

A Review of Medical Evacuations Related to Dental Emergencies and Oral-Maxillofacial Injuries

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ABSTRACT

A literature review was performed to determine the frequency of medical evacuations (MEDEVAC) that are required for dental emergencies (DE) and oral-maxillofacial (OMF) injuries. Fourteen studies were reviewed altogether – eight which quantified evacuation of DEs or OMF injuries in military personnel (from 1982–2013) and six studies that discussed medical evacuation of DEs occurring in civilians working in offshore oil and gas rigs and wilderness expeditions (from 1976–2015). Among military personnel, DE/OMF issues were frequently among one of the top categories of medical evacuations, ranging from 2–16% of all evacuations. Among oil and gas industry workers, 5.3–14.6% of evacuations were dental-related, while one study of wilderness expeditions found that DEs ranked as the third most frequent type of injury that required evacuation. Previous studies have shown that dental and OMF problems often account for one of most frequently cited reasons for evacuation. However, due to the limited study base of DE/OMF medical evacuations, further research is needed to determine their impact on the cost of health care delivery.

KEYWORDS: *medical evacuation; medevac; military personnel; dental emergencies; oil and gas industry; emergencies; dental care; health care costs; stomatognathic diseases*

Introduction

Medical evacuations are extremely expensive, especially those that require an air ambulance. A 2019 civilian study by Bai et al. reported that the median cost of an air evacuations within the US to be close to \$40,000.¹ One civilian study, led by Thibodaux et al., estimated the average cost of air evacuation off an oil rig to be almost \$50,000.² A military study by Griffith described the US Department of Defense's (DoD) cost of air evacuations of ill or injured US servicemembers deployed as part of US Africa Command (AFRICOM).³ Depending on the location in Africa, the cost of a military air evacuation to military medical care in Landstuhl, Germany ranges wildly. The range goes from \$17,000 from locations along the Mediterranean Ocean to \$265,000 from locations in countries such as Djibouti, Kenya, Mali and Nigeria. DE and more severe problems related to OMF trauma require a dentist and/or an oral-maxillofacial surgeon to provide proper treatment. DE and OMF injuries affecting military personnel during operations or civilians located in remote environments may require evacuation for receiving medical/dental facilities. For example,

a 2011 study of French soldiers in Mali during Operation Serval (Gunepin et al.) showed that nearly 16% of medical evacuations of French soldiers were due to DEs.⁴ Afghanistan has a mountainous topography which makes having an advanced road system next to impossible. According to Mitchener, Dickens & Simecek, as of 2006, only 29% of the roadway system there is paved.⁵ Therefore, it is difficult to set up remote military healthcare facilities or to easily use ground transportation to travel to seek treatment. This made the reliance of air evacuations in this type of rugged environment much more crucial for military personnel seeking treatment for DEs and OMF trauma. A 2015 study by Gunepin et al. of French soldiers deployed to Afghanistan (with no organic dental support) showed that 65% of troops that experienced oral-facial problems required evacuation to the nearest dental treatment facility.⁶ On the other hand, very few studies have looked at medical evacuations in the civilian sector and simultaneously addressed dental issues as a cause for evacuation.

The objective of this study is to determine the percentage of MEDEVACs that are required for DE/OMF issues. This study looks at such issues in US military personnel and in foreign military personnel. Additionally, this study examines such issues in the civilian population in both the US and abroad.

Methods

A literature search was performed on pubmed.gov, a freely searchable database provided by the US National Library of Medicine of the National Institutes of Health, and Google Scholar, a freely accessible web search engine used to search for scholarly literature. The objective was to find studies which quantified DEs that required medical evacuation support in military members and the civilian population. Keywords such as “Dental” AND “MEDEVAC” (medical evacuation), “Dental Emergency” AND “Medical Evacuation” were used. From these searches, we were able to identify 14 peer-reviewed articles that span 39 years (1976–2015) that quantified the medical evacuations and their reasoning. Eight studies quantified evacuations of DEs or OMF injuries in military personnel (from 1982–2013) and six studies discussed medical evacuation of DEs occurring in civilians (from 1976–2015). Table 1 lists the 14 articles included in this review in chronological order by study year, along with the full title, population in the study, and years the study was conducted. The full citations for these articles are listed in the references. Results were categorized as military or civilian and summarized in chronological order.

