periodontal status among United States of America Navy personnel.	United States of America	1,107	Naval personnel
Deutsch & Simecek, 1996	<i>Military Medicine</i>	Retrospective	To determine the incidence of dental emergency visits for Marine Corps personnel ashore during Operations Desert Shield/Storm between 18 August 1990 and 19 April 1991.	United States of America personnel in Southwest Asia	47 515	Marines

**Table 2** Assessment parameters and prevalence of dental diseases/emergency reported in the included studies

Author, year of publication	Assessment parameters		Prevalence of dental disease/emergency	Study conclusions
	Clinical parameters	Other parameters		
da Silva <i>et al.</i> , 2022	PPD, VPI, and GBI	Questionnaire (Lipp's Stress Symptom Inventory for Adults)	There was higher PPD (0.98mm), VPI (8.0%) and GBI (13.5%) on the last day of the mission, when compared to the first (PPD = 0.92mm; VPI = 5.2% and GBI = 10.2%), with significant statistical difference. A higher VPI was observed in anterior teeth (11.7%) than in posterior teeth (1.1%) on the first day; and in posterior teeth, between the first (1.1%) and last day (5.5%). In the GBI, there was a difference for posterior teeth between the first (10.3%) and last day (14.9%) ( $p = 0.004$ ). There was no correlation between stress and gingival conditions.	The participants demonstrated a higher incidence of VPI and GBI at the end of the mission, especially in the posterior teeth. However, the stress was similar at the beginning and end of the mission.
Schlagenhauf <i>et al.</i> , 2020	BOP, GI, PCR, PAL, and PPD on Ramfjord teeth	NR	Baseline BOP was $37 \pm 20\%$ (placebo) and $41 \pm 22\%$ (test) while the baseline GI were $1.3 \pm 0.4$ (placebo) and $1.3 \pm 0.5$ (test). The baseline PCR were $88 \pm 11\%$ (placebo) and $83 \pm 11\%$ (test).	The consumption of probiotic <i>L. reuteri</i> -lozenges is an efficacious measure to improve and maintain periodontal health in situations with waning efficacy of personal oral hygiene.
Alwohaibi <i>et al.</i> , 2020	NR	Questionnaire (dental pain, head and orofacial pain)	The prevalence of dental injury was 52.3% while diving, of which 63.7% of them had injury in dental restorations, and 22.1% of them had injury in dental crowns. Sudden pain during or after diving was experienced by 67.1% in head or facial area, 69.2% in nose and paranasal sinuses, and 52.3% have experienced dental injury. The treatment of diver's teeth during their annual examination was carried out in 63.6% of divers, in which 75.7% for broken restoration or dental crown.	Dental and orofacial pain were experienced by more than half of the military divers at least once during their dive. Factors like increased frequency of diving, deep divers, and increased atmospheric pressure increases the extent of pain.
Veiga <i>et al.</i> , 2018	DMFT, Silness & Loe Index	Questionnaire (oral health habits, eating habits and habits in sea)	The DMFT index was 8.46. For the Silness and Loe index, it was observed a higher prevalence of scores 2 and 3. For the navigation periods, half of the military (50%) felt that their eating habits became worse, 9% of the military have had a dental emergency, 26.5% considered that the navigation affected their oral health, and 10.4% referred as the main reason of poorer oral health the lack of time due to changing of timetables.	The navy military have good oral health and good oral hygiene habits when compared with the military of other countries. The dietary and oral hygiene habits were worse during navigation periods.

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**Table 2** (continued)

