

# Dental infections increase the likelihood of hospital admissions among adult patients with sickle cell disease

B. Laurence<sup>1</sup>, C. Haywood<sup>2</sup> Jr and S. Lanzkron<sup>2</sup>

<sup>1</sup>Howard University College of Dentistry, Washington, DC, US; <sup>2</sup>Division of Hematology, The Johns Hopkins School of Medicine, Baltimore, MD, US

**The objective:** To determine if dental infections increase the likelihood of hospital admission among adult patients with sickle cell disease (SCD). **Basic Research Design:** Cross-sectional analysis of data from the Nationwide Emergency Department Sample (NEDS) pooled for the years 2006 through 2008. Prevalence ratios (PR) for the effects of interest were estimated using Poisson regression with robust estimates of the variance. **Participants:** Adults, aged 18 and over, diagnosed with SCD using ICD-9-CM codes excluding participants discharged with a code for sickle cell trait. **Main outcome measure:** Emergency department (ED) visit disposition, dichotomised to represent whether or not the ED visit ended in admission versus being treated and released. **Results:** Among patients having a sickle cell crisis, those with dental infections were 72% more likely to be admitted compared to those not having dental infections (PR=1.72, 95%CI 1.58-1.87). No association was observed among adult SCD patients not having a sickle crisis event. Based on preliminary data from this analysis, prevention of dental infection among patients with SCD could result in an estimated cost saving of \$2.5 million dollars per year. **Conclusions:** Having a dental infection complicated by a sickle cell crisis significantly increases the likelihood of hospital admission among adult SCD patients presenting to the ED.

**Key words:** sickle cell diseases, emergency treatment, hospital admission, dental care, oral health, sickle cell crisis, resource allocation

## Introduction

Recent estimates suggest that the numbers of individuals in the United States living with sickle cell disease (SCD) is approaching 100,000 of which approximately 90% are African-American (Brousseau *et al.*, 2010). Sickle cell disease is associated with significant mortality and morbidity and the most common clinical symptom of SCD is the painful vaso-occlusive crisis. Some of the chronic complications that occur among patients with SCD include, but are not limited to, avascular necrosis of the long bones, leg ulcers, stroke and renal failure (Olujuhunge and Howard, 2008; Piccin *et al.*, 2008). Patients with SCD attend the emergency department (ED) to obtain medical care at a particularly high rate. Patients with SCD also have a high rate of being admitted for inpatient care following an ED visit (Lanzkron *et al.*, 2010). The chronic nature of SCD, in conjunction with the frequent hospital admissions for the management of pain associated with sickle cell crisis can also lead to impaired psychosocial functioning and a reduced quality of life (Edwards *et al.*, 2005).

Little attention is paid to SCD and oral health in health policy discussions concerning SCD despite evidence that shows that SCD is associated with very specific adverse oral health outcomes including an increased risk of localised dental infection, increased risk of dental caries and death of the vital portion of the tooth (Adeyemo *et al.*, 2011; Demirbas Kaya *et al.*, 2004). One study suggests that dental infections among patients with SCD could lead to an increased likelihood of having a sickle cell crisis event (Rada *et al.*, 1987).

There has been an increased emphasis in recent years on developing a medical home for patients with SCD and other chronic conditions (Baker *et al.*, 2005). The medical home model focuses on characteristics that can lead to improvements in the level of care provided to patients by incorporating patient-centred, coordinated comprehensive care and by providing patients with a long-term regular source of care (Bruder *et al.*, 2010). Properly applied, the medical home model can lead to improvements in the quality of care for patients with chronic conditions and a reduction in health care costs (Starfield and Shi, 2004). If dental infections among patients with SCD can lead to an increased likelihood of hospital admission among patients with SCD, then the integration of dental care into medical home models for patients with SCD with a focus on prevention could lead to long term gains in the overall quality of care for patients with the disease. The objective for this study was to determine if dental infections were associated with an increased likelihood of hospital admission among adult patients with SCD visiting the ED.

