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# A Serial Cross-sectional Study of Pediatric Inpatient Hospitalizations for Non-traumatic Dental Conditions

## ABSTRACT

Investigators have examined children's dental utilization in various settings (*e.g.*, dental offices, emergency departments, operating rooms), but no studies have examined inpatient hospitalizations for non-traumatic dental conditions (NTDCs). The authors examined NTDC-related hospitalization trends in the United States and identified the relationship between complex chronic condition (CCCs) and NTDC-related inpatient hospitalizations. We analyzed data from the U.S. Nationwide Inpatient Sample (2000-2010) for children ages 3 to 17 years (N = 3,030,970). The predictor variable was number of CCCs (0/1/2+). The outcome variable was whether the child had a NTDC-related hospitalization (no/yes). Covariate-adjusted multivariable logistic regression models were used to estimate prevalence odds ratios (PORs). From 2000 to 2010, there were 17,993 NTDC-related hospitalizations (0.59%) and a slight increase in NTDC-related hospitalizations ($p$ = .049). This increase was not significant in the final regression model. There was no difference in odds of NTDCs for children with 0 or 1 CCCs (POR = 1.08; 95%CI = 0.99, 1.18), but children with 2+ CCCs had significantly greater odds (POR = 1.61; 95%CI = 1.42, 1.83), as did non-White, publicly insured, and lower income children. NTDC-related hospitalizations for children did not increase from 2000 to 2010. Children with 2+ CCCs had the greatest odds of being hospitalized for NTDCs, which highlights the need to develop preventive interventions targeting children with 2+ CCCs.

**KEY WORDS:** children, complex chronic conditions, trends, hospitalization, dental caries, health services research.

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## INTRODUCTION

In 2008, 1.8% of U.S. inpatient hospitalizations were for dental conditions, resulting in $1.2 billion in related costs (Allareddy *et al.*, 2012). Cellulitis (Kim *et al.*, 2012) and periapical abscesses (Allareddy *et al.*, 2010) are dental diagnoses commonly associated with hospitalizations for non-traumatic dental conditions (NTDCs). Over 90% of patients hospitalized for a NTDC present with a co-morbidity (Jundt and Gutta, 2012), which suggests that co-morbidities or chronic conditions are important risk factors for NTDC-related hospitalizations.

NTDCs in children are caused primarily by the sequelae of untreated tooth decay, which can be prevented through early diagnosis and treatment. Only 2 publications have focused on pediatric NTDC-related hospitalizations. A 2010 study reported that 16.8% of facial cellulitis patients under age 20 yrs were hospitalized for cellulitis of odontogenic origin (Thikkurissy *et al.*, 2010). In another study, 9.3% of pediatric emergency department visits for dental problems resulted in hospital admission (Pettinato *et al.*, 2000). Both studies were based on data from single hospitals, and neither included child-level measures of chronic conditions.

To date, no studies have examined U.S. pediatric inpatient hospitalization trends for NTDCs. Furthermore, chronic conditions are related to office-based dental care use for children (Chi *et al.*, 2011; Chi and Raklios, 2012) and may be associated with NTDC-related hospitalizations (Jundt and Gutta, 2012), but this hypothesis has not been empirically evaluated. We examined U.S. pediatric inpatient hospitalization trends for NTDCs and hypothesized that complex chronic conditions (CCCs) and other child-level factors (*e.g.*, age, gender, race, insurance, income) would be associated with NTDC-related hospitalizations.

## METHODS

This was a serial cross-sectional study that conformed to STROBE Guidelines. The analyses focused on U.S. children ages 3 to 17 yrs who were hospitalized between 2000 and 2010 (N = 3,030,970). We excluded children under age 3 yrs because CCCs, particularly developmental disabilities, are not diagnosed until age 3 (Pinto-Martin *et al.*, 2005). In addition, tooth decay is the primary etiology of NTDCs and requires time to develop. Including young children would bias our findings by disproportionately overpopulating the number of children with no NTDCs. We analyzed 11 datasets from the Nationwide Inpatient Sample (NIS), which is part of the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP)

(HCUP, 2013). The NIS is the largest source of U.S. inpatient hospitalization data. The 2010 NIS, the most recent year, includes over 8 million hospital stays across 1,000 hospitals in 45 states. The University of Iowa Institutional Review Board did not require human subjects review or approval for this study.

