The Incidence of Dental Needs During Isolated Missions Compared to Non-isolated Missions: A Systematic Review and Implications for Future Prevention Strategies

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ABSTRACT Introduction: Dental emergencies in isolated groups have always been difficult to treat. Especially in people or groups who cannot be evacuated and who need urgent dental assistance: long-term submarine missions, long-term spaceship trips, military or non-governmental organizations deployments in conflict areas, military maneuvers, etc. The dental and evacuation problems could put the success of the mission at risk, with relevant associated economic and strategic costs. Our study summarizes current evidence about dental problems in isolated personnel (submarines and Antarctic missions) compared to other non-isolation conditions (military deployment in conflict area, military maneuvers) with the objective to assess the need for specific dental equipment in special long-term isolation conditions. Materials and Methods: We searched Medline, Cochrane Library, and Dentalgate between 1960 and 2017 for studies reporting dental disease in long-term isolation conditions (minimum 1 month) versus non-isolation conditions. We conducted the systematic review with all studies fitting the inclusion criteria. The comparison of the incidence rate was performed fitting a Poisson regression model to see the effect of the individual's condition on the incidence of dental event. Results: Thirty-eight studies were included in the systematic review. Antarctic missions showed a higher dental incidence rate compared to non-isolation conditions, but submarine missions showed the lowest dental incidence rate. In the sub-analysis of acute dental events, those with great impact on unit effectiveness, the incidence rates were higher. Caries and secondary decay events were the most prevalent dental problem in all conditions, followed by periodontal pathology and fractures of teeth or tooth problems not due to tooth decay in isolation conditions, and then by molar problems and endodontic problems in non-isolation conditions. The most common acute dental events were third molar problems and endodontic problems in all conditions. Conclusion: This systematic review shows that the incidence of dental pathology in long-term isolation conditions may seem relatively infrequent but it exists and is relevant. Dental events are unpredictable, unrelated to trauma, and caused mainly by poor dental status. Preventive measures considerably reduce dental prevalence.

INTRODUCTION

Dental problems in isolated and confinement groups have become a concern not only for the possible patients, but also to the dentists who must deal with the prevention as well as the treatment. Groups that are subject to isolation or with no chance to freely access or evacuate a location are particularly sensitive. With the expansion of the manned space program, research in Antarctica, and submarine missions, dental planning for populations serving in isolated or confined environments is essential.[1]

Military and space health services in dentistry have as their primary endpoint to achieve a stable oral health status, so that personnel will be prepared to carry out assigned duties without loss of time or effectiveness attributable to an oral cause. In other words, the attainment of the objective or mission cannot be delayed or impaired by a predictable oral health problem.[2,3] The direct economic cost due to dental emergencies of U.S. troops deployed in Iraq and Afghanistan during Operation Iraqi Freedom was estimated at $14 million to return the soldiers to service. This was twice the cost of the treatment required for these dental events.[4]

Thus, if risk factors for an emergency can be determined, it should be possible to address those factors and decrease the risk of emergencies.[1] In this sense, the preventive medicine has been widely used in different situations, servicemen on submarine missions are known to have lower levels of vitamin C in their blood due to the unique environmental conditions aboard submarines; this is true even for patients receiving dietary supplements of vitamin C.[5] In the case of space travel, unique environmental conditions result in the depletion of nutrients from the body, the main problem being calcium homeostasis.[6,7] Regarding dental medicine, the preventive measures taken are an exhaustive and effective dental screenings in submarines previous to the missions[8] and in the case of deployment, several countries have a dental classification system, previous the mission, for send personnel with adequate dental conditions.[9]

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doi: 10.1093/milmed/usy364

Few studies, with a wide range of dental emergency rates, have addressed dental problems that occur in isolated conditions.[1,10–13] The variability in rates observed in these studies is due to differences in study design, observation periods, dental class status, and access to clinical services due to environmental and operational challenges.[14]

Although this systematic review is focused on military studies because the patients are in special conditions – including isolation and non-isolation (e.g., military deployment in conflict areas and military maneuvers) – it also has significance for prevention and treatment of dental emergencies in long-term missions (e.g., space missions). Our study summarizes current evidence of dental problems (non-acute and acute) in isolated personnel, with the objective to assess the need for specific dental equipment in special conditions, mainly in long-term isolation missions.

METHODS

Search Strategy

We searched the Medline, Cochrane, and Dentalgate databases for studies of dental disease, dental events, and dental emergencies in special long-term isolation (e.g., submarines and Antarctic missions) and other non-isolation conditions (e.g., military deployment in conflict areas and military maneuvers) published between 1960 and 2017. Search terms used were: *dental disease* OR *dental events* OR *dental emergencies* AND *isolated conditions*, *long-term period*, *space*, *submarine*, *Antarctic missions*, *military personnel*, *deployment*, *maneuver*, or *conflict* AND *dental incidence*. We also searched in the reference lists of published studies.