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TABLE 1 Articles Identified in this Review Listed in Chronological Order by Year of Study

Title	Population	Year of Study
Medical evacuations from offshore structures	UK Civilian	1976–1984
A survey of US Navy medical communications and evacuations at sea	US Military	1982–1983
A survey of the dental health of the workers on two groups of offshore installations	UK Civilian	1990
Dental events during periods of isolation in the US submarine force	US Military	1991–1999
Dental problems in the offshore oil and gas industry: a review	UK Civilian	1996
Ten years of war: A characterization of craniomaxillofacial injuries incurred during operations Enduring Freedom and Iraqi Freedom	US Military	2001–2011
Medical incidents and evacuations on wilderness expeditions	US Civilian	2002–2005
Air medical evacuations of Soldiers for oral-facial disease and injuries	US Military	2003–2004
Air medical evacuations of Soldiers for oral-facial disease and injuries	US Military	2005
Air medical evacuations of Soldiers for oral-facial disease and injuries	US Military	2006
Analysis of the causes of medical evacuation of injured and sick soldiers of the Polish Military Contingent in the Islamic State of Afghanistan taking part in International Security Assistance Force operations	Polish Military	2010–2011
Medical evacuations in the oil and gas industry: A retrospective review with implications for future evacuation and preventative strategies	International Civilian	2008–2012
Medical evacuation of French forces for dental emergencies: Operation Serval	French Military	2013
Medical evacuations and work absences in offshore oil and gas industry personnel	UK Civilian	2014–2015

Results

Studies reporting dental-related evacuations are few. Fourteen studies were identified altogether, which included the number of medical evacuations reported and the reasons for needing evacuation. Eight of these studies were centered on medical evacuations occurring in military populations, and six studies citing medical evacuations occurring in civilian populations.

Medical Evacuations Occurring in Civilian Populations

The first of the civilian studies that was identified was titled “Medical evacuations from offshore structures” by Norman et al.⁷ This was a retrospective review that covered the years 1976–1984. The population of interest was offshore installation workers in the oil and gas industry operating in the United Kingdom. It was reported that during this study period that 2,162 total medical evacuations were required. The most common cause for medical evacuation was digestive issues and half of “digestive issue” medical evacuations were dental related (115 cases or 5.3% of total such evacuations).

The next study was titled “A survey of the dental health of the workers on two groups of offshore installations,” by Ballantine

et al.⁸ A total of 493 medical records of offshore installation workers in the oil and gas industry from the United Kingdom were reviewed. Dental pathology was discovered to be a common trend among this population. Records indicated that 4.9% of the operator’s employees and 8.1% of contractors were medically evacuated for dental reasons. Furthermore, records spanning from June 1983 to December 1985 indicated that a total of 34 evacuations occurred due to dental problems, which made up 5.3% of total medical evacuations.

Another study was titled “Dental problems in the offshore oil and gas industry: A review” by Duffy et al.⁹ Medical evacuation records of offshore installation workers at Shell UK Exploration and Production (Shell Expro) from 1988–1994 were reviewed. The data showed a similar trend of frequently occurring dental pathology among offshore oil and gas personnel leading to medical evacuations – in 1988, 11 out of a total of 145 medical evacuations were dental related (7.6%). In 1989, 52 out of 363 total evacuations were dental related (14.3%), in 1990, 68 evacuations out of 547 total evacuations were dental related (12.4%), in 1991, 63 evacuations out of a total of 475 evacuations were dental related (13.3%), in 1992, 66 evacuations out of a total of 452 evacuations were dental related (14.6%), in 1993, 45 evacuations out of a total of 419 evacuations were dental related (10.7%), and in 1994, 52 evacuations out of a total of 424 occurring medical evacuations were dental related (12.2%).⁹ The Duffy et al. study is the only civilian study that broke down the types of dental emergencies. Duffy et al. noted that 57% of the medical evacuations due to DE were due to issues with caries (“tooth decay” (38%), “failed restorations” (15%) & “new restorations/post-treatment problems” (4%)). “Gum disease”/“Infections” (a single category) accounted for 35% and “trauma” accounted for 8% of DE medical evacuations.

