Caries Process and Prevention Strategies: Epidemiology

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Disclaimer: Participants must always be aware of the hazards of using limited knowledge in integrating new techniques or procedures into their practice. Only sound evidence-based dentistry should be used in patient therapy.

Introduction

This is part 1 of a 10-part series entitled *Caries Process and Prevention Strategies*. Oral epidemiology is the area of public health that deals with the distribution and the impact of oral disease on the human population. In this course, emphasis is placed on the relevance of epidemiology to clinical practice and information about the prevalence, incidence and trends of dental caries in the United States is presented. The term DMF (decayed, missing, and filled teeth) is introduced, along with variations and limitations of the DMF index, and an explanation of how to calculate DMF scores.

Conflict of Interest Disclosure Statement

- Dr. Lo was a member of the dentalcare.com Advisory Board.

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Course Contents

Overview

Oral epidemiology is the area of public health that deals with the distribution and the impact of oral diseases on the human population. In this section, emphasis is placed on the relevance of epidemiology to clinical practice and information about the prevalence, incidence and trends of dental caries in the United States is presented. The term DMF (decayed, missing, and filled) teeth/surfaces is introduced, along with variations and limitations of the DMF index, and an explanation of how to calculate DMF scores.

Clinical Significance Snapshots

What is the practical significance of the epidemiology of Dental Caries? As a dental practitioner why should this interest me?

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Information that reports the amount of any disease in a population is of tremendous importance in planning, funding and delivery of health services so that enough healthcare professionals of the correct skill sets are trained, enough clinical centers are built, and that new and improved materials and clinical techniques are developed through adequately funded research programs. Access to care is a critical issue for oral health – many of the US population are currently unable to receive the dental care they need. Having knowledge of this need for care helps health planners create preventive programs to avoid disease in the first place (e.g., water fluoridation, availability of low sugar foods and beverages) and to ensure that enough dentists are produced to provide services, and that those services are adequately funded through private or public systems.

What is the value of a dental index to me in dental practice?

Recording of a patient's health status is important, not only to plan any treatment currently needed, but also to assess a patient's changes in disease status and their response to treatment over time. The dental chart of cavities and restorations is similar to an index, and while it is not quantified numerically, it does allow comparison over time. As early carious lesions are reversible and typically should be treated not by restorative means, but by preventive means such as fluoride agents and dietary modification, the methods of measurement and recording of the lesions is critically important. The DMF Index does not differentiate between early and late stage lesions, but new caries assessment indices having that capability, such as the ICDAS (International Caries Diagnosis and Assessment System), are being introduced into dental school curricula.

Learning Objectives

Upon the completion of this course, the dental professional should be able to:

- Discuss the need for epidemiological studies.
- Apply the results of oral epidemiology studies to clinical practice.
- Be familiar with the prevalence, incidence, and trends of dental caries in the United States.
- Describe the value of the DMF index in measuring oral disease.
- Use the DMF index to measure the prevalence of dental caries.

- Understand the results of the NHANES surveys that are related to dental caries.
- Identify the factors that may or may not affect the DMF scores in adults.
- Calculate a DMFT, DMFS, dmft or dmfs index score from a patient tooth charting.

Keywords/Definitions

incidence - The number of new cases of a disease or condition over a given time period. It is the rate at which new cases occur in a defined population group (e.g., the incidence rate of lung cancer is 2.5% per year in 25- to 29-year-old Hispanic males in the US). This term is frequently confused with and used interchangeably in error with the term prevalence which describes how common a disease is. In epidemiology of dental caries, it is important to note the denominator – people or individual teeth.

index - A standard numerical measure of a disease or condition. It extends from the proportion of individuals with a disease or condition to the number of millimeters of probing depth around a tooth. Common indices in dentistry are the DMF Index, which is a measure of caries, the O'Leary Plaque Index, which measures plaque/oral hygiene, and PSR (periodontal screening and report), which indicates treatment need for periodontal therapy.

mean - The arithmetical average, a measure of central tendency together with the measures of mode (the most commonly occured value) and median (the value in an order of numbers that is the midpoint – there are as many values above as below).

