Streptococcus Mutans and Dental Caries

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Keywords

Streptococcus Mutans • S. mutans • Dental Caries • Oral Health • Oral Biofilm

Introduction

Dental caries, commonly known as dental cavities or tooth decay, are the most common noncommunicable diseases and are especially found in children. Caries are developed when *S. mutans* take advantage of excess sugars found on the tooth surface, triggering acid production, and thus loss of tooth surface (Pitts et al., 2017). In terms of signs and symptoms, caries may cause a toothache depending on the individual and the severity of the disease, but when it does, it could be debilitating (Pitts et al., 2017). Dental caries and demineralization may cause visual changes to the teeth, specifically in color, that may cause psychological issues, including a lack of self-esteem and embarrassment (Pitts et al., 2017). These effects may be further exacerbated by a more progressive form of dental caries that may be caused by the loss of teeth, leading to the need for dentures or other dental prosthetics (Pitts et al., 2017).

Thus far, society has strived to treat dental caries as they come along by preventing the demineralization of the tooth enamel. However, leaning into ways to prevent dental caries from existing by directly targeting *S. mutans* may be a beneficial solution to a major public health issue.

Epidemiology

Dental caries are an enormous public health issue. According to Pitts et al. (2017), approximately half of the United States (US) population is affected by dental caries. Worldwide, about 60–90% of children have dental caries, which rises to 100% in adulthood (Quock, 2015). Additionally, untreated dental caries was the most prevalent medical condition globally for all individuals, children, and adults (Pitts et al., 2017). This is a significant burden on not only the well-being of the public but the economy as well. In an analysis of dental caries, Quock explains that oral diseases are

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the fourth most expensive condition to treat worldwide, which includes dental caries. In addition to that, 5–10% of public health resources are used to contribute to the improvement of oral health (Quock, 2015). However, Pitts et al. (2017) believe that this is not sufficient. Since oral diseases are so prevalent, these authors are calling for more extensive public health attention to the topic. Pitts et al. (2017) also report that, when comparing studies from 2004 and 2012 in the US, the prevalence of caries in children only decreased from 28% to 23%. This difference is not seen as significant enough when considering how prevalent the disease is, how serious the implications are, and how many interventions are accessible and available.

There are additionally little to no sex or ethnic differences when considering the prevalence of caries in conjunction with sugar intake and economic status (Pitts et al., 2017). However, when considering the social determinants of health, there are likely differences in the prevalence of untreated versus treated caries between individuals from different socioeconomic statuses, as in one report, more than 90% of caries found in individuals from a developing country were untreated (Chow, 2017).

Risk Factors

According to Pitts et al. (2017), the most common risk factor for dental caries is being a child (Pitts et al., 2017). Children often have high-sugar diets that heighten the exposure to sucrose and thus the risk of caries. Children under the age of 6 years old are at a particularly high risk for early childhood caries (ECC), which is a severe form of caries. It is additionally of note that although children are the most susceptible to caries, it is prevalent in adults due to the development of the disease as a child and/or the high consumption of sugar (Pitts et al., 2017). Oftentimes, health inequities do not dissipate from the transition from childhood to adulthood, so the implications of caries can follow an individual throughout their lifespan (Pitts et al., 2017). Another high-risk population is those with low salivary secretions since salivary secretions help neutralize the acid produced by *S. mutans* (Peckham & Awofeso, 2014).

Since dental caries are most seen in individuals with high sugar diets, which is a risk factor of its own, Pitts et al. (2017) report that dental caries are more common in developed countries compared to developing countries. They name the reasoning behind this to be the fact that developed countries often have the economic development to support a high-sugar diet.

The overarching influencing risk factor is simply a high-sugar diet. Since *S. mutans* thrives in high sucrose environments, individuals, like children and those living in developed countries, reducing the amount of sugar consumption will put every individual at a much lower risk of developing dental caries.