A study titled “Medical incidents and evacuations on wilderness expeditions” by McIntosh et al.¹⁰ described medical emergencies occurring in wilderness expeditions. This retrospective study during 2002–2005 reported medical emergencies occurring in participants and staff at the National Leadership Outdoor School based in Lander, Wyoming. A total of 996 medical incidents/emergencies took place during this time period among the population, which were categorized as illness or injury related. Of the total medical emergencies, 512 required medical evacuations. A total of 27 (5.3%) medical evacuations were dental related. Dental related MEDEVACs were cited as the third most common reason for MEDEVACs among the injury categories.

The next study was titled “Medical evacuations in the oil and gas industry: a retrospective review with implications for future evacuation and preventative strategies” by Toner et al.¹¹ Several different operations’ records were reviewed, which included international offshore Shell workers in the oil and gas field, as well as data from operations in UK, Russia, and Malaysia from 2008–2012. Dental issues in this study were not listed as a frequent category/reason for medical evacuations, and the only medical evacuations to have occurred due to dental reasons were among the workers in Malaysia – 10 evacuations out of a total of 130 (7.7%).

The last civilian study identified was titled “Medical evacuations and work absences in offshore oil and gas industry personnel” by Smith et al.¹² In this study conducted during a

16-week period from October 2014 to March 2015, global oil and gas industry workers attending a 1-day course at a training facility in Aberdeen, Scotland were provided with a questionnaire in order to identify the prevalence of medical evacuations occurring among this population. Of the total 44 reported evacuations, five were related to dental issues (11.4%).

Medical Evacuations Occurring in Military Populations

The first study of the military studies was titled “A survey of US Navy medical communications and evacuations at Sea” by Nice.¹³ This was a nine-month study from 1 December 1982 to 31 August 1983. The population of interest was all United States Navy surface ships, Pacific fleet submarines, and all ships of the Military Sealift Command. A total of 743 medical evacuations were reported during this study period, of which 17% of were due to digestive problems, particularly due to teeth and supporting structures or appendicitis. Of more interest, 52 cases (7% of the total) were due to non-injury related dental problems. Nice broke down the cases and was the only military study of DE medical evacuations (US or foreign) to do so. The author provided raw numbers, and the leading category was “infection” with 26 medical evacuations (50%). “Undiagnosed pain”/“unspecified pain” accounted for 13 (25%), “wisdom teeth” accounted for nine (17%), and “caries” accounted for four DE medical evacuations (8%).

The next study was titled “Dental events during periods of isolation in the US submarine force” by Deutsch et al.¹⁴ The aim of the study was to examine dental events that occurred on 240 submarine patrols from the time period of January 1997 to September 2000, which contained medical evacuation data from the Atlantic and Pacific submarine fleets from 1991–1997. Of the total such evacuations, 6.9% were due to dental reasons among the Pacific fleet, and 9.3% of total medical evacuations were due to dental reasons among the Atlantic fleet.

Another study was titled “Ten years of war: A characterization of craniomaxillofacial injuries incurred during operations Enduring Freedom and Iraqi Freedom” by Chan et al.¹⁵ In this study, the Joint Theater Trauma Registry was reviewed to identify the types of battle injuries occurring among Department of Defense personnel deployed to Iraq and Afghanistan during October 2001 to March 2011, the time period of Operations Enduring Freedom and Iraqi Freedom. Based on the data obtained in the study, a total of 9,530 battlefield injury medical evacuations occurred out of theater, of which 4,020 craniomaxillofacial battle injury related medical evacuations occurred. Maxillary and mandibular fractures due to battle injuries were frequent – 824 in total which made up 20.4% of craniomaxillofacial battle injury medical evacuations and 8.6% of total battle injury medical evacuations.¹⁵