## Study Variables

### Outcome Variable

The outcome variable was whether the hospitalization involved a NTDC (no/yes). We defined NTDCs using codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) (*e.g.*, 521, 522, 523, 525.3, 525.9, 873.63) (Okunseri *et al.*, 2008) in any diagnostic field.

### Predictor Variable

The main predictor variable was the number of CCCs (0/1/2+). CCCs were based on a non-categorical approach (Stein *et al.*, 1993) and included medical conditions expected to last at least 12 mos and requiring specialized care (Feudtner *et al.*, 2000). This approach is based on ICD-9-CM codes to identify the following types of CCCs: cardiovascular, respiratory, renal, neuromuscular, gastrointestinal, hematology and immunodeficiency, metabolic, other congenital or genetic defect, or malignancies (Feudtner *et al.*, 2000). We examined relevant ICD-9-CM codes from any of the diagnostic fields, aggregated the total number of CCCs for each child, and classified each child as having 0, 1, or 2+ CCCs. Previous pediatric medicine publications have used these methods (Feudtner *et al.*, 2001; Simon *et al.*, 2010).

## Model Covariates

Five additional child-level covariates were hypothesized as being associated with NTDC-related hospitalizations: age, gender, race, insurance type, and income. Age was classified into 3 categories corresponding to developmental dentition periods (3-5, 6-12, and 13-17 yrs). Race was originally a seven-category variable (White/Black/Hispanic/Native American/Pacific Islander or Asian/unknown/missing). Preliminary analyses indicated no differences in hospitalizations for non-Whites. To ease interpretation of our models, we collapsed race into 3 categories: White, non-White, and unknown/missing. Insurance type was a three-category variable: private, public (Medicaid/Medicare), or other (self-pay/no charge). Community income was based on the median income in the child's residential ZIP Code and was a proxy for the child's household income. We used income quartiles. For example, in 2010, we used the following income quartiles: quartile 1 [Q1] ≤ $40,999; Q2 $41,000-$50,999; Q3 $51,000-$66,999; and Q4 ≥ $67,000.

## Statistical Analyses

We generated descriptive statistics and examined bivariate relationships between model covariates and the outcome variable for each year (2000-2010) by using logistic regression models to derive prevalence odds ratios (PORs) ($\alpha = 0.05$). Then we ran 11 separate covariate-adjusted regression models for each NIS year. Finally, we combined the datasets and ran 2 multiple variable logistic regression models, which included a covariate for NIS year. The first regression model was used to examine the main effect of each model covariate. The second regression model was used to test our hypotheses and evaluate whether there was an interaction between CCCs and age. All analyses adjusted for clustering by NIS and hospital stratum to account for the complex survey design. Patient discharge weights were used to generate national estimates (HCUP, 2013). All analyses were completed with the PROC SURVEY LOGISTIC function in SAS Version 9.3 for Windows (SAS Institute Inc., Cary, NC, USA).

# RESULTS

## Descriptive Statistics

From 2000 to 2010, the prevalence of CCCs among hospitalized children in the United States increased from 14.3% to 20.3% (Table 1). The proportion of children with 2+ CCC also increased to 2.5% in 2010 from 1.0% in 2000. Nearly 50% of hospitalized children were ages 13 to 17 yrs, 35% were ages 6 to 12 yrs, and 15% were ages 3 to 5 yrs. In 2000, most hospitalized children were privately insured (53.7%), whereas in 2010 most were publicly insured (47.7%).

In 2000, 0.53% of all U.S. pediatric hospitalizations for children ages 3 to 17 yrs involved NTDCs (Table 1). This increased to 0.65% in 2010. In the bivariate analyses (Table 2), the following factors were associated with increased odds of NTDC-related hospitalizations: CCCs, younger age, male gender, non-White race, non-private health insurance, and low income. Results were similar in the covariate-adjusted models (Table 3).

The most common NTDC diagnosis codes were 521 (diseases of hard tissue of teeth; 37.1%), 522 (diseases of pulp and periapical tissues; 36.8%), 873.63 (internal structures of the mouth; 19.0%), and 523 (gingival and periodontal diseases; 17.0%) (data not shown). The most common non-dental diagnosis codes for children with any CCCs were 780.39 (convulsions; 10.5%), 204.00 (lymphoid leukemia; 9.3%), 343.9 (cerebral palsy; 8.9%), 288.0 (agranulocytosis; 7.3%), and 780.6 (fever; 7.2%).

