

Operational Cost Analysis of Dental Emergencies for Deployed U.S. Army Personnel During Operation Iraqi Freedom

MAJ Paul M. Colthirst, DC USA*; Rosann G. Berg, BSc*; COL Philip DeNicolo, DC USA*; John W. Simecek, DDS, MPH†

ABSTRACT The documentation of dental emergency (DE) rates in past global conflicts has been well established; however, little is known about wartime DE costs on the battlefield. Using DEs as an example for decreased combat effectiveness, this article analyzes the cost of treating DEs in theater, both in terms of fixed and variable costs, and also highlighted the difficulties that military units experience when faced with degradation of combat manpower because of DEs. The study found that Dental-Disease and Non-Battle Injury cost the U.S. Army a total of \$21.4M between July 1, 2009 and June 30, 2010, and \$21.9M between July 1, 2010 and June 30, 2011. The results also revealed that approximately 32% of DE required follow-up treatment over the 2-year period, which increased the costs associated with a DE over time. Understanding the etiology and cost of DE cases, military dental practitioners will be better equipped to provide oral health instructions and preventive measures before worldwide deployments.

INTRODUCTION

War has always been a costly venture. Dental emergency (DE) rates in past conflicts have been well documented.^{1,2} DE rates during combat range from 26 to 260 per 1000 personnel per year.³ However, little is known about wartime costs for DEs on the battlefield. Adding the cost of decreased combat effectiveness, it can be shown that the cost of DEs has far-reaching implications beyond the actual treatment costs of the emergency. DEs can result in loss of life, both from the actual dental disease or from the potential of engagement with the enemy during transport of the patient to a treatment facility. Additionally, a unit that has decreased manpower will undoubtedly struggle to accomplish its mission, which results in a degradation of combat effectiveness. Chaffin and Moss⁴ concluded that a less dentally fit force would see a higher number of DEs, which can diminish the combat effectiveness of a unit, albeit indirectly.

This article analyzes the cost of treating DEs in theater, both in terms of fixed and variable costs, and also highlights the difficulties that military units experience when faced with the degradation of combat manpower because of DEs.

*Dental and Trauma Research Detachment, Institute of Surgical Research, 3650 Chambers Pass, Building 3610, Fort Sam Houston, TX 78234-6315.

†Naval Medical Research Unit - San Antonio, 3650 Chambers Pass, Building 3610, Fort Sam Houston, TX 78234-6315.

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METHODS

Dental Emergencies

DE care is designed to relieve oral pain, eliminate acute infection, control life-threatening oral conditions (hemorrhage, cellulitis, or respiratory difficulty); and treat trauma to teeth, jaws, and associated facial structures. It is considered the most austere form of dental care provided to deployed soldiers engaged in tactical operations.⁵

Dental officers document each DE visit by completing a questionnaire contained in the Dental Emergency Encounter Module of the Corporate Dental Application. The module enables the provider to categorize the DE into one or more of the 47 choices of DE etiology. The 47 categories were divided by the authors into three subsets: severe, moderately severe, and pain/loss of function (see Table I). The severe category was defined as DEs causing debilitation because of infection or loss of function and/or might, if left untreated, result in a life-threatening condition. The moderately severe category consists of DEs causing moderate to severe pain and/or infection, and the pain/loss of function category includes DEs that result in discomfort and/or loss of function that can be tolerated by patients until dental support is available.

All U.S. Army DE encounters and unique DE cases during the periods of July 1, 2009 to June 30, 2010 and July 1, 2010 to July 1, 2011 were included for this study.

Operational Costs (Total Dollar Cost)

DE Operational Costs, also called Total Dollar Cost (TDC), is defined as all measureable dollar costs, both fixed and variable, that are associated with the treatment of DEs on the battlefield. The DE cost includes (1) transportation to and from the dental treatment facility (DTF), (2) time away from the soldier's unit, and (3) treatment costs.

