# Trends in paediatric dental caries by poverty status in the United States, 1988–1994 and 1999–2004

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**Background.** Recent reports have suggested that dental caries among some young children is increasing in the United States.

**Aim.** To describe changes in paediatric caries prevalence by poverty status in the United States.

**Design.** National Health and Nutrition Examination Survey (NHANES) data for children aged 2–11 years for 1988–1994 and 1999–2004 were used.

**Results.** Caries in the primary dentition increased among poor and non-poor boys aged 2–8 years (45–53% and 23–31%, respectively) and among non-poor boys aged 2–5 years (13–21%) from

#### Introduction

Although the Surgeon General's Report on Oral Health described important improvements in dental caries prevalence over the past 50 years, significant disparities have persisted socio-demographic groups, between kev including between those who live in poverty and those who do not<sup>1</sup>. Dental caries continues to be the most common chronic disease of childhood in the United States. Asthma, a common chronic medical condition in US children. affected 6% of children aged 0-4 years and 10% of children aged 11-17 years in 2003- $2005^2$ . During 1999–2004, the prevalence of dental caries was 24% for children aged 2-4 years and 51% for 12–15 year-olds<sup>3</sup>.

Since the 1960s, information from national health examination surveys has been used to

1988–1994 to 1999–2004. Caries experience also increased on buccal-lingual, mesio-distal, and occlusal primary dental surfaces among poor children aged 2–8 years and this increase may be attributed to an increase in the number of dental surfaces restored. In the mixed dentition, caries remains relatively unchanged. Caries continues to decline in the permanent dentition for many children, but is increasing among poor non-Hispanic whites aged 6–8 years (8–22%) and poor Mexican-Americans aged 9–11 years (38–55%).

**Conclusions.** For many older children, caries continues to decline or remain unchanged. Nevertheless, for a subgroup of younger children, caries is increasing and this increase is impacting some traditionally low-risk groups of children.

demonstrate a decline in dental caries among children in the United States. Nevertheless, recent findings have suggested that the decline in dental caries has not been consistent among all children. For instance, a comparison between the third National Health and Nutrition Examination Survey (NHANES), 1988-1994 and NHANES 1999-2004 showed that dental caries prevalence increased in the primary dentition from 24 28% among 2–5 year-olds, remained to unchanged in the mixed dentition among 6-8 year-olds (52-53%), and decreased in the permanent dentition from 57 to 51% among 12–15 year-olds<sup>3</sup>. Nevertheless, this report did not assess changes in caries prevalence among children by poverty status.

The increase in caries prevalence among preschool children is particularly disturbing as one of the best predictors for future tooth decay is the presence of current caries or evidence of past caries in the form of existing restorations<sup>4–6</sup>. Understanding dental caries trends within youth socio-demographic

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groups is an important first step towards identifying key factors that are promoting early childhood caries in the US. An earlier systematic review of the literature concluded that there was a consistent inverse relationship between dental caries prevalence and socio-economic status (SES), where children in families of low SES have a higher prevalence of dental caries compared with children in families of high SES, especially for children younger than 12 years<sup>7</sup>.

The association between oral health status and poverty has recently been raised as an important topic for further discussion and study<sup>8</sup>. Because poverty is an important factor affecting caries disparity in the US, the main aim of this report is to describe dental caries trends by poverty status for children. This study is the first that documents trends in paediatric caries by poverty status for children comparing nationally representative data collected from 1988–1994 and 1999-2004. dental Changes in caries experience, untreated dental caries and dental caries severity are presented and discussed.

## Methods

#### Data source

Data from NHANES III, which was conducted during 1988–1994, and from NHANES 1999– 2004, were used for this study. Both survey periods used a stratified, multistage sampling design to obtain a representative probability sample of the civilian, noninstitutionalized population of the United States. Data for both surveys were collected via in-home interviews with health examinations and laboratory tests conducted in mobile examination centres (MEC). The home interviews included an extensive questionnaire that assessed a variety of socio-demographic characteristics and numerous health issues, including oral health.

Oral health examinations in both surveys followed essentially the same protocol for topic areas common to both survey periods. Survey participants aged 2 years and older were examined by a trained dentist in the MEC. The dental exam was conducted under artificial light with a nonmagnifying mirror and a dental explorer; dental surfaces were dried with compressed air as needed. Assessments for dental caries and restorations were made at the tooth surface level and conformed to Radike's criteria with minor modifications. In brief, a dental surface was considered carious if an untreated cavitated lesion was detected. Additional information on survey sample design, informed consent, or on the NHANES dental examination protocols are available elsewhere<sup>9–12</sup>.

## Study population

For this study, we used information on 13,168 children aged 2–11 years who participated in either NHANES III or NHANES 1999–2004. Participants were required to have information on poverty and to have completed an oral health exam to be included in the analytical sample. There were 14,406 children who completed a home questionnaire during the NHANES surveys and among these children, 13,168 completed an oral health exam. Data from 7572 children participating in NHANES III and from 5596 children participating in NHANES 1999–2004 were used in the analyses for this report. Selected sample sizes are presented in the Appendix.

## Variables

Dental caries status was analysed as untreated caries, caries experience which included untreated caries and filled teeth, and severe caries defined as the presence of three or more teeth with carious lesions. In addition, caries experience also was analysed using the dfs/DFS index where 'd/D' represents the number of diseased primary/permanent tooth surfaces and 'f/F' represents the number of filled (restored) primary/permanent tooth surfaces. Information from buccal-lingual, mesio-distal, and occlusal dental surfaces was used. Dental caries status is presented for the primary, mixed, and permanent dentitions.

Basic demographic variables included age, gender, and race/ethnicity. Age was collected in single years and categorized in groups following the children's dentition status: primary dentition from 2 to 8 years of age (2–5 and 6–8 year olds), mixed dentition from 6 to 11 years of age (6–8 and 9–11 year olds), and permanent dentition from 6 to 11 years of age (6–8 and 9–11 year olds). Race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, and Mexican-American.