## Final Regression Models

There was a significant increase in the odds of NTDC-related pediatric inpatient hospitalizations over the 11-year study period (POR = 1.01; 95% CI: 1.01, 1.02) (Table 4), but this increase was not significant in model 2. In model 1, there was no difference in the odds of hospitalization for NTDCs between children with 0 CCCs and those with 1 CCC (POR = 1.08; 95% CI: 0.99, 1.18). Children with 2+ CCCs had a significantly greater odds of NTDC-related hospitalization than those with 0 CCCs (POR = 1.61; 95% CI: 1.42, 1.83) (Table 4). Children ages 13 to 17 yrs and girls were significantly less likely to be hospitalized for NTDCs, whereas non-Whites and non-privately insured children were significantly more likely to be hospitalized for a NTDC. Children living in the highest income communities were significantly less likely to be hospitalized.

**Table 1.** Descriptive Characteristics of Children Ages 3 to 17 yrs (N = 3,030,970) in the U.S. Nationwide Inpatient Sample (NIS) Datasets from 2000 to 2010, N (%)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Outcome Variable** | | | | | | | | | | | |
| Hospitalization for a non-traumatic dental condition | 1,433 (0.53) | 1,393 (0.51) | 1,650 (0.59) | 1,601 (0.55) | 1,772 (0.61) | 2,057 (0.65) | 1,624 (0.62) | 1,695 (0.64) | 1,579 (0.62) | 1,428 (0.57) | 1,761 (0.65) |
| **Main Predictor Variable** | | | | | | | | | | | |
| Complex chronic conditions (CCCs) | | | | | | | | | | | |
| 0 | 233,353 (85.7) | 232,309 (85.1) | 233,720 (83.2) | 249,372 (85.3) | 242,016 (83.4) | 252,980 (79.5) | 220,158 (83.5) | 220,120 (82.7) | 207,348 (81.7) | 205,542 (82.7) | 216,749 (79.7) |
| 1 | 36,184 (13.3) | 37,664 (13.8) | 43,531 (15.5) | 39,594 (13.5) | 43,852 (15.1) | 58,621 (18.4) | 39,788 (15.1) | 41,404 (15.6) | 41,591 (16.4) | 38,303 (15.4) | 48,447 (17.8) |
| 2+ | 2,772 (1.0) | 3,123 (1.1) | 3,639 (1.3) | 3,508 (1.2) | 4,248 (1.5) | 6,573 (2.1) | 3,701 (1.4) | 4,543 (1.7) | 4,776 (1.9) | 4,787 (1.9) | 6,654 (2.5) |
| **Model Covariates** | | | | | | | | | | | |
| Age (yrs) | | | | | | | | | | | |
| 3-5 | 43,767 (16.1) | 46,368 (17.0) | 47,193 (16.8) | 46,927 (16.0) | 48,201 (16.6) | 54,742 (17.2) | 43,463 (16.5) | 43,558 (16.4) | 41,243 (16.3) | 42,493 (17.1) | 45,613 (16.8) |
| 6-12 | 94,081 (34.6) | 95,847 (35.1) | 102,422 (36.5) | 109,058 (37.3) | 104,561 (36.0) | 121,531 (38.2) | 92,945 (32.3) | 89,742 (33.7) | 86,960 (34.3) | 86,960 (35.6) | 98,862 (36.4) |
| 13-17 | 134,461 (49.4) | 130,881 (47.9) | 131,275 (46.7) | 136,489 (46.7) | 137,354 (47.3) | 141,901 (44.6) | 127,239 (48.3) | 132,767 (49.9) | 125,512 (49.5) | 117,589 (47.3) | 127,375 (46.9) |
| Gender | | | | | | | | | | | |
