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Non-Traumatic Dental Condition-Related Emergency Department Visits and Associated Costs for Children and Adults with Autism Spectrum Disorders

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Abstract

We analyzed 2010 U.S. National Emergency Department Sample data and ran regression models to test the hypotheses that individuals with ASD are more likely to have non-traumatic dental condition (NTDC)-related emergency department (ED) visits and to incur greater costs for these visits than those without ASD. There were nearly 2.3 million NTDC-related ED visits in 2010. Less than 1.0% (children) and 2.1% (adults) of all ED visits were for NTDC. There was no significant difference in NTDC-related ED visits or costs for children by ASD status. Adults with ASD had significantly lower odds of NTDC-related ED visits (OR=0.39; 95% CI: 0.29, 0.52; $P<0.001$) but incurred significantly greater mean costs for NTDC-related ED visits ($P<0.006$) than did adults without ASD.

Keywords

Autism spectrum disorders; emergency department visits; non-traumatic dental conditions; dental costs

Autism spectrum disorders (ASD) are a group of lifelong developmental disabilities characterized by qualitative impairments in communication and social interaction, and by restricted repetitive behavior patterns (American Psychiatric Association 2000). According to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria, ASD include the following diagnoses: autism, Asperger syndrome, and pervasive developmental disorders not otherwise specified (PDD-NOS) (American Psychiatric Association 2000). Autism is the most severe form of ASD. Children with autism often

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demonstrate adverse behaviors such as temper tantrums, impulsivity, agitation, anger, aggressiveness, and self-injury (Friedlander et al. 2006). Individuals with Asperger syndrome demonstrate social impairment and repetitive behavior, but exhibit normal speech development and normal or near normal intelligence (Spence et al. 2004). PDD-NOS is a diagnosis of exclusion in which a child shares symptomology with the other ASD, but does not fully meet the clinical criteria of autism or Asperger syndrome or exhibits milder or atypical manifestations of ASD (Barbaresi et al. 2006; Filipek et al. 1999). Based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), diagnoses of autism, Asperger syndrome, and PDD-NOS are now combined into a single diagnosis of ASD to account for the common set of behaviors across these conditions (American Psychiatric Association 2013). The DSM-5 also differentiates ASD from intellectual developmental disorders (though the conditions frequently co-occur) and social (pragmatic) communication disorder and provides guidance on assigning a severity level to individuals with ASD based on the level of support required.

Children with ASD are two to four times as likely to have unmet dental care needs as children without ASD (Newacheck et al. 2000; Brickhouse et al. 2000; Lai et al. 2012). There are a number of possible explanations. The first is increased frequency of fermentable carbohydrate intake. Fermentable carbohydrates are found in foods or liquids that break down into sugar (e.g., white breads, chips, crackers, rice, sugar sweetened beverages, fruit juices). Children with ASD are known to be selective eaters and commonly take medications containing sucrose, which leads to increased risk for tooth decay (Marí-Bauset et al. 2013; Bigeard 2000). Caregivers of children with ASD may use sweets as rewards, which further increases the frequency of carbohydrate intake. The second is uncooperative behavior, making it difficult for caregivers to enforce consistent oral hygiene at home, such as twice daily toothbrushing with fluoridated toothpaste (Lowe and Lindeman 1984; Stein et al. 2012b). The third is xerostomia (dry mouth) that results from chronic use of psychotropic medications (Friedlander et al. 2006), which leads to lowered salivary buffering capacity and decreased ability for remineralization of enamel. The fourth is poor access to dental care. Children with intellectual and developmental disabilities and ASD have poor access to timely preventive dental care (Chi et al. 2011b; Barry et al. 2014). Many dentists are hesitant about treating patients with ASD who are uncooperative in dental office settings (Casamassimo et al. 2004; Loo et al. 2008). These risk factors make individuals with ASD susceptible to poor oral health, including severe dental caries (tooth decay) and other non-traumatic dental conditions (NTDC).

NTDC include tooth decay, intraoral abscesses, gingivitis and periodontitis, and other conditions of the teeth or supporting structures caused by infection. Individuals without a place to go for regular preventive and restorative dental care frequently present at hospital emergency departments (EDs) for treatment of pain caused by NTDC (Wallace et al. 2011). Management of NTDC within EDs is problematic because treatment is limited to non-definitive care (e.g., pain medications, antibiotics) and the underlying etiology of dental disease is not addressed, which can lead to repeat ED visits (Davis et al. 2010; McCormick 2013; Pajewski and Okunseri 2014). Furthermore, NTDC-related ED visits are a suboptimal use of scarce health care resources and can cost up to 10 times more than definitive treatment provided in dental offices (Pettinato et al. 2000).

Despite evidence that individuals with ASD are at increased risk for poor oral health, there are no relevant studies on NTDC-related ED use and costs. The goals of this study are two-fold: 1) to compare NTDC-related ED utilization for individuals with and without ASD; and 2) to estimate the costs associated with NTDC-related ED use for individuals by ASD status. We tested the hypotheses that individuals with ASD are more likely to utilize EDs for NTDC and to incur greater costs for NTDC-related dental visits than those without ASD.