Poverty level was used as the indicator of SES. Poverty level is defined by the ratio of family income to the Federal Poverty Level (FPL), which is a threshold of family income that varies by family size and calendar year. For example, in 2004 the poverty threshold for a family of four was \$19,223. This means that a 2004 survey participant with this family income and this family size was classified to be at 100% of the poverty level. For consistency, poverty was defined as poor (0–99% FPL), near-poor (100–199% FPL), and non-poor (200% FPL and higher) following previously published reports<sup>3,13</sup>.

# Data analysis

The analytical approach used in this report was comparable to methods used in a previously published report on oral health trends in the US<sup>3</sup>. Estimates were age adjusted using single years of age to the 2000 US population to account for changes in population distribution between the two periods of data collection. Estimates with a relative standard error greater than 30% were considered data statistically unreliable (DSU) nonreportable. Statistical analyses and included bivariate distributions: differences between groups were established with double tailed *t*-tests at the 0.05 alpha level. Tests were conducted without adjustment for other socio-demographic factors, except for age adjustment as previously described. All estimates included the sample weights provided in the datasets to obtain national representation by accounting for over-sampling and nonresponse. Standard errors were calculated using SUDAAN (version 9.0: Research Triangle Institute, Research Triangle Park, NC, USA), a statistical package that takes into consideration the surveys' complex sample design.

## Results

Table 1 presents dental caries trends in the primary dentition for children aged 2-8 years stratified by poverty status. Although the overall prevalence of dental caries experience did not significantly change between 1988-1994 and 1999-2004 (35 vs 38%), for poor children, dental caries experience significantly increased from 46 to 52% during the same period. Caries experience significantly increased for all boys aged 2-8 years (33 vs 41%), but remained unchanged for similarly aged girls during the same period (36%). Among the boys, caries experience significantly increased for the poor (45 vs 53%) and for the non-poor (23 vs 31%). Although the prevalence of caries experience was higher for poor and non-poor boys when stratified by age (2-5 and 6-8 years) during 1999-2004 compared with 1988–1994, the difference only reached statistical significance among non-poor boys aged 2-5 years (13 vs 21%).

Untreated dental caries remained statistically unchanged for children aged 2-8 years between 1988-1994 and 1999-2004 (22 vs 24%). Although the prevalence of untreated caries did not significantly increase for all boys, it did significantly increase for non-poor boys (10 vs 17%). A significant increase in untreated caries also was observed for nonpoor boys aged 2-5 years (8 vs 14%) and those aged 6-8 years (13 vs 21%). For all girls aged 2-8 years, untreated caries remained unchanged and no significant changes were observed by age and poverty. Although the prevalence of untreated overall caries remained nearly unchanged among non-Hispanic white children aged 2-8 years (17 vs 20%), a significant increase in untreated disease was observed for non-Hispanic white children who were non-poor and 2-5 years old (8 vs 12%).

The third part of Table 1 shows that the prevalence of severe untreated dental caries remained unchanged between 1988–1994 and 1999–2004 (10%) for children aged 2–8 years. For non-poor children aged 6–8 years, however, severe disease significantly increased from 4 to 7% during the same period. This increase was observed for