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TABLE I. Categorization of Severity of DEs and Listing of CDT Codes Required for Treatment

Severe	CDT Code	Moderately Severe	CDT Code	Pain Loss of Function	CDT Code
Anatomic Space Infection-Endodontic	D0140/D7510	Alveolar Osteitis	D0140/D9110 D9630/D9930	Aphthous Ulceration	D0140/D9110 D9910
Anatomic Space Infection-Periodontal	D0140/D7510	Candidiasis	D0140/D9110 D9910	Defective Restoration—No Caries	D0140/D0220 D9910/D2150
Anatomic Space Infection-Third Molar Related	D0140/D7510	Defective Permanent and Temporary Prosthesis	D0140/D8693	Defective Restoration—Caries	D0140/D0220 D9910/D2150
Fractured Facial Bones	NR ^a	Failing Implant	D0140/D9110 D9910/	Dental Caries	D0140/D0220 D9910/D2150
Fractured Tooth	D0140/D0220/ D0460/D9110	Myofascial Pain	D0140/D9110	Dentinal Hypersensitivity	D9911/D9110 D1204
Hemorrhage	NR ^a	Necrotic Pulp	NR ^a	Eruption Pain	NR ^a
Herpetic Gingivostomatitis	D0140/D9110	Oral Tumor/Cysts	D0140/D7286	Fractured Tooth/ Restoration—Caries	D0140/D0220 D9910/D2150
Necrotizing Ulcerative Gingivitis	D0140/D4341	Other Orofacial Pain	D0140/D9110	Fractured Tooth/ Restoration—No Caries	D0140/D0220 D9910/D2940
Oral Infection or Abscess of Undetermined Origin	D0140/D7510	Other Periodontal Problem	D0140/D1310 D1330/D4341	Gingivitis	D0140/D1310 D1330/D4341
Other Trauma-Related Problem	D0140/D7210 D9110/D9630	Other Pulpal Problem	D0140/D0220/D9110	Other Dental Condition	D0140/D9910 D9110
Partially Avulsed Tooth	D0140/D0220 D7270/D9910	Pain of Undetermined Origin	D0140/D0220 D9110	Other Dentoalveolar Problem	D0140/D9110 D7210/D9630
Swelling of Undetermined Origin	D0140/D7510	Pericoronitis	D0140/D7210 D0220/D7903	Postoperative Pain	D0140/D0220 D9110
Totally Avulsed Tooth	D0140/D0220 D7270/D9110	Periodontal Abscess	D0140/D0220/D7510	Tooth or Restoration in Hyperocclusion	D0140/D9970
		Periradicular Abscess	D0140/D0220 D0230/D7510		
		Periradicular Periodontitis	D0140/D0220 D0230/D7510		
		Pulpitis	D0140/D0220 D0230/D7510		
		Pulpless	D0140/D0220/ D0230/D7510		
		Sequestrum From Extraction	D0140/D9110 D9630/D9930		
		Soft Tissue Laceration, Abrasion, or Contusion	D0140/D7910 D9110		
		Temporomandibular Problem	D0140/D1310 D9110		

^aNR, None reported.

Fixed Costs

Fixed costs are expenses that are not subject to high degrees of variations⁶ in utilization of dental services, such as the cost of treatment and the pay associated with the soldiers, dental officers, and dental assistants. Treatment is calculated after categorizing the type of DE and assigning the American Dental Association Current Dental Terminology⁷ (CDT) treatment codes associated with treating the problem (Table I). The CDT codes correlate with fiscal year (FY) 2009 to 2010 and FY 2010 to 2011 Department of Defense (DOD) Dental Weighted Value⁸ (DWV) costs, which have dollar costs associated with treatment. The DWVs are based on the 95% level of the National Average American Dental Association fee survey and other regional fee schedules. One DWV represents approximately \$100 in cost for dental treatment. The authors determined the CDT codes most likely to reflect the treatment provided for each DE category. Our treatment cost analysis is calculated by taking the mean of the estimated definitive treatment costs associated with the specific DE.

Variations in transportation (i.e., how the soldier arrives at the DTF) is a key criterion in calculating total cost. If the soldier arrives by helicopter (medical evacuation or in-theater service transport flights) or ground vehicle, two different types of costs can be associated with the trip. Special-cause variations, such as transportation costs, are considered nonquantifiable, unpredictable, and unusual conditions that appear within a process.⁹ Even though there are costs associated with transporting DE patients to the nearest DTF, and in many cases, the expenses are considerable, this analysis did not incorporate those special-cause variation costs because of the uncertainty of the method by which soldiers arrived at the DTF. We therefore consider our estimates to be conservative at best.