Streptococcus mutans

Streptococcus mutans is a gram-positive, facultative anaerobe bacteria endogenous to the oral cavity (Nakano et al., 2008). *S. mutans* is a member of one of the eight streptococcus groups, a dominant species in the oral cavity and upper respiratory tract (Abranches et al., 2018). According to Abranches et al. (2018), the streptococcus species, including *S. mutans*, are vital for the formation of the oral microbiota, and specifically the dental plaque of the teeth, since they provide the perfect environment for bacteria to grow - warm, moist, and rich in nutrients. *S. mutans* require an environment that fulfills three requirements: able to synthesize extracellular polymers of glucan, able

to metabolize carbohydrates, and can succeed under stressful environments (Lemos et al., 2019). *S. mutans* is the key cariogenic organism responsible for dental caries (Lin et al., 2021). There is a balance in the oral microbiome that is constantly swaying from health to disease. When the number of cariogenic bacteria, such as *S. mutans*, outweighs the number of non-cariogenic bacteria, there is the opportunity and possibility of the development of disease, including dental caries.

Mechanisms of Pathogenesis

S. mutans-dominant biofilms thrive in the oral cavity due to the high-sucrose environment. When comparing dietary sugars like glucose, fructose, and lactose, sucrose is easily diffusible and ready to be metabolized, making it more cariogenic (Zero, 1999). Sucrose is primarily found in added sugars from sodas and other beverages, sweets, and snacks, which have taken an increasingly large portion of the average US diet (Chow, 2017). In the current diet, sugar contributes to up to 16% of the daily calories when it should be less than 5% of the daily calories (Chow, 2017).

Additionally, *S. mutans* are acid producers, meaning they will generate lactic acid to aid in the formation of the biofilm (Pitts et al., 2017). As the acid builds up, the pH is consistently decreasing to the point of demineralization of the tooth surface. Demineralization is a loss of the mineralized tissue, hydroxyapatite, on the tooth surface that results in fractures or caries (Roberts et al., 2022; Fiorillo et al., 2020). According to Pitts et al. (2017), after the exposure to sucrose is cleared, the acids will begin to be neutralized, the pH will begin to return to neutral, and remineralization will start. This process is represented by the Stephan Curve, which is shown in *Figure 1*, retrieved from the Wrigley Oral Healthcare Programme. As seen in this curve, the demineralization process happens quickly, while the remineralization process takes about twice as long. This means that after exposing sucrose to the tooth surface, the damage takes a long time to repair itself.

When thinking about the Stephan Curve in terms of an individual drinking a sugary beverage, they are consistently being exposed to sucrose every sip, further delaying the remineralization, and thus exacerbating the presence of *S. mutans*. Pitts et al. (2017) continue by explaining that the demineralization of the tooth surface will continue to grow, allowing the acid to work deeper into the tooth to cement the damage. The lactic acid will continue to keep the pH low, further promoting demineralization and resulting in a subsurface lesion. The authors then explain that this lesion appears as a white spot on the tooth. This white spot is a clinically meaningful sign since it indicates the presence of potential dental caries and, thus, the need for intervention. Since this

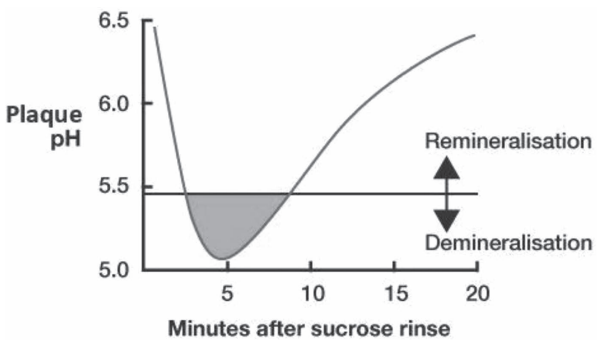

Figure 1. The Stephen Curve

disease is dynamic in terms of constant demineralization, remineralization, and exposure to sucrose, the initial stages of caries can be reversed when presented with an intervention mentioned in the following section of this essay.