METHODS

Study Design, Data, Population, and Human Subjects

This is a cross-sectional study based on U.S. emergency department (ED) data from calendar year 2010. We analyzed the 2010 Nationwide Emergency Department Sample (NEDS) data, which were available through the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP). The 2010 NEDS consists of data from 28 million ED visits across 28 states (Agency for Healthcare Research and Quality 2012). According to the 2010 NEDS, there were nearly 129 million ED visits in the U.S., an estimate similar to those reported by three other national U.S. datasets. The ED discharge data contain information on patient characteristics (e.g., gender, age, county of residence urban-rural designation, community income, diagnosis codes, payer information, charges). We restricted our study to individuals ages 3 years and older. Although diagnoses of ASD can be made as early as age 2 years (Kleinmann et al. 2007), we excluded children under age 3 years because most children are diagnosed after the child's third birthday (Autism and Developmental Disabilities Monitoring Network Surveillance Year 2008 Principal Investigators and Centers for Disease Control and Prevention 2012; Mandell et al. 2010; Rosenberg et al. 2011). Because the NEDS is a publicly-available dataset, the study was exempt from human subjects approval from the University of Washington Institutional Review Board.

Study Variables

Outcome Measures—There were two main outcome measures. The first was whether the individual received a NTDC-related diagnosis (no/yes). We examined each of the 15 diagnosis fields in NEDS for the following International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) Codes indicating a NTDC: 521-521.9 (diseases of dental hard tissues of teeth), 522-522.9 (diseases of pulp and periapical tissues), 523-523.9 (gingival and periodontal disease), 525.3 (retained dental root), 525.9 (unspecified disorder of the teeth and supporting structures), and 873.63 (internal structures of mouth, without broken tooth) (Cohen et al. 2002; Okunseri et al. 2008; Chi and Masterson 2013). Pain and infection (related to untreated tooth decay) are the two common examples of why individuals present to the ED with a NTDC. The second was total mean charges for ED services, a continuous measure (2010 U.S. dollars).

Predictor Variable—The predictor variable was ASD status (no/yes). Because the 2010 NEDS data utilized the DSM-IV, we applied previously published criteria based on the DSM-IV (Chi et al. 2010) to identify the following ICD-9-CM codes indicating ASD from the 15 diagnosis fields in NEDS: 299.0 (autistic disorder), 299.1 (childhood disintegrative disorder), 299.8 (other specified pervasive developmental disorders), and 299.9 (unspecified pervasive developmental disorder).

Model Covariates—We adapted the Behavioral Model for Vulnerable Populations and previous work (Gelberg et al. 2000) based on the notion that an array of predisposing, enabling, and need-based factors are related to health service utilization patterns. We included five covariates in our explanatory models that been shown to be important determinants of ED dental visits (Chi et al. 2014). There were two predisposing variables: sex (male, female) and age (categorical variable: 3–5, 6–12, 13–17, 18–21, 22–49, 50–64, 65–75, 76 years and older). Age categories were based on the types of teeth present in the mouth and the developmental life stages relevant in the clinical management of oral health. We had three enabling variables: health insurance type (private or health maintenance organization, Medicare, Medicaid, self-pay, no charge, other), median community income (quartiles: $1–$40,999, $41,000–$50,999, $51,000–$66,999, ≥$67,000), and rurality of patient's community of residence (large central metropolitan, large fringe metropolitan, medium metropolitan, small metropolitan, micropolitan, non-core). The NEDS dataset estimates median community income from the patient's zip code and served as a proxy for household income. The need variable was ASD status, a binary variable (no/yes) defined previously.

Statistical Analyses

All analyses were stratified on age to examine our hypotheses separately for children (ages 3 to 17 years) and adults (ages 18 years and older) based on previous work indicating that the factors related to NTDC-related ED use are heterogeneous across age (Chi et al. 2014). We generated weighed descriptive statistics for children and adults by ASD status. Weights are used to derive nationally representative estimates. The Pearson chi-square test was used to assess the bivariate relationships between each model covariate and the outcome and predictor variables (α=0.05). Linear regression was used to assess bivariate relationships between model covariates and mean costs. We used multiple variable logistic regression models to generate covariate-adjusted odds ratios and corresponding 95% confidence intervals and test the hypothesis that individuals with ASD would be more likely to use the ED for NTDC. Multiple variable linear regression models were used to test the hypothesis that individuals with a NTDC-related ED visit, those with ASD would incur greater costs than those without ASD. All analyses accounted for hospital clustering, hospital strata, and patient discharge weights. We also conducted subgroup analyses for children and adults in Medicaid to examine whether the relationships between ASD status and NTDC-related ED use and costs differed for Medicaid-enrolled individuals. All data were analyzed using Stata IC version 13 (StataCorp, College Station, TX).

RESULTS

Descriptive and Bivariate Statistics

Our study population included 17,223,414 children and 103,450,324 adults. About 0.4% of children and less than 0.1% of adults were identified as having ASD (Table 1). There were nearly 2.3 million NTDC-related ED visits in 2010. NTDC-related ED visits made comprised 0.8% (141,940) and 2.1% (2,132,349) of total ED visits by children and adults, respectively. Most children in our sample were male (51.9%), ages 6 to 12 years (38.7%), insured by Medicaid (46.5%), and resided in lower-income (31.5%) and large central metropolitan areas (26.4%). Most adults in our sample were female (57.4%), ages 21–49 years (50.4%), privately insured (29.7%), and resided in a lower-income (32.3%) and large central metropolitan areas (26.9%). In terms of the unadjusted bivariate statistics, there was no significant relationship between ASD status and NTDC-related ED visits for children (P=0.47) whereas significantly larger proportions of adults with ASD had a NTDC-related ED visit than adults without ASD (P<0.0001) (Table 1). Among individuals with a NTDC-related ED visit, there was no difference in costs for children (P=0.347) but adults with ASD incurred significantly higher mean costs than adults without ASD ($1462 and $802, respectively; P=0.002) (Table 2). For both children and adults, the following population subgroups incurred significantly higher costs: males, older individuals (ages 13 to 17 and ages 76 and older), Medicare enrollees, those living in the highest income communities, and those living in larger communities.

