# The Impact of Gender on Caries Prevalence and Risk Assessment

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**KEYWORDS**

• Dental caries • Risk assessment • Risk management • Gender disparities

**KEY POINTS**

- A gender gap created by biologic and cultural influences, including behavioral and dietary variations, places women at a disadvantage in oral health.
- Cultural and social differences between men and women influence their oral health status by affecting their exposure to risk factors and shaping their access to protective factors and care.
- The large biologic differences between men and women and their relationship to oral health have not been sufficiently studied.
- There is a definite lack of evidence in regard to gender differences and dental caries. Therefore, there is a need to develop the evidence necessary to meet the oral health needs of both women and men.

## INTRODUCTION

### *Disease Description*

See **Box 1** for a description of dental caries.

### *Risk Factors for Dental Caries*

The World Health Organization (WHO) defines risk as the probability of an adverse event or a factor that can raise this probability.[10] Thus, identifying the risk factors

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**Box 1**
**Description of dental caries**

Dental caries remains the most common childhood disease worldwide,[1,2] disproportionally affecting women in many populations.[3-6] Dental caries is a site-specific, multifactorial disease that results from individual biofilm composition and metabolism,[7] which is influenced by several biologic factors. These biologic determinants include saliva, diet, and possibly genetic factors. At the individual or population level, multiple cultural, behavioral, and socioeconomic factors also influence caries development. Well-documented gender differences in these factors have also been reported to influence oral health status.

Although dental caries is multifactorial and complex, it is preventable. Fluoride and sealants have proven to prevent dental caries.[8] However, prevention of this disease is largely influenced by patient behaviors and attitudes as well as access to preventive dental services.[9]

that correlate to the individual burden of the disease[11] has been a long-standing goal. Caries management at the public health level[12-14] or individual level[15,16] relies on the identification of risk factors for correct categorization of a community or an individual and appropriate policy or management plan implementation. Unfortunately, the most reliable indicator of future risk is previous caries experience,[15,17] which is an antithesis when the aim is prevention of the disease. There is a multitude of variables that are included in risk prediction models[18]; the issue is very complex because the predictive values are influenced by many factors, and it is unlikely that any individual risk factor will provide a strong predictive value.[16]

There is evidence indicating that many caries risk factors provide a gender bias, placing women at a higher caries risk than men.[3] These factors may include different salivary composition and flow rate, hormonal fluctuations, dietary habits, genetic variations, and particular social roles among their family.[19] Additionally, there are systemic diseases that have been found to be associated with caries and to have an association with the female gender.[20]

Risk factors can be regarded as those that are risk indicators and those that are risk modifiers. There are risk factors related to the host (past caries experience, teeth, saliva, patient age, sociodemographic factors, behavioral factor, genetic factors), those related to the diet (type, quantity, frequency), those related to the dental biofilm (bacterial counts, genera and species, bacterial metabolism, and metagenomics), and those that are protective factors (adequate fluoride exposure, good oral hygiene, and positive dietary behaviors).

### *Risk Factors Related to the Host*

#### *Past caries experience*

This predictor is the single most reliable predictor of future risk and evidence supports its inclusion in considerations of risk assessment to increase sensitivity.[21,22] Epidemiologic studies have shown a positive strong correlation between past caries experience and future caries development.[23,24] The presence of caries in the mother and siblings increases the risk for a young child.[25] Caries prevalence in primary teeth can help predict future caries in permanent teeth.[26] If young girls are found to have a higher caries prevalence,[27-29] it can place them at a higher future risk.[30] In adults, there is a moderate association between existing caries and the risk of developing root caries.[31]

#### *Teeth*

Caries risk differs among different morphologic tooth types and between primary and permanent teeth. In permanent teeth, molars are more susceptible, followed by premolars, incisors, and canines.[32,33] Lesion progression on individual teeth also differs according to tooth type, with lesions on molars progressing faster than lesions in premolars and anterior teeth.[34] In the primary dentition, in early childhood caries (ECC), anterior teeth are more susceptible.[35] Occlusal surfaces are the most susceptible surfaces to caries,[36-44] followed by approximal surfaces.[42] Higher caries prevalence among girls may be explained by earlier eruption of teeth,[19] hence, longer exposure of teeth to the cariogenic oral environment, although to date there is no evidence.[20]