NHANES - National Health and Nutrition Examination Survey (NHANES) is a survey conducted by the US National Center for Health Statistics, part of the Centers for Disease Control & Prevention (commonly referred to as CDC), which investigates and publishes reports on the health and nutritional status of Americans. Currently, approximately 5000 people are examined each year.

prevalence - The proportion (%) of individuals exhibiting the disease or condition (e.g., dental caries, TB, lung cancer) in a defined population group (e.g., the prevalence of dental caries is 50% in children aged 6 to 11 years). This term is frequently confused with and used interchangeably in error with another term incidence which reports on the occurrence of new disease cases.

Introduction

Approximately 500 million dental visits occur each year in the United States, and they come at a hefty price. According to a 2015 report,[1] dental care represented 4% of the total US health care costs. As noted in this report: "Spending for dental services increased 4.2 percent in 2015 to $117.5 billion, which was an acceleration from 2.4 percent growth in 2014. Out-of-pocket spending for dental services (which accounted for 40 percent of dental spending) increased 1.8 percent in 2015 after increasing 0.8 percent in 2014. Private health insurance (which accounted for 47 percent of dental spending) increased 3.0 percent in 2015 following 2.1 percent growth in 2014."

Dental caries, commonly known as tooth decay, is an oral disease in which the acid generated by oral bacteria cause damage to hard tooth structure. Although preventable, it is one of the most common chronic, infectious diseases among American children and adults, and remains one of the most common diseases throughout the world. In spite of major improvements that have been made in the US dental health care system over the past few decades, particularly with regard to the percentages of cavities found in both children and adults, some population groups continue to experience caries at higher rates than others. This is particularly true for populations with lower income and lower education and also for some ethnic and racial groups.[2]

Epidemiology: Oral Epidemiology in Clinical Practice

Studies conducted in the field of oral epidemiology provide information on normal biological processes and on diseases of the oral cavity, identify populations at risk of oral disease or in need of specific care, and compare regional, environmental, social, and access similarities and differences in dental

care between populations.[3] Oral epidemiology also tests preventive interventions for controlling disease and evaluates the effectiveness and quality of interventions and oral health programs.[3]

To understand epidemiology, it is important to understand the definitions of the following terms:

Prevalence: This is the proportion of individuals with disease (cases) in a population at a specific point in time.[3]

Incidence: This is the number or proportion of individuals in a population who experience new disease during a specific time period.[3]

Trends: These are the changes or differences in the prevalence or incidence of disease with respect to time, location, or socioeconomics.[3]

Epidemiology: Measuring Oral Diseases

In oral epidemiology, there are a number of crucial terms that will help dentists to understand how oral disease data is measured and presented. These include:

Index: This is a standard method of rating a disease in which there is a graduated, numerical scale with values corresponding to specific criteria. Types of measurement scales for indices include:

nominal, which simply names conditions;

ordinal, which lists conditions in order of severity;

interval or ratio, which establishes a mathematical relationship;

irreversible, which measures cumulative conditions that cannot be reversed (such as enamel loss due to erosion);

reversible, which measures conditions that can be reversed (such as gingivitis).[3,4]

An index is only valuable if the information it reports is:

Valid: An index must be designed to measure the aspect of disease that it is intended to measure and correspond to clinical stages of the disease.[3,4]

Reliable: An index should be reproducible and repeatable, and should provide consistent measurement at any given time under a variety of conditions.[3,4]

Clear, Simple, Objective: An index should have clearly stated, unambiguous criteria with mutually exclusive categories, and should be simple enough for an examiner to memorize and score using the criteria.[3,4]

Quantifiable: An index must present data that can be numerically analyzed and treated. Group status should be expressed by distribution, mean, median, or other statistical measures.[3,4]

Sensitive: An index should identify small yet significant shifts in the condition studied.[3,4]

Acceptable: The use of the index should not be unnecessarily painful, time-demanding, or demeaning to subjects.[3,4]

Video 1. What are the important characteristics of a valid index, with reference to a disease such as dental caries?
Click on image to view video online.