Author, year of publication	Assessment parameters		Prevalence of dental disease/emergency	Study conclusions
	Clinical parameters	Other parameters		
Rohani <i>et al.</i> , 2016	DMFT index, rates of root canal filling, pulp involvement and periapical lesions, oral lesions, tooth wear, dental fluorosis, dental calculus, dental trauma, clicking in the TMJ	Questionnaire (problems during the mission, health behaviours, the rate of dental visits)	The DMFT index for the submarine and marine groups were 5.24 ± 4.16 and 8 ± 5.94, respectively. The incidence rate of dental problems per 100,000 days of the mission was 27 and 35.7 for the submarine and marine groups, respectively.	The oral and dental health status of the submarine crew was better than that of the marine group.
Wang <i>et al.</i> , 2016	DI-S, CI-S, SBI, CPI	NR	Compared with the baseline, the post-voyage DI-S score showed a median 22.5% increase in group I and a median 22.5% increase in group II while no marked change was observed in group III. The post-voyage CI-S score showed a median 36.67% increase in group I and a median 33.33% increase in group II, but no apparent change in group III. The post-voyage SBI scores showed a median 82.86% increase and a median 36.67% increase in group II. By contrast, group III exhibited a median 58.33% reduction in post-voyage SBI scores.	Long seafaring mission adversely impacts the periodontal health of sailors. Pre-voyage dental health education and the use of mouthwash during seafaring prevent a decline in periodontal health in seafarers.
Gunepin <i>et al.</i> , 2016	NR	Questionnaire (oral health, diving and career features, and barodontalgia while diving)	A total of 96 (7.3%) suffered from at least one episode of barodontalgia while diving, with a total of 119 episodes of barodontalgia. Barodontalgia was more frequent in the upper (62.2%) than the lower dentition (37.8%) (OR 5 2.7; 95% CI, 1.6–4.5) and appeared more common during descent (77.3%) than ascent (22.7%) (OR 5 11.6; 95% CI, 6.3–31.3). Barodontalgia experience was higher in divers who have an examination less than once per year (14.5%) in comparison to divers who usually have a dental examination once a year or more (6.3%) (OR 5 2.5; 95% CI, 1.5–4.2).	Barodontalgia mostly appeared in the maxilla and during descent; therefore, a great role for barosinusitis in the etiology of oral pain while diving may be suggested. The risk of barodontalgia might decrease with the maintenance of a good oral status.
Nor Azman <i>et al.</i> , 2015	NR	Questionnaire (oral health experience, oral health practice)	Seven percent of the respondents reported orofacial pain and discomfort; 9.3% reported bleeding gums and 12.8% experienced halitosis while underwater. Of those who experience oral problems, 82% reported disruption of their daily activities while underwater.	Brushing and rinsing are practiced regularly by submariners regardless of whether they are on land or underwater, but flossing is not a common practice. Dental emergencies, such as toothache, TMJ pain and discomfort do occur during submarine operations and disrupt their daily activities.

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**Table 2 (continued)**

Author, year of publication	Assessment parameters		Prevalence of dental disease/emergency	Study conclusions
	Clinical parameters	Other parameters		
Zhao <i>et al.</i> , 2015	OHI-S, GI, PI, BOP, PPD, CAL, CPI, tooth mobility, and number of missing teeth, prevalence of periodontal disease	NR	Before sailing, total prevalence of periodontal disease was 59.7%. After sailing, total prevalence increased to 83.3%. The percentage of gingivitis and mild periodontitis increased to 38.7%, 27.4% respectively, and the percentage of moderate and severe periodontitis increased to 10.8%, 6.5% respectively (P < 0.01). Significant differences were found in all indices between post-sailing and pre-sailing.	Significant differences were found in all indices between post-sailing and pre-sailing. Prolonged sailing environment, food constraint and poor oral hygiene could notably influence periodontal status of naval personnel.
von Wilimowsky <i>et al.</i> , 2014	NR	Reason for attendance to dentist on warship and treatment provided from a service logbook	Out of 136 treatments, 17.65% were for emergency treatment, which is equivalent to 3.69% of all servicemen of the task group. Combining the reasons for dental emergencies, 95.84% were caused by caries.	The dental emergency rate during a three-month naval deployment was 147.7 per 1,000 soldiers per year. Caries remains the main threat for the occurrence of dental Emergencies.
Simecek <i>et al.</i> , 2011	NR	Treatment provided to service members by Dental Officers using the Current Dental Terminology (CDT) codes of the American Dental Association	Out of 13,933 dental visits, 1,641 were encounters to treat an oral/facial problem. In all, 37 (2.2%) of the 1,641 encounters for oral/facial problems were considered severe, 266 (16.2%) moderately severe, and 1,338 (81.5%) were for pain/loss of function.	Although most military personnel with oral/facial problems experience mild to moderate pain or loss of dental function, approximately 20% are of sufficient severity to cause them to experience a limitation of their operational capability.
Deutsch, 2008	NR	Central Repository for Shipboard Non-Tactical ADP Program Automated Medical System (SAMS) Submarine data including ICD-9 codes	One hundred nine initial dental emergency visits and 45 revisits were recorded during these patrols. Endodontic emergencies accounted for 22.0% of initial visits for dental emergencies and 57.8% of all revisits. Caries accounted for 26.6% of initial visits and 11.1% of all revisits. Initial visits due to periodontal problems accounted for 9.2% and trauma accounted for 8.3%. The rate of dental emergencies for the first seven days of deployment was 7.5 per 100,000 person-days at sea. Dental problems accounted for 6.9%–9.3% of all medical evacuations from submarines between 1991 and 1999.	NR
Simecek, 2008	NR	Dental emergencies, dental classification system documenting conditions that are urgent (class 3) and are routine (class 2)	58.4% to 70.3% of conditions resulting in dental emergencies were nonpreventable. The estimated range of dental emergencies that can be expected if all urgent treatment indicated on the previous dental examination is completed is 77 to 92 dental emergencies per 1,000 personnel per year.	Results from this study suggest that an estimated 60% of all dental emergencies are not preventable, even if all urgent conditions classified according to current guidelines are completed.