***Saliva***

In individuals with markedly reduced salivary function, caries activity is significantly increased.[45] Unstimulated flow rates are usually more predictable of caries risk and, when significantly low, can be isolated as a dominant risk factor.[46] However, the equation can be balanced and the risk altered by protecting agents, such as fluoride,[46] because of the prolonged retention time of fluoride in the mouth and the absence of diluting and clearance functions of saliva. There is an indication that fluctuating hormone levels in women and the associated physiologic changes during events, such as puberty, menstruation, and pregnancy, alter the biochemical composition of saliva and overall saliva flow rate.[19,47] These changes would make the oral environment significantly more cariogenic for women than for men and provide a possible explanation of the gender differences in caries rates.[19]

**Age**

Epidemiologic surveys of caries show an increase in caries prevalence with age. Newly erupted teeth (nonmature) are more susceptible to caries, particularly at pit and fissure sites.[48,49] The susceptibility also seems increased by the difficulty of cleaning the teeth until they have reached the occlusal plane.[50] Accordingly, children are at greatest risk at those ages when teeth have just erupted.[51] The earlier eruption pattern in girls could place them at a higher risk during teeth eruption years.[19] As children reach young adulthood, there is some indication that the caries incidence slows down.[52] The elderly are particularly at a greater risk for root caries; however, elderly women are not at a particularly higher risk.[53,54]

***Sociodemographic factors: race, culture, ethnicity, income, and education level***

Sociodemographic factors are seen as potential contributors to risk.[22] The data are controversial; some studies have found a clear relationship[55-57] between sociodemographic factors, whereas others failed to identify this relationship as significant.[22] It is clear that the impact depends on several variables or a combination of variables being studied, for instance, tooth surface, age, gender, and country. There are indications that race contributes to caries risk,[27,58-61] usually associated with income and education level; but few studies look at ethnicity as a variable.[62] Recent data have examined genetic variations observed in different populations and their association to dental caries.[63] Those in the lower-income brackets are likely to be at a higher risk for caries[56,57] as well as those in rural areas.[57] In children, the impact of sociodemographic factors on ECC differs among countries.[60,64,65] There is some indication that sociodemographic factors are a risk factor for caries in primary teeth[66,67] but not on permanent teeth.[68]

The issue of gender is controversial. In children, girls were found to have a higher risk for caries,[27-29] whereas others have found it to be a modifier,[69] and yet others found boys to have a higher or similar risk.[4] In adults, white men have been found to be at a higher risk for root caries,[53,54] whereas studies on other tooth surfaces have either found no effect of gender on caries risk[70] or found women to be at a higher risk.[3,4,19] It is likely that the culture-based division of labor and gender-based dietary preferences play a role in the gender bias on caries risk.[3] Genome-wide association studies have found caries susceptible and caries protective loci, some of which are X-linked, that influence variation in taste, saliva, and enamel proteins, affecting the oral environment and the microstructure of enamel, which may partly explain gender differences in caries.[3] Because of the complexity of the data related to sociodemographic factors in caries risk assessment and management, they should be considered as a modifier or potential contributor to risk.[22,71]

***Behavior***

Positive oral health attitudes and behaviors have been associated with decreased caries prevalence.[72-74] Positive oral health behaviors are regular tooth brushing, regular use of fluorides, and consumption of little or no sugar.[75] However, there are concerns about the reliability of measuring behavior, and mostly behavioral variables are not found to be good predictors of caries risk.[75,76] There is a tendency by anthropologists to favor explanations of the increased caries risk in women to factors involving behavior, including sexual division of labor and women's domestic role in food production.[19] There are suggestions that higher caries prevalence among women could be caused by easier access to food supplies and frequent snacking during food preparation[19] and by behaviors related to access to dental care.[74] In certain countries, the gender difference in oral health seems to involve social and religious causes, such as son preference, ritual fasting, and dietary restrictions during pregnancy.[3,4]