Selection of Studies

There are few studies about dental health in isolation conditions. Because of that, comparative studies, studies including similar populations (submarine and Antarctic personnel; with limited or no access to dental assistance) in periods of isolation, or in relative or no isolation but in special missions (military deployment in conflict areas and military maneuvers) were used. The selected studies must have had a study duration ≥1 month, been published between 1960 until 2107, been written in English or Spanish, and have the highest number of citations in journals in the first three quartiles.

Data Extraction and Quality Assessment

Data were abstracted and quality was assessed using guidelines published by the Cochrane Collaboration[15] (Table I, Supplementary Table S1). Any disagreement was resolved by discussion between the authors in consultation with a statistician. Characteristics of studies included in the systematic review are shown in Table I. Supplementary Table S1 shows excluded studies and exclusion criteria.

Dental Event Definition and Type of Event

Due to the high variability in the definition of a "dental event" in published articles, we defined "dental event" as any of the following terms: dental emergency, evacuation due to dental disease, initial emergency visit to dentist, emergency visit to dentist, traumatic injury, dental trauma, oral facial injury, and dental problem.

Additionally, a sub-analysis of acute events was made, only was selected dental events from sources in which a great impact on unit effectiveness is claimed. The selected terms and its explanation from the articles (Table I) were: dental emergency, infectious disease (health problems requiring medical care disease or a trauma [physical or psychological]), dental disease and non-battle injury (defined as any oral or craniofacial issue perceived by the soldier to be a problem that caused them to seek the help or advice of a dental officer), emergency visit, dental disease (with operational incapacity), dental condition (their effects can have a great impact on unit effectiveness, fighting strength and morale or military personnel), orofacial injuries, dental trauma (commando fighters are highly predisposed to dental trauma, resulting in the interference of their continuous daily activity). Terms excluded as non-acute events were: traumatic injury (no statistical correlation between personal weapon impact and dental injury), dental trauma (dental traumas comprise 2–8% of all military dental emergency cases), dental problem with no details, and dental event (potentially mission-impacting medical events reported among crew members that were rare).

Different dental events were classified and grouped in their respective preference term. The groups were: caries and secondary decay events, endodontic problems (which are always secondary to caries), fractures of teeth or tooth problems not due to tooth decay, fractures and problems with prosthesis, third molar problems, periodontal pathology, oral pathology, mandibular problems, joint and occlusal problems, postoperative problems, and others.

Variables

The dental incidence is defined as the number of new dental events accounted for that appear in a given period of time. In our study, the main variable was the dental event incidence rate, presented as events per person-years and calculated as number of events/number of units at risk (the number of units at risk being the number of person-year). The calculation of the units at risk was based on the number of individuals that remains constant during the observation period, and is calculated as the number of individuals multiplied by the observation period in years.

The classification variable to be compared refers to "personnel condition" such as in deployment in conflict area, in maneuvers or field exercises, submarines or Antarctic stations. In the case of deployment in a conflict area, a comparison was also performed for periods before and after 2006 in