| Male | 123,611 (45.4) | 127,147 (46.6) | 130,427 (46.4) | 133,507 (45.7) | 133,384 (46.0) | 148,863 (46.8) | 119,923 (45.5) | 121,123 (45.5) | 116,527 (45.9) | 114,566 (46.1) | 129,340 (47.6) |
| Female | 148,650 (54.6) | 145,934 (53.4) | 150,455 (53.6) | 154,076 (52.7) | 152,341 (52.5) | 165,529 (52.0) | 139,739 (53.0) | 141,248 (53.1) | 133,489 (52.6) | 130,103 (52.3) | 139,520 (51.3) |
| Race | | | | | | | | | | | |
| White | 117,330 (43.1) | 114,142 (41.8) | 104,846 (37.3) | 112,517 (38.5) | 117,700 (40.6) | 114,463 (36.0) | 101,529 (38.5) | 93,176 (35.0) | 108,300 (42.7) | 107,903 (43.4) | 123,910 (45.6) |
| Non-White | 90,744 (33.3) | 95,238 (34.8) | 103,705 (36.9) | 101,290 (34.6) | 103,260 (35.6) | 99,082 (31.1) | 90,824 (34.5) | 89,548 (33.7) | 93,085 (36.7) | 973,50 (39.1) | 116,574 (42.9) |
| Unknown | 64,235 (23.6) | 63,716 (23.3) | 72,339 (25.8) | 78,667 (26.9) | 69156 (23.8) | 104,629 (32.9) | 71,294 (27.0) | 83,343 (31.3) | 52,330 (20.6) | 43,379 (17.5) | 31,366 (11.5) |
| Insurance Type | | | | | | | | | | | |
| Private | 146,662 (53.7) | 146,977 (53.8) | 147,058 (52.4) | 148,914 (50.9) | 140,866 (48.6) | 159,438 (50.1) | 128,335 (48.7) | 123,888 (46.6) | 121,975 (48.1) | 112,836 (45.4) | 120,597 (44.4) |
| Public | 101,547 (37.3) | 102,592 (37.6) | 110,740 (39.4) | 119,227 (40.8) | 122,120 (42.1) | 129,375 (40.7) | 113,252 (43.0) | 116,855 (43.9) | 112,761 (44.4) | 115,271 (46.3) | 129,708 (47.7) |
| Other | 22,787 (8.4) | 22,674 (8.3) | 22,440 (8.0) | 23,710 (8.1) | 26,538 (9.2) | 29,040 (9.1) | 21,678 (8.2) | 24,442 (9.2) | 18,393 (7.3) | 19,893 (8.0) | 20,956 (7.7) |
| Mean Community Income (Quartile) | | | | | | | | | | | |
| Q1 | 31,503 (11.6) | 20,755 (7.6) | 17,584 (6.3) | 91,596 (31.3) | 96,237 (33.2) | 88,997 (28.0) | 81,676 (31.0) | 86,716 (32.6) | 80,865 (31.9) | 74,516 (30.0) | 81,262 (29.9) |
| Q2 | 83,872 (30.8) | 67,543 (24.7) | 59,520 (21.2) | 74,780 (25.6) | 72,661 (25.1) | 74,994 (23.6) | 63,634 (24.1) | 63,946 (24.0) | 63,224 (24.9) | 62,705 (25.2) | 65,704 (24.2) |
| Q3 | 65,704 (25.0) | 70,841 (25.9) | 73,455 (26.2) | 66,458 (22.7) | 56,910 (19.6) | 73,447 (23.1) | 57,216 (21.7) | 54,756 (20.6) | 52,627 (20.7) | 54,310 (21.8) | 63,429 (23.3) |
| Q4 | 83,475 (30.7) | 111,005 (40.7) | 123,604 (44.0) | 53,169 (18.2) | 58,104 (20.0) | 72,198 (22.7) | 54,887 (20.8) | 53,053 (19.9) | 52,596 (20.7) | 48,566 (19.5) | 54,495 (20.0) |

In model 2, which included an interaction term between CCCs and age, children ages 13 to 17 yrs with 0 CCCs or 1 CCC were less likely to be hospitalized for NTDCs than were children ages 3 to 5 yrs with no CCC (Table 4). Compared with children ages 3 to 5 yrs with no CCC, children ages 3 to 5 yrs and those ages 6 to 12 yrs with 2+ CCCs were significantly more likely to be hospitalized for NTDCs.