Child Regression Models

In the covariate adjusted models, there was no significant difference in the odds of having a NTDC-related ED visit for children with and without ASD (Odds Ratio [OR]: 1.06; 95% Confidence Interval [CI]: 0.87, 1.27; P=0.575) (Table 3). There was also no difference in costs for NTDC-related ED visits for children by ASD status (P=0.859) (Table 4). In terms of the other significant factors for children, females were significantly less likely to have a NTDC-related ED visit (P<0.0001) and incurred significantly lower costs than males (−$163.15; P<0.0001). Two gradients were observed: an age gradient in which older children were significantly more likely to have an ED visit for NTDC (and incur significantly higher costs) and an income gradient in which children living in higher income communities were less likely to have a NTDC (as well as higher costs). Non-privately insured children were more likely to have a NTDC-related ED visit. Rurality was not significantly related to NTDC-related ED visits for children. Findings were similar in the analyses restricted to Medicaid-enrolled children (Table 5).

Adult Regression Models

Adults with ASD were significantly less likely to have a NTDC-related ED visit than adults without ASD (covariate-adjusted OR: 0.39; 95% CI: 0.29, 0.52; P<0.001) (Table 3). However, among adults with a NTDC-related ED visit, those with ASD incurred significantly higher costs ($581.88; P=0.006) (Table 4). Female were significantly less likely to have a NTDC-related ED visit (P<0.001). Compared to adults ages 18 to 21 years, those ages 22 to 49 years had a greater odds of an ED visit (OR: 1.41; 95% CI: 1.38, 1.44; P<0.001) whereas the odds of an ED visit was significantly lower for adults ages 50 years and older. Compared to privately insured adults, the odds of a NTDC-related ED visit was highest for self-paying adults (OR: 3.08; 95% CI: 2.94, 3.22; P<0.001). Adults living in lower-income and smaller communities were significantly less likely to have ED visits for NTDC. In the analyses restricted to Medicaid enrollees, the utilization findings were similar (Table 5) but there were two differences in regards to the cost findings: no significant difference in costs by ASD status or by median community income (Table 6).

DISCUSSION

This is the first publication to our knowledge to examine emergency department (ED) use and associated costs for non-traumatic dental conditions (NTDC) for children and adults with autism spectrum disorders (ASD). We analyzed a nationally representative ED dataset to test two hypotheses: 1) children and adults with ASD would have greater odds of NTDC-related ED use than those without; and 2) among NTDC-related ED utilizers, children and adults with ASD would incur greater costs than those without ASD. We also evaluated potential differences in the relationship between ASD status, on the one hand, and ED use and costs, on the other, for Medicaid enrollees. We have two main findings.

The first finding is that children with ASD, regardless of health insurance type, are not at increased risk for NTDC-related ED visits nor do they incur greater costs for NTDC-related ED visits than children without ASD. We had hypothesized children with ASD would be at greater risk for NTDC-related ED visits and higher costs because of documented difficulties accessing dental care and high levels of unmet dental care need (Newacheck et al. 2000; Brickhouse et al. 2000; Lai et al. 2012; Chi et al. 2011b). Untreated tooth decay is the main driver of NTDC-related ED visits and visits to the dentist are intended to help prevent tooth decay (Sun and Chi 2014). Our findings are consistent with previous studies suggesting no relationship between ASD status and caries (Loo et al. 2008; Lowe and Lindeman 1985; Morinushi et al. 2001). Our findings are inconsistent with two recent studies reporting that children with ASD were less likely to have office-based dental visits (Capozza and Bimstein 2012; Stein et al. 2012a) as well as studies from pediatric medicine indicating that Medicaid-enrolled children with ASD incur significantly greater health care costs than those without ASD (Peacock et al. 2012; Wang and Leslie 2010). There are three potential explanations for our findings. First, even though children with ASD have difficulties accessing routine office-based dental care and have unmet needs, they may be able to obtain treatment for dental problems before ED visits become necessary. Addressing symptomatic dental problems may be a high priority for parents of children with ASD, whereas routine preventive care might have been postponed because of alternative priorities and lack of urgency (Chi et al. 2013). Dentists may also be more willing to see children with ASD with symptomatic dental problems. Second, ED dental treatment is non-definitive and consists mainly of pain and infection management through prescriptions and may not differ for children by ASD status, resulting in similar costs. Third, EDs may not consistently code ASD, leading to misclassification bias with fewer identified patients with ASD (Aharonson-Daniel et al. 2014). Additional mixed methods studies are needed to determine potential reasons why children with ASD have high levels of unmet dental care need but are not at increased risk for NTDC-related ED visits.

The second finding is that adults with ASD are at significantly reduced odds of having a NTDC-related ED visits than adults without ASD, regardless of type of health insurance. This is consistent with a small study from Spain reporting that patients with ASD were at lower risk for caries than those without ASD (Orellana et al. 2012). However, among adults in our study with a NTDC-related ED visit, those with ASD incurred significantly greater costs than those without. These findings are inconsistent with studies reporting that adults with ASD had significantly greater odds of using the ED (Nicolaidis et al. 2013) and greater inpatient hospitalization costs (Lokhandwala et al. 2012). Collectively, our findings suggest adults with ASD who present to the ED with NTDC may have far more serious NTDC than adults without ASD, which could explain the nearly twofold difference in costs. Future investigators should conduct additional studies to identify adults with ASD at increased risk for NTDC-related ED visits and develop relevant interventions aimed at improving the oral health of these high-risk individuals.