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		Total				Males				Female	ş			Mexica	n-Am	erican		Non-Hi	spani	c Black	~	Non-H	ispani	c Whi	e
	Poverty	1988- 1994		1999– 2004		1988– 1994		1999– 2004		1988– 1994		1999– 2004		1988– 1994		1999– 2004		1988– 1994		1999– 2004		1988– 1994		1999–2	2004
Category	Status	%	SE	%	SE	%	SE	%	SE	%	N N	%	SE	%	E E	%	SE	%	SE	%	SE	%	SE	%	SE
Caries experie	ance																								
2–5 years	Poor	35.5	2.4	41.8	2.3	34.6	3.1	42.0	3.2	36.2	2.9 4	t1.6	3.2	45.6	2.0	50.2	3.2	32.5	2.3	37.4	3.3	29.7	4.7	41.7	4.7
	Near-poor	29.1	2.1	30.4	3.2	30.5	3.2	31.8	4.0	27.5	2.2 2	29.1	3.7	42.8	3.6	11.8	4.0	32.6	2.9	27.5	4.3	24.3	2.8	26.6	4.7
	Non-poor	14.0	1.2	17.8	1.5	12.9	1.5	21.1	3.0*	15.3	2.2	14.5	1.9	24.3	8.4	26.5	3.5	18.7	2.5	23.3	2.8	12.6	1.4	17.1	1.9
6–8 years	Poor	60.6	2.2	65.7	3.2	59.3	4.6	67.2	3.9	62.5	4.5	54.3 4	4.4	68.1	8.8	59.8	3.6	49.5	3.6	55.7	3.6*	59.9	5.4	66.0	5.8
	Near-poor	54.0	4.0	61.1	3.5	54.1	6.6	60.6	3.9	53.9	6.5	51.7 (	5.5	68.5	5.0	52.5	4.5	53.1	5.3	48.3	4.0	49.4	5.9	63.2	5.1
	Non-poor	38.4	3.5	39.4	3.5	35.3	4.9	43.4	4.2	42.3	4.3	35.8	6.8	49.8	5.2	59.9	5.8	39.9	5.6	44.9	3.3	37.5	3.9	37.8	4.3
Total	Poor	46.4	1.6	52.3	2.3*	45.4	2.4	53.0	3.0*	47.6	2.8	51.5	2.6	55.4	2.1	58.7	2.7	39.9	2.3	49.7	2.5*	42.8	3.3	52.3	4.2
	Near-poor	39.9	1.7	43.8	2.7	40.8	2.9	44.3	3.2	39.0	3.0	t3.3	9.9	54.0	4.8	50.8	с. С.	41.5	3.0	36.5	3.2	35.2	2.5	42.5	8. 0.00
	Non-poor	24.6	1.8	27.2	2.0	22.7	2.6	30.8	2.4*	27.0	2.2	23.7	2.0	35.4	2.6	41.0	3.5	27.9	3.2	32.7	2.4	23.4	2.0	26.1	2.1
	Total	34.8	1.1	38.2	1.5	33.3	1.6	40.6	2.0*	36.3	1.6	35.7	1.8	50.7	1.5	51.7	1.9	37.4	1.6	41.1	1.8	29.9	1.4	34.4	2.2
Untreated car	ies																								
2–5 years	Poor	30.1	2.6	31.3	1.9	30.6	3.0	30.5	2.6	29.4	2.8	32.4	8 <sup>.0</sup>	39.7	2.4	39.0	2.9	28.1	2.1	29.1	3.1	25.0	4.5	30.4	4.1
	Near-poor	24.5	2.1	23.1	3.0	26.5	3.3	24.4	3.9	22.1	2.3	21.8	3.2	36.8	€. 	30.8	3.6	26.6	2.6	20.9	4.1	20.3	3.0	19.6	4.1
	Non-poor	9.3	0.9	12.9	1.2	8.3	1.1	14.4	2.4*	10.3	1.7	1.1	1.5	19.1	4.0	18.4	2.7	16.3	2.6	18.3	2.9	8.0	1.1	12.2	1.5*
6–8 years	Poor	45.6	2.9	39.3	2.4	43.5	5.3	40.6	3.5	48.0	5.6	39.4	.00 0.00	55.4	4.0	41.2	8 <sup>.0</sup> *	38.0	3.6	47.1	3.1	43.5	5.8	38.1	4.4
	Near-poor	28.4	3.1	35.2	4.1	29.1	4.3	32.6	5.3	27.4	4.8	39.0	7.1	42.6	<u>.</u> ,	34.8	4.6	35.3	5.8	30.5	4.4	22.3	4.8	35.5	6.4
	Non-poor	14.7	2.4	17.5	2.1	13.0	2.3	20.7	3.0*	17.2	3.6	14.6	2.3	23.5	0.0	30.0	5.6	24.1	00. 00.	28.0	3.1	13.1	2.7	15.1	2.9
Total	Poor	36.8	2.0	34.8	1.8	36.2	2.9	34.9	2.5	37.5		35.4	2.3	46.5	2.6 4	10.0	2.1	32.4	2.4	36.9	2.4	33.0	3.9	33.7	Э.Э
	Near-poor	26.2	1.6	28.4	3.0	27.7	2.4	28.0	3.8 .0	24.4	2.3	6.93	8.00	39.3	9.0	32.5	.1	30.4	3.4	25.1	3.3	21.2	2.4	26.5	4.5
	Non-poor	11.6	1.2	14.9	1.2	10.3	1.1	17.1	2.1*	13.3	2.0	12.6	1.3	21.0	0.0	23.4	8.4	19.7	2.4	22.5	2.3	10.2	1.3	13.5	1.5
	Total	22.3	1.0	23.7	1.4	21.4	1.1	24.8	2.0	23.4	1.4	22.6	1.5	39.5	9.	33.8	1.8*	28.5	1.4	28.9	1.7	16.7	1.3	20.1	2.1
Severe caries																									
2–5 years	Poor	15.9	1.9	16.0	2.0	15.8	2.5	14.7	2.4	15.9	2.3	17.6	2.9	20.1	. 7	16.9	2.8	14.4	1.6	12.7	2.6	13.1	3.2	16.9	3.5
	Near-poor	13.1	1.8	13.4	2.5	13.4	2.8	11.6	2.7	12.9	2.0	15.2	2.9	20.8	. 2.8	16.9	8.1	11.5	2.1	10.9	2.4	10.1	2.0	10.4	8. 8
	Non-poor	3.3	0.6	3.6	0.8	Э.Э	0.8	I	Ι	I	1	4.2	1.2	7.9	2.4	4.2	1.4	5.4	1.0	8.7	2.2	2.3	0.7	3.0	0.9
6–8 years	Poor	22.7	3.4	16.3	2.0	18.9	2.9	15.3	2.6	26.6	5.5	I6.9	8 <sup>.0</sup>	29.6	₩.	18.9	2.6*	13.8	2.7	20.5	2.7	18.1	3.9	13.1	4.1
	Near-poor	9.5	1.7	14.1	2.6	11.2	2.6	10.6	2.5	7.8	6.1	18.5	4.4*	18.0	, 0.4	16.0	8. 0.	10.7	4.	15.5	3.7	7.9	2.4	13.2	4.1
	Non-poor	4.0	0.9	7.2	1.2*	Э.Э	0.9	9.4	2.0*	4.9	1.5	5.1	1.3	7.3	2.9	9.0	0.0 .0	10.8	2.8	11.2	3.2	3.1	0.9	6.7	1.5*
Total	Poor	18.9	1.9	16.1	1.6	17.1	2.0	15.0	2.0	20.6	2.9	17.3	2.0	24.2	2.5	17.8	2.2	14.2	1.6	16.1	2.0	15.3	2.5	15.2	З.О
	Near-poor	11.6	1.3	13.7	2.3	12.4	2.1	11.2	1.9	10.7	1.5	I6.7	8.1	19.6	2.6	16.5	2.5	11.2	2.2	12.9	2.4	9.1	1.5	11.6	3.6
	Non-poor	3.6	0.7	5.1	0.7	Ю.Э	0.7	5.7	1.1	9.6	0.8	4.6	0.9	7.7	2.0	6.3	1.5	7.7	1.4	9.8	1.7	2.7	0.6	4.6	0.9
	Total	9.9	0.8	10.2	1.0	9.2	0.8	9.7	1.2	10.8	1.2	6.01	1.0	19.5	4.	15.0	1.1*	11.6		12.9	1.4	6.5	0.8	8.2	1.3

Table 1. Trends for dental caries in the primary dentition for children age 2–8 years by poverty status. NHANES 1988–1994 and NHANES 1999–2004.