TABLE I. Characteristics of Studies Included in the Systematic Review

Study	Population	Condition	Time	Number of Events	Time (Person-Year)
Tansey WA. 1979[32] (*)	U.S. Navy submarines Polaris	Submarine	>1 month	50	20,958.9
Thomas TL. 2000[34] (*)	U.S. Navy submarines	Submarine	>1 month	41	3,561.6
Thomas TL. 2003[33] (*)	U.S. Navy submarines	Submarine	>1 month	83	50,028
Deutsch W. 2008[1]	U.S. Navy submarines	Submarine	3 months	109	5,946.89
Nielsen AG. 1963[24]	U.S. Navy submarines	Submarine	>1 months	641	9,230
O´Shea MK. 2009[25]	U.K. submarines Vanguard Class	Submarine	2 months	121.98	928.6
Rohani B. 2016[28]	Iran submarines	Submarine	>1 month	0.00327	12
Fletcher LD. 1983[19] (*)	Australian Base Davis	Antarctica	>1 month	10	21
	Australian Base Mawson	Antarctica	>1 month	22	42.75
	Australian Base Macquarie	Antarctica	>1 month	41	69.75
SimeceK JW. 2014[31]	US Army Personnel in Afganistan/Kuwait	Deployment		1,020.6	9,018
	US Army Personnel in Irak	Deployment		3,354	20,066
von Wilmowsky C. 2014[35]	German warships	Deployment	3 months	24	162.5
Dunn WJ. 2004[18]	U.S. Soldiers in Saudi Arabia	Deployment	6 months	759	4,974
Dunn WJ. 2004b[17]	U.S. Soldiers in Oman	Deployment	6 months	135	986
Aoun O. 2014[14]	French soldiers in Afghanistan	Deployment	3–6 months	0	432
	French soldiers in Lebanon	Deployment	3–6 months	8	476
	French soldiers in Côte d'Ivoire	Deployment	3–6 months	8	450
Sauvet F. 2009[29]	French soldiers in Ivory Coast	Deployment	4 months	30	200.1
Teweles R. 1987[40]	U.S. Soldiers in Sinai Penninsula	Deployment	5 months	39	244.29
Mombiedro R. 2007[2]	Spanish soldiers in Bosnia-Herzegovina	Deployment	2 months	56	185,4
Gunepin M. 2015[20]	French soldier in Mali	Deployment	3 months	54	955
Ludwick W. 1974[23]	Vietnam War 1970	Deployment		2,398	15,057.4
	Vietnam War 1996	Deployment		3,370	16,041.5
Deutch WM. 1996[8]	US soldier in Kuwait	Deployment		4,776	31,835
Zadik Y. 2008[36]	Israeli elite commando units	Maneuver	38 months	76	889
Payne FT. 1981[26]	US Soldiers	Maneuver		360	2,500
Parker (Roberts JE)[27]	US Soldiers 1981	Maneuver		92	2,482.6
Immonen M. 2014[21] (*)	Finnish Defense Forces	Maneuver	12 months	185	28,256
Colthirst P. 2012[16]	U. S. Brigade Combat Team	Maneuver	3 months	255	1,142.6
Fairchild (Roberts JE)[27]	US Soldiers 1996	Maneuver		35	455.59
	US Soldiers 1997	Maneuver		57	697.9
	US Soldiers 1998	Maneuver		50	762.6
Becker T. 2009[15] (*)	Israeli soldiers in basic combat training	Maneuver	8 months	118	7,405.51
Sumnicht (Roberts JE)[27]	US Soldiers 1964	Maneuver		1453	9,257
King JE. 1984[22]	US Soldiers	Maneuver		355	1,367.17
Grover PS. 1983[9]	U.S. Army recruits in basic field training	Maneuver	6 months	1294	2,500
SimeceK JW. 2008[30]	U.S. Marine Corps personnel	Maneuver	4 years	262	1,999.7

Note: (*): Studies excluded in the sub-analysis of acute dental events.

order to assess the differences between studies of conflict with greater deployment of soldiers before and after the establishment of dental care measures. Moreover, a sub-analysis of acute events was made.

Statistical Analysis

All variables were analyzed descriptively by condition. Incidence rates were described by means of summary statistics and confidence intervals. The comparison of the incidence rate has been performed fitting a Poisson regression model to see the effect of the individual's condition on the incidence of dental event. As over-dispersion appeared, the final model was based on a negative binomial distribution of events, estimating the number of events and the ratios of incidence rates. For the calculation of the incidence rate in a group (condition), the sum of the events in each group was divided by the total number of individuals-year multiplied by the mean of years in that group. Proportions of types of events in each group were described by means summary statistics. STATA IC 15 ([StataCorp2015] Stata Survey Data Reference Manual – Release 15. College Station, TX, USA: Stata Press) was used for managing and analyzing all data.

RESULTS

Literature Search of Included Studies

We identified 13,783 studies according to the search criteria. Of these, 12,853 were not in compliance with the complete search criteria and were excluded based on the title and abstract, leaving 47 studies to be assessed for eligibility due to scientific proximity to the research itself. Thirty-eight studies were included in the systematic review (Table I, Fig. 1). Nine publications were excluded because the population was

different from the one included in the review's criteria and/or lack of data (Supplementary Table S1).

Events

A total of 3,412 dental events were recorded, 1,506 (44.1%) in *maneuvers*, 1,023 (29.9%) in *deployment*, 813 (23.8%) in *submarines*, and 70 (2.2%) in *Antarctic missions*.

Caries and secondary decay events ranged from 441 (43.1%) to 693 (46%) in non-isolation conditions while were present in 7 (10%) to 334 (41.1%) of long-term isolation conditions. Periodontal pathology was more prevalent with 176 events (21.6%) in *submarines*, while fractures of teeth or tooth problems not due to tooth decay appeared more frequently in *Antarctic missions* with 36 events (51.4%). Third molar problems: 183 events (17.9%) and 187 events (12.4%) and endodontic problems 119 events (11.6%) and 159 events (10.6%) in *deployment* and *maneuvers* were the second-rated dental problems in non-isolation conditions (Table II).