Epidemiology: The DMF Index

The **D**ecayed, **M**issing, **F**illed (**DMF**) index has been used for almost 80 years and is well established as the key measure of caries experience in dental epidemiology.[5] The DMF Index is applied to the permanent dentition and is expressed as the total number of teeth or surfaces that are decayed (D), missing (M), or filled (F) in an individual. When the index is applied to teeth specifically, it is called the DMFT index, and scores per individual can range from 0 to 28 or 32, depending on whether the third molars are included in the scoring. When the index is applied only to tooth surfaces (five per posterior tooth and four per anterior tooth), it is called the DMFS index, and scores per individual can range from 0 to 128 or 148, depending on whether the third molars are included in the scoring.[6]

When written in lowercase letters, the dmf index is a variation that is applied to the primary dentition. The caries experience for a child is expressed as the total number of teeth or surfaces that are decayed (d), missing (m), or filled (f). The dmft index expresses the number of affected teeth in the primary dentition, with scores ranging from 0 to 20 for children. The dmfs index expresses the number of affected surfaces in primary dentition (five per posterior tooth and four per anterior tooth), with a score range of 0 to 88 surfaces. Because of the difficulty in distinguishing between teeth extracted due to caries and those that have naturally exfoliated, missing teeth may be ignored according to some protocols. In this case, it is called the df index.[6]

Calculating DMFT: The teeth not counted are unerupted teeth, congenitally missing teeth or supernumerary teeth, teeth removed for reasons other than dental caries, and primary teeth retained in the permanent dentition. Counting the third molars is optional. When a carious lesion(s) or both carious lesion(s) and a restoration are present, the tooth is recorded as a D. When a tooth has been extracted due to caries, it is recorded as an M. When a permanent or temporary filling is present, or when a filling is defective but not decayed, this is counted as an F. Teeth restored for reasons other than caries are not counted as an F.[6]

Calculating DMFS: There are five surfaces on the posterior teeth: facial, lingual, mesial, distal, and occlusal. There are four surfaces on anterior teeth: facial, lingual, mesial, and distal. The list of teeth not counted is the same as for DMFT calculations, and listing D, M, and F is also done in a similar way: When a carious lesion or both a carious lesion and a restoration are present, the surface is listed as a D. When a tooth has been extracted due to caries, it is listed as an M. When a permanent filling is present, or when a filling is defective but not decayed, this surface is counted as an F. Surfaces restored for reasons other than caries are not counted as an F. The total count is 128 or 148 surfaces.[6]

Calculating dmft and dmfs: For dmft, the teeth not counted are unerupted and congenitally missing teeth, and supernumerary teeth. The rules for recording d, m, and f are the same as for DMFT. The total count is 20 teeth. For dmfs, the teeth not counted are the same as for dmft. As with DMFS, there are five surfaces on the posterior teeth and four surfaces on the anterior teeth. The total count is 88 surfaces.[6]

Limitations of DMF Index: While DMF indices can provide powerful data and perspectives on dental caries, they also have some limitations. For one, researchers have noted a significant amount of inter-observer bias and variability.[7] Other criticisms include that the values do not provide any indication as to the number of teeth at risk or data that is useful in estimating treatment needs; that the indices give equal weight to missing, untreated decay, or well-restored teeth; that the indices do not account for teeth lost for reasons other than decay (such as periodontal disease); and that they do not account for sealed teeth since sealants and other cosmetic restorations did not exist in the 1930s when this method was devised.[8,9]

Epidemiology: NHANES Surveys

The NHANES, or National Health and Nutrition Examination Survey, is a series of surveys

conducted in the United States beginning in the 1960s to examine the oral and nutritional status of a large, representative population. A paper published in 2007 described the trends in oral health status based on data collected from people aged 2 years and over from 1988–1994 and 1999–2004.[10] Two more recent papers reported on the information from the 2005-2008[11] and 2011-2012[12] surveys. The information collected focused on caries, dental history, tooth retention, edentulism (tooth loss), periodontal status, and prosthodontic status. It is clear from the most recent NHANES surveys that for most Americans, oral health has improved since the 1980s. What follows are some of the most significant findings of the last few surveys.

Caries in Children and Adolescents in the United States

Children between the ages of 2 and 19 were included in this group. Overall, it was seen that in children over 5, there was a decrease in dental caries prevalence. On the other hand, there was an increase in caries prevalence in children between 2 and 5.

While there is a decrease in caries prevalence overall, it was noted that children are more likely to get caries as they age: In the 1999 to 2004 period, 75.8% of the children aged 2 to 5 years were caries-free and corresponding percentages for children aged 6 to 11 years, 12 to 15 years and 16 to 19 years were 50.1%, 42.7% and 21.8%, respectively. The proportion of children with dental restorations also increased with age: In the 2005 to 2008 period, 38.7% of the children aged 5 to 11 years had dental restoration while the percentage for children aged 12 to 19 years was 52.0%.