SE, standard error; \* $P \le 0.05$ ; (-) DSU – data statistically unreliable (the relative standard error was  $\le 30\%$ ).



**Fig. 1.** Decayed and filled primary dental surfaces (dfs) for children age 2–8 years by surface group and federal poverty level status: United States, 1988–1994 and 1999–2004. \* $P \le 0.05$ .

non-poor boys aged 6–8 years (3 *vs* 9%), but not for girls (5%). For near-poor girls aged 6–8 years, however, severe caries increased from 8% to approximately 19%, whereas no increase was observed for near-poor boys (11%).

Figure 1 shows caries experience in the primary dentition (mean dfs) for children age 2-8 years. Overall, mean dfs for total dental surfaces increased significantly between 1988-1994 and 1999-2004 (2.95-3.70). For children living in poverty, the mean dfs significantly increased across the buccal-lingual, mesio-distal, and occlusal dental surfaces during the same period; however, there were no significant changes in mean dfs across dental surfaces for children living in non-poor households. For near-poor children, caries experience significantly increased only for mesio-distal surfaces. The mean increase in dfs for all dental surfaces between 1988-1994 and 1999-2004 can be attributed to an increase in the mean number of filled (restored) dental surfaces (1.61 vs 2.41).

Table 2 presents dental caries trends in the mixed dentition for children aged 6–11 years stratified by poverty status. Overall, caries experience remained unchanged (approximately 55%) in the mixed dentition for children aged 6–11 years between 1988–1994 and 1999–2004. Likewise, there were no significant changes observed for poor (64 *vs* 66%) or non-poor (48 *vs* 45%) children.

Among children aged 6–8 years, however, dental caries experience increased in the mixed dentition for poor non-Hispanic blacks (51 *vs* 68%) and for non-poor Mexican-Americans (52 *vs* 68%) during the same period.

The prevalence of untreated caries in the mixed dentition remained unchanged for all children aged 6–11 years (nearly 27%) between 1988–1994 and 1999–2004. Although the overall differences in prevalence remained for untreated caries nearly unchanged by race/ethnicity between 1988-1994 and 1999–2004, the trends for untreated dental caries among Mexican-Americans were mixed. Among poor Mexican-American children. untreated dental decay declined from 51 to 42% for children aged 6-11 years and for children aged 6-8 years as well (57 vs 44%). For non-poor Mexican-American children aged 6-11 years, however, untreated decay increased from 20 to 32% during the same period.

Severe decay declined for poor children aged 6–11 years from 33% in 1988–1994 to 27% during 1999–2004. During the same period, the prevalence of severe decay remained unchanged for near-poor and non-poor children aged 6–11 years. The prevalence of severe decay also declined for poor boys aged 6–11 (31 *vs* 23%) during the same period, but the prevalence did not significantly change for similarly aged poor girls.