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Table 2 (continued)

Author, year of publication	Assessment parameters		Prevalence of dental disease/emergency	Study conclusions
	Clinical parameters	Other parameters		
Diefenderfer <i>et al.</i> , 2007	Tobacco use status, and periodontal health status using the PSR	NR	Over 98% of navy recruits exhibited some level of periodontal disease at initial examination. From initial to final examination, periodontal status improved for 29.2% of subjects, deteriorated for 31.3%, and remained unchanged for 39.5%.	Although a needs-based dental care model appears effective in managing periodontal disease among those receiving active therapy, patients who receive sporadic care may deteriorate over time. To maintain periodontal health in this population, appropriate preventive and periodontal therapies should be provided soon after entry and repeated at intervals specific to individual patient need.
Deutsch & Simecek, 1996	NR	Dental treatment logs containing information of the dental visits	A total of 4,776 dental emergency visits by marines ashore were documented. Annual incidence of dental emergencies was estimated to be 149.3 per 1,000 personnel per year. The percentages of dental emergencies specified by type were: caries (38.9%), pericoroniti (17.8%), endodontic (15.4%), periodontal (10.7%), surgical post-operative (4.0%), trauma (2.0%) and other (11.2%).	It has been suggested that an incidence of approximately 70 dental emergencies per 1,000 per year can be expected to occur in a force whose personnel are in ideal dental health. If this rate is accurate, the Operation Desert Shield/storm incidence of 149.3 indicates that over 50% of the emergencies presenting were potentially preventable.

Notes: BOP: Bleeding on probing; CAL: Clinical attachment loss; CI-S: Calculus index-simplified; CPI: Community periodontal index; DI-S: Debris index-simplified; DMFT: Decayed, missing, filled teeth; TMJ: Temporomandibular joint; GBI: Gingival bleeding index; GI: Gingival index; OHI-S: Oral hygiene index-simplified; PAL: Probing attachment level; PCR: Plaque control record; PI: Plaque index; PPD: Periodontal probing depth; PSR: Periodontal screening and recording; SBI: Sulcus bleeding index; VPI: Visible plaque index; NR: Not reported.

### Prevalence of Dental Emergencies

Based on the reports of four studies, there is a high prevalence of dental emergencies experienced by the different naval armed forces. It was reported that 3.69% of all servicemen on a German warship had emergency dental treatment during deployment (von Wilmowsky *et al.*, 2014) and that 11.8% of all dental visits by Navy and Marine Corps personnel deployed to Iraq were for dental emergencies (Simecek *et al.*, 2011). Similarly, there were 109 dental emergency visits on 240 submarine patrols in the United States of America where dental problems accounted for 6.9% to 9.3% of all medical evacuations (Deutsch, 2008). It has been estimated that in the United States of America Marine Corps Personnel, 58.4% to 70.3% of conditions resulting in dental emergencies were nonpreventable (Simecek, 2008).