Some of the most noteworthy data were found in the 2- to 11-year-old age group when comparing the 1988–1994 and 1998–2004 data. In this age group, the prevalence of untreated tooth decay was found to remain stable at approximately 23%, but the mean number of decayed and filled primary teeth (dft) significantly increased from 1.39 to 1.58. This increase seems to be due primarily to increases in dental caries in the youngest age group—the 2- to 5-year-olds. When examined further, this increase in caries in 2- to 5-year-olds was not linked to an increase in untreated decay, but to an increase in the number of restored dental surfaces. This suggests that the observed increase in dft scores in primary teeth may be the result of more restorative treatment in young children.

Also of note was the link between children's df scores and poverty. The highest d and f scores were in children living under the **F**ederal **P**overty **L**ine (**FPL**). These numbers increased between 1988-1994 and 1999-2004, suggesting less access to dental care in low-income families over time. Mean dfs scores also tended to peak earlier in age for children living under the FPL, compared to children living in families with incomes that are equal to or greater than the FPL. In addition, in 1999-2004, levels of untreated decay were highest in children living below the FPL: 33% compared to 28% of children living at, or up to twice the FPL, and 15% of children living at greater than twice the FPL.

There was also a link between levels of untreated decay and race. For example, in children under 11, 33% of Mexican-American children had untreated decay, compared to 28% of African-American children and 19% of non-Hispanic white children.

Caries in Adults in the United States
People aged 20 to 64 were included in this group. Overall, a decrease in caries was seen in American adults with coronal caries dropping from 95% in 1988-1994 to 92% in 1998-2004, and the largest decline being seen in the 20- to 34-year age group. In the 2011-2012 update for this same age group, caries has decreased further, to 91%.[12]

Data collected in 1999-2004 found that 85.6% of people aged 20 to 34 had caries experience, while the prevalence was 94.3% in people aged 35 to 49, and 95.6% in people aged 50 to 64. Also of note was that there was an effect of gender: men had fewer caries compared to women (90.6% vs. 92.7%). The proportion of adults with untreated dental caries in the period 2005-2008 varied between 19.6% in people aged 65 to 74 and 25.1% in people aged 20 to 44. In the 2011-2012 update for 20-64 year olds,

untreated tooth decay was found to be higher for Hispanic (36%) and non-Hispanic black (42%) adults compared with non-Hispanic white (22%) and non-Hispanic Asian (17%) adults. When combined, the 2011-2012 data showed that roughly 27% of adults, aged 20-64, had untreated tooth decay.[12] Also noteworthy was that the prevalence of root caries decreased from 19% during 1988-1994 to 14% during 1999-2004, with the greatest decline in the 50- to 64-year age group. The prevalence of root caries was 8% in people aged 20 to 34, 14.8% in people aged 35 to 49, and 21.6% in people aged 50 to 64. In the case of root caries, there was also a difference based on gender, with men having more root caries (15.8%) than women (12.7%).

Mean DMFT and DMFS scores for adults were lower in 1999-2004. The authors of the NHANES study observed that one reason for this is increased tooth retention in adults since the 1988-1994 study period (see Table 1 for a comparison of DMFT and DMFS scores according to age, gender, and race). One interesting finding related to DMFT and DMFS scores in adults was that there were no significant differences based on poverty levels, as was found in children. Also, while there were some differences in DMF scores based on race, they were not as significant as seen in children. Finally, there was also a difference in DMFT and DMFS scores between the genders: Women demonstrate higher scores compared to men of the same age, but this is not because women are more susceptible to dental caries. It is most likely due to the fact that women seek dental care more frequently than men, and women experience earlier tooth eruption patterns. However, recent papers in peer reviewed

Table 1. DMFT and DMFS scores in American adults in 1999–2004.