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		Total				Male	s			Femal	Se		-	Mexica	n-Ame	rican	-	Von-Hi	spanic	Black	-	Non-Hi	spanic	White	đ
	Doutor	1988- 1994		1999 2004	<u></u> ц.	1988 1994		1999– 2004		1988– 1994	• • • •	1999– 2004		1988– 1994	<b>7</b> 7	999- 004		1988– 1994	7 7	-666 004		1988– 1994		999– 004	
Category	status	%	SE	%	SE	%	SE	%	SE	%	L S	%	E E	%	SE	S	, ц.	%		°	, , ,	%		~	R
Caries experien	JCe																								
6-8 years	Poor	61.7	2.3	67.3	3.2	60.3	4.7	69.0	3.6	63.6	4.7 6	55.2 4	4.5 6	59.4	3.7 7	1.8	3.7	51.3	3.4 6	8.4 3	8.7* (	50.5	5.5	6.0	0.0
	Near-poor	59.5	4.5	62.6	3.6	57.9	6.7	61.5	3.9	61.6	5.4 6	53.9 (	5.1	70.0 (	5.0 6	3.9 4	1.2	54.3	5.4 4	9.7 4	с.	55.2 (	5.1	5.6	5.0
	Non-poor	42.3	3.1	41.3	3.5	40.0	4.5	44.7	4.2	45.0	4.3	38.1 4	4.0	52.1 4	4.7 6	7.6 5	5.1*	39.6	5.6 4	6.3 3	× ۳.	41.7	3.5	9.3 4	4.9
9–11 years	Poor	66.3	3.6	63.9	3.2	58.4	6.0	63.4	3.8 0.0	72.1	4.0 6	54.7	4.9 6	58.2	5.3 7	5.2 3	8.	57.1 2	4.3 5	1.7 4	1.2	72.3	5.8	8.3	5.7
	Near-poor	63.2	4.9	65.5	3.5	65.3	5.8	67.9	5.4	61.1	5.8 (	54.4	3.6	58.0 (	5.5 6	7.1 5	5.6	54.7 4	1.9	4.1 5	5.2 (	56.6	5.7 6	7.8	<u>с.</u>
	Non-poor	53.6	4.1	47.9	2.4	57.6	5.6	48.6	3.3	49.0	4.6 4	17.3	3.3 6	54.0 (	5.0 6	3.3	8.0	56.1	3.6 4	5.5 4	с. <del>.</del>	52.1 4	4.6 4	5.1 2	2.8
Total	Poor	64.0	2.6	65.5	2.7	59.3	4.5	66.1	3.1	68.0	3.4 (	55.0	3.4 (	58.8	3.0 7	3.6 2	5	54.3	3.0	9.8	6.3	56.6	4.4	7.2 4	4.4
	Near-poor	61.4	3.6	64.1	2.8	61.7	3.8 .0	64.8	3.7	61.4	4.4 (	54.2	3.3 (	53.8 4	4.5 6	5.6 3	6.6	54.5 4	4.4 5	1.9 3		51.1	5.0	6.7	3.7
	Non-poor	48.1	2.7	44.7	2.3	49.0	3.9	46.7	2.9	47.1	2.2 4	12.8	2.9	58.2 2	3.5 6	5.4 3	3.5 4	18.1	2.9	5.9 3	0.5	47.0	3.0	2.3 2	2.7
	Total	55.6	1.9	54.8	1.9	54.5	3.0	56.6	2.0	56.5	1.8	52.9	2.5 (	55.2	2.6 6	9.5 2		53.0	1.7 5	3.3 2	0	53.6	2.2	1.1	2.5
Untreated carie	SS																								
6–8 years	Poor	47.6	3.0	41.2	2.6	44.3	5.3	43.5	3.7	51.2	5.9 4	10.3	3.8	56.7	3.9 4	4.3 3	3.1* 2	10.0	3.6 4	9.1 3	5.1	44.2	2.8	0.2 4	4.9
	Near-poor	31.5	3.2	36.9	3.9	32.8	4.9	34.0	5.2	29.9	4.5 4	11.0	7.1 4	45.7 5	5.8 3	5.5 4	1.4	37.4 5	5.5	2.8 4	.6	25.7	0.0	6.9	<u>о</u> .3
	Non-poor	16.3	2.4	18.8	2.3	13.5	2.3	20.7	3.0	20.4	3.6	17.0	2.7 2	26.1 (	5.1 3	4.5 5	4.9	25.3	3.9 2	9.4 2	б.	14.7	2.7	6.3	
9–11 years	Poor	38.3	3.7	33.3	3.1	35.2	5.0	34.0	5.5	40.8	4.6	32.7 4	4.2 4	44.8 4	4.2 3	9.6 3	.1	34.8	8.7 3	1.0 3	.7	. 0.88	7.6	2.2	7.1
	Near-poor	28.9	с. С.	36.8	3.7	32.9	4.8	40.0	5.1	25.3	3.5	33.8	5.0	34.0	5.8	8.9	0.3	36.1 4	4.3 2	9.1 3	0.	29.4		8.9	5.1
	Non-poor	20.2	2.8	16.2	1.9	23.6	3.7	17.2	2.6	16.4	3.5	15.3	2.9	15.1 4	4.8 3	0.0 4	*61	25.6	8.0	6.6 2	· *6:	18.7	8.0	3.4	2.0
Total	Poor	42.8	2.5	37.2	2.1	39.6	3.9	38.6	3.1	45.8	3.2	36.4	3.3*	50.6	2.7 4	1.9 2	.4*	37.3 2	2.8	9.8 2	.6	41.0	6.1	6.1	9.9
	Near-poor	30.2	2.3	36.8	2.9	32.8	3.8 .0	37.1	4.0	27.6	2.8	37.3 4	4.3	39.7	4.7 3	7.2 <u>3</u>	8.	36.8	 8.0	0.9 3	0.0	27.6	8.4	7.9 4	4.6
	Non-poor	18.3	1.00	17.5	1.6	18.7	2.3	18.9	1.7	18.3	2.3	16.1	2.4	20.4	3.9 3	2.2 3	*8.	25.4	2.0 2	2.8 2	0	16.8	1.9	4.8	1.9
	Total	27.6	1.4	27.3	1.5	26.7	1.7	28.9	1.8	28.6	1.6	25.7	2.4	41.0	2.9 3	8.9		34.4	1.4	1.6	Ľ.	22.9	1.6	3.4	2.3
Severe caries																									
6–8 years	Poor	27.5	3.6	21.6	2.5	25.2	3.6	20.1	З.1	30.3	5.6	22.5	3.5	36.7 4	4.5 2	 	*0.5	0.61	2.7 2	1.9 2	2	24.3	5.5	8.5	4.0
	Near-poor	13.6	2.1	20.5	3.5	16.9	3.0	20.4	3.5	10.0	2.2	21.0 4	4.7*	19.1	4.8 2	1.0 	4.8	14.0	3.6 1	7.4 4	9.1	13.3	8.0	1.6	<u>л</u> .5
	Non-poor	9.0	1.9	11.8	1.5	9.7	2.7	15.5	2.5	7.9	1.8		1.9	16.9 4	4.3	6.8 4	- · -	13.6 2	2.8	3.6 	3.2	7.5	2.1	1.1	<u>~</u>
9–11 years	Poor	37.9	2.5	31.6	2.4	35.6	4.3	25.8	3.3	40.5	3.8	38.5 4	4.2	34.1 2	2.4 3	5.8	3.3	10.4 J	2.6 4	0.4 3		30.9	9.6	8.3	4.w
	Near-poor	30.7	3.7	28.1	3.3	29.3	4.2	23.6	4.5	31.7	5.2	32.3 4	4.3	35.1 (	5.1 3	3.8 4	1.8 2	14.4	3.7 3	5.1 4	0.1	23.2	5.2	2.8	4.6
	Non-poor	18.7	1.0	20.4	1.9	14.3	2.2	17.4	Э.1	23.1	2.6	23.2	2.4	31.5	5.3 1	9.0	*9:	31.5		3.9 	9.	16.6	2.0	9.3	2.2
Total	Poor	32.9	2.2	26.7	1.8*	30.5	3.1	23.0	2.3*	35.6	3.5	30.7	2.6	35.4 2	2.7 2	9.9 2	7	30.0	2.0 3	1.4 2		27.7	4.3	3.5	2.9
	Near-poor	22.3	2.2	24.4	2.3	23.3	2.5	22.0	3.2	21.2	2.9 2	26.8	2.9	27.3 4	4.1 2	7.7 3	5.5	29.6	2.7 2	6.5 3	` M.	18.4	2.8	2.2	<u>Э.</u> Э
	Non-poor	14.0	1.3	16.2	1.1	12.1	1.8	16.6	1.8	15.7	1.6	16.0	1.5	24.4	3.4 1	8.0		22.8	2.3 2	4.1 2	4	12.2	1.5	5.3	1.2
	Total	20.8	1.2	21.1	0.9	19.2	1.6	20.4	1.4	22.4	1.4	21.8	1.2	30.0	1.9 2	6.9 2	0.0	27.3	1.4 2	7.3 1	9	16.0	1.4	8.3	1.2

Table 2. Trends for dental caries in the mixed dentition for children age 6–11 years by poverty status, NHANES 1988–1994 and NHANES 1999–2004.