Variable Costs

Variable costs are defined as expenses that change over time and are dependent upon the level of activity¹⁰ or utilization of dental services. The variable cost associated with a DE is time lost from a unit. Because there are no data that describe time lost for military personnel because of DE, former deployed dental commanders, operational medical planners, and clinic noncommissioned officers who deployed to Iraq were contacted and asked to estimate the average time lost for a soldier seeking treatment. These experts were asked to determine the average travel time to their DTF, the average wait time before being seen, the average length of treatment, and how soon after treatment the soldiers could return to their respective units. The averages of these times were used as the basis of our calculations.

Information provided by the FY 2009 to 2010 Department of Defense (DOD) Military Personnel Composite Standard Pay and Reimbursement Rates⁶ was used to calculate the average hourly rate of a typical deployed soldier (enlisted service member with a pay grade of E-5). The FY 2009 to 2010 and FY 2010 to 2011 DOD Military Personnel Composite Standard Pay and Reimbursement Rates pro-

vided by the Office of the Under Secretary of Defense were referenced to obtain the average annual rate of a typical deployed soldier (enlisted service member with a pay grade of E-5). The annual rates indicated were \$76,878 and \$78,666, respectively. Per the guidelines, hourly rates were calculated by multiplying the annual rate by the ratio factor of 0.00055.^{11,12} Accordingly, the FY 2009 to 2010 and FY 2010 to 2011 hourly rates of a typical deployed soldier were \$42.28 and \$43.26, respectively.

The following formula was used to calculate TDC of DEs for this study: TDC = Fixed Dollar Cost (Treatment) + Variable Dollar Cost (Time).

RESULTS

We determined that 11,642 soldiers were seen for DEs between July 1, 2009 and June 30, 2010. Of the 11,642 soldiers, there were 14,547 DE encounters (1.2 encounters [treatment visits] per patient). Additionally between July 1, 2010 and June 30, 2011, a total of 10,810 soldiers were seen for DEs, with 13,428 DE encounters (1.2 encounters per patient). The aforementioned group of experts determined that the average time lost by a unit was 3 days with an 8-hour work schedule for a total of 24 hours. This translated into a variable cost (time) of \$14.7M between July 1, 2009 and June 30, 2010, and \$13.9M between July 1, 2010 and June 30, 2011 (Table II). Additionally, the total fixed cost (treatment) for the severe, moderately severe, and pain/loss of function categories was \$6.7M between July 1, 2009 and June 30, 2010, and \$8.0M between July 1, 2010 and June 30, 2011, respectively (Table III). The total combined cost to the U.S. Army totaled \$21.4M between July 1, 2009 and June 30, 2010, and \$21.9M between July 1, 2010 and June 30, 2011 (Table IV). Table IV suggests that the vast

TABLE II. Cost of Absence Because of DEs for Deployed Soldiers in Two Time Periods

Number of Dental Encounters	3-Day Total Soldier Cost ^a (24 hours)	TDC ^b
	Deployed July 1, 2009–June 30, 2010	
14,547	\$1,014.72	\$14,761,131.84
	Deployed July 1, 2010–June 30, 2011	
13,428	\$1,038.24	\$13,941,486.72

^aTotal soldier cost (soldier cost/hour) = DOD E5 annual composite rate × 0.00055. ^bTDC = number of encounters × soldier cost per 24 hours.

TABLE III. Cost of DE Treatments by Level of Severity for Deployed Soldiers in Two Time Periods

Level of Severity	July 1, 2009–June 30, 2010	July 1, 2010–June 30, 2011	Total Severity
Severe	\$700K	\$160K	860K
Moderately Severe	\$3.4M	\$3.6M	7.0M
Pain/Loss of Function	\$2.6M	\$4.3M	6.9M
Total	\$6.7M	\$8.0M	\$14.7M

TABLE IV. Total Fixed and Variable Dollar Cost of DEs for Deployed Soldiers in Two Time Periods

Cost	Periods	
	July 1, 2009– June 30, 2010	July 1, 2010– June 30, 2011
Variable	\$14.7M	\$13.9M
Fixed	\$6.7M	\$8.0M
Total	\$21.4M	\$21.9M

TABLE V. Percent Disposition Comparison for Deployed Soldiers Receiving Dental Care in Two Time Periods

Disposition	July 1, 2009– June 30, 2010 (%), N = 11,642	July 1, 2010– June 30, 2011 (%), N = 10,810
	Returned to Duty, No Further Care	57
Returned to Duty, With Follow-up Appointment	36	27
Referred for Advanced or Specialty Care	3	1
Unknown	2	2
Held Over	<1	<1
Transported In-Theater to Higher Level of Care	<0.5	<0.5
Evacuated from Theater	<0.5	<0.5
Totals	100	100

majority of DE operational costs may be attributed to variable cost, i.e., calculated dollar cost because of time lost from unit.