## Methods

Data were obtained from the Nationwide Emergency Department Sample (NEDS). The NEDS contains information about emergency department (ED) visits across the US and includes information on geographic characteristics, hospital characteristics, patient characteristics and the recorded reasons for the ED visit (AHRQ, 2010). The analysis included pooled data from the years 2006 through 2008.

The NEDS is the largest all-payer ED database that is currently publicly available in the United States. For the 2008 dataset, the NEDS captured information from over 28 million ED visits at 980 hospitals that approximated a 20-percent stratified sample of US hospital-based EDs. Similarly large estimates were obtained for the years 2006 and 2007. The NEDS provides sample weights that are used to facilitate the calculation of national-level estimates.

The presence or absence of dental infection was defined by our dichotomous independent variable of interest which included the presence of periodontal infections or periapical/pulpal infections. We defined this variable as the presence of any of the following ICD-9-CM codes: Periodontal infections 523.0 to 523.9; and Periapical/Pulpal infections 522.0 to 522.9.

The outcome measure for this study was ED visit disposition, which was dichotomised to represent whether or not the ED visit ended in admission versus being treated in the ED and released. All other ED event outcomes were excluded including ED visits in which the patient was transferred to another short-term hospital (about 1.3% of ED visits), ED visits in which the patient died in the ED (about 0.2% of ED visits) and ED visits in which the patient was not admitted to the same hospital but the final destination was unknown (about 0.7% of ED visits).

The ED visits of individuals with SCD were identified using the following ICD-9-CM codes: 282.41, 282.42, and 282.60 through 282.69. Discharges with a code for sickle cell trait (282.5) were excluded from our study. Based on a review of the literature, we included in the analysis clinical variables that could lead to an increased likelihood of hospital admission among patients with SCD, in addition to demographic variables and hospital characteristics. Information collected on potentially confounding demographic variables included the patient's age, gender, the primary expected payer and the median household income for the patient's zip code. Potentially confounding clinical characteristics were identified by ICD-9-CM codes (unless otherwise noted) and included the presence or absence of the following: an injury that could cause the patient to visit the ED (identified using Clinical Classification Software (CCS) codes 225 through 244), pulmonary hypertension (416.0,416.8,416.9), cerebrovascular accident (430,431,433,433.0-433.9,434,434.0-434.1,434.9,436,437,437.0-437.9), leg ulcers excluding decubitus (707.1-707.15,707.19), gall bladder disease/cholelithiasis (574.0-574.9,575.0-575.9,576.2), retinopathy (362.10,362.21,362.29), avascular necrosis (733.40-733.42,733.44,733.49), chronic renal failure (585,585.1-585.9), acute chest syndrome (517.3), bacteremia/septicemia (790.7,038.0,038.1,038.2,038.3,038.4,038.40-038.49,038.8,038.9) and pneumonia (CCS code 122). The potentially confounding hospital characteristics that we studied were the hospital's trauma centre level (level I trauma centres provide the most complex care while those at level IV provide initial care), the hospital region and the hospital teaching status.

The presence or absence of a sickle cell crisis event was examined as a potential effect modifier of the relationship between the presence/absence of a dental infection and inpatient admission from the ED. This variable was defined by the presence/absence of any of the following ICD-9-CM codes: 1, sickle cell thalassemia with crisis, code 282.42; 2, Hb-SS disease with crisis, code 282.62; 3, sickle cell/

HB-C disease with crisis, code 282.64; 4, other sickle cell disease with crisis, code 282.69