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SE, Standard Error; \*P ≤ 0.05; (–) DSU – data statistically unreliable (the Relative Standard Error was ≤ 30%).



**Fig. 2.** Decayed and filled mixed dentition surfaces (dfs-DFS) for children age 6–11 years by surface group and federal poverty level status: United States, 1988–1994 and 1999–2004. \* $P \le 0.05$ .

Caries experience for children aged 6–11 years in the mixed dentition (mean dfs-DFS) is shown in Fig. 2. Overall, mean dfs-DFS for total dental surfaces increased significantly between 1988–1994 and 1999–2004 (4.18–5.02). There was a significant increase in mean dfs-DFS for mesio-distal dental surfaces among poor and near-poor children as well as an increase in buccal and lingual surfaces for near-poor children during the same period.

Table 3 shows that dental caries experience in the permanent dentition significantly decreased from approximately 25% from 1988-1994 to 21% during 1999-2004 for children aged 6-11 years. Dental caries also decreased for all non-poor children (22 vs 16%) but caries experience remained unchanged for all poor children aged 6–11 years. Among all boys aged 6–11 years, caries experience significantly decreased from 23 to 19% from 1988-1994 to 1999–2004. During the same period, caries experience significantly decreased for all nonpoor boys aged 6-11 years (22 vs 14%) and for those aged 6-8 years (12 vs 4%). For poor boys aged 6-11 years, however, the prevalence of caries appeared to be increasing, but this increase was not statistically significant. Overall, caries experience for girls appeared to be trending down or remaining unchanged, but the observed differences in prevalence was not significant.

Overall, caries experience significantly decreased for non-Hispanic white children

aged 6-11 from 24 to 19% from 1988-1994 to 1999-2004. Although the prevalence of caries significantly decreased for all non-poor non-Hispanics whites aged 6-11 years (21 vs 16%), caries prevalence may be increasing for similarly aged poor non-Hispanic whites (25 vs 30%). This increase was statistically significant for children aged 6-8 years (8 vs 22%). The prevalence of caries may be trending downwards for non-Hispanic black children aged 6-11 years and this decrease was statistically significant for those who were non-poor (23 vs 14%). For poor Mexican-American children aged 9-11 years, however, caries significantly increased from 38 to nearly 55%.

The prevalence of untreated caries in the permanent dentition of children 6–11 years of age did not change between 1988–1994 and 1999–2004 (approximately 8%). The only major difference was a decrease in prevalence of untreated caries among Non-Hispanic black children from 13 to 9%; this change is driven by non-poor children who had a decrease from 10 to 4%.

Figure 3 shows caries experience in the permanent dentition (mean DFS) for children age 6–11 years. Although the overall mean DFS for total dental surfaces decreased significantly between 1988–1994 and 1999–2004, the difference was clinically small (0.82–0.65). During the same period, the only significant decrease by dental surfaces and poverty was