In the sub-analysis of acute events, those with great impact on unit effectiveness, a total of 1,474 acute dental events were recorded, 671 (45.5%) in *maneuvers*, 450 (30.5%) in *deployment*, 300 (20.4%) in *submarines*, and 53 (3.6%) in *Antarctic missions*.

Third molar problems 119 (26.5%), 183 (40.7%), and 116 (38.7%) were the event more prevalent in all situations except in *Antarctic missions* 0 (0%). Endodontic events were the second more prevalent with 187 (27.9%), 159 (23.7%) and 57 (19.0%) events in all situations except in *Antarctic missions* 0 (0 %). Fractures of teeth or tooth problems not due to tooth decay appeared more frequently in *Antarctic missions* with 36 (67.9%) events followed *deployment* 109 (24.2%) events, however this event appeared only in 33 (4.9%) in *maneuvers* and 20 (6.7%) in *submarines* (Table III).

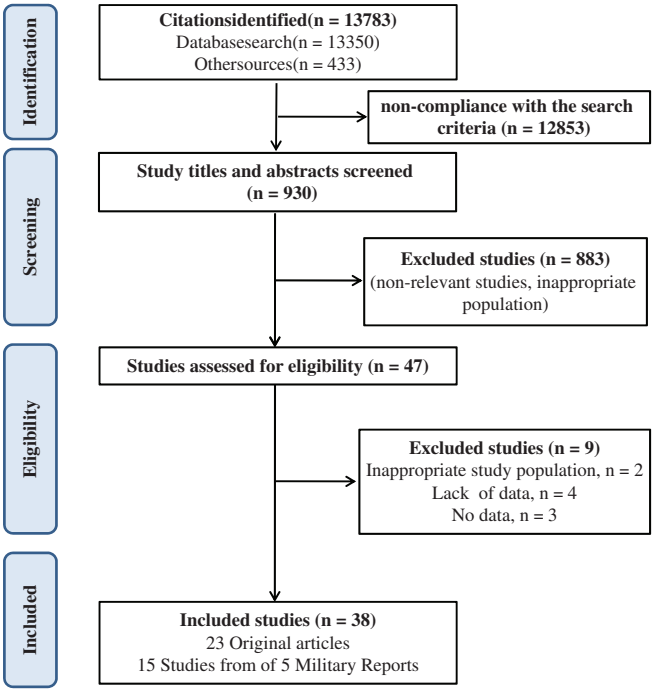

FIGURE 1. Study flow diagram following the preferred reporting items for systematic reviews. Of the 13,783 citations identified according to the search dental problems, we included finally 38 studies.

Dental Incidence

The dental incidence rate was obtained from the 38 studies from data on number of events and exposure time (Table I). There were differences in the dental incidence rate across the different conditions, which was higher in *Antarctic missions* (467/1000 person-year; 95% confidence interval [CI]: 359.7, 574.2), followed military *deployment* in conflict areas. In U.S. studies after 2006, dental incidence rate was less than half the rate before 2006 (Table IV). The lowest dental incidence rate was found in *submarine* missions (2.39/1,000 person-year; CI: 2.24, 2.53). In long-term isolation condition (*Submarines* + *Antarctic*) the dental incidence rate was 4.12/1,000 person-year, which was very lower compared with the other non-isolation conditions (Table IV).

In the sub-analysis of acute dental events, those with great impact on unit effectiveness, military *deployment* in

TABLE II. Dental Events

Type of Event	Deployment		Maneuvers		Submarines		Antarctica	
	N	%	*N*	%	*N*	%	*N*	%
Caries and secondary decay events	441	43.1	693	46.0	334	41.1	7	10.0
Endodontic problems	119	11.6	159	10.6	57	7.0	0	0.0
Fractures of teeth or tooth problems not from tooth decay	109	10.7	33	2.2	20	2.5	36	51.4
Fractures and problems with prosthesis	30	2.9	12	0.78	3	0.4	3	4.3
Third molar problems	183	17.9	187	12.4	116	14.3	0	0.0
Periodontal pathology	65	6.4	130	8.6	176	21.6	7	10.0
Oral pathology	9	0.9	109	7.2	2	0.2	0	0.0
Mandibular problems	0	0.0	14	0.9	10	1.2	0	0.0
Joint and occlusal problems	37	3.6	0	0	0	0.0	0	0.0
Postoperative problems	2	0.2	152	10.0	55	6.8	0	0.0
Others	28	2.7	17	1.1	40	4.9	17	24.3
Total	1,023	100.0	1,506	100.0	813	100.0	70	100