The next study was titled “Air medical evacuations of Soldiers for oral-facial disease and injuries” by Mitchener et al.¹⁶ This research was a series of studies conducted in 2003–2004, 2005, and 2006 to identify the nature and causes of serious oral-facial (or OMF) illnesses and injuries among US Army personnel deployed to Iraq and Afghanistan. The US Air Force Transportation Regulating and Command & Control Evacuation System database for MEDEVACS was reviewed in the three mentioned study years. In 2003–2004, it was found that disease, battle injuries, and non-battle injuries involving oral-facial structures

made up 2.1% of total MEDEVACS. There were 374 of these types of MEDEVACS out of theater. Disease of the oral facial region accounted for 158 MEDEVACS (42%). Battle injuries accounted for 136 (36%) of these MEDEVACS. Non-battle injuries accounted for 80 (21%).¹⁶ In 2005, disease, battle injuries and non-battle injuries involving oral-facial structures made up 3.0% of total MEDEVACS. There were 206 of these types of MEDEVACS out of theater. Battle injuries accounted for 109 (53%) of these MEDEVACS. Disease of the oral facial region accounted for 64 MEDEVACS (31%). Non-battle injuries accounted for 33 (16%).¹⁷ Lastly, in 2006, disease, battle injuries and non-battle injuries involving oral-facial structures made up 2.3% of total MEDEVACS. There were 132 of these types of MEDEVACS out of theater. Battle injuries accounted for 78 (59%) of these MEDEVACS. Non-battle injuries accounted for 31 (23.5%). Diseases of the oral facial region accounted for 23 MEDEVACS (17.5%).¹⁸

The study entitled “Analysis of the causes of medical evacuation of injured and sick soldiers of the Polish Military Contingent in the Islamic State of Afghanistan taking part in International Security Assistance Force Operations” by Ziemia described medical reports of the Polish Military Contingent that took part in Operation Enduring Freedom from January 2010 to December 2011.¹⁹ The author reported that 3,278 soldiers suffered from acute inflammations of teeth or periodontium and complications of these inflammations. The cause of evacuation among 18 (0.5%) of these soldiers were due to more severe dental conditions, which included dental osteomyelitis, segmental mandibular/ maxillary necrosis, and persistent inflammation of the masticatory apparatus. In total, 565 medical evacuations occurred, of which 3.0% were due to dental reasons.

The last study was titled “Medical evacuation of French Forces for dental emergencies: Operation Serval” by Gunepin et al.⁴ In this study, medical evacuation data occurring from February 2013 to May 2013 was reviewed to identify the frequency of medical evacuations that was required for French soldiers during Operation Serval. Data revealed that 338 total evacuations occurred, of which 54 (16.0%) were due to dental pathology. Notably, dental reasons were the top cited reasons for medical evacuations during this five-month period.⁴

Among military personnel, DE/OMF issues were frequently among one of the top categories of medical evacuations, ranging from 2–16% of all such evacuations. Among oil and gas industry workers, 5.3–14.6% of medical evacuations were dental related, while one study of wilderness expeditions found that DEs ranked as the third most frequent type of injury that required medical evacuation. Table 2 shows the comparison of dental emergency, oral-facial, and craniofacial battle injury medical evacuations to the total number of medical evacuations. Percentages are then calculated. The Chan et al. study only looked at medical evacuations due to battle injuries of the craniofacial region. Chan et al. compared those numbers to the total number of medical evacuations due to battle injury only. The study did not look at the total numbers due to non-battle injury or disease.

Only six dental emergency studies compared the frequency of dental emergency evacuations to other types of medical evacuations. For these six studies (three civilian, two foreign military, and one US military), Table 3 compares dental evacuations to

TABLE 2 Comparison of Dental Emergencies (DE), Oral-Facial (OF) or Craniomaxillofacial (CMF) Medical Evacuations to Total Medical Evacuations*

Dental Emergencies		OF-Disease, Battle Injury, Non-battle Injury		CMF-Battle Injury only	
DE/Total	Percent	OF/Total	Percent	CMF/Total	Percent
Norman 115/2162	5.3%	Mitchener 1-374/18036	2.1%	Chan* 4020/9530	42.2%
Ballantine 34/642	5.3%	Mitchener 2- 206/6795	3.0%		
Duffy 357/2825	12.6%	Mitchener 3- 132/5647	2.3%		
Macintosh 27/512	5.3%				
Toner 10/130	7.7%				
Smith 5/44	11.4%				
Ziemba 18/565	3.2%				
Gunepin 54/338	16.0%				
Nice 52/743	7.0%				
Deutsch 70/852	8.2%				

*Chan et al. only compared to the total of medical evacuations due to battle injury only

the top categories of medical evacuations. Dental emergencies ranked in the top ten categories of medical evacuation in all six studies and was the number one category of medical evacuation in the Gunepin et al. French military study.