Our regression models also highlight three additional factors associated with NTDC-related ED visits: older age, being insured by Medicaid or self-pay (uninsured), and living in a lower-income community. Nearly 75% of NTDC-related ED visits for children occurred among those ages 6 to 17 years and for adults nearly 80% occurred among those ages 22 to 49 years (Table 1). The findings pertaining to adults are similar to previous work (Hong et al. 2011; Lee et al. 2012; Lewis et al. 2003). While individuals ages 76 years and older comprised only 1.1% of adults with a NTDC-related ED visit, they incurred the highest mean costs ($2,026) (Table 2). In terms of health insurance, Medicaid-enrolled children (53.5%) and self-paying (i.e., uninsured) adults (40.1%) were the most likely to utilize the ED for NTDC, which is consistent with other studies (Lewis et. al 2003; Hong et al. 2011; Chi and Masterson 2013). Finally, similar to other studies (Hong et al. 2011; Lee et al. 2012) but inconsistent with non-significant findings from another study (Nalliah et al. 2010), children and adults living in the lower-income communities (i.e., median community income of less than $50,999) made up nearly 70% of ED utilizers. Collectively, our findings suggest vulnerable populations may benefit from oral health promotion programs aimed at addressing and preventing NTDC. Additionally, public health interventions should target socioeconomically vulnerable adolescents to reduce the high prevalence of NTDC-related ED visits for individuals ages 22 to 49 years, particularly because office-based dental care utilization rates begin to drop and oral health behaviors (e.g., toothbrushing, diet) deteriorate during adolescence (Chi et al., 2011a; Astrøm and Samdal 2001).

As with all studies, there were limitations with the current investigation. First, the analyses are based on observational data and all findings are associations rather than causal. Prospective studies are needed to further evaluate the relationship between ASD and ED-related outcomes. Second, ASD may be underdiagnosed in the ED and there may be coding errors present in NEDS. We are unable to assess the reliability of ASD coding in the NEDS datasets. A recent study reported 1.5% of eight-year-old children in the U.S. and 0.98% of adults in the U.K. have a diagnosis of ASD (Developmental Disabilities Monitoring Network Surveillance Year 2010 Principal Investigators 2014; Brugha et al. 2011), both of which are higher than our ASD prevalence rates of 0.4% for children and 0.1% for adults. This comparison suggests underdiagnosis of ASD by ED providers or that individuals with ASD are not as likely to visit the ED. In the future, changes in ASD diagnostic criteria described in the DSM-5 may affect the extent to which ED providers diagnose and code ASD. Additional research is needed to determine the extent to which ASD are underdiagnosed in the ED, which has important implications for accurate identification of individuals with ASD within large national datasets, including the U.S. NEDS data. Third, our conceptual model was limited by the number of variables available in NEDS and did not include behavioral factors (e.g., toothbrushing with fluoride toothpaste, diet, preventive dental visits) that could moderate the influence of ASD status. Future work should continue to construct and test explanatory models on NTDC-related used for individuals with ASD as a way to monitor utilization trends and identify strategies to reduce NTDC-related ED use. There is a need for mixed methods studies that examine the reasons why individuals with ASD utilize EDs for NTDC. Fourth, the NEDS data only contain total ED charges without itemized costs and it is unknown whether all expenditures are related to NTDC or other conditions. Use of itemized claims data, such as state Medicaid data, would allow for a more accurate assessment of costs related to NTDC-related ED use. Fifth, our study was based on U.S. data, which limits generalizability to other countries. However, similar to other countries, the U.S. has a mixed dental financing system consisting of both publicly- and privately-financed dental insurance, which broadens the generalizability and relevance of our study findings. Similar studies from outside of the U.S. are needed to assess these issues.

Despite these limitations, our study has broader clinical, policy, and research relevance. The clinical relevance is that all individuals, particularly those with ASD, should have adequate access to age-appropriate, office-based preventive and restorative dental care through a dental home that is consistent with a life course perspective (Nowak and Casamassino 2002; Chi and Ettinger 2014). Modified patient management strategies that account for sensory difficulties common in patients with ASD could be adopted to deliver patient care (Kuhanek and Chisholm 2012; Stein et al. 2012a). Dental school training could provide students with more meaningful didactic and hands-on experiences in treating patients with ASD (Casamassimo et al. 2004; Wolff et al. 2004). In addition, caregivers of individuals with ASD could be educated on the risk factors for poor oral health and strategies for modifications in dietary and hygiene practices at home. In terms of policy relevance, dental care should be considered a mandatory benefit within private and public health insurance plans, including Medicaid and Medicare. While all Medicaid programs provide dental benefits for child enrollees, dental is optional for adult enrollees. There are currently no dental benefits as part of Medicare, leaving older adults at risk for poor oral health and symptom-drive dental care utilization patterns. Medicaid and Medicare should recognize the importance of oral health and provide comprehensive dental benefits for all enrollees, which would help vulnerable individuals maintain good oral and general health. In addition, there is a need to ensure access to dental care provided under general anesthesia (Hulland et al. 2000; White et al. 2008), particularly for patients with ASD, which may require federal legislation to standardize policies across states. Additional mixed methods research is needed to understand the determinants and outcomes associated with NTDC-related ED visits. These efforts will help to drive evidence-based clinical guidelines and policies aimed at optimizing the oral health of individuals with ASD.

