Is 75 Percent of Dental Caries Really Found in 25 Percent of the Population?

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Abstract

Objectives: *Dental caries prevalence is used to quantify inequalities and to target high-risk populations for interventions. Prevalence can be described via measures of centrality; however, some have used cumulative frequency distribution curves (Lorenz curves). This investigation provides dental caries Lorenz curves for the primary and permanent dentitions at selected ages. Results provide accurate age-specific and dentition-specific X values for the general statement, "75 percent of dental caries is found in X percent of the population."* ***Methods:*** *Data were derived from the Third National Health and Nutrition Examination Survey, a cross-sectional study conducted between 1988 and 1994. Cumulative frequency distributions for total dfs or DMFS were plotted against cumulative frequency distributions for the total population.* ***Results:*** *X values varied substantially between dentitions and across ages. Total dental caries experience in the permanent dentition was more dispersed than it was in the primary dentition, and the total dental caries experience in older persons was more dispersed than it was in younger persons. For those aged 2–5 years, 75 percent of dental caries (primary dention) was found in 8.1 percent of the population. For those aged 6 years or older, 75 percent of dental caries (permanent dentition) was found in 33.0 percent of the population.* ***Conclusions:*** *For accuracy and relevancy, the statement, "75 percent of dental caries is found in X percent of the population" must be applied to a particular dentition or age group, and must account for appropriate severity and prevalence reference points. [J Public Health Dent 2004;64(1):20-25]*

Key Words: dental caries, dental health survey, children, adults, United States.

Dental caries prevalence is used to quantify inequalities and to identify high-risk populations for targeted preventive and treatment interventions. National surveys from around the world show that the prevalence of dental caries in developed nations is relatively low (1). These surveys also show that a small proportion of the population manifests the majority of disease.

Typically, dental caries experience is described via measures of centrality (mean, mode, and median) or via histograms. A different method of depicting dental caries distributions, which has gained wider use during the last two decades, relies on cumulative frequency curves to relate a particular proportion of disease with a particular proportion of the population. Several investigations have incorporated this method. For example, the National Prevention Dentistry Demonstration Project (2) used this approach and concluded that 60 percent of dental caries in permanent teeth occurred in about 20 percent of 8-year-old children. Kaste and colleagues (3) used data from the Third National Health and Nutrition Examination Survey to show that approximately 25 percent of children aged 5–17 years accounted for 80 percent of decayed, missing, or filled permanent teeth (DMFT). Kaste and colleagues also found that, among 12-year-olds, 75 percent of the DMFT was found in 25 percent of children, and among 17-year-olds, 60 percent of the DMFT was found in 25 percent of children.

Summary statements, such as "80 percent of the DMFT is found in 25 percent of the population," have been used extensively by researchers and policy makers to guide the reallocation of funds and bring attention to the unequal distribution of dental caries in the United States (4,5). Despite the best intentions of these researchers and policy makers, however, the summary statements have been applied too broadly, with little regard for age or the type of dentition that is involved in the research or policy.

The purpose of this investigation was to provide cumulative frequency distributions of dental caries for the primary and permanent dentitions and selected age cohorts. The nationally representative estimates derived from this investigation will provide accurate age-specific and dentition-specific X values for the general statement, "75 percent of dental caries is found in X percent of the population." Findings will provide a reference for policy makers and public health practitioners who wish to describe the distribution of dental caries across age groups and design targeted health promotion activities from the distributions. Findings will also provide a framework against which the relevancy of general statements may be discussed.

Methods

The data for this investigation were derived from Phases I and II of the Third National Health and Nutrition Examination Survey (NHANES III)

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(6), a cross-sectional investigation administered by the National Center for Health Statistics between 1988 and 1994. NHANES III relied upon a complex, multistage probability sampling design to select a sample of children and adults that was representative of the US civilian, noninstitutionalized population. The total number of sample persons included in NHANES III was 39,695. A detailed description of the plan and operation of NHANES III has been published elsewhere (7). NHANES III consisted of three components, including a health questionnaire, physical examination, and laboratory assessment (7). The oral health portion of the physical examination component consisted of a visual-tactile examination lasting approximately 7.5 minutes, on average.