In terms of the rate of dental emergencies, Deutsch & Simecek (1996) reported a rate of 149.3 per 1,000 personnel per year while Simecek (2008) estimated a rate of 77 to 92 per 1,000 personnel per year if all urgent treatment indicated during previous dental treatment was completed. Deutsch (2008) reported a lower rate of 7.5 per 100,000 person-days at sea. The incidence rate of dental problems per 100,000 days of mission was 27 and 35.7 for the submarine and marine groups as reported by Rohani *et al.* (2016).

### Prevalence of Dental Caries

The DMFT among the Portuguese Navy Military were 8.46 (Veiga *et al.*, 2018) while the DMFT in an Iranian submarine and marine groups were  $5.24 \pm 4.16$  and  $8 \pm 5.94$ , respectively (Rohani *et al.*, 2016). As for caries prevalence, only the prevalence of emergencies due to caries were reported which ranges from 95.84% (von Wilmowsky *et al.*, 2014) to 38.9% (Deutsch & Simecek, 1996) and 26.6% (Deutsch, 2008).

### Prevalence of Periodontal Disease

The studies in the review mostly reported clinical parameters such as bleeding on probing without the diagnosis of periodontal disease. Only two reports of periodontal disease prevalence were available which varied from 59.7% (Zhao *et al.*, 2015) to a high prevalence of 98% (Diefenderfer *et al.*, 2007). Severe periodontitis was reported by Zhao *et al.* (2015) and had at least two sites with attachment loss  $\geq 6$  mm (not on same tooth) and at least one site with PD  $\geq 5$  mm. At least two sites with attachment loss  $\geq 4$  mm (not on same tooth) or at least two sites with PD  $\geq 5$  mm which indicate a moderate periodontitis. If neither of these criteria applies, mild or no periodontitis was recorded. Diefenderfer *et al.* (2007) on the other hand utilised the Periodontal Screening and Recording (Landry & Jean, 2002) to classify the periodontal disease.

### Prevalence of Barodontalgia

There were only two reports of barodontalgia among military divers. Alwohaibi *et al.* (2020) reported a prevalence of 52.8% while Gunepin *et al.* (2016) reported 7.3%. All authors utilised patient-reported signs and symptoms for the assessment of the barodontalgia prevalence. There were associations between pain during diving and the frequency of diving, diving depth, and atmospheric pressure (Alwohaibi *et al.*, 2020), while barodontalgia experience was higher in divers who have an examination less than once per year (Gunepin *et al.*, 2016).

### Oral Health Parameters Used in Clinical Assessment

Most retrospective or cross-sectional studies reporting the oral health in the naval armed forces worldwide had utilised questionnaires or descriptive data from medical notes on board the ships (Deutsch & Simecek, 1996; Deutsch, 2008; Simecek *et al.*, 2011; von Wilmowsky *et al.*, 2014; Nor Azman *et al.*, 2015; Alwohaibi *et al.*, 2020). Other

parameters that had been utilised includes the DMFT index (Veiga *et al.*, 2018), Silness & Loe Index (Veiga *et al.*, 2018), OHI-S (Singh, 2009) and dental emergencies classification system (Simecek, 2008). Periodontal health was clinically assessed in four studies, out of which two had utilised the CPI (Zhao *et al.*, 2015; Wang *et al.*, 2016), while another two used the PSR (Diefenderfer *et al.*, 2007; Schlagenhauf *et al.*, 2020) and one used PPD (da Silva *et al.*, 2022).

As for longitudinal and randomised controlled trials, relatively more comprehensive clinical parameters were utilised (Diefenderfer *et al.*, 2007; Zhao *et al.*, 2015; Wang *et al.*, 2016; Schlagenhauf *et al.*, 2020; da Silva *et al.*, 2022). These includes various bleeding on probing and gingival indexes, plaque index, probing attachment levels and screening tools such as the CPI and PSR.