TABLE III. Acute Dental Events

Type of Event	Deployment		Maneuvers		Submarines		Antarctica	
	N	%	*N*	%	*N*	%	*N*	%
Endodontic problems	119	26.5	159	23.7	57	19.0	0	0.0
Fractures of teeth or tooth problems not from tooth decay	109	24.2	33	4.9	20	6.7	36	67.9
Third molar problems	183	40.7	187	27.9	116	38.7	0	0.0
Oral pathology	9	2.0	109	16.2	2	0.7	0	0.0
Mandibular problems	0	0.0	14	2.1	10	3.3	0	0.0
Postoperative problems	2	0.44	152	22.7	55	18.3	0	0.0
Others	28	6.2	17	2.5	40	13.3	17	32.1
Total	450	100.0	671	100.0	300	100.0	53	100

TABLE IV. Dental Incidence Rate by Condition

Condition	Events	Person-Year	Years (mean)	Incidence Rate by 1,000 Person-Year[a]	95% Confidence Intervals
Maneuver	4,592	59,715.7	0.707	108	104.8–111.1
Deployment	16,031.6	101,083.2	0.475	333.9	328.7–339.0
Before 2006	10,853	63,178.2	0.46	364.1	357.1–371.0
After 2006	4,374.6	29,084.0	1.2	125	121.2–128.7
Submarines	1,045.9	90,665.9	4.809	2.39	2.24–2.53
Antarctica	73	133.5	1.17	467	359.7–574.2
Submarines + Antarctica	1,118.9	90,799.4	2.99	4.12	3.87–4.36

[a]Based on mean of years.

conflict areas not showed changes. However, the acute dental incidence rate found submarine missions was 12.0/1,000 person-year (CI: 11.20, 12.80), that was five times higher regarding all submarine dental events. In *maneuvers*, the acute dental incidence rate was 260.7/1,000 person-year (CI: 252.80, 268.50), that was 2.4 times higher regarding all maneuvers dental events (Supplementary Table S2).

Estimated incidence rates calculated from the negative binomial model are presented in Table V and Supplementary Table S3. Submarine condition was used as reference group. The estimated mean of events for Antarctic station was not significant (3,492 events; 95% CI: −395–7,378). In the other conditions, the means was significant. In deployment in conflict areas, the predicted mean number of events was 855, showing a predicted incidence rate of 3.5 times the incidence rate found in submarines. In maneuver conditions, the predicted mean number of events was 918, showing an incidence rate of 3.76 times the incidence rate in submarines. With respect to Antarctic stations, the rate of incidence was 14.3 times that of submarines. When comparing deployment in conflict areas before and after 2006, the means look similar (after, 2,159 and before, 2,631). The estimated incidence rate ratio after 2006 was 0.82 (95% CI: 0.62–1.08) (Table V).

In the sub-analysis of acute dental events, Submarine condition was used as reference group. In deployment in conflict areas, the predicted mean number of acute events was 607, showing a predicted incidence rate of 1.97 times the incidence rate found in submarines. In maneuver conditions, the predicted mean number of acute events was 763, showing an incidence rate of 2.47 times the incidence rate in submarines (Supplementary Table S3).

TABLE V. Estimated Dental Incidence Rate by Condition

Condition	Estimated Mean (95% CI)	Estimated IRR (95% CI)
Deployment in conflict area	855 (437–1,272)	3.5 (1.44–8.5)
Maneuvers	918 (439–1,397)	3.76 (1.51–9.3)
Antarctic station	3,492 (−395–7,378)	14.3 (3.7–54.5)
Submarine	244 (63–426)	
Deployment in conflict area after 2006	2,159 (1677–2,641)	0.82 (0.62–1.08)
Deployment in conflict area before 2006	2,631 (2191–3,071)	

DISCUSSION

This study shows that the dental incidence in long-term isolation conditions is relevant. The dental incidence rate in Antarctic missions is the highest; however, the rate is lowered when considering all long-term isolation conditions (*Antarctic missions + submarines*). The dental incidence rate is high in the other conditions analyzed in this study; moreover, the sub-analysis of acute dental incidence rates shows higher incidence rates. Dental events were mainly related to caries and secondary decay events across all conditions, followed by periodontal pathology and fractures of teeth or tooth problems not originated in tooth decay in long-term isolation conditions, and problems related to third molar and endodontic in non-isolation conditions. Acute dental events,

those with great impact on unit effectiveness, were mainly related to third molar problems and endodontic problems in the three conditions analyzed.

Despite the fact that the information is scarce and dental problems are poorly assessed as medical emergencies, the obtained information is valuable and relevant. The main problem encountered was the different terms used to describe dental incidents and dental problems in the literature. Our systemic review builds on the results of 38 published evidence studies evaluating dental problems and their incidence.[1,2,8–11,16–36] Moreover, the information was homogenized and classified to facilitate data interpretation.