A total of five carefully trained and calibrated dental examiners conducted the oral examination using a reclining dental chair and a high intensity fiber-optic light source. The examinations took place in a mobile examination center consisting of four trailers that were transported to the examination sites and connected onsite. Published analysis for Phase I of NHANES III (8) showed that interexaminer kappa reliability statistics for the comparison of the examiners with a gold standard were between 0.96 and 1.00. Intraexaminer reliability statistics were between 0.85 and 1.00 for the scoring of dental caries in the primary and permanent dentitions. The examiners identified periodontal diseases, oral mucosal tissue changes, coronal and root caries, presence of third molars, dental sealants, history of traumatic injuries, restorations and tooth conditions, occlusal and dentofacial characteristics, and prosthesis integrity (8). Dental caries was assessed using established criteria (7), a sharp sickle-shaped dental explorer, and nonmagnifying dental mirror. The dental examiners assessed four surfaces of each anterior tooth (mesial, distal, buccal, and lingual) and five surfaces of each posterior tooth (mesial, occlusal, distal, buccal, and lingual).

NHANES III described the dental caries experience of each survey participant aged 2 years or older via the sum of decayed or filled teeth (dft) or tooth surfaces (dfs) for the primary teeth, and the sum of the decayed, missing, or filled teeth (DMFT) or tooth surfaces (DMFS) for the permanent dentition. We used the tooth surface-level scores—dfs and DMFS—for this investigation. The dental caries experience assessment for the primary dentition did not include the missing component because it is difficult for an examiner to know whether a missing tooth in a young child was absent due to dental caries or some other reason, such as trauma, elective extraction (orthodontic treatment), or normal exfoliation.

Cumulative Percent Distribution Curves. We derived two types of weighted cumulative percent distributions in this investigation. The first was the cumulative percent distribution of the total dfs or DMFS, and the second was the cumulative percent distribution of the total population. Derivation of these distributions is described below.

Cumulative Percent Distribution of Total dfs or DMFS. For any population, the total dental caries experience is equal to the total number of tooth surfaces in the population exhibiting treated or untreated dental caries. For the primary dentition, the total dental caries experience is the total number of decayed or filled tooth surfaces. For the permanent dentition, the total dental caries experience is the total number of decayed, missing, or filled tooth surfaces. NHANES III collected dental caries data on an individual level, and not on a population level. To translate the individual-level NHANES III data to population-level data, it was necessary to weight individual-level dfs or DMFS scores by the number of individuals with each score.

Table 1 presents hypothetical data that illustrate the translation of individual-level data to population-level data. The hypothetical data correspond to weighted population estimates derived from a survey sample representing a hypothetical target population of 5 million persons. In the hypothetical target population, 40,000 individuals had a dfs equal to 5; 60,000 had a dfs equal to 4; 100,000 had a dfs equal to 3; 300,000 had a dfs equal to 2; 500,000 had a dfs equal to 1; and 4 million had a dfs equal to 0. To produce population-level distributions, each of the hypothetical dfs scores was multiplied by the total number of individuals with that score. For example, 40,000 individuals had a dfs equal to 5, and these individuals provided 200,000 (5 times 40,000) decayed or filled surfaces to the total dental caries experience in the population. Similarly, 60,000 individuals had a dfs equal to 4, and these individuals provided 240,000 (4 times 60,000) decayed or filled surfaces to the total dental caries history in the population. The first 200,000 surfaces represented 10.9 percent of the total 1,840,000 decayed or filled surfaces, and the next 240,000 surfaces represented 13.0 percent of the 1,840,000 decayed or filled surfaces, and so on.