Comparison of FY 2009 to -2010 and FY 2010 to 2011 shows that >50% of all DEs were treated and returned to duty, whereas the remainder required follow-up evaluation, treatment, or advanced specialty care, which may have resulted in increased numbers of hours away from their units (Table V).

DISCUSSION

In analyzing the cost of DE in theater, we estimate a TDC of \$44M over a 24-month period or \$1.8M per month. Although the amount is large, as previously stated, it is most likely an underestimate because of our inability to quantify and include the cost to transport 22,452 soldiers from their unit to the DTF.

The greatest expense was because of time away from a soldier's unit. This result is significant with respect to combat effectiveness of a unit and overall dental fitness of our soldiers. Although some DEs cannot be avoided, others can be mitigated. Using the DOD Dental Fitness Classification (DFC) system, teeth with problems are assigned a classification of 2 or 3 based on their probability of causing a DE over a 12-month period. For example, a tooth identified as a DFC 2 indicates the probability of a soldier developing a DE within 12 months is low. Although the DFC system has been validated,^{13,14} dental providers should take additional steps to ensure their examinations and diagnoses are indeed

accurate and justifiable, especially for deploying soldiers. Simecek¹⁵ reported that 51% of restorative DE and 47% of endodontic DE were not predicted on previous annual oral examinations. If a tooth was identified as a DFC 2 but has a DE experience within 365 days then perhaps that tooth should have been categorized as a DFC 3 (the likelihood of having a DE within 12 months is high). Future DE epidemiological studies should be designed to track previous oral examination to time of first initial DE experience. Failure to accurately classify a deploying soldier's dental readiness puts the soldier at a greater risk of becoming a DE casualty in theater.

Another cost not routinely documented for DE is risk avoidance. According to U.S. Army Field Manual 100-14, risk management (avoidance) is the utilization of risk management techniques to help units protect combat power through identifying and controlling hazards to conserve combat power and resources.¹⁶ The absence of one soldier because of a DE can obviously be calculated in dollars; however, the true value of that one soldier to the unit is not quantifiable. The unit, minus one or more soldiers, means that the combat power and effectiveness of the cohesive unit is degraded. The fact that another soldier must "cover down" to replace the missing soldier for an average of 3 days can suggest decreased morale, adjustments of time-off schedules, work schedules, tower guard schedules, and perimeter guard duties. It is evident the second- and third-order effects of DE go far beyond treatment cost and undoubtedly affect the entire unit's combat readiness and morale.

The overall cost seen in theater justifies the case for predeployment dental screenings and treatment. The majority of DEs seen in a dentally fit force can be definitively managed in theater. It is believed that if predeployment treatments were not conducted, the DE rates and associated costs would far exceed what is currently observed in theater. This underscores the need for having adequate dental services within the theater of operations to support the overall war effort. For example, the data showed that 43% of all DEs from July 1, 2009 through June 30, 2010 and 32% of all DEs from July 1, 2010 through June 30, 2011 required some type of follow-up or specialty care. This suggests that a unit lost a soldier for a longer period of time or the soldier returned at a later date for treatment that had not been initially resolved. In 2000, Mahoney and Coombs¹⁷ reported that a well-prepared dentally ready volunteered force would experience an annual DE rate of approximately 150 to 200 per 1000 soldier case. In contrast, Mahoney also wrote that a less dentally ready force would see an annual DE rate of 750 per 1000 soldier case. We can therefore conclude that if the U.S. Army was not a dentally fit force, the cost to treat these soldiers on the battlefield would be three times the amount that it currently costs. Dela Cruz and Colthirst¹⁸ concluded "Oral diseases can cause impaired duty performance, work loss, restricted activity, poor diet, difficulty pronouncing words, inability to sleep, and excruciating pain. If they are not prevented or

treated early, oral diseases can cause severe, life-threatening illness and may even require medical evacuation from theater.”