CONCLUSION

We found that children with ASD were not significantly more likely to use the ED for NTDC or to incur greater costs for NTDC-related ED visits than children without ASD. Although adults with ASD had significantly lower odds of NTDC-related ED use, associated costs were significantly higher for adults with ASD who utilized the ED for NTDC. Management of NTDC within EDs is a costly and inefficient use of scarce health care dollars. Because most NTDC are preventable, our study findings reinforce the importance of developing strategies that reduce NTDC-related ED use for individuals with ASD. This will require additional quantitative and qualitative research on the determinants of and outcomes associated with NTDC-related ED visits.

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TABLE 1

Descriptive Characteristics and Unadjusted Bivariate Relationships between Model Covariates and NTDC-Related ED Visits for Children (n=17,223,414) and Adults (n=103,450,324) in the 2010 U.S. National Emergency Department Sample (NEDS)

	Children Ages 3 to 17 Years N=17,223,414			Adults Ages 18 Years and Older N=103,450,324		
Model Covariates	**NTDC-related ED Visit (n=141,940) n (%)**	**Other ED Visits (n=17,081,474) n (%)**	**P-value**	**NTDC-related ED Visit (n=2,132,349) n (%)**	**Other ED Visits (n=101,317,975) n (%)**	**P-value**
Autistic Spectrum Disorder (ASD) Status			P=0.470			P<0.001
ASD	606 (0.4)	68,032 (0.4)		370 (<0.1)	37,520 (<0.1)	
No ASD	141,334 (99.6)	17,013,442 (99.6)		2,131,979 (99.9)	101,280,455 (99.9)	
Sex			P<0.001			P<0.001
Male	77,144 (54.3)	8,876,474 (52.0)		1,007,611 (47.3)	43,057,725 (42.5)	
Female	64,792 (45.7)	8,204,376 (48.0)		1,124,648 (52.7)	58,251,309 (57.5)	
Age			P<0.001	n/a	n/a	
3–5	33,135 (23.3)	4,378,426 (25.6)		n/a	n/a	
6–12	56,275 (39.7)	6,607,341 (38.7)		n/a	n/a	
13–17	52,530 (37.0)	6,095,708 (35.7)				P<0.001
18–21	n/a	n/a		211,760 (9.9)	8,715,180 (8.6)	
22–49	n/a	n/a		1,655,980 (77.7)	50,521,526 (49.9)	
50–64	n/a	n/a		208,812 (9.8)	20,072,898 (19.8)	
65–75	n/a	n/a		33,431 (1.6)	9,692,189 (9.6)	
76 and older	n/a	n/a		22,367 (1.1)	12,316,182 (12.2)	
Health Insurance Type			P<0.001			P<0.001
Private including HMO	43,649 (30.8)	6,976,085 (41.0)		351,556 (16.6)	30,457,371 (30.2)	
Medicare	359 (0.3)	46,797 (0.3)		170,934 (8.1)	26,688,671 (26.4)	
Medicaid	75,670 (53.5)	7,940,470 (46.6)		647,470 (30.5)	18,751,665 (18.6)	
Self-pay	16,920 (12.0)	1,380,281 (8.1)		850,519 (40.1)	19,207,497 (19.0)	
No charge	228 (0.2)	20,777 (0.1)		30,099 (1.4)	812,620 (0.8)	
Other	4,705 (3.3)	662,884 (3.9)		70,118 (3.3)	4,986,219 (4.9)	
Median Community Income			P<0.001			P<0.001

	Children Ages 3 to 17 Years N=17,223,414			Adults Ages 18 Years and Older N=103,450,324		
Model Covariates	**NTDC-related ED Visit (n=141,940) n (%)**	**Other ED Visits (n=17,081,474) n (%)**	**P-value**	**NTDC-related ED Visit (n=2,132,349) n (%)**	**Other ED Visits (n=101,317,975) n (%)**	**P-value**
$1 – $40,999	51,848 (37.1)	5,373,980 (32.0)		841,766 (40.4)	32,665,524 (33.0)	
$41,000 – $50,999	41,506 (29.7)	4,781,132 (28.5)		653,157 (31.3)	27,376,814 (27.7)	
$51,000 – $66,999	28,366 (20.3)	3,718,795 (22.1)		390,055 (18.7)	21,558,849 (21.8)	
$67,000 or more	17,847 (12.8)	2,929,323 (17.4)		200,927 (9.6)	17,246,520 (17.4)	
Rurality of Patient's County of Residence			P<0.001			P<0.001
Large central metropolitan	37,909 (26.8)	4,512,055 (26.5)		462,465 (21.8)	27,393,191 (27.2)	
Large fringe metropolitan	25,833 (18.3)	3,613,476 (21.2)		367,409 (17.3)	20,754,119 (20.6)	
Medium metropolitan	31,667 (22.4)	3,637,577 (21.4)		514,706 (24.3)	21,930,397 (21.8)	
Small metropolitan	15,915 (11.3)	1,725,484 (10.1)		268,320 (12.7)	10,579,262 (10.5)	
Micropolitan	18,725 (13.2)	2,126,593 (12.5)		333,552 (15.7)	12,255,633 (12.2)	
Non-core	11,439 (8.1)	1,410,681 (8.3)		173,745 (8.2)	7,698,448 (7.7)	

* Due to sampling, subgroup totals may not add up to the total number of NTDC-related and other ED visits.