## DISCUSSION

Dental morbidity in the naval armed forces represents a significant challenge to the military populations worldwide. The reporting of data from this population is however scarce, and the studies utilised different study designs and various clinical parameters. There are also differing levels of access to dental services across the different naval armed forces worldwide. Most studies in this field are retrospective (Deutsch & Simecek, 1996; Deutsch, 2008; Simecek, 2008; Simecek *et al.*, 2011; von Wilmowsky *et al.*, 2014), utilising existing dental records. This may limit the amount of information available for analysis, as well as introducing biases to the study.

In the studies, the participants were reported to be subjected to unique conditions that may impact their oral health such as restricted access to fresh water for oral hygiene purposes, limited habitation space, staggered resting time, hot environment and increased atmospheric pressure (Zhao

*et al.*, 2015; Alwohaibi *et al.*, 2020). During emergency operations, other factors such as psychological importance and operational tempo (Deutsch & Simecek, 1996) may also influence their oral health. The studies to date however do not directly investigate the impact of these unique conditions with the design of the studies being mostly limited to cross-sectional and retrospective in nature. Hence, the cause and effect of these factors on oral health during naval operations is still undetermined.

Two randomised controlled trials reported interventions in the form of the consumption of probiotics (Schlagenhauf *et al.*, 2020) and dental health education plus a novel mouthwash (Wang *et al.*, 2016) among the navy personnel on operations at sea. Both reported significant improvement in the oral health of these navy personnel in the test group compared to the control group. This suggests that adjunctive oral health measures may be necessary in situations with declining efficacy of personal oral hygiene and other factors impacting oral health. Additional long-term studies on different populations are suggested to further investigate the efficacy of these and other adjuncts in the naval armed forces.

The occurrence of barodontalgia where pain or injury from the dentition is caused by the alteration in barometric pressure is of specific interest among naval submarine crews and divers undergoing underwater training (Robichaud & McNally, 2005). Oral health of divers and submariners during operations was reported by five studies (Deutsch, 2008; Nor Azman *et al.*, 2015; Gunepin *et al.*, 2016; Rohani *et al.*, 2016; Alwohaibi *et al.*, 2020). However, only two had reported the occurrence of barodontalgia. Alwohaibi *et al.* (2020) reported that 52.8% of Saudi military divers had experienced pain originating from the dentition during submarine operations. Increased frequency of diving, deep divers, and increased atmospheric pressure were reported to increase the extent of pain. A much lower proportion of 7.3% was reported among the French Armed Forces

military personnel by Gunepin *et al.* (2016). Barodontalgia was higher during descent compared to ascent and higher in divers who have a dental examination less than once per year. The differences in the proportion of divers reporting this phenomenon can be due to the oral health status that is different in both groups. Generally, there are very limited studies on barometric effects on the oral tissues in the naval armed forces.

The limitations of this scoping review include the varying definitions and parameters used to define dental diseases by the different studies that restrict the ability to compare between the reports. Additionally, five of the included studies were cross-sectional studies (Nor Azman *et al.*, 2015; Gunepin *et al.*, 2016; Rohani *et al.*, 2016; Veiga *et al.*, 2018; Alwohaibi *et al.*, 2020) and another five were retrospective in nature (Deutsch & Simecek, 1996; Deutsch, 2008; Simecek, 2008; Simecek *et al.*, 2011; von Wilmowsky *et al.*, 2014). The design of these studies does not allow for a cause-and-effect evaluation as they only described the study population at a given time point. Hence, the oral diseases reported may already been present before the naval operations. Furthermore, the limited information on calibration, standardisation and clear definitions of the clinical parameters investigated did not allow for comparison between the naval armed forces from different populations or countries.

## CONCLUSION

Based on the limited studies available in the literature, data on dental diseases among the naval armed forces are still scarcely reported. Occurrence of caries, periodontal disease and barodontalgia is high among the naval armed forces, with a significant number of dental emergencies during deployment and training operations. Unique conditions experienced by this population seem to impact their oral health. Given the far-reaching effects of dental diseases among personnel in the naval armed forces, further prospective studies investigating oral health and dental diseases

are recommended. Oral health services in the naval armed forces can also be improved by increasing the dentist-to-navy personnel ratio both at the military bases and on board the vessels during missions, as well as designing preventive strategies to improve oral health among the naval personnel.

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