Multivariable Poisson regression with robust estimates of variance was used to estimate prevalence ratios (PRs) and 95% confidence intervals (CIs) for the association between dental infection and ED visit discharge disposition (admitted vs. released). As shown by Barros and others, the analysis of binary outcome data with a Poisson regression model using robust estimates of variance allows for the direct estimation of relative risks or prevalence ratios, and avoids the "built in bias" and overestimation of relative risks found in the use of odds ratios provided by logistic regression analyses when the outcome of interest is common in prevalence (>10%) (Barros and Hirakata, 2003; Cummings, 2009). Each individual emergency department visit served as the unit of analysis. Only adults aged 18 and over were included in the analysis. An interaction term was included in the model to assess the presence of statistically significant effect modification by sickle crisis status. A statistically significant interaction was followed up by an evaluation of the association between dental infection and ED visit disposition in separate multivariable models stratified according to the presence/absence of a sickle cell crisis event. We excluded from the analysis those ED visits with missing values for any of the independent, dependent or confounding variables. A p-value of  $\leq 0.05$  was considered statistically significant and all analyses were carried out using STATA software, v.11. We hypothesised that dental infections could interact with a sickle cell crisis and could make a sickle cell crisis event more severe and difficult to manage and therefore more likely to require hospitalisation.

## Results

Table 1 presents selected characteristics of the sample. Using the methods described above with application of the sample weights led to an estimated 1,572 visits for patients with SCD and dental infections and an estimated 549,045 visits for patients with SCD but without dental infection nationally for the years 2006 through 2008. A lower proportion of visits were diagnosed with a sickle cell crisis event for SCD patients with dental infections than those without, 64.3% vs 74.3%. Having a dental infection was associated with a greater chance for SCD patients of admission following an ED visit, 65.7% vs 40.0%. There were no significant differences in distribution between groups by the primary expected payer, median household income by zip code or mean age. However, there were differences with regards to gender distribution with those with dental infection more likely to be female.

The clinical characteristics of the SCD patients with and without dental infection were significantly different for three of the included variables; those with a dental infection had higher prevalences of injury and acute chest syndrome, and a lower prevalence of pneumonia. For the hospital characteristics, SCD patients with dental infection were also more likely to come from the Midwest region of the US compared to those without who were more likely to come from the Northeast, South and West regions of the US.

The adjusted prevalence ratio (PR) for the relationship between dental infection and hospital admission among patients with SCD is shown in Table 2. In the multivariable model, SCD patients with a dental infection were more

**Table 1.** SCD study characteristics according to the presence or absence of dental infection for adults aged 18 and over based on national level estimates obtained using weighted data

	<i>SCD with dental infection (n=1,572)</i>	<i>SCD with no dental infection (n=549,045)</i>	<i>p</i>
Mean (sd) age in years	32.1 (0.6)	31.9 (0.2)	0.66
Admitted following ED visit (%)	65.7	40.0	<b>&lt;0.001</b>
Gender Male (%)	36.1	43.8	<b>&lt;0.05</b>
<i>Primary expected payer (%)</i>			
Medicaid	49.6	43.6	0.11
Medicare	26.1	28.3	
Private	11.6	16.5	
Other	12.7	11.6	
<i>Median household income (%)</i>			
Under \$39,000	55.5	51.0	0.46
\$39,000-\$48,999	22.1	25.8	
\$49,000-\$63,999	14.6	15.0	
\$64,000 or more	7.8	8.2	
<i>Clinical characteristics (%)</i>			
Crisis present	64.3	74.3	<b>&lt;0.05</b>
Indicator for injury code present	10.2	7.0	<b>&lt;0.05</b>
Pulmonary hypertension present	3.3	1.9	0.08
Cerebrovascular Accident present	0.0	0.2	0.62
Leg Ulcers excluding Decubitus present	1.6	1.0	0.29
Gall bladder disease/cholelithiasis present	0.0	0.1	0.68
Retinopathy present	0.0	0.1	0.78
Avascular Necrosis present	4.2	3.0	0.17
Chronic Renal Failure present	1.8	3.0	0.22
Acute Chest Syndrome present	4.2	2.4	<b>&lt;0.05</b>
Bacteremia/Septicemia present	3.7	2.3	0.09
Pneumonia present (%)	2.5	5.1	<b>&lt;0.05</b>
<i>Hospital characteristics, Trauma level (%)</i>			
Non-trauma centre	55.1	54.3	0.24
Trauma level I	23.9	22.1	
Trauma level II	8.9	7.0	
Trauma level III	5.8	7.5	
Trauma level I or II	4.0	3.3	
Trauma level I,II or III	2.6	5.9	
<i>Hospital region (%)</i>			
Northeast	14.6	19.5	<b>&lt;0.001</b>
Midwest	25.7	15.1	
South	52.8	56.5	
West	6.9	9.0	
<i>Hospital teaching status (%)</i>			
Metropolitan non-teaching	26.8	31.6	0.22
Metropolitan teaching	64.8	58.6	
Non-metropolitan	8.4	9.8	