TABLE 3 Dental Emergency Studies that Compared Dental Evacuations to the Top Categories of Medical Evacuations

Norman et al.: Top reasons for medical evacuation (in raw number):
Injury – “Fractures of the Arm” – 234
Injury – “Sprains and Strains” – 192
Illness – (Tie) “Disorders of the Musculoskeletal Systems” – 156 & Injury – “Foreign Bodies” – 156
Injury – “Fractures of the Leg” – 140
Injury – “Contusions” – 132
Illness – “Disorders of the Digestive System (other than dental)” – 124
Injury – “Open Wounds of the Limb” – 120
Illness – “Disorders of the Respiratory System” – 117
Illness – “Disorders of the Digestive System (dental)” – 115
Macintosh et al.: Top categories of medical evacuations due to injury (illness/disease not included)
“Athletic” – 55%
“Soft Tissue” – 17%
“Dental” – 5.2%
“Skin/wound infection” – 4%
“Fractures” – 3.7%
Toner et al.: Top categories of medical evacuations (Malaysia only)
“Injury” – 34.1%
“Short term illness” – 31.8%
“Other” – 18.2%
“Dental” – 11.4%
“Emotional Problems” – 4.5%
Nice: Top medical evacuation categories
“Injury” – 36%
“Ill-defined” – 8%
“Infectious disease” – 8%
Tie “Digestive-dental” – 7% and “Mental Disorders” – 7%
Ziemba: Top medical evacuation categories
“Combat injuries” – 29%
“Respiratory Tract Infection” – 23%
“Complications acute GI infections” – 12%
Tie – “Mental Health Problems” & “chronic neuralgia” – 11%
“Non-combat injuries” – 4%
“Dental/maxillofacial problems” – 3%
Gunepin et al.: Top medical evacuation categories
“Dental” – 16%
“Anxiety” – 8.6%
“Sprains (ankle/knee)” – 8.0%
“Gastroenteritis” – 7.4%
(Tie) “Dehydration” and “renal colic” – 6.5%

Of the ten civilian and (foreign and US) military dental emergency studies, seven had adequate information to calculate rates of dental emergencies needing medical evacuation. Table 4 gives those rates (per 1,000 per year). Note that the highest rate of dental emergencies needing medical evacuation belong to the French military.

TABLE 4 Rates of Dental Emergencies (Per 1000 Per Year)

Norman et al.	N/A
Ballantine et al.	23.4
Duffy et al.	21.6
Macintosh et al.	N/A
Toner et al.	0.31
Smith et al.	20.8
Ziemba	0.88
Gunepin et al.	41.8
Nice	0.16
Deutsch et al.	N/A

Discussion

As a consequence of the ongoing Coronavirus pandemic since early 2020, fuel prices have risen dramatically throughout the world. In addition, the costs to build and maintain air and ground vehicles to transport patients have also risen sharply. In certain cases, there are secondary and tertiary effects of the pandemic that include parts and supply shortages. This affects the capability and speed of air evacuations. Bhaskar et al. reports that the global supply chain issues have also created shortages in frontline medical devices, personal protective equipment, and hospital bed availability – which can be a more detrimental issue for developing nations and remote environments that host military deployments and operations.²⁰ According to Kumar et al. the pandemic has caused many manufacturing plants to shut down or run at limited capacity, thus affecting the supply chain of finished goods, and causing shortages in products.²¹ Additionally, distribution was negatively impacted by new trade and travel restrictions. Another challenge noted in the research was the pandemic's impact on the scheduling of trained medical personnel, pharmaceutical supply chain shortages, and vehicle scheduling for both patients and medical workers. Additionally, production process and standard operation procedures to maintain social distancing creates an additional burden as extra time is needed to follow new protocols. The combination of these problems brought on by the COVID pandemic can lead to many

challenges when needing immediate medical evacuation services, which studies have reported are crucial to both military and civilian populations alike.