Note that in Table 1, we listed the dfs scores in descending order. We chose this order because we wanted the cumulative percent distribution to

TABLE 1
Derivation of Cumulative Distributions for Total dfs and Total Population Using Hypothetical Data

	Distribution of Total Population			Distribution of Total dfs		
dfs	Frequency	%	Cumulative %	dfs* Frequency	%	Cumulative %
5	40,000	0.8	0.8	200,000	10.9	10.9
4	60,000	1.2	2.0	240,000	13.0	23.9
3	100,000	2.0	4.0	300,000	16.3	40.2
2	300,000	6.0	10.0	600,000	32.6	72.8
1	500,000	10.0	20.0	500,000	27.2	100.0
0	4,000,000	80.0	100.0	—	—	—
Total	5,000,000	100.0	—	1,840,000	—	—

Note: In this example, 40.2 percent of the total dfs is exhibited by 4.0 percent of the total population, and 100.0 percent of the total dfs is exhibited by 20.0 percent of the total population.

capture more severe disease scores before less severe scores. Derivation of the cumulative percent distribution of the total DMFS followed the same protocol; however, missing surfaces were also included in the total dental caries experience.

Cumulative Percent Distribution of Total Population. We derived the cumulative percent distribution of the total population with dental caries by summing the percentage of the total population with each dfs score. For example, 0.8 percent (40,000/5,000,000) of the total hypothetical population had a dfs equal to 5, 1.2 percent (60,000/5,000,000) had a dfs equal to 4, 2.0 percent (100,000/5,000,000) had a dfs equal to 3, 6.0 percent (300,000/5,000,000) had a dfs equal to 2, 10.0 percent (500,000/5,000,000) had a dfs equal to 1, and 80 percent (4,000,000/5,000,000) had a dfs equal to 0. The cumulative percent distribution was the sum of these percentages. Again, note that we listed the dfs scores in descending order.

Plotting Two Cumulative Percent Distributions. In the hypothetical population, 20 percent of individuals had dental caries and 80 percent were caries-free. Thus, 100 percent of the total dental caries experience (1,840,000 decayed or filled surfaces) was located in 20 percent of the population (500,000 individuals), which is equivalent to stating that 20 percent of the population had a dental caries history and 80 percent did not.

To show what percentage of the total population exhibited 75 percent of the total dental caries experience, we plotted the two cumulative percent distributions on a graph (Figure 1). Note, that we arbitrarily selected the 75 percent reference point—we just as easily could have used a 60 percent reference point or a 70 reference percent point. In the graph, the cumulative percent distribution of the total dental caries experience is on the Y-axis, and the cumulative percent distribution of the total population is on the X-axis. The point where the curve crossed the 75 percent point on the Y-axis (bold horizontal line) is equivalent to the percentage of the total population that exhibited 75 percent of the total dfs—about 10.5 percent. It would be impossible to generate standard errors or confidence intervals for the 10.5 value, because the intersection of the two cumulative distribution curves represents the intersection of two different types of data: person-level and tooth surface-level data. Standard errors and confidence intervals cannot be generated when two different types of data are combined graphically.

FIGURE 1
Cumulative Percent of Total dfs per Cumulative Percent of Total Population—a Hypothetical Example (Source: Hypothetical Data)