The dental incidence rate in long-term isolation conditions may seem relatively modest, but it is relevant. Moreover, it is possible that the rate is higher in part because some personnel may have experienced mild injuries that went unreported, and in part because of the relatively short time period of the missions (maximum three months). The low incidence rate found in submarines was due to the intense and effective dental screenings carried out.[8] Several military services across different countries have introduced a dental classification system to reduce the number of dental emergencies and to avoid deployment of personnel with non-adequate dental conditions.[9] Hence, the primary objective of this classification is to achieve the performance of the mission.[22] Despite this, the dental incidence is 4.12/1,000 person-year in isolation conditions, and 108–333.9/1,000 person-year in similar populations in complicated or stressed conditions. These differences could be explained in part by the above-mentioned dental screenings for submarine crew members compared to other military populations,[1] or by pre-existing dental pathologies in the case of deployment or maneuvers,[22] or by length of the mission[22] or by different diets.[22]

The lower dental incidence (less than half) found in deployment in conflict areas after 2006 can be explained because, in 2006, the U.S. House Armed Services Committee added permanent health and dental benefits to soldiers and the National Guard. These benefits were added when a large number of reservists during the Persian Gulf War mobilizations of 1990–1991 could not be deployed due to poor dental status.[37] The reduction in dental incidence after 2006 shows that preventive measures notably reduce dental events in these conditions, thus increasing the number of deployable soldiers.

It is interesting to note that the higher dental incidence found in Antarctic missions, and several arguments could explain this data. Antarctic missions are staffed mainly by scientific personnel, who are older and have a higher level of education, which aligns with the data reported by Thomas et al about the dental incidence in submarine officers being half of the enlisted personnel.[34] Although level of education is important in health status, dental screenings prior to the mission likely have greater weight; dental exams are therefore likely to be less intense and effective for military personnel.[1] Another factor that affects the dental health of individuals in the Antarctic is repeated cold exposure, which has been described as a serious contributive factor, affecting fracture damage, new carious lesions, and dentinal erosion.[21] The main dental event found in our analysis of Antarctic missions was tooth fractures.

When analyzed the acute dental incidence, there are an increase (12/1,000 person-year in submarines, and 260.7–333.9/1,000 person-year in similar populations in complicated or stressed conditions). This acute incidence represents the dental incidence in the operational theater, which means on the one hand, a strategic costs in form of effectiveness of the mission decrease and reduction in the morale of the deployed personnel, due to the average time lost of the affected personnel is 3 days per unit and entails other non-quantifiable costs as overload the duties of the other unit members, replace the affected personnel, etc.[4,38] And regarding the economic costs as the evacuation or transportation to a dental facility, treatment costs, specialized dental personnel costs, etc.[38] This economic costs are variable and depend mainly of the incidence of acute dental events and level of activity of the dental services.[39] In this sense, Colthirst showed that these variable costs were twice the fixed costs.[4]

Dental problems are sometimes unpredictable and can require an evacuation to a dental treatment facility, assuming the loss of the soldier to their mission joint to the personnel to translate him/her.[32] In this sense, Deutsch et al found that non-injury-related dental problems accounted for 6.9–9.3% of all medical evacuations from submarines between 1991 and 1999,[1] and Gunepin et al found that 15.7% of the medical evacuations recorded in soldiers deployed in Mali were to treat non-battle dental emergencies.[22] Although the conditions are different, the evacuation percentages are similar, showing that dental evacuations are independent of the mission condition. These data demonstrate the need for dental equipment and trained dental personnel to address dental conditions.[9,22]

The data obtained show that the most common dental problems that occur both in long-term isolation (except in Antarctic missions) and non-isolation conditions are caries and secondary decay events. Periodontal pathology and fractures of teeth or tooth problems not from tooth decay in isolation conditions, and third molar problems and endodontic problems in non-isolation conditions, were the next most-frequent events. In the case of acute dental problems, the most common were mainly related to third molar problems and endodontic problems. All these events occurred despite previous dental screenings being carried out. In this sense, York et al found that more than 50% of recruits began their military service with the worst dental classification and, after 4 years, only 57.4% of them achieved the best dental classification.[40] On the other hand, Mahoney reported that a well-prepared dentally force experiment 150–200 dental emergencies per year and in contrast this incidence is the triple in soldiers with less dental health status.[41] Moreover, other studies showed that the monotony of diet, lack of variety of fresh foods,[22] and poor dental hygiene[21] make it difficult to maintain good dental status. On the other hand, tooth fractures observed in isolation conditions, mainly in Antarctic missions, were minor and occurred during

mastication in teeth that had been previously treated (i.e., affected by an underlying dental problem).[21]

Finally, the dental events studied were largely unrelated to traumatic causes across all conditions. Our results align with a non-included manuscript that reported that 11% of unscheduled absences on British warships are due to trauma.[42] Hence, these data corroborate the idea that unpredictable dental problems should be considered in future long-term isolation conditions, like spaceflights or Mars missions.