Group	DMFT score	DMFS score
Age: 20-34	6	13.4
Age: 35-49	10.9	31.5
Age: 50-64	15	53.9
Gender: Male	9.9	29.8
Gender: Female	10.7	32.1
Race: Non-Hispanic White	10.7	31.4
Race: African-American	9.8	31.9
Race: Mexican-American	8	24.1

Adapted from Dye BA, Tan S, Smith V, et al. Trends in oral health status, 1988 to 1994 and 1999 to 2004. National Center for Health Statistics. Vital Health Statistics. 2007; series 11(248).

journals examined the gender differences and suggested several possibilities including a hereditary component for caries susceptibility carried on the X chromosome.[13-15]

In 2016, the Health Policy Institute of the American Dental Association (ADA) made available oral health fact sheets for every US state. These data can be accessed via the following ADA link: *http://www.ada.org/en/science-research/health-policy-institute/oral-health-care-system*, and may be of interest to both dental health professionals and their patients.

Conclusion

Dental caries is a serious public health issue and collecting data on its prevalence, incidence, and trends is an important field in oral epidemiology. The DMF index is a standard method for assessing dental caries experience in populations. While linear increases in caries with age in both children and adults indicate that caries affects individuals throughout life, longitudinal surveys indicate a decline in dental caries experience over the past two decades, yet dental caries remains a prevalent oral disease among the children and adults.

Course Test Preview

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1. What types of information do studies in oral epidemiology provide?

A. The data is used to identify populations at risk of oral disease.
B. The data compare regional similarities.
C. The data compare differences in dental care between populations.
D. All of the above.

2. What is the correct term for the proportion of individuals with a disease in a population at a specific point in time?

A. Incidence
B. Prevalence
C. Trend
D. Index

3. What is the correct term for the changes in prevalence or incidence of disease with respect to time, location, or socioeconomics?

A. Validity
B. Ordinal
C. Trend
D. Index

4. All of the followings are types of measurement scales for indices except:

A. Ordinal
B. Mean
C. Interval
D. Reversible

5. An index must be designed to measure the aspect of disease it is intended to measure, corresponding to the clinical stages of the disease. This statement defines which of the following terms?

A. Quantifiability
B. Reliability
C. Objectivity
D. Validity

6. Which of the following is true about the DMF index?

A. It is expressed as the total number of teeth or surfaces that are decayed, missing, or filled.
B. It is expressed only as the total number of teeth that are decayed, missing, or filled.
C. It is applied to permanent and primary dentition.
D. It is a new measure of caries experience.

7. What is the score range of the DMFS index?

A. 0 to 20
B. 0 to 28 or 32
C. 0 to 128 or 148
D. 0 to 88

8. Which index calculates the number of surfaces that are decayed, missing, or filled in primary dentition?

A. DMFS
B. dmft
C. dmfs
D. DMFT

9. Which of the following are types of teeth not counted in calculating DMFT and DMFS?

A. Unerupted teeth
B. Congenitally missing teeth
C. Supernumerary teeth
D. All of the above

10. Which of the following is a limitation of DMF indices?

A. They do not account for sealed teeth.
B. They only count five surfaces on the posterior teeth.
C. They do not count unerupted teeth as missing.
D. They count a defective filling as an F.

11. What types of oral health data was collected with the NHANES surveys?

A. Dental history
B. Periodontal status
C. Caries
D. All of the above.

12. Which statistic accurately reflects the percentage of caries-free children in 1999-2004?

A. 21.8% of children aged 2 to 5 are caries-free.
B. 75.8% of children aged 2 to 5 are caries-free.
C. 28% of children aged 6 to 11 are caries-free.
D. 50.1% of children aged 12 to 15 are caries-free.

13. Which of the following statements about the findings of the NHANES survey with regards to dental caries in children is true?

A. Caries prevalence differs significantly based on gender.
B. There are no differences in caries prevalence based on race.
C. Untreated decay is highest in children living below the federal poverty line (FPL).
D. The prevalence of untreated decay rose significantly between 1988–1994 and 1998–2004.

14. Which of the following is an important gender difference in caries epidemiology?

A. Men are less likely to have caries on occlusal surfaces of teeth.
B. Men tend to have more caries on the facial surfaces of teeth.
C. Women and men have an equal prevalence of coronal and root caries.
D. Men have a higher prevalence of root caries.

15. Which of the followings is a likely reason for women to have higher DMF scores?

A. Female hormones make them more susceptible to caries.
B. Women seek dental care more frequently than men.
C. Women tend to not take good enough care of their teeth.
D. Women experience later tooth eruption patterns.

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