likely than those without to be admitted (PR=1.65, 95%CI 1.51-1.80). After finding a statistically significant interaction term assessing the potential interaction of dental infection status and SCD crisis status, we repeated our analysis among groups stratified by SCD crisis status (Table 3). For adult SCD patients diagnosed with a sickle cell crisis event, those with dental infection were 72% more likely than those without to be admitted (PR=1.72, 95%CI 1.58-1.87). Among adult SCD patients not diagnosed with any sickle

cell crisis, there was no statistically significant association observed between dental infection and likelihood of admission (PR=1.39, 95%CI 0.95-2.03).

## Discussion

We believe that this is the first study to show that among adult SCD patients presenting to an ED, having a dental infection was associated with an increased likelihood of

being admitted to a hospital. Interestingly, this relationship seems to be found only among those adult SCD patients coded as also having a vaso-occlusive crisis. The increased likelihood of admission as a result of a dental infection (72%) in stratified analysis is similar in magnitude to the increased likelihood observed with some other established clinical variables, such as avascular necrosis (79%) and pneumonia (72%), respectively observed within this analysis. These findings are clinically important and suggest a need for greater emphasis on the oral health of patients with SCD by healthcare providers and the patients themselves. More research is needed to understand the factors associated with receiving dental care among patients with SCD. In earlier studies of oral health outcomes among patients with SCD, 46.1% of the patients with SCD classified their employment status as “Unemployed or on disability” compared to 4.9% of the non-SCD comparison group. This suggests the possibility that a greater loss of income or lack of dental insurance among SCD patients compared to the non-SCD population may contribute to the observed oral health disparities between those with and without SCD (Laurence *et al.*, 2006a; 2006b). A recent Brazilian study on dental caries and periodontal disease prevalence among patients with SCD suggested that the increased prevalence of dental decay among patients with SCD could be due to poverty,

a low priority on seeking care or an increased reluctance on the part of dentists to treat patients with SCD due to fear of complications (Passos *et al.*, 2012). This would suggest that income disparities, the relatively high cost of obtaining dental care, the lack of dental insurance among patients with SCD, or patient-level and provider-level knowledge and attitudes could be significant barriers to obtaining preventive dental treatment or comprehensive dental care for this patient population. Studies have shown that increased efforts at preventive dental care can lead to improved oral health (Curtis *et al.*, 2008; Moskovitz *et al.*, 2009). Thus there is an incentive to develop an intervention that can lead to improved dental care for persons with SCD, possibly through the integration of dental care into the medical home model for patients with SCD.

Dental infection can influence systemic health among patients with SCD through a variety of potential pathways. One possibility is that inflammatory mediators such as cytokines, endotoxins and vascular injury play a role in the causal pathway (D’Aiuto *et al.*, 2010). Patients with SCD are at increased risk of general infection and are also at more risk of dental infection than patients without SCD. Dental infection through inflammatory mediators could potentially trigger or exacerbate an already existing crisis and lead to an ED visit with subsequent hospital admission. Almost 25 years ago, Rada *et al.* (1987) discussed two cases of sickle cell crisis that were precipitated by a periodontal infection. In both of these cases, the authors ruled out additional sources of infection such as urinary tract infection, upper respiratory tract infection or bacteremia and the authors suggested that a dental infection severe enough to produce a clinically visible, extra-oral swelling may disturb the SCD patient’s physiology enough to precipitate a crisis. A dental infection could therefore exacerbate the severity of the crisis event to make admission more likely as the associated clinical symptoms become more difficult to manage.