TABLE 2

Bivariate Relationships between Model Covariates and Mean NTDC-Related ED Costs for Children (n=17,223,414) and Adults (n=103,450,324) in the 2010 U.S. National Emergency Department Sample (NEDS)

	Children Ages 3 to 17 Years N=17,223,414		Adults Ages 18 Years and Older N=103,450,324	
Model Covariates	**Mean Costs and 95% Confidence Intervals**	**P-value**	**Mean Costs and 95% Confidence Intervals**	**P-value**
ASD Status		P=0.347		P=0.002
ASD	$1,035.94 ($757.51, $1,314.37)		$1,461.78 ($1,044.79, $1,878.77)	
No ASD	$906.56 ($857.56, $955.57)		$802.49 ($766.78, $838.20)	
Sex		P<0.001		P<0.001
Male	$981.39 ($924.71, $1,038.08)		$825.83 ($787.52, $864.14)	
Female	$819.21 ($768.98, $869.43)		$781.16 ($746.92, $815.40)	
Age		P<0.001		P<0.001
3–5	$775.25 ($710.80, $839.69)		n/a	
6–12	$860.43 ($807.58, $913.28)		n/a	
13–17	$1,034.02 ($971.78, $1,096.27)		n/a	
18–21	n/a		$735.40 ($701.99, $768.81)	
22–49	n/a		$750.40 ($716.89, $783.91)	
50–64	n/a		$1,081.57 ($1,023.64, $1,139.49)	
65–75	n/a		$1,518.99 ($1,404.48, $1,633.50)	
76 and older	n/a		$2,025.77 ($1,898.66, $2,152.89)	
Health Insurance Type		P<0.001		P<0.001
Private including HMO	$1,122.71 ($1,050.04, $1,195.38)		$969.01 ($913.94, $1,024.09)	
Medicare	$1,201.58 ($798.31, $1,604.85)		$1,106.84 ($1,048.44, $1,165.24)	
Medicaid	$800.11 ($746.85, $853.37)		$708.57 ($674.32, $742.82)	
Self-pay	$804.72 ($715.03, $894.40)		$738.32 ($705.29, $771.35)	
No charge	$576.96 ($457.03, $696.90)		$764.18 ($660.39, $867.98)	
Other	$987.03 ($858.33, $1,115.73)		$954.61 ($841.35, $1,067.87)	
Median Community Income		P<0.001		P<0.001
$1 – $40,999	$835.87 ($766.61, $905.14)		$782.67 ($742.34, $822.99)	
$41,000 – $50,999	$842.31 ($786.43, $898.20)		$746.10 ($706.35, $785.84)	
$51,000 – $66,999	$1,004.16 ($922.09, $1,086.22)		$869.37 ($808.27, $903.48)	
$67,000 or more	$1,143.78 ($1,040.91, $1,246.65)		$965.98 ($888.36, $1,043.60)	
Rurality of Patient's County of Residence		P=0.001		P<0.001
Large central metropolitan	$972.39 ($881.27, $1,063.52)		$1,010.38 ($915.20, $1,105.56)	
Large fringe metropolitan	$995.12 ($913.02, $1,077.21)		$834.13 ($766.47, $901.79)	
Medium metropolitan	$949.72 ($85058, $1,048.85)		$841.89 ($762.12, $921.67)	
Small metropolitan	$835.10 ($748.90, $921.30)		$726.81 ($651.85, $801.77)	

	Children Ages 3 to 17 Years N=17,223,414		Adults Ages 18 Years and Older N=103,450,324	
Model Covariates	**Mean Costs and 95% Confidence Intervals**	**P-value**	**Mean Costs and 95% Confidence Intervals**	**P-value**
Micropolitan	$737.03 ($628.03, $846.04)		$611.07 ($575.41, $646.72)	
Non-core	$766.51 ($573.70, $959.33)		$571.72 ($533.92, $609.51)	

TABLE 3

Covariate-Adjusted Logistic Regression Models for Non-Traumatic Dental Condition-Related Emergency Department Visits for U.S. Children and Adults