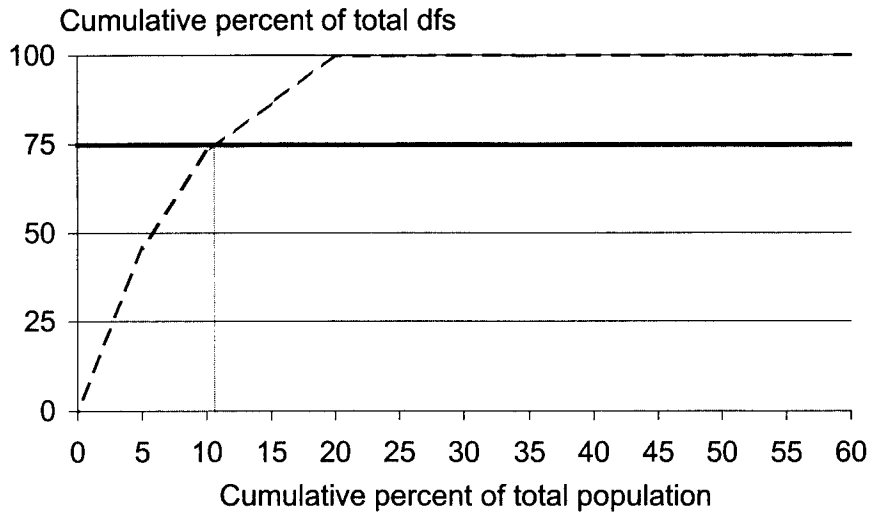
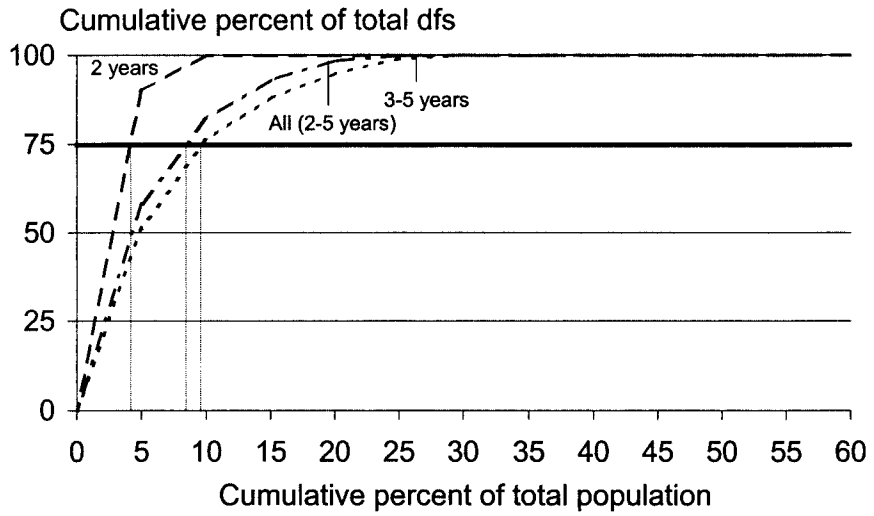


FIGURE 2
Cumulative Percent of Total dfs per Cumulative Percent of Total Population, by Age Group (Source: NCHC, CDC, NHANES III)



Analysis. The NHANES III sampling method was designed to provide statistically reliable estimates for the following age groups (9): 1–2 years, 3–5 years, 6–11 years, 12–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years or older. We used these age groups during the analysis stage; however, the 1–2 years category was reduced to include only children aged 2 years because children younger than 2 years of age received an abbreviated early childhood caries assessment that was not comparable with the coronal caries assessment received by older children and adults. We also used full sample weights so that the descriptive estimates would be representative of

TABLE 2
Weighted Proportion of Children Exhibiting 75 Percent of dfs, by Age Group, United States, 1988–94

Age Group (Years)	%
2	3.3
3–5	9.8
All (2–5)	8.1

Source: CDC/NCHS, Third National Health and Nutrition Examination Survey.
Note: Data represent children with at least one primary tooth eligible for scoring.

TABLE 3
Weighted Proportion of Children and Adults Exhibiting 75 Percent of DMFS, by Age Cohort, United States, 1988–94

Age Group (Years)	%
6–11	11.4
12–19	29.1
20–29	38.4
30–39	44.8
40–49	49.8
50–59	54.3
60–69	57.0
70–79	59.0
80 or older	61.5
All (6 or older)	33.0

Source: CDC/NCHS, Third National Health and Nutrition Examination Survey.
Note: Data represent children and adults with at least one permanent tooth eligible for scoring.

the civilian, noninstitutionalized population of persons aged 2 months or older, in the United States. Sample weights represented those applicable to the physical examination component of NHANES III and to Phase I (1988–91) and Phase II (1991–94) of data collection. We used the SAS statistical software program (10) to derive cumulative frequency curves for dfs at age 2 years, 3–5 years, and 2–5 years, as well as cumulative frequency curves for DMFS at age 6–11 years, 12–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years or older.