Interventions

There are currently a plethora of interventions that are targeted at reducing the risk of demineralization and dental caries before they happen. Early detection of tooth demineralization can help identify dental caries, which is vital for applying an intervention and preventing further damage. Each intervention has a unique approach to dental caries prevention. These may include the reduction of acid formation, disruption of pH regulation, and/or inhibiting demineralization, but these are all forms of stopping *S. mutans* from doing a significant amount of damage (Thurnheer & Belibasakis, 2018).

One of the most important interventions is reducing sucrose intake. As previously mentioned, *S. mutans* thrives in high-sucrose environments, which allows it the perfect location to produce acids, demineralization, and dental caries. Reducing the amount of sucrose that is ingested can help immediately combat the exposure of *S. mutans* to one's oral cavity and thus significantly reduce the prevalence of dental caries (Phonghanyudh et al., 2022).

Sodium Fluoride is the most used form of demineralization prevention. It works by converting hydroxyapatite to fluorapatite, a coating that covers the tooth surface (Peckham & Awofeso, 2014). This process helps reduce the solubility of the enamel and thus prevents demineralization. Sodium fluoride is found in toothpaste, mouthwashes, and gels that work to inhibit demineralization. This intervention is commonly seen as the main cause of the decrease in dental caries prevalence worldwide (Pitts et al., 2017).

As explained by Fiorillo et al. (2020), tooth brushing is usually combined with toothpaste and is aimed at maintaining the health of the teeth. Toothbrushing does not provide any direct protection to the tooth surface; however, it provides indirect protection by reducing the thickness of dental plaque. This is important because plaque, or biofilm, thickness is associated with lower levels of calcium, phosphate, and fluoride. The reduced prevalence of these materials gives a better opportunity for a cariogenic takeover, keeping the dental plaque minimal, which will overall promote healthier teeth (Attin & Hornecker, 2005).

Interventions may be used independently of one another, however, they are best used when in combination. While mechanical treatments, like toothbrushing, break up the plaque, combining that with Sodium Fluoride-containing toothpaste will temporarily inhibit the biofilm formation. Additionally, having an overall low-sucrose diet creates a less opportunistic environment for *S. mutans* to grow, leaving less build-up for the mechanical treatment and for Sodium fluoride to work with. There is, however, concern about the feasibility of dental caries prevention via a low-sucrose diet. Chow et al. (2017) state that "the whole world has been addicted to sugar for the past 100 years and is increasingly so"; thus, a complete reduction is not necessarily possible, but a decrease to 5% of the total dietary intake per day from added sugars may be incredibly beneficial.

Future Outlooks

S. mutans is a highly prevalent bacteria that causes oral health morbidity for essentially the entire population, though they are particularly at risk to children and those in developed countries. Dental

caries, caused by *S. mutans*, are dangerous to not only the physical health of the individual but also the emotional well-being, as having yellow-presenting teeth often leads to insecurity and low self-esteem. Caries are oftentimes dealt with as they develop via medical treatments with a dentist, however, there are a plethora of current interventions that exist to combat the *S. mutans* accumulation. By addressing caries before they become a medical issue, we can prevent the negative health effects that come with it. In order to do this, a shift to the viewpoint of primary prevention, or preventing the disease from ever occurring, is needed.

Individual-level primary prevention methods include behavioral changes like having a low-sugar diet, using proper toothbrushing technique, and the consistent use of Sodium fluoride. All of these methods combined will greatly reduce the risk of developing dental caries. Additionally, there is a need for policy advocacy regarding dental caries, including the need for basic recognition. Policymakers can work to recognize caries in their noncommunicable disease plans, promote oral health education to citizens and healthcare professionals, and ensure equitable access to caries prevention measures like Sodium fluoride (Pitts & Mayne, 2021). Dental caries are preventable, but they are not commonly recognized as a significant issue, which makes it difficult to prevent from a population health lens. To achieve optimal health, a multifaceted approach must be utilized, and thus there is a calling for public health professionals to put greater resources into the prevention of an outstandingly prevalent disease, improving health for all.

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