									•				•											
		Total				Males				Female	S		-	Mexicar	I-Ame	rican	z	on-His	anic B	llack	No	n-Hisp.	anic M	/hite
		1988- 1994		1999- 2004		1988– 1994	-	1999– 2004		1988– 1994	7 7	999– 004		1988– 1994	19	199- 104	÷ ÷	988- 994	199	99- 04	198	88- 14	199 200	- - 4
Category	status	%	SE	%	SE	%	SE	%	SE	%	SE	~	Щ	% S	Е	S	%	SI	%	SE	%	SE	%	SE
Caries experie	ance																							
6–8 years	Poor	16.2	3.2	16.5	2.7	9.7	2.7	15.6	3.5	21.9	4.4 1	7.1		17.8 3	.7 15	5.7 2.	6 1	2.4 2.	б	7 2.0	7.	7 2.3	21.8	8 6.1*
	Near-poor	18.5	3.3	11.8	1.8	19.9	4.4	11.1	2.0	17.0	5.5 1	2.7 3	8.4	21.0 5	5 15	5.9 3.	0 1	3.2 2.	6.9.	5 2.6	17.	7 4.7	11.(	5 2.8
	Non-poor	11.8	2.0	9.9	1.4*	12.4	2.6	3.9	1.1*	11.5	2.9	9.1 2	2.1	7.2 2	-			3.8 2.	9.0	7 1.7	12.	3 2.5	0.0	1.6
9-11 years	Poor	39.2	3.8 .0	39.4	3.1	35.8	4.8	37.4	4.2	41.5	4.3 4	2.1 4	t.4	38.1 3	.8 54	1.5 4	0* 3.	3.8 3.	8 30.	3 3.3	42.	1 7.6	37.	9.9
	Near-poor	40.6	4.0	35.8	3.2	33.7	5.9	32.5	4.1	47.3	5.8 4	2 0.0-	1.7	34.0 5	.1 45	5.4 5.	36	5.9 4.	8 32.	5 3.6	42.	7 6.1		5.5
	Non-poor	32.2	3.4	25.5	2.2	31.5	3.8 0.0	23.9	2.3	32.6	4.3 2	7.1 3	с. С.	38.6 3	.5 29	9.2 4.	2 3	5.9 4.	7 20.	5 4.7	* 29.	5 3.7	24.9	9 2.6
Total	Poor	28.0	3.0	28.2	2.3	23.1	2.9	26.8	2.9	32.0	3.9 2	6.6	8.1	28.2 2	.9 35	5.7 2.	7 23	8.4 2.	7 20.	3 2.1	25.	4.3	29.(	6.4.9
	Near-poor	29.9	3.0	24.1	2.1	27.0	4.3	22.1	2.6	32.6	4.7 2	7.2 2	00.0	27.7 4	.3 31	.1 3.	4 25	5.4 2.	9 21.	3 2.4	30.	6 4.6	21.7	7 3.7
	Non-poor	22.3	1.9	16.3	1.3*	22.2	2.3	14.2	1.4*	22.3	2.2 1	8.4	0.0	23.4 1	.8 23	3.2 4.	3 2.	2.7 2.	9 13.	8 2.8	* 21.	1 2.0	15.1	7 1.5*
	Total	25.5	1.6	21.1	*6.0	23.3	1.9	19.4	1.2*	27.5	2.0 2	2.9	m.	27.6 1	.6 30	0.8 2.	1 2	8.4 2.	0 19.	0 1.5	23.	7 1.8	18.(	5 1.4*
Untreated car	ies																							
6–8 years	Poor	10.0	2.3	7.1	2.0	I	I	I	I	16.0	4.2	6.2 1	` *6.1	12.0 3	0.	3.7 2.	2	9.1 2.	6 5.	8 1.7	Ι	I	T	I
	Near-poor	6.8	2.0	5.7	1.8	I	I	I	I	I	I	' I		I I	4	1.8 1.	2 1(	0.1 2.	۱ د	I	I	T	Т	I
	Non-poor	4.2	1.2	I	I	I	I	I	I	Ι	Ι	I	I	5.2 1	۔ 9.	I	,	1	Ι	I	Ι	Ι	Ι	I
9–11 years	Poor	17.3	2.6	16.1	2.3	17.2	3.8	17.3 .	3.7	17.0	3.3 1	4.7 2	. 00	17.4 3	.0 20	).5 2.	4 18	3.8 3.	1 14.	4 2.3	13.	6 5.1	15.	5.3
	Near-poor	14.1	2.7	17.8	2.9	14.3	3.8	19.2	4.3	13.7	3.7 1	7.6 4	, E.t	15.5 3	.8 18	3.3 3.	5 2	I.4 3.	6 14.	9 2.5	14.	1 4.0	13.6	3.8
	Non-poor	6.4	1.7	5.2	1.1	5.4	1.9	3.9	1.1	7.4	2.6	6.4 1	∞.	7.8 2	9 12		4 15	5.3 2.	о П	I	ъ.	0 1.5	4.	t 1.3
Total	Poor	13.8	1.8	11.8	1.7	10.4	2.1	13.0	2.5	16.5	2.7 1	0.6 1	` ∞.	14.8 1	.9 14	1.8 1.	5 14	t.1 2.	4 10.	3 1.6	Ι	I	Т	I
	Near-poor	10.6	1.7	11.9	2.0	11.8	2.7	12.2	2.6	9.2	2.0 1	2.4 2	. 00.0	I3.6 3	.0	.7 2.	0 1!	5.9 2.	5 9.	9 1.9	9.	9 2.7	6	7 2.7
	Non-poor	5.3	1.2	3.6	0.7	4.1	1.2	2.4	0.6	6.9	1.8	4.7	I.2	6.5 1	<u>∞</u>	9.1 2.	0	9.5 1.	5 4.	4 1.3	* 4.	7 1.2	2.8	3 0.8
	Total	8.6	0.9	7.7	0.9	7.1	1.0	7.5	1.0	10.1	1.3	7.9 1		12.9 1	.7 12	2.7 1.	1	8.1 1.	00	6 1.0	.9 *	2 1.0	5.(	5 1.2
SE, standard DSU.	error; * <i>P</i> ≤ 0.(	)5; (–)	DSU -	data si	tatistica	Ily unrel	iable (	the rela	tive sta	Indard	error w	/as ≤ 3	0%); E	stimates	for se	vere cã	ries are	not in	cluded	because	e estimo	ates we	ere uni	formally

Table 3. Trends for dental caries in the permanent dentition for children age 6–11 years by poverty status, NHANES 1988–1994 and NHANES 1999–2004.

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observed for buccal-lingual dental surfaces for non-poor children. The mean decrease in DFS for all dental surfaces between 1988–1994 and 1999–2004 can be attributed to a decrease in the mean number of filled (restored) dental surfaces (0.64 *vs* 0.48).

## Discussion

National Health and Nutrition Examination Survey data are fundamental to national surveillance efforts for monitoring oral health trends in the United States. The data reported in our study illustrate changes in dental caries status among children between 1988-1994 and 1999-2004 by poverty status. Overall, our findings indicate that the previously reported increase in dental caries in the primary dentition<sup>3</sup> has affected boys at a disproportionately higher rate compared with girls. Dental caries in the primary dentition significantly increased from 33 to 41% for boys aged 2-8 years whereas remaining unchanged for similarly aged girls (36%). The prevalence of caries appears to be concentrated among poor and non-poor boys aged 2-8 years and particularly among non-poor boys aged 2-5 years. Furthermore, untreated disease in the primary dentition has significantly increased for boys as opposed to girls, particularly among non-poor boys aged 2-8.

Findings in the permanent dentition are much more favourable. Dental caries either

Fig. 3. Decayed and filled permanent dental surfaces (DFS) for children age 6–11 years by surface group and federal poverty level status: United States, 1988–1994 and 1999–2004. \* $P \le 0.05$ .

continues to decline across many youth subgroups or has remained essentially unchanged from 1988–1994 to 1999–2004. In the mixed dentition, dental caries experience has remained unchanged for most children aged 6–11 years. Although untreated caries has remained unchanged for most 6–11 year-old children as well, untreated caries has significantly decreased for poor Mexican-American children (51 *vs* 42%), but has significantly increased for non-poor Mexican-American children (20 *vs* 32%).

Because one of the best predictors of future tooth decay is current untreated decay or evidence of past caries<sup>4–6</sup>, an increase in dental caries in the primary dentition among children is particularly disturbing. Historically, dental caries has affected minority and poor children disproportionately<sup>1,14</sup>. Nevertheless, current trends show that dental caries is increasing among 2-8 year-olds at the same rate for both poor and non-poor boys (8% point change). Although we did not investigate the reasons for the recent changes observed in caries epidemiology, two traditional risk factors that might be influencing this increase in caries prevalence among young children may be unhealthy eating habits and inadequate dental insurance coverage.