## DISCUSSION

This is the first published study to examine pediatric inpatient hospitalizations for non-traumatic dental conditions (NTDCs). We analyzed U.S. National Inpatient Sample data from 2000 to 2010 to: (1) evaluate whether there were increases in NTDCs; (2) examine whether complex chronic conditions (CCCs) were

**Table 2.** Bivariate Statistics from Unadjusted Logistic Regression Models[1] Indicating Factors Associated with Non-traumatic Dental Condition-related Hospitalizations for U.S. Children Ages 3 to 17 yrs with Prevalence Odds Ratios[2]

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Main Predictor Variable** | | | | | | | | | | | |
| Complex chronic conditions (CCCs) | | | | | | | | | | | |
| 0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 1 | **1.21*** | 1.12 | **1.18*** | 1.19 | 1.08 | 1.21 | 1.11 | **1.31*** | **1.35**** | **1.26*** | 1.05 |
| 2+ | **2.43***** | 1.39 | **2.08***** | **1.74**** | **1.56*** | **1.98***** | **1.96***** | **1.63*** | **1.94***** | **2.01**** | **1.82***** |
| **Model Covariates** | | | | | | | | | | | |
| Age (yrs) | | | | | | | | | | | |
| 3-5 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 6-12 | 0.96 | **0.86*** | 0.98 | 1.01 | **1.21**** | 1.00 | 1.08 | 1.01 | 0.90 | 0.94 | 0.97 |
| 13-17 | **0.44***** | **0.48***** | **0.48***** | **0.61***** | **0.66***** | **0.53***** | **0.62***** | **0.55***** | **0.49***** | **0.55***** | **0.59***** |
| Gender | | | | | | | | | | | |
| Male | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Female | **0.62***** | **0.69***** | **0.63***** | **0.68***** | **0.64***** | **0.65***** | **0.61***** | **0.70***** | **0.74***** | **0.67***** | **0.74***** |
| Race | | | | | | | | | | | |
| White | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-White | **1.20*** | 1.18 | **1.27**** | 1.13 | 1.17 | **1.23**** | 1.16 | 1.16 | **1.44***** | **1.33**** | **1.30***** |
| Unknown | 0.96 | 0.86 | 1.01 | 0.93 | 0.93 | 1.07 | 0.90 | 0.99 | 1.02 | 0.83 | 0.82 |
| Insurance Type | | | | | | | | | | | |
| Private | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Public | **1.23**** | **1.34***** | **1.54***** | **1.33***** | **1.47***** | **1.47***** | **1.39***** | **1.25**** | **1.38***** | **1.38***** | **1.53***** |
| Other | 1.13 | 1.16 | **1.82***** | **1.77***** | **1.56***** | **1.42***** | **1.52***** | **1.57***** | 1.16 | **1.82***** | **1.47***** |
| Mean community income (Quartile) | | | | | | | | | | | |
| Q1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Q2 | **0.68***** | 1.15 | 1.18 | 0.96 | 0.95 | 0.91 | 0.88 | 1.03 | 1.07 | 0.90 | **0.81*** |
| Q3 | **0.67***** | 1.03 | 1.29 | **0.79**** | 0.85 | **0.79**** | 0.92 | **0.81**** | 0.92 | 0.87 | **0.81*** |
| Q4 | **0.68**** | 0.87 | 1.04 | **0.59***** | **0.66***** | **0.73***** | **0.68***** | **0.79*** | 0.83 | **0.76***** | **0.66***** |

[1]Regression models unadjusted for covariates but adjusted for NIS strata, hospital clustering, and patient discharge weights.
[2]Nationally representative estimates.
*$p \geq .01$ to $p < .05$.
**$p \geq .001$ to $p < .01$.
***$p < .001$.

positively associated with hospitalizations for NTDCs; and (3) identify the other factors associated with NTDC-related hospitalizations. We present our main findings below.