	Children Ages 3 to 17 Years		Adults Ages 18 Years and Older	
Model Covariates	**Odds Ratio and 95% Confidence Intervals**	**P-value**	**Odds Ratio and 95% Confidence Intervals**	**P-value**
ASD Status				
ASD	1.06 (0.87, 1.27)	P=0.575	0.39 (0.29, 0.52)	P<0.001
No ASD (reference)	1.00	-	1.00	-
Sex				
Male (reference)	1.00	-	1.00	-
Female	0.89 (0.87, 0.91)	P<0.001	0.81 (0.80, 0.83)	P<0.001
Age				
3–5 (reference for children)	1.00	-	n/a	n/a
6–12	1.16 (1.12, 1.20)	P<0.001	n/a	n/a
13–17	1.20 (1.14, 1.26)	P<0.001	n/a	n/a
18–21 (reference for adults)	n/a	n/a	1.00	-
22–49	n/a	n/a	1.41 (1.38, 1.44)	P<0.001
50–64	n/a	n/a	0.54 (0.52, 0.56)	P<0.001
65–75	n/a	n/a	0.21 (0.20, 0.22)	P<0.001
76 and older	n/a	n/a	0.11 (0.11, 0.12)	P<0.001
Health Insurance Type				
Private including HMO (reference)	1.00	-	1.00	-
Medicare	1.17 (0.93, 1.46)	P=0.174	1.42 (1.36, 1.49)	P<0.001
Medicaid	1.46 (1.39, 1.53)	P<0.001	2.59 (2.46, 2.73)	P<0.001
Self-pay	1.89 (1.78, 2.00)	P<0.001	3.08 (2.94, 3.22)	P<0.001
No charge	1.71 (1.15, 2.54)	P=0.008	2.85 (2.43, 3.35)	P<0.001
Other	1.11 (1.02, 1.22)	P=0.019	1.08 (0.96, 1.23)	P=0.186
Median Community income				
$1 – $40,999 (reference)	1.00	-	1.00	-
$41,000 – $50,999	0.92 (0.88, 0.96)	P<0.001	1.00 (0.95, 1.04)	P = 0.835
$51,000 – $66,999	0.83 (0.79, 0.88)	P<0.001	0.87 (0.83, 0.91)	P < 0.001
$67,000 or more	0.73 (0.68, 0.78)	P<0.001	0.71 (0.66, 0.75)	P < 0.001
Rurality of Patient's County of Residence				
Large central metropolitan (reference)	1.00	-	1.00	-
Large fringe metropolitan	0.94 (0.87, 1.02)	P=0.126	1.29 (1.17, 1.42)	P<0.001
Medium metropolitan	1.01 (0.93, 1.11)	P=0.744	1.39 (1.26, 1.54)	P<0.001
Small metropolitan	1.04 (0.94, 1.16)	P=0.406	1.49 (1.32, 1.68)	P<0.001
Micropolitan	0.98 (0.90, 1.07)	P=0.626	1.58 (1.42, 1.77)	P<0.001
Non-core	0.87 (0.79, 0.96)	P=0.007	1.38 (1.24, 1.53)	P<0.001

TABLE 4

Covariate-Adjusted Linear Regression Models for Non-Traumatic Dental Condition-Related Emergency Department Costs for U.S. Children and Adults

	Children Ages 3 to 17 Years		Adults Ages 18 Years and Older	
Model Covariates	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**
ASD Status				
ASD	$22.60 (-$226.53, $271.74)	P=0.859	$581.91 ($165.02, $998.80)	P=0.006
No ASD (reference)	-	-	-	-
Sex				
Male (reference)	-	-	-	-
Female	−$163.15 (−$208.11, −$118.19)	P<0.001	−$37.87 (−$52.10, −$23.64)	P<0.001
Age				
3–5 (reference for children)	-	-	n/a	n/a
6–12	$77.98 ($28.47, $127.48)	P=0.002	n/a	n/a
13–17	$292.16 ($231.25, $353.07)	P<0.001	n/a	n/a
18–21 (reference for adults)	n/a	n/a	-	-
22–49	n/a	n/a	$10.70 (−$6.84, $28.24)	P=0.232
50–64	n/a	n/a	$281.53 ($242.37, $320.68)	P<0.001
65–75	n/a	n/a	$674.43 ($571.73, $777.12)	P<0.001
76 and older	n/a	n/a	$1,180.87 ($1,068.05, $1,293.69)	P<0.001
Health Insurance Type				
Private including HMO (reference)	-	-	-	-
Medicare	$130.03 (−$285.23, $545.29)	P=0.539	−$80.78 (−$122.14, −$39.43)	P<0.001
Medicaid	−$267.05 (−$339.90, −$194.20)	P<0.001	−$204.87 (−$245.53, −$164.22)	P<0.001
Self-pay	−$310.28 (−$403.95, −$216.60)	P<0.001	−$187.29 (−$225.13, −$149.46)	P<0.001
No charge	−$551.06 (−$691.07, −$411.04)	P<0.001	−$254.58 (−$390.69, −$118.46)	P<0.001
Other	−$109.86 (−$246.44, $26.71)	P=0.115	$12.15 (−$90.74, $115.05)	P=0.817
Median Community income				
$1 – $40,999 (reference)	-	-	-	-
$41,000 – $50,999	−$3.91 (−$76.96, $69.14)	P=0.916	−$26.52 (−$65.89, $12.85)	P=0.187
$51,000 – $66,999	$117.81 ($14.24, $221.38)	P=0.026	$40.68 (−$15.01, $96.37)	P=0.152
$67,000 or more	$195.88 ($79.59, $312.18)	P=0.001	$76.65 ($4.39, $148.91)	P=0.038
Rurality of Patient's County of Residence				
Large central metropolitan (reference)	-	-	-	-
Large fringe metropolitan	−$66.00 (−$174.69, $42.68)	P=0.234	−$199.56 ($305.93, −$93.19)	P<0.001
Medium metropolitan	−$21.84 (−$150.97, $108.30)	P=0.750	−$148.86 (−$265.78, −$31.94)	P=0.013
Small metropolitan	−$119.47 (−$244.23,$5.30)	P=0.061	−$255.09 (−$370.89, −$139.28)	P<0.001
Micropolitan	−$217.57 (−$357.12, −$78.03)	P=0.002	−$367.94 (−$461.47, −$274.41)	P<0.001

	Children Ages 3 to 17 Years		Adults Ages 18 Years and Older	
Model Covariates	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**
Non-core	−$216.75 (−$377.41, −$56.10)	P=0.008	−$415.40 (−$510.86, −$319.95)	P<0.001