Chaffin and Moss⁴ suggested researchers should develop a predictive model of DEs that considers known risk factors, such as tobacco usage, access to fluoride during deployment, and stress management. Chaffin argued that understanding external environmental factors and implementing behavioral modification programs are essential in preventing DE. If indeed such a model were to be developed, it would no doubt be revolutionary. However, knowing the types of DE and the associated costs (i.e., treatment and combat power lost) is a first step in developing such a model.

CONCLUSION

Although the majority of DEs are preventable, the result of the study estimates the overall DE operating costs within theater to be over \$1.8M per month. The authors recommended that dental providers reference the type of DEs seen in past military conflicts and meticulously assess the status of predeployment oral health. With a better understanding of the etiology and cost of DE cases, dental practitioners will be better equipped to provide oral health instructions and preventive measures before deployment.

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REFERENCES

1. Chisick M, King J: Dental epidemiology of military operations. *Mil Med* 1993; 158: 581–5.
2. Mahoney G, Coombs M: A literature review of dental casualty rates. *Mil Med* 2000; 165: 751–6.
3. Simecek J: Dental classification and risk assessment prevention of dental morbidity in deployed military personnel. *Mil Med* 2008; 173(Suppl 1): ix.
4. Chaffin J, Moss D: Review of current U.S. Army dental emergency rates. *Mil Med* 2008; 173(1): 23–6.
5. Army Publishing Directorate. Chapter 1, para 37. Available at http://armypubs.army.mil/doctrine/Active_FM.html; accessed March 12, 2012.
6. Mitchell J, Price A: *Economics: Principles in Action*. Upper Saddle River, NJ, Pearson Prentice Hall, 2003.
7. America Dental Association Current Dental Terminology. Available at http://www.deltadentalwa.com/Dentist/Public/ResourceCenter/~/_media/PDFs/Dentist/policies%20and%20manuals/2011_2012%20CDT%20Codes.ashx; accessed August 24, 2012.
8. DoD Guidelines for Dental Procedure Codes and Dental Weighted Values. Falls Church, VA, Tricare Management Activity, U.S. Dept of Defense, October 1, 2009. Available at <http://www.tricare.mil/ocfo/mcfs/ubo/archives.cfm>; accessed February 1, 2012.
9. Scott I, Youlden CM: Are diagnosis specific outcome indicators based on administrative data useful in assessing quality of hospital care. *Qual Saf Health care* 2004; 13: 32–9.
10. Garrison RH, Noreen EW, Brewer PC: *Managerial Accounting*, Ed 13. Boston, MA, McGraw-Hill Irwin, 2009.
11. FY 2010 Department of Defense (DOD) Military Personnel Composite Standard Pay and Reimbursement Rates. Washington, DC, Office of the Under Secretary of Defense. Available at https://comptroller.defense.gov/rates/fy2010/2010_k.pdf; accessed March 12, 2012.
12. FY 2011 Department of Defense (DOD) Military Personnel Composite Standard Pay and Reimbursement Rates. Washington, DC, Office of the Under Secretary of Defense. Available at https://comptroller.defense.gov/rates/fy2011/2011_k.pdf; accessed January 7, 2013.
13. Teweles R, King J: Impact of troop dental health on combat readiness. *Mil Med* 1987; 152: 233–5.
14. Simecek J, Diefenderfer K: An evaluation of US Navy dental classification guidelines. *Mil Med* 2010; 175: 895–900.
15. Simecek J: Estimation of non-preventable dental emergencies in U.S. Navy and Marine Corps personnel. *Mil Med* 2008; 173: 1104–7.
16. Risk Management. Field Manual 5-19. Washington, DC, Headquarters, Department of the Army, 2006. Available at http://armypubs.army.mil/doctrine/Active_FM.html; accessed February 13, 2013.
17. Mahoney G, Coombs M: A literature of dental casualty rates. *Mil Med* 2000; 165(10): 751.
18. Dela Cruz G, Colthirst P: Chapter 17: Oral health effects of combat stress, pp 259–72. In: *Textbooks of Military Medicine*. Washington, DC, Department of the Army, Office of the Surgeon General, Borden Institute, 2011.

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