First, there was no significant increase in the odds of NTDC-related pediatric inpatient hospitalizations in the United States from 2000 to 2010. Thus, we failed to reject the hypothesis of no increase in NTDC-related hospitalizations. This finding parallels pediatric utilization of emergency departments for dental problems from 2001 to 2008 (Lee *et al.*, 2012). One explanation is that office-based dental care utilization rates for children ages 2 to 20 yrs in the United States increased to 77% in 2010 from 71.8% in 1997 (Wall *et al.*, 2012). Larger proportions of children have access to preventive and restorative dental care services, which may alleviate some demand for hospital-based dental care. However, in light of our current findings, increases in office-based dental care have not reduced NTDC-related inpatient hospitalizations. While the causes for NTDCs are varied, these findings call for improvements in the quality, appropriateness, and timeliness of office-based dental care provided to children. State-level variation in the use of dental care services (Choi *et al.*, 2011) may lead to differences in NTDC-related hospitalizations across states. Future studies should examine state-level variation to identify the states in which NTDC-related hospitalizations have decreased over time and the factors associated with these decreases.

Second, compared with children without CCCs, children with 2+ CCCs had a significantly greater odds of hospitalization for NTDCs, whereas children with 1 CCC were not more likely to be hospitalized for NTDCs. Thus, we rejected the hypothesis of no difference in NTDC-related hospitalizations by number of CCCs. The absence of a CCC-based gradient (*i.e.*, greater odds of NTDC-related hospitalization for children more CCCs) is consistent with previous findings from the dental literature (Beil *et al.*, 2009; Chi *et al.*, 2011a; Iida and Lewis, 2012). On the surface, these findings suggest that children with single CCCs are not different from children with no CCCs in terms of odds of NTDC-related inpatient hospitalizations. However, children with CCCs are different from children with no CCCs in 2 important ways. First, children with CCCs with a NTDC-related hospitalization most commonly received cancer chemotherapeutics (ICD-9-CM code 99.25) and packed cell transfusions (99.04). Tooth extraction (23.09 and 23.19) was the most common procedure for children with no CCCs, but was third for children with 1 CCC and fourth for children with 2+ CCCs. Thus, cancer

**Table 3.** Covariate-adjusted Logistic Regression Models[1] on Non-traumatic Dental Condition-related Hospitalizations for U.S. Children Ages 3 to 17 yrs with Prevalence Odds Ratios[2]

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Main Predictor Variable** | | | | | | | | | | | |
| Complex chronic conditions (CCCs) | | | | | | | | | | | |
| 0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 1 | 1.03 | 0.98 | 1.07 | 1.07 | 0.95 | 1.13 | 1.02 | 1.20 | 1.21 | 1.18 | 0.96 |
| 2+ | **2.04**** | 1.18 | **1.71**** | **1.55*** | 1.31 | **1.72**** | **1.70***** | 1.42 | **1.58***** | **1.77*** | **1.62***** |
| **Model Covariates** | | | | | | | | | | | |
| Age (yrs) | | | | | | | | | | | |
| 3-5 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 6-12 | 0.94 | **0.86*** | 0.98 | 1.02 | **1.23**** | 1.02 | 1.07 | 1.03 | 0.93 | 0.95 | 0.99 |
| 13-17 | **0.48***** | **0.50***** | **0.53***** | **0.63***** | **0.70***** | **0.57***** | **0.67***** | **0.58***** | **0.53***** | **0.60***** | **0.63***** |
| Gender | | | | | | | | | | | |
| Male | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Female | **0.70***** | **0.77***** | **0.70***** | **0.73***** | **0.69***** | **0.70***** | **0.65***** | **0.77***** | **0.82***** | **0.73***** | **0.79***** |
| Race | | | | | | | | | | | |
| White | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-White | 1.03 | 1.07 | 1.11 | 0.99 | 1.02 | 1.08 | 1.02 | 1.06 | **1.37***** | 1.16 | 1.13 |
| Unknown | 0.91 | 0.88 | 1.01 | 0.96 | 0.91 | 1.01 | 0.89 | 1.00 | 1.04 | 0.85 | 0.82 |
| Insurance Type | | | | | | | | | | | |
| Private | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Public | **1.23**** | **1.29***** | **1.54***** | **1.25**** | **1.41***** | **1.40***** | **1.31***** | **1.20**** | **1.29*** | **1.26**** | **1.38***** |
| Other | 1.16 | 1.15 | **1.82***** | **1.73***** | **1.53***** | **1.36***** | **1.39***** | **1.46***** | 1.08 | **1.67***** | **1.42***** |
| Mean community income (Quartile) | | | | | | | | | | | |
| Q1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Q2 | **0.71**** | 1.19 | 1.27 | 0.98 | 1.01 | 0.95 | 0.92 | 1.06 | **1.17*** | 0.95 | 0.86 |
| Q3 | **0.72**** | 1.11 | **1.46**** | **0.84*** | 0.94 | **0.84*** | 0.98 | **0.83*** | 1.02 | 0.93 | 0.88 |
| Q4 | **0.73*** | 0.96 | 1.25 | **0.64***** | **0.76**** | **0.81*** | **0.77**** | 0.85 | 0.99 | 0.86 | **0.76*** |