## ***Risk Factors Related to the Diet***

***Diet***

Diet plays an important role in dental caries. There is a large body of evidence linking frequent consumption of fermentable carbohydrates and caries prevalence. Historical studies have linked the shift from lower to higher sugar consumption to an increase in dental caries prevalence.[77,78] The classic Vipeholm study demonstrated the relationship between an increase in sugar consumption and the different types of sugars to an increment in dental caries.[79] More recent data compiled from 90 countries examining sugar consumption and dental caries in 12-year-old children related an increase in decay/missing/filled (DMFT) scores with sugar consumption.[80] Sucrose is considered the most cariogenic sugar because it can form glucan,[81] which enables bacterial adhesion to the teeth and restricts diffusion acid and buffers in the plaque.[82] However, in industrialized nations, the sugar-caries relationship is not always found, suggesting that other factors, for instance, other aspects of diet, exposure to fluoride, and genetic effects, need to be considered as explanatory.[80,83,84] Some foods, such as milk and milk products, provide a protective effect.[85,86] In children, gender differences in food tastes does not corroborate with gender differences in caries rates because boys have been reported to prefer sugary foods,[87] but preferences may be influenced by the mother's preferences[88] and culture.[89,90] In adults, women have been reported to prefer carbohydrates and sugary foods,[91] although no gender difference has been reported in the frequency of consumption of sugary snacks.[92,93]

**ECC *and baby bottle tooth decay***

The distinct clinical presentation of ECC has not been consistently associated with poor feeding practices.[94] Studies have been inconclusive in associating prolonged bottle use, use of the bottle at bedtime,[76] the contents of the bottle,[71] or nursing ad libitum[94] with caries risk.

### Risk Factors Related to the Dental Biofilm

#### Microbiological counts

Despite the univariate associations of *Streptococcus mutans* counts and lactobacilli levels with caries prevalence,[95] the correlation with future risk is weak.[22] There have been many findings indicating an association of microbial counts and caries in children with differing levels of confidence,[95-97] although this association was not found in root caries.[98] The accuracy of salivary tests for mutans streptococci in predicting future caries in the whole population is less than 20% to 50%.[99] In populations with low caries prevalence, the caries predictability of microbiological tests is further decreased.[100] Lactobacilli microbiological tests are even less sensitive at predicting caries than the mutans tests.[101] There have not been reported gender differences in bacterial counts.[102-105]

### Protective Factors

#### Oral hygiene

Although caries might be reduced by the mechanical removal of plaque, the evidence that tooth brushing reduces caries is weak; effectiveness of mechanical cleaning alone is hard to evaluate because tooth brushing is usually done using fluoridated toothpaste.[71] Additionally, most patients do not remove it effectively.[106] There is evidence that any condition that affects the patients' ability to maintain good oral hygiene are positively associated with caries risk.[25] Girls tend to have significantly higher scores than boys for desire to improve oral care and toothbrushing.[107-109]

#### Fluoride exposure

Fluoride in various forms is significant evidence of being efficacious on the prevention of dental caries.[110-122] Fluoride's main mechanism of action is posteruptive, controlling the initiation and progression of carious lesions by promoting remineralization of early caries lesions and reducing sound enamel demineralization.[123] Differences in fluoride have been reported among racial groups; however, these differences have been described as complex and are in need of further investigation.[124] Gender differences in fluoride exposure have not been correlated with differences in caries prevalence.[109]

### Prevalence and Incidence of Dental Caries in the United States

Based on data from the National Health and Nutrition Examination Survey from 1999 to 2002,[125] the mean number of caries in permanent teeth (DMFT) among children and adults in the United States is reported in **Tables 1** and **2.**

**Table 1**
**Mean number of caries in permanent teeth (DMFT) among children in the United States**

| Age | Mean | 95% Confidence Interval | Total Sample | Total Weighted Population |
|---|---|---|---|---|
| 6-11 | 0.42 | (0.35, 0.48) | 2149 | 23 569 639 |
| 12-15 | 1.74 | (1.49, 1.99) | 2333 | 15 556 985 |
| 16-19 | 3.20 | (2.98, 3.42) | 2155 | 15 006 863 |
| Mean for males (6-19) | 1.44 | (1.27, 1.62) | 3327 | 27 680 453 |
| Mean for females (6-19) | 1.70 | (1.55, 1.85) | 3310 | 26 453 034 |

*Data from* NIDCR/CDC. NIDCR/CDC Dental, Oral, and Craniofacial Data Resource Center. 2012. Available at: http://drc.hhs.gov/index.htm. Accessed October 2012.