As noted in this review, medical evacuations related to dental problems and OMF injuries occur rather frequently in both military and civilian populations and have been shown to be an international occurrence. Previous studies have shown that dental and OMF problems often account for one of most frequently cited reasons for medical evacuation. The Macintosh, Toner, and Nice studies have shown dental issues were a top four reason for medical evacuation.^{10,11,13} The Gunepin et al. study showed that dental issues were the number one reason for medical evacuation of deployed French troops. As stated earlier, the Gunepin et al. study demonstrated the highest dental emergency evacuation rate.⁴ Studies have also shown that a large percentage of offshore workers in the oil and gas are classified as medium to high risk for dental disease. Among the civilian population, particularly the offshore workers in the oil and gas industry, dental pathology and preventable dental causes were more often the reason for DEs that led to medical evacuation, whereas among the military populations and wilderness expeditions, a combination of injury and dental pathology led to emergencies requiring evacuation.

Preventive dental care is not going to affect roughly 60–80% of medical evacuations of oral-facial medical evacuations out of theater. Especially, US military pre-deployment dental clearance will not have an effect on medical evacuation due to craniofacial injuries and OMF injuries. However, as Duffy et al. described, dental fitness standards for civilian oil rig workers in the UK were in place but not enforced.⁹ Before going offshore to work, dental examinations and treatment must be done to prevent potential acute dental issues from occurring and necessitating the need for medical evacuation. Duffy et al. also described providing additional dental training to “rig medics” assigned to oil rigs and to provide a robust “dental first-aid kit.” Between the training and the kit, they may allay the need for costly medical evacuation.⁹

Dental readiness is one of six criteria specified in the DoD Instruction (DoDI) 6025.19, which determines the deployability of military personnel to environments in which dental care may be limited. Each Sailor, Soldier, Airman, and Marine must receive a periodic annual dental examination and have all emergent dental conditions (any condition that is likely to cause a DE within 12 months of examination) treated before deployment.^{22,23} Furthermore, all services have preventive dentistry and health promotion programs. Navy and Marine Corps personnel are required to have a dental caries and periodontal risk assessment at each annual dental examination to determine preventive treatment required to reduce the risk of DE in personnel who have had emergent conditions treated. High caries risk personnel are provided one or more of the following, dependent on each individual’s risk and needs: oral hygiene instruction and oral disease education, fluoride dentifrice, sealants for pits and fissures, incipient caries remineralization, nutritional counseling, professional topical fluoride, home fluoride rinses, antibacterial mouth rinses, bacterial testing (if available), and evaluation of salivary flow.²⁴ Periodontal disease risk assessment is also provided annually, with high risk members provided the following as needed: referral for comprehensive exam by a periodontist or equivalent and prophylaxis by a dental hygienist, recall based on individual

patient needs, and evaluation and discussion of periodontal disease risk factors.

Pre-assignment dental treatment could reduce the need for medical evacuations and be useful to all civilian and military personnel working in remote environments.

Conclusion

For both military and civilian populations, increased dental support on site with appropriate equipment could help prevent medical evacuation use. Due to the limited study base of DE/OMF evacuations, further research is needed to determine their impact on the cost of health care delivery. Increased dental care and prevention strategies should be targeted among personnel who work or are deployed to austere environments. A key focus should be on applying good preventive dental care and applying dental fitness standards to civilian workers and foreign military prior to going remotely to work. These standards include dental treatment to reduce the number of acute dental emergencies from potentially occurring. A simple application of dental fitness standards similar to the US military would reduce the numbers of DE needing evacuation and acute treatment. Another focus should be continued monitoring of US military dental fitness standards and procedures. If dental fitness of US military units appears to decrease, measures should be addressed and utilized to correct the situation.

Author Contributions

IQ performed the literature review, organized and collected data, and wrote the manuscript. TM and JS conceived study concept and provided critical revision. All authors read and approved the final manuscript

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Conflict of Interest

The authors have no conflicts of interest to report.

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