[1]Regression models adjusted for NIS strata, hospital clustering, and patient discharge weights.
[2]Nationally representative estimates.
*$p \geq .01$ to $p < .05$.
**$p \geq .001$ to $p < .01$.
***$p < .001$.

appears to be related to hospitalizations for NTDCs for children with any CCCs (further supported by the finding that lymphoid leukemia is the second most common non-dental diagnosis for children with CCCs), whereas tooth decay is the main driver of NTDC-related hospitalizations for children without CCCs. Second, the mean length of stay for children with a NTDC-related hospitalization was 4.3 days for those with no CCC and 8.1 and 11.0 days, respectively, for children with 1 or 2+ CCCs. Broadly, these findings suggest that the odds of NTDC-related hospitalization, as well as predictors and outcomes associated with hospitalizations, are different for children with and those without CCCs.

Children with CCCs are at risk for recurrent hospitalizations for systemic health problems (Berry *et al.*, 2011), during which time NTDCs may become problematic. A shortage of outpatient hospital dental facilities for children with CCCs (Kerins *et al.*, 2011) and concerns about patient safety may translate to the management of NTDCs within inpatient settings for children with CCCs. Furthermore, our models revealed that children ages 3 to 12 yrs with 2+ CCCs have the greatest odds for NTDC-related hospitalizations, which supports targeted preventive policies and clinical interventions. Future work should continue to examine the role of CCCs and identify the subgroups of children at greatest risk for NTDC-related hospitalizations.

Third, there were 4 additional factors related to hospitalizations for NTDCs: gender, race, insurance type, and income. Across all 11 yrs and in the regression models, boys had greater odds of hospitalization for NTDCs than girls. Previous work has demonstrated that boys are at greater risk for dental and orofacial trauma-related hospitalizations (Nalliah *et al.*, 2012), but our outcome measure excluded trauma. The reasons for our findings are unclear. A possible explanation is higher rates of untreated tooth decay among boys (Dye *et al.*, 2007). Future work should examine underlying causes of gender-based disparities in dental disease and NTDC-related hospitalizations. The other 3 factors related to hospitalization for NTDCs (non-White race, non-private health insurance, low income) are consistent with previous findings that social disadvantage and poverty are related to dental disease (Sohn *et al.*, 2007; Telford *et al.*, 2011; Fisher-Owens *et al.*, 2013).

Broadly, our findings have important implications for future research and the development of policies and interventions aimed at reducing inpatient hospitalizations for NTDCs. Studies to date have focused on office-, emergency department-, and operating

**Table 4.** Final Covariate-adjusted Multiple Variable Logistic Regression Models[1] on Non-traumatic Dental Condition-related Hospitalizations for U.S. Children Ages 3 to 17 yrs with Prevalence Odds Ratios[2] and Corresponding 95% Confidence Intervals