TABLE 5

Covariate-Adjusted Logistic Regression Models for Non-Traumatic Dental Condition-Related Emergency Department Admission for U.S. Children and Adults Enrolled in Medicaid

	Children Ages 3 to 17 Years		Adults Ages 18 Years and Older	
Model Covariates	**Odds Ratio and 95% Confidence Intervals**	**P-value**	**Odds Ratio and 95% Confidence Intervals**	**P-value**
ASD Status				
ASD	1.16 (0.92, 1.46)	P=0.198	0.36 (0.24, 0.54)	P<0.001
No ASD (reference)	1.00	-	1.00	-
Sex				
Male (reference)	1.00	-	1.00	-
Female	0.90 (0.87, 0.94)	P<0.001	0.86 (0.83, 0.88)	P<0.001
Age				
3–5 (reference for children)	1.00	-	n/a	n/a
6–12	1.17 (1.11, 1.24)	P<0.001	n/a	n/a
13–17	1.34 (1.27, 1.43)	P<0.001	n/a	n/a
18–21 (reference for adults)	n/a	n/a	1.00	-
22–49	n/a	n/a	1.49 (1.43, 1.55)	P<0.001
50–64	n/a	n/a	0.46 (0.44, 0.49)	P<0.001
65–75	n/a	n/a	0.23 (0.18, 0.28)	P<0.001
76 and older	n/a	n/a	0.12 (0.10, 0.15)	P<0.001
Median Community income				
$1 – $40,999 (reference)	1.00	-	1.00	-
$41,000 – $50,999	0.96 (0.90, 1.02)	P=0.147	1.01 (0.95, 1.07)	P=0.775
$51,000 – $66,999	0.89 (0.83, 0.95)	P=0.001	0.91 (0.85, 0.98)	P<0.011
$67,000 or more	0.82 (0.75, 0.89)	P<0.001	0.83 (0.76, 0.90)	P<0.001
Rurality of Patient's County of Residence				
Large central metropolitan (reference)	1.00	-	1.00	-
Large fringe metropolitan	0.97 (0.88, 1.07)	P=0.522	1.39 (1.22, 1.59)	P<0.001
Medium metropolitan	1.03 (0.93, 1.15)	P=0.563	1.42 (1.24, 1.63)	P<0.001
Small metropolitan	1.09 (0.96, 1.23)	P=0.197	1.61 (1.37, 1.88)	P<0.001
Micropolitan	1.04 (0.94, 1.14)	P=0.479	1.76 (1.53, 2.03)	P<0.001
Non-core	0.95 (0.85,1.06)	P=0.359	1.47 (1.28, 1.68)	P<0.001

TABLE 6

Covariate-Adjusted Linear Regression Models for Non-Traumatic Dental Condition-Related Emergency Department Costs for U.S. Children and Adults Enrolled in Medicaid.

	Medicaid-Enrolled Children Ages 3 to 17 Years		Medicaid-Enrolled Adults Ages 18 years and older	
Model Covariates	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**	**Adjusted Mean Costs and 95% Confidence Intervals**	**P-value**
ASD Status				
ASD	$ 147.67 (−$189.96, $485.30)	P=0.391	$516.01 (−$156.22, $1,188.25)	P=0.132
No ASD (reference)	-	-	-	-
Sex				
Male (reference)	-	-	-	-
Female	−$136.91 (−$185.40, −$88.43)	P<0.001	−$41.38 (−$62.50, −$20.25)	P<0.001
Age				
3–5 (reference for children)	-	-	n/a	n/a
6–12	$22.83 (−$51.87, $97.53)	P=0.549	n/a	n/a
13–17	$132.97 ($52.08, $213.85)	P=0.001	n/a	n/a
18–21 (reference for adults)	n/a	n/a	-	-
22–49	n/a	n/a	$42.22 ($23.15, $61.30)	P<0.001
50–64	n/a	n/a	$289.73 ($236.17, $343.29)	P<0.001
65–75	n/a	n/a	$479.04 ($97.65, $860.42)	P=0.014
76 and older	n/a	n/a	$1,034.97 ($489.67, $1,580.26)	P<0.001
Median community income				
$1 – $40,999 (reference)	-	-	-	-
$41,000 – $50,999	−$27.30 (−$104.51, $49.91)	P=0.488	−$31.43 (−$74.24, $11.37)	P=0.150
$51,000 – $66,999	$107.97 (−$41.87, $257.81)	P=0.158	$4.95 (−$49.16, $59.07)	P=0.857
$67,000 or more	$107.72 (–$31.31, $246.74)	P=0.129	−$35.45 (−$106.53, $35.64)	P=0.328
Rurality of patient’s county of residence				
Large central metropolitan (reference)	-	-	-	-
Large fringe metropolitan	−$103.37 (−$224.39, $17.65)	P=0.094	−$216.03 (−$323.62, −$108.44)	P<0.001
Medium metropolitan	−$62.02 (−$202.61, $78.58)	P=0.387	−146.49 (−$260.97, −$32.02)	P=0.012
Small metropolitan	−$151.69 (−$296.16, −$7.23)	P=0.040	−$262.87 (−$378.72, −$147.02)	P<0.001
Micropolitan	−$225.68 (−$339.86, −$111.49)	P<0.001	−$373.68 (−$470.21, −$277.14)	P<0.001
Non-core	−$225.53 (−$448.74, −$2.31)	P=0.048	−$407.68 (−$503.52, −$311.84)	P<0.001