The main change in unhealthy eating habits is an increase in sweetened beverage (juice drinks, fruit juices, flavoured juices, and sodas) consumption by children<sup>15,16</sup>. Sugar

consumption, especially sucrose, has been strongly linked to dental caries for many vears<sup>17,18</sup>. Among children, juices and sweetened beverages consumption has been increasing with age, while milk consumption has decreased<sup>16,19</sup>. Particularly among toddlers, consumption of juices and sweetened beverages appear to be displacing consumption of milk<sup>20</sup>. This is a cause for concern considering that by 24 months of age, 70% of toddlers are consuming juices and sweetened beverages<sup>21</sup>. Marshall co-workers found an increase in soda consumption among children ages 1–5 years and a strong association between soda intake and caries presence and extent of disease<sup>22</sup> and a more recent study has reported that preschool children who changed from drinking small amounts of soda to higher levels were 75% more likely to have new levels of caries experience<sup>23</sup>.

Changes in dental insurance could also be an important contributing factor in the increase of paediatric dental caries among young children as well. Dental coverage, whether private or public-supported, is associated with receiving preventive dental care<sup>24</sup>. Moreover, private dental insurance coverage, which is more common among more affluent families, has decreased in the United States over the past decade<sup>25</sup>. Loss of public or private dental insurance might be expected to result in a long-term worsening of oral health status and may well result in increased overall health costs<sup>26</sup>.

If the increase in caries prevalence among young children remains constant, another concern would be the ability of the dental workforce to address the dental needs of these children. Studies analysing access barriers to dental care for the paediatric population have found that dentists are not very likely to treat children less than 5 years of age<sup>27,28</sup> or who have high levels of dental caries<sup>28</sup>. Furthermore, a shortage of paediatric dentists<sup>29</sup> along with a 3% increase in the number of births in the US<sup>30</sup> could further impact access to paediatric dental care.

Another important finding from this report is that most differences between the two time periods by poverty status in dental caries experience and untreated decay were not statistically significant. Medicaid, the social insurance programme for the poor, eligibility was expanded through the State Children's Health Insurance Programme in 1997 to provide public health insurance for near-poor children from families previously not eligible for Medicaid. Consequently, NHANES data (collected from 1988–1994 to 1999–2004) is uniquely positioned to ecologically assess the impact these changes may have had on access to dental care issues for poor and near-poor children. Overall, the differences in the dental caries status for the majority of poor and near-poor children between the two survey periods were not significant in our findings. This lack of significance may be the result of small sample sizes of some poverty-demographic subgroups evaluated.

When looking at treated and untreated caries levels by surface location, most of the major differences in caries experience can be attributed to the 'filled' component of the dfs/DFS index between 1988-1994 and 1999-2004. This suggests that children who are able to access the US dental care delivery system are receiving restorative care. In the primary dentition, there was no real difference between the location of dental surfaces and caries experience - that is, caries experience seemed to be uniform across buccal-lingual, mesio-distal, and occlusal surfaces for each poverty group. Whereas in the permanent dentition, there appears to be little caries activity on mesio-distal surfaces with the greatest activity on occlusal surfaces. This suggests that preventive programmes such as community water fluoridation is benefiting children regardless of poverty status, but additional efforts directed towards sealant utilization should be considered to address the higher prevalence of caries on occlusal dental surfaces.

Although dental caries in most older children continues to decline or remain unchanged, increasing tooth decay among some young children is a concern. Moreover, it is also troublesome that paediatric caries appears to be disproportionately affecting young boys compared with girls considering that here has not been a difference in prevalence of caries between boys and girls observed in national surveys prior to NHANES 1999–2004<sup>31,32</sup>. Although the increasing prevalence of dental caries appears to be occurring in some of our traditionally 'low-risk' groups such as the non-poor, primary caries is also increasing in a small number of 'high-risk' groups as well. Our find-ings suggest that future caries research should be expanded towards better understanding of not only the factors that promote paediatric dental caries among traditionally high-risk children, but also among those once considered low-risk for tooth decay.

What this paper adds

- This paper provides new information on the distribution of dental caries among children by poverty in the United States.
- This paper shows in-depth analyses of caries in the mixed dentition for children in the United States for the first time.
- This study presents new information detailing the distribution of treated and untreated caries among children in the United States by affected dental surfaces and dentition status.

#### Why this paper is important to paediatric dentists

- Paediatric caries appears to be affecting more young boys compared with young girls – this is important given that in earlier US oral health surveys, there has been no difference in the distribution of paediatric caries by gender.
- Although the increasing prevalence of dental caries appears to be occurring in some of our traditionally 'low-risk' groups such as the non-poor, primary caries is also increasing in a small number of 'high-risk' groups as well.
- The increase of dental caries in primary teeth is an early indication of changes that are occurring now that will impact future health status and dental utilization as the young cohort of children ages.

#### Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centres of Disease Control and Prevention.

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	NHANE	5 19888–19	94		NHANE	5 1999–200	4	
Characteristics	Total	Poor	Near-poor	Non-poor	Total	Poor	Near-poor	Non-poor
Age								
2–5 years	4397	1814	1188	1395	2510	963	693	854
6–8 years	1539	624	428	487	1544	528	430	586
9–11 years	1636	647	411	578	1542	534	419	589
Gender								
Males	3788	1519	1013	1256	2769	1048	757	964
Females	3784	1566	1014	1204	2827	977	785	1065
Race/ethnicity								
Non-Hispanic whites	2255	335	580	1340	1662	321	384	957
Non-Hispanic blacks	2431	1224	672	535	1777	821	483	473
Mexican-Americans	2532	1352	695	485	1704	729	546	429
Total	7572	3085	2027	2460	5596	2025	1542	2029

#### Appendix. Selected sample sizes.

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