| | Final Model 1 Main Effects Model | | Final Model 2 Main Effects Model with Interaction Term between CCCs and Age | |
|---|---|---|---|---|
| | Prevalence Odds Ratio | 95% CI | Prevalence Odds Ratio | 95% CI |
| **Main Predictor Variable** | | | | |
| Complex chronic conditions (CCCs) | | | | |
| 0 | 1.00 | – | – | – |
| 1 | 1.08 | 0.99, 1.18 | – | – |
| 2+ | **1.61** | **1.42, 1.83** | – | – |
| **Model Covariates** | | | | |
| NIS Data Year | **1.01** | **1.01, 1.02** | 1.01 | 0.99, 1.02 |
| Age (yrs) | | | | |
| 3-5 | 1.00 | – | – | – |
| 6-12 | 1.00 | 0.95, 1.05 | – | – |
| 13-17 | **0.58** | **0.55, 0.61** | – | – |
| Gender | | | | |
| Male | 1.00 | – | 1.00 | – |
| Female | **0.73** | **0.70, 0.76** | **0.73** | **0.71, 0.76** |
| Race | | | | |
| White | 1.00 | – | 1.00 | – |
| Non-White | **1.10** | **1.02, 1.18** | **1.10** | **1.02, 1.18** |
| Unknown | 0.96 | 0.88, 1.05 | 0.96 | 0.88, 1.05 |
| Insurance Type | | | | |
| Private | 1.00 | – | 1.00 | – |
| Public | **1.33** | **1.26, 1.40** | **1.33** | **1.26, 1.40** |
| Other | **1.44** | **1.34, 1.53** | **1.44** | **1.35, 1.54** |
| Mean community income (Quartile) | | | | |
| Q1 | 1.00 | – | 1.00 | – |
| Q2 | 0.97 | 0.91, 1.03 | 0.97 | 0.91, 1.03 |
| Q3 | **0.92** | **0.86, 0.99** | **0.92** | **0.86, 0.99** |
| Q4 | **0.83** | **0.76, 0.90** | **0.83** | **0.76, 0.90** |
| Interaction between CCCs x age (yrs) | | | | |
| 0 CCC x age 3-5 | – | – | 1.00 | – |
| 0 CCC x age 6-12 | – | – | 0.98 | 0.95, 1.01 |
| 0 CCC x age 13-17 | – | – | **0.55** | **0.53, 0.57** |
| 1 CCC x age 3-5 | – | – | 0.98 | 0.93, 1.04 |
| 1 CCC x age 6-12 | – | – | 1.02 | 0.88, 1.17 |
| 1 CCC x age 13-17 | – | – | **0.69** | **0.59, 0.80** |
| 2+ CCCs x age 3-5 | – | – | **1.23** | **1.11, 1.36** |
| 2+ CCCs x age 6-12 | – | – | **1.65** | **1.28, 2.13** |
| 2+ CCCs x age 13-17 | – | – | 1.06 | 0.82, 1.37 |

[1]Regression models adjusted for NIS strata, hospital clustering, and patient discharge weights.
[2]Nationally representative estimates.

room–based dental care utilization for children and have overlooked inpatient hospitalization, which is the most costly method of managing caries-related dental problems (Allareddy *et al.*, 2012). *Post hoc* analyses indicated that the average total charge for children with a NTDC-related hospitalization was $25,211 (compared with $18,061 for non-NTDC-related hospitalizations). Over the 11-year period, NTDC-related hospitalizations cost nearly $500 million. Additional research is needed to monitor costs associated with hospitalizations for NTDCs. These data will play a critical role in the development of Federal and state dental health policies aimed at improving the oral health of children. In addition, NTDC-related hospitalization rates may be a useful benchmark for tracking the quality of health plans or systems and could be incorporated into national performance measures such as the Healthcare Effectiveness Data and Information Set (HEDIS) (NCQA, 2013). While additional research is warranted before interventions can be developed, our findings support targeted preventive and behavioral interventions that focus on children at the greatest risk for NTDC-related hospitalization, including children with multiple CCCs. Such interventions will involve children and their caregivers as well as dentists, medical specialists, and other members of the health care team.

Our study had limitations. First, we were unable to identify the specific reasons for the NTDC-related inpatient hospitalizations. Some children may have been admitted through the emergency department because of cellulitis, while others may have been transferred from an outpatient clinic or admitted for post-general anesthesia monitoring. Future studies should examine the reasons for NTDC-related hospitalizations. Second, not all states are included in the NIS. However, the 2010 NIS dataset included 45 states, and the hospitals are nationally representative (HCUP, 2013). Third, our models included child-level covariates but did not include child-level behavioral or area-level social determinants. Future work should consider merging other available datasets (*e.g.*, U.S. Census Bureau Area Resource Files) with the NIS data and collecting primary data. Fourth, the income variable was not a direct measure of child-level household income but a proxy based on the child's residential ZIP Code. Fifth, our analyses were cross-sectional and based on secondary data. Despite these limitations, this study on pediatric inpatient hospitalizations for NTDCs is an important first step in reducing oral health disparities for children at risk for NTDC-related hospitalizations.

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