It is also possible that the pain associated with dental infection could drive patients directly to the ED for treatment and the most severe cases may warrant admission following the initial ED visit due to increased difficulties with pain management. Patients with SCD are not only more likely to suffer from pain-inducing dental disorders compared to the general population, they are also more likely to suffer from dental pain of undetermined or unspecified origin (O’Rourke and Hawley, 1998; O’Rourke and Mitropoulos, 1990).

Overall we observed a total of 1572 visits due to dental infections when we pooled the data for the years 2006 through 2008. Annually, this works out as an average of 524 visits due to dental infection among adult patients with SCD. If patients with SCD and dental infection on average are 65% more likely to be admitted as compared to SCD patients without dental infection, then an additional 341 admissions each year are estimated to occur among this population that are due, at least in part, to dental infections. In an earlier analysis, Lanzkron *et al.*, estimated that the average cost charge for hospital admission for patients where SCD was listed as the principal diagnosis using the 2006 NEDS was \$7,309 (Lanzkron *et al.*, 2010). Thus prevention of dental infections that eliminate the need for hospital admission could reasonably result in a possible annual costs savings of up to almost \$2.5 million among adult patients with SCD.

**Table 2.** Adjusted prevalence ratio (PR) for the relationship between dental infection and hospital admission among adults with SCD

Variable	PR	95%CI
Dental infection present (ref. Absent)	1.65*	1.51,1.80

\*p<0.001. This table shows the result from the multivariable model that adjusts for age, gender, the primary expected payer, the median household income, the presence or absence of the following clinical variables: a sickle cell crisis, an injury, pulmonary hypertension, cerebrovascular accident, leg ulcers, gall bladder disease, retinopathy, avascular necrosis, chronic renal failure, acute chest syndrome, bacteremia, pneumonia, and the hospital characteristics and the hospital region.

**Table 3.** Adjusted prevalence ratios for the relationship between having a dental infection and hospital admission among adults with SCD stratified according to the presence or absence of any crisis event

Variable	Any sickle crisis (n=409,169)		No sickle crisis (n=141,448)	
	PR	95%CI	PR	95%CI
Dental infection present (ref. Absent)	1.72*	1.58,1.87	1.39	0.95,2.03

\*p<0.001. This table shows the result from the multivariable model that adjusts for age, gender, the primary expected payer, the median household income, the presence or absence of the following clinical variables: a sickle cell crisis, an injury, pulmonary hypertension, cerebrovascular accident, leg ulcers, gall bladder disease, retinopathy, avascular necrosis, chronic renal failure, acute chest syndrome, bacteremia, pneumonia, and the hospital characteristics and the hospital region.

Given the potential economic burden to society of dental infections on patients with SCD, it may be necessary to develop and implement oral health policies that take into account the sickle cell status of the population. Using the observed association between hospital admission and dental infection can be an effective mechanism to communicate to policymakers the importance of taking the necessary first steps towards improving access to dental care for patients with SCD. Our research findings make unique contributions in this area.

We believe that the strengths of this study include the large sample size that allowed for the computation of estimates with narrow confidence intervals despite the relatively low prevalence of SCD in the US. Furthermore, the nationally representative nature of the NEDS study sample increases the external validity of the study. There are also several limitations to this study that should be considered. It is possible that errors occurred in the coding of sickle cell disease and sickle cell crisis. However, the potential for coding errors will always exist for studies using administrative databases. In addition, as the NEDS did not include information on the race of the patients, we were not able to control for any effects that ethnicity or race may have had on our analyses. That said, it is reasonable to assume that the overwhelming majority of the SCD patients seen in the ED were black or of African descent.

This study is one of the first to show a positive relationship between dental infection and the likelihood of hospital admission among SCD patients visiting the ED. The results suggest that an increased focus on preventive oral health, or on the early identification and treatment of dental infections, may reduce the need for admission following ED visits. Future research is needed to investigate both provider and patient barriers to improving access to dental care for patients with SCD.

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