**Table 2**
**Mean number of caries in permanent teeth (DMFT) among adults in the United States**

| Age (y) | Mean | 95% Confidence Interval | Total Sample | Total Weighted Population |
|---|---|---|---|---|
| 20-39 | 7.14 | (6.77, 7.52) | 3149 | 73 758 539 |
| 40-59 | 13.53 | (13.03, 14.03) | 2614 | 70 407 492 |
| 60+ | 20.01 | (19.55, 20.46) | 2989 | 41 735 510 |
| Mean for males (6-19) | 11.83 | (11.35, 12.31) | 4159 | 89 342 776 |
| Mean for females (6-19) | 13.02 | (12.56, 13.49) | 4593 | 96 558 766 |

*Data from* NIDCR/CDC. NIDCR/CDC Dental, Oral, and Craniofacial Data Resource Center. 2012, Available at: http://drc.hhs.gov/index.htm. Accessed October 2012.

Dental caries in the United States is no longer a population-wide problem but it is endemic to specific population subsets. In general, dental caries disproportionally affects the poor and racial and ethnic minorities, with women suffering more from the disease than men.[12] However, gender differences in caries prevalence or access to treatment have been reported to be decreasing or no longer exist for some age and racial groups. For example, among 2 to 5 year olds, boys were reported to have 20.0% untreated caries from 2001 to 2004, whereas girls had 20.1 %.[126]

### *Worldwide Prevalence and Incidence of Dental Caries*

Worldwide, dental caries continues to be the most prevalent disease of childhood, particularly in the Americas, the Eastern Mediterranean, and Southeast Asian regions. In 2003, it was estimated that 5 billion people worldwide suffered from dental caries.[126] Based on the reported data, it is not always possible to discern if gender differences present global patterns. Other distinct trends in dental caries prevalence have emerged worldwide, with certain regions observing a decline in the prevalence of disease and others, mostly low-income countries, reporting a continuous increase.

However, even in countries where dental caries continues to increase, the distribution of disease also affects certain segments of the population disproportionately.[1] In general, in countries with a high-income economy, dental caries disproportionally affect the poor and racial and ethnic minorities, with women suffering more from the disease than men. In countries with middle- and low-income economies, dental caries is a highly prevalent disease often characterized by marked differences within the same country.[1] In the United States and Europe, 20% of children suffer 60% to 80% of the disease. A similarly skewed distribution is found throughout the world, with some children having none or very few caries and others having a high number.

Many epidemiologic studies conducted around the world have recorded oral health data of 12-year-old children. In many countries, this is the last age at which data can be easily obtained through the school systems. For this reason, prevalence data for children is often more accurate than that of adults, which is often based on estimates in many countries. The most commonly used index for assessing caries prevalence and treatment needs among populations has been the DMFT index.[127] This index is based on subjective visual examination. Because the DMFT index does not include radiographs, it has been shown to underestimate the prevalence and treatment needs.[127]

In the current article, prevalence estimates were extracted from the WHO Oral Health Country/Area Profile Project for 12-year-old children using the DMFT index.[128] This database is updated and expanded continuously, with monthly updates. Data ranges are presented by region; however, meaningful comparisons worldwide are not feasible mostly because of temporal differences for data collection.