Plausible solutions to the observed dental events exist. For example, caries and endodontic problems can only be solved by placing on-site dental services with qualified personnel (dentist or trained crew). Third molar problems (second most common problem in deployment and maneuvers and third in submarines, but the first acute event in all situations) could be solved by extraction during the previous dental screening, thus eliminating the inherent risk. On the other hand, the fact that periodontal problems are the second most common dental problem in long-term isolation conditions suggests that this prolonged period affects dental hygiene and is probably aggravated by diet. That situation would be easily solved by training the on-board medical officer in dental hygiene with a Cavitron, and requiring the crew to receive routine professional hygiene. The use of discharge splints in a routine way would diminish the bruxism secondary to the stress in different conditions, thereby diminishing the incidence of dental fractures not secondary to caries as well as the incidence of joint and occlusal problems. We believe that with these measures could diminish 29.9% of dental events observed in deployment in conflict conditions, 44.1% in maneuvers, and 23.8% in submarines.

CONCLUSIONS

This systematic review shows that dental incidence in long-term isolation conditions may seem relatively low compared with non-isolation conditions (deployment and maneuvers) but is a fact and is relevant. The use of preventive measures and previous screenings considerably reduce dental incidence rates. The dental events are mainly related to caries and secondary decay events in all conditions, followed by periodontal pathology and problems related to the third molar. These events are unpredictable and caused mainly by previous poor dental status, lack of fresh and varied food, and poor dental hygiene, and are unrelated to traumatic causes. These results reflect the need to implement specific dental personnel and equipment in special conditions, mainly in future long-term space missions.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Military Medicine* online.

REFERENCES

1. Deutsch WM: Dental events during periods of isolation in the U.S. submarine force. Mil Med 2008; 173(1 Suppl): 29–37.
2. Mombiedro Sandoval R, Llena Puy C: Emergencias orales en los militares españoles desplegados en Bosnia Herzegovina. Incidencias durante 9 semanas (2000–2001). Revista del colegio odontólogos y estomatólogos de España 2007; 12(4): 237–44.
3. Wojcik BE, Szeszel-Fedorowicz W, Humphrey RJ, et al: Risk of dental disease non-battle injuries and severity of dental disease in deployed U. S. Army personnel. Mil Med 2015; 180(5): 570–7.
4. Colthirst PM, Berg RG, Denicolo P, Simecek JW: Operational cost analysis of dental emergencies for deployed US Army personnel during operation Iraqi freedom. Mil Med 2013; 178(4): 427–31.
5. Gilman S, Biersner RJ, Thornton RD: Vitamin C status of submariners. Edited by Bethesda MD. Bethesda, MD, Naval Submarine Medical Research Laboratory, 1981.
6. Holick MF: Perspective on the impact of weightlessness on calcium and bone metabolism. Bone 1998; 22: 105–111s.
7. Caillot-Augusseau A, Lafage-Proust MH, Soler C, Pernod J, Dubois F, Alexandre C: Bone formation and resorption biological markers in cosmonauts during and after a 180-day space flight (Euromir 95). Clin Chem 1998; 44(3): 578–85.
8. Payne TF, Posey WR: Analysis of dental casualties in prolonged field training exercises. Mil Med 1981; 146(4): 269–71. 265.
9. von Wilmowsky C, Kiesewetter MR, Moest T: Dental treatment on a German warship during a three-month deployment. J R Army Med Corps 2014; 160(1): 42–5.
10. Deutsch WM, Simecek JW: Dental emergencies among Marines ashore in Operations Desert Shield/Storm. Mil Med 1996; 161(10): 620–3.
11. Grover PS, Carpenter WM, Allen GW: Dental emergencies occurring among United States Army recruits. Mil Med 1983; 148(1): 56–7.
12. Groves RR: Dental fitness classification in the Canadian forces. Mil Med 2008; 173(1 Suppl): 18–22.
13. Richardson PS: Dental morbidity in United Kingdom Armed Forces, Iraq 2003. Mil Med 2005; 170(6): 536–41.
14. Brauner MK, Jackson T, Gayton E: Medical Readiness of the Reserve Component. Rand Health Q 2012; 2(2): 7.
15. Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration, 2011. Available at http://www.cochrane-handbook.org/.
16. Aoun O, Roqueplo C, Rapp C: Spectrum and impact of health problems during deployment: a prospective, multicenter study of French soldiers operating in Afghanistan, Lebanon and Cote d'Ivoire. Travel Med Infect Dis 2014; 12(4): 378–84.
17. Becker T, Ashkenazi M: Incidence of reported dental trauma among soldiers during basic training. Mil Med 2009; 174(2): 190–2.
18. Colthirst P, DeNicolo P, Will R, Simecek JW: Use of the dental disease nonbattle injury encounter module to assess the emergency rate on an Army military installation within the United States. Mil Med 2012; 177 (9): 1100–4.
19. Dunn WJ: Dental emergency rates at an expeditionary medical support facility supporting Operation Enduring Freedom. Mil Med 2004; 169 (5): 349–53.
20. Dunn WJ, Langsten RE, Flores S, Fandell JE: Dental emergency rates at two expeditionary medical support facilities supporting operations enduring and Iraqi Freedom. Mil Med 2004; 169(7): 510–4.
21. Fletcher LD: Dental observations at Australian Antarctic stations. Aust Dent J 1983; 28(5): 281–5.
22. Gunepin M, Derache F, Blatteau JE, Bombert C, Simecek J: Medical evacuation of French forces for dental emergencies: Operation Serval. Mil Med 2015; 180(5): 578–81.
23. Immonen M, Anttonen V, Patinen P, et al: Dental traumas during the military service. Dent Traumatol 2014; 30(3): 182–7.
24. King JE, Brunner DG: Theater of Operations Dental Workload Estimation. Ft. San Antonio, Tex, US Army, 1984.