Results

Figure 2 presents the cumulative percent distribution of the total dental caries experience (dfs) plotted against the cumulative percent distribution of the total population of children with at least one primary tooth, for three age groups. This information is also presented in Table 2, which presents the weighted proportion of children exhibiting 75 percent (cumulative) of the total dfs. The graph shows that 75 percent (cumulative) of the total dfs was in a substantially smaller proportion of children aged 2 years than it was in children aged 3 through 5 years. The curve for all children aged 2 years through 5 years fell between the other two curves—3.3 percent of children aged 2 years exhibited 75 percent of the dfs compared to 9.8 percent for children aged 3–5 years, and 8.1 percent for children aged 2–5 years (Table 2).

FIGURE 3
Cumulative Percent of Total DMFS per Cumulative Percent of Total Population, by Age Group (Source: NCHC, CDC, NHANES III)

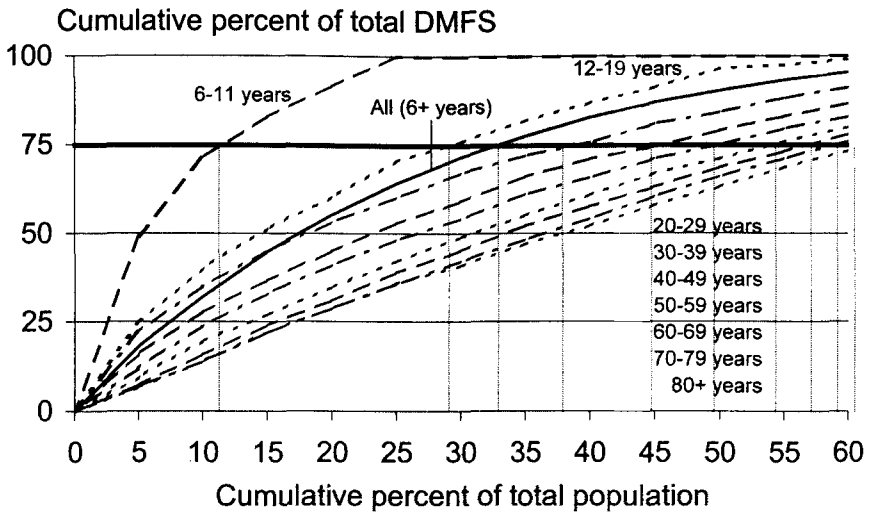


Figure 3 presents the cumulative percent distribution of the total dental caries experience (DMFS) plotted against the cumulative percent distribution of the total population of children and adults with at least one permanent tooth, for several age groups. This information is also presented in Table 3, which presents the weighted proportion of persons exhibiting 75 percent (cumulative) of the DMFS. The graph shows that the proportion of persons exhibiting 75 percent (cumulative) of the total DMFS increased with each incremental change in age. Whereas 11.4 percent of children aged 6–11 years exhibited 75 percent (cumulative) of the DMFS, the proportions for persons aged 20–29 years, 40–49 years, 60–69 years, and 80 years or older were 38.4 percent, 49.8 percent, 57.0 percent, and 61.5 percent, respectively.

Tables 2 and 3 list the weighted proportion of persons exhibiting 75 percent (cumulative) of the total dfs and DMFS, respectively, for different age groups. In general, the weighted proportion of persons exhibiting 75 percent (cumulative) of the total dfs and DMFS increased with age, with greater changes appearing among the younger cohorts and smaller changes appearing among the older cohorts. The two tables also show that the weighted proportion of persons exhibiting 75 percent (cumulative) of the total dental caries experience was higher for the permanent dentition than it was for the primary dentition.