- For the Americas region, data are derived from surveys conducted in 12-year-old children from 1987 (Argentina) to 2008 (El Salvador). The region is home to countries from low, middle, and high incomes; as such, the contrasts in caries prevalence are stark, ranging from a DMFT of 0.2 for Bermuda to 6.7 for Martinica.
- For Europe, data are derived from surveys conducted in 12-year-old children from 1985 to 1990 (Armenia, Georgia, and Kazakhstan) to 2009 to 2010 (Belgium and Croatia). The region is home to countries with middle and high incomes, with DMFTs ranging from of 0.65 for Cyprus to 4.8 for Croatia.
- For Africa, data are derived from surveys conducted in 12-year-old children from 1981 (Angola) to 2003 to 2004 (Nigeria), with multiple countries having never reported or collected DMFT data nationally. The region is home to countries with low and middle incomes, with DMFTs ranging from of 0.3 for Togo and Tanzania to 4.9 for Mauritius.
- For the Eastern Mediterranean region, data are derived from surveys conducted in 12-year-old children from 1990 (Djibouti) to 2007 to 2008 (Sudan and Libya). The region is home to countries from low, middle, and high incomes, with DMFTs ranging from of 0.4 for Egypt to 5.9 for Saudi Arabia.
- For the Southeast Asia region, data are derived from surveys conducted in 12-year-old children from 1984 (Maldives) to 2009 (Indonesia). The region is home to countries from low and middle incomes, with DMFTs ranging from of 0.5 for Nepal to 3.9 for India.
- Finally, for the Western Pacific region, data are derived from surveys conducted in 12-year-old children from 1984 (Micronesia) to 2007 (Malaysia), with several countries having never reported or collected DMFT data nationally. The region is home to countries from low, middle, and high incomes, with DMFTs ranging from of 0.8 for Hong Kong to 4.8 for Brunei and Tokelau.

Dental caries has been reported to disproportionally affect women in many populations around the world. The magnitude of this disparity by gender increases from childhood to adolescence and into adulthood. This difference was observed as early as 4000 BP. Surveys conducted in Bangladesh, Hungary, India, Nepal, Spain, Sri Lanka, and in isolated traditional Brazilian villages have reported higher caries rates in women than men.[1-6,129] Following a similar pattern as that observed for caries, tooth loss in women is greater than in men and has been linked to caries and parity. However, in a patter similar to that observed for the United States, gender inequalities have recently been reported to be decreasing or no longer exist beyond adolescence through the reproductive years.[130]

### *Clinical Correlation*

The treatment of dental diseases is expensive, accounting for between 5% and 10% of total health care expenditures in industrialized countries. In the United States, the Centers for Disease Control and Prevention reported that in 2009 to 2010,14% of children aged 3 to 5 years had untreated dental caries. For children aged 6 to 9 years, 17% had untreated dental caries; and 11% of adolescents aged 13 to 15 years had untreated dental caries.[131] Differences in untreated caries also reflect disparities among racial and ethnic populations and the poor. On the other hand, in most low-income countries, more than 90% of caries is untreated.

There is extensive data from high-income countries reporting medical and dental services use differences among genders, with women being reported to use services more frequently than men.[132,133] Differences in untreated decay among genders have also been reported for certain communities in low-income countries. For example, women in small, rural, isolated communities in Guatemala were most likely to have their teeth extracted and replaced by dentures, reflecting their concern with appearance as well as their of fear pain and their desire to ensure the best possible marriage.[130]

## SUMMARY AND DISCUSSION

A gender bias placing women at a disadvantage in oral health has been reported in many regions in the world and has been associated with genetic, hormonal, and cultural influences, including behavioral and dietary variation. Although there are some reports that have indicated that definite biologic (sex) and social (gender) differences exist, much is not known.

Cultural and social differences between men and women can influence their oral health status in several different ways. Marked differences in daily lives can affect their exposure to risk factors and also shape their access to protective factors and care.

The large biologic differences between men and women and their relationship to oral health have not received sufficient attention. This point is especially relevant because it is well known that biologic factors are partly responsible for differences in disease incidence and prevalence. Other than hormonal variation during reproductive cycles and their relationship to periodontal health, little has been studied in the context of oral health.

The current article indicates the lack of evidence in regard to gender differences and dental caries. There is a definite need to develop the evidence base necessary to meet the oral health needs of both women and men. This evidence would support the development of tools that would aid clinicians in determining the caries activity and risk status of patients in real time. This information would then be used to tailor appropriate preventive intervention strategies to improve the oral health of both genders.

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