25. Ludwick WE, Gendron EG, Pogas JA, Weldon AL: Dental emergencies occurring among Navy-Marine personnel serving in Vietnam. Mil Med 1974; 139(2): 121–3.
26. Nielsen AG: Oral Health Problems of Submarine Personnel and Suggested Program for Their Management . Conecticut, USA, U. S. Naval Medical Research Laboratory, 1963.
27. O'Shea MK, Scutt MJ: Morbidity rates on Vanguard Class submarines during nuclear deterrent patrol: a retrospective review over 13 years. J R Nav Med Serv 2009; 95(3): 127–35.
28. Roberts JE, Emens-Hesslink KE, Konoske PJ: A Descriptive Analysis of Dental Conditions Occurring During Conflicts, Deployments, and Field Training Exercises. San Diego, CA, Naval Health Research Center, 1999.
29. Rohani B, Shahamatnia H, Maddah M, Sameti AA, Najafpour AH, Fekrazad R: Evaluation of the prevalence of oral and maxillofacial diseases in submarine navy personnel of the Army of the Islamic Republic of Iran. J Arch Mil Med 2016; 4(1): e33056.
30. Sauvet F, Lebeau C, Foucher S, Flusain O, Jouanin JC, Debonne JM: Operational impact of health problems observed during a four-month military deployment in Ivory Coast. Mil Med 2009; 174(9): 921–8.
31. Simecek JW: Estimation of nonpreventable dental emergencies in U.S. Marine Corps personnel. Mil Med 2008; 173(11): 1104–7.
32. Simecek JW, Colthirst P, Wojcik BE, et al: The incidence of dental disease nonbattle injuries in deployed U.S. Army personnel. Mil Med 2014; 179(6): 666–73.
33. Tansey WA, Wilson JM, Schaefer KE: Analysis of health data from 10 years of Polaris submarine patrols. Undersea Biomed Res 1979; 6 (Suppl:): S217–246.
34. Thomas TL, Garland FC, Mole D, et al: Health of U.S. Navy submarine crew during periods of isolation. Aviat Space Environ Med 2003; 74(3): 260–5.
35. Thomas TL, Hooper TI, Camarca M, et al: A method for monitoring the health of US Navy submarine crewmembers during periods of isolation. Aviat Space Environ Med 2000; 71(7): 699–705.
36. Zadik Y, Levin L: Orofacial injuries and mouth guard use in elite commando fighters. Mil Med 2008; 173(12): 1185–7.
37. Fryer A. Dental problems hurting soldiers' readiness In. The Seattle Times, May 21, 2005 at 12:38 am. Alex Fryer: 206-464-8124. Available at afryer@seattletimes.com.
38. Chaffin J, Moss D: Review of current U.S. Army dental emergency rates. Mil Med 2008; 173(1 Suppl): 23–6.
39. Garrison RH, Noreen EW, Brewer PC: Managerial Accounting, 13 ed., Boston, MA, McGraw-Hill Irwing, 2009.
40. York AK, Moss DL, Martin G: A longitudinal study of dental experience during the first four years of military experience. Mil Med 2008; 173(1 Suppl): 38–41.
41. Mahoney GD, Coombs M: A literature review of dental casualty rates. Mil Med 2000; 165(10): 751–6.
42. Alexander DC: Dental recall status and unscheduled dental attendances in British warships. Mil Med 1996; 161(5): 268–72.