Discussion

For almost a century, researchers have used cumulative frequency curves to describe distributions in populations. Economist Max O. Lorenz was one of the first to use frequency curves (to become known as Lorenz curves) to illustrate unequal distributions of wealth (11). Pareto curves, which are cumulative frequency distributions that prioritize components of the distribution according to their relative importance, have been used in inventory manage-

ment. More recently, Nugent and colleagues (12) used cumulative frequency curves to describe oral health disparities among Scottish children. Tickle and colleagues (13) used frequency curves to describe dental caries distributions among 5-year-old children from the northwest of England. Poulsen and coauthors (14) used cumulative frequency curves to describe the distribution of dental caries among 15-year-old Danish children.

In this investigation, we used cumulative frequency curves to describe the distribution of total dental caries experience in the US population. As the results showed, the distribution of total dental caries experience varied by dentition and the age range of the population considered—the total dental caries experience in the permanent dentition was more dispersed across the population than it was in the primary dentition, and the total dental caries experience in older persons was more dispersed across the population than it was in younger persons. These findings were not surprising, given that: (1) the scoring criteria for dental caries is cumulative in nature (the dfs and DMFS indexes are irreversible), and (2) teeth that are present in the oral cavity for longer periods are at greater risk of developing disease.

Public health professionals and policy makers should be more accurate when referring to the distribution of dental caries in the United States. A general statement, such as "75 percent of dental caries is found in X percent of the population," that is applied to the wrong population subgroup can have devastating ramifications when programs are evaluated and limited resources are allocated. For example, a public health professional might remember that 75 percent of dental caries was found in 25 percent of her constituency population in 1990 (inaccurate statement referring to the permanent dentition and to children aged 6–17 years). Ten years later, after implementation of an innovative health promotion program, that same public health professional might learn that 75 percent of dental caries was found in only 10 percent of her constituency population (accurate statement referring to the primary dentition and children aged 2–5 years). If the public health professional were not careful, she might conclude that her public health program was very effective, when, in fact, it might not have had an effect at all.

We displayed cumulative distribution curves for different age groups using cross-sectional data. The reader should be careful not to conclude that age caused a dispersion of dental caries experience across the population, especially among adults. With cross-sectional data, it is difficult to differentiate associations caused directly by age from cohort effects. Given that researchers and public health professionals often have derived their erroneous "75 percent of dental caries is found in X percent of the population" statements from cross-sectional data, we offer one more reason why accuracy is important and the oversimplification of complex disease burden issues in a population might be counterproductive.

The purpose of this investigation was to provide accurate age-specific and dentition-specific X values for the general statement, "75 percent of dental caries is found in X percent of the population." Although this investigation accomplished its objective, there is another issue that ought to be addressed—accuracy is important, but so is relevancy and perspective. As Table 2 and Figure 2 show, 75 percent (cumulative) of dental caries in the primary dentition is found in 8.3 percent of children aged 2–5 years. In terms of public health policy, one might argue that this is a distressing finding, showing that dental caries is still a public health problem for an unfortunate subpopulation, a subpopulation that somehow missed the benefits of health promotion efforts that were enjoyed by the rest of the population. By contrast, one might be equally justified in arguing that this is an encouraging finding, showing that dental caries is almost entirely eliminated from the population. What causes the discrepancy is a lack of perspective. Neither argument takes into consideration a reference point, a predetermined dfs or DMFS cut-off that is indicative of severe disease. In addition, neither argument takes into consideration a reference prevalence, a predetermined level that is indicative of high prevalence.

Future research should investigate methods to determine relevant reference values for severity and prevalence, which are specific to the dentition and age groups of interest. Future research also should investigate dental caries scoring methods that take into consideration the cumulative nature of the disease. Until statements such as "75 percent of dental caries is found in X percent of the population" are presented accurately, and until reference points for severe dental caries and high dental caries prevalence are developed and uniformly applied, discussions regarding the cumulative frequency distribution of dental caries in the United States will provide limited usefulness, at best.

This investigation was subject to at least two study limitations. The criteria and methods used to assess dental caries probably underestimated the true prevalence of disease, because dental caries scoring criteria were conservative and no radiographs were used to detect proximal lesions. In addition, the missing tooth component of the DMFS was subject to misclassification in older adults, given that older adults were at increased risk of tooth loss because of periodontal disease. These limitations notwithstanding, the investigation exhibited an important strength, in that the findings were representative of the US population.

In conclusion, this investigation showed that the general statement, "75 percent of dental caries is found in X percent of the population" must be applied to a particular dentition or age of interest, and must account for relevant severity and prevalence reference points, if accurate interpretations are to result. When more precise application of the statement has occurred, public health professionals and policy makers will be able to accurately describe the dental caries disparities that exist across population subgroups in the United States. Once disparities are delineated more clearly, then high-risk groups can receive targeted interventions (15). Although this investigation has provided age-specific and dentition-specific X values for the general statement, additional research must strive to identify relevant severity and prevalence reference points. In addition, this method of representing the percentage of dental caries found in a population should be used to identify age- and dentition-specific disparities in dental caries experience across subgroups of the population.

Given the concentration in the population of dental caries in the primary dentition and the dispersion in

TABLE 4
Weighted Proportion of Children Exhibiting 75 Percent of ds, by Age Group, United States, 1988–94

Age Group (Years)	%
2	3.1
3–5	7.8
All (2–5)	6.6

Source: CDC/NCHS, Third National Health and Nutrition Examination Survey. Note: Data represent children and adults with at least one permanent tooth eligible for scoring.

TABLE 5
Weighted Proportion of Children and Adults Exhibiting 75 Percent of DS, by Age Group, United States, 1988–94

Age Group (Years)	%
6–11	4.2
12–19	7.2
20–29	10.6
30–39	9.8
40–49	7.8
50–59	7.9
60–69	5.8
70–79	5.4
80 or older	6.3
All (6 or older)	7.6

Source: CDC/NCHS, Third National Health and Nutrition Examination Survey. Note: Data represent children and adults with at least one permanent tooth eligible for scoring.

the population of dental caries in the permanent dentition, our findings might appear to support the use of targeted approaches to prevention and treatment in younger age groups and more broadly based prevention and treatment approaches in adult populations. Such an intervention strategy might be incorrect for two reasons. The first reason relates to the fact that the cumulative frequency curves and values in Tables 2 and 3 represent overall dental caries experience, as dfs and DMFS include past and current disease. As such, cumulative frequency distributions for these two dental caries measures would represent the accumulation of disease over time, and would not necessarily represent the spread of disease over a broader segment of the population. For example, Tables 4 and 5 show values for the statement "75 percent of UNTREATED dental caries is found in X percent of the population" for the primary and permanent dentitions. Note how there is very little change in the X values for untreated disease across age cohorts and across dentitions. The second reason relates to the fact that these cumulative frequency distributions (whether for overall dental caries experience or untreated disease) do not indicate where the disease exists, in which populations dental caries manifests, and under which conditions the disease progresses. For instance, Tickle (16) showed that cumulative frequency distributions of dental caries (dmft) in a sample of 5-year-old English children could not be related to areas of deprivation in the population.

Our findings showed that the precise use of language when describing disease burden in a population is critical. At the very least, attention should be given to the age of the population and the dentition being described. Although precision would lead to more appropriate dialogue, it should not be assumed that a more accurate description of the "75 percent of dental caries is found in X percent of the population" statement would bring policy makers any closer to an understanding of which population subgroups were more likely to have prevention and treatment needs. Future studies must untangle the complex and interrelated factors which determine who has dental caries and why. Precision is the first step, but a long walk still might be necessary.

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