

Vedhika Sathish

Systems Thinkers in STEM Ambassadorship (STISA) Research Paper

1 January 2026

## Adolescent Oral Health in a Systems Context: Determinants, Disparities, and Preventive Leverage Points

### Introduction

Adolescent oral health is often framed as an individual responsibility, yet national surveillance data show that cavities and untreated tooth decay remain common and are patterned by social conditions. Tooth decay, also known as dental caries, is damage to teeth caused by acid produced when bacteria break down sugars. The Centers for Disease Control and Prevention (CDC) reports that about 10.0% of adolescents aged 12 to 19 had one or more permanent teeth with untreated decay in the 2017 to March 2020 National Health and Nutrition Examination Survey (NHANES) cycle, and the prevalence was higher among older adolescents aged 16 to 19 (12.1%) than among those aged 12 to 15 (8.6%) (CDC, 2024). The same surveillance tables show higher untreated decay among adolescents in high and middle poverty groups combined (13.2%) compared with those in the low poverty group (8.2%) (CDC, 2024).

These differences matter because untreated decay is not a cosmetic issue. It can cause pain, infection, disrupted sleep, and avoidance of eating or speaking, all of which interfere with school performance and well being. The school day is also a period of repeated exposure to common drivers of tooth decay, also known as caries, including sugary beverages and convenience foods. When caries progresses, families may face urgent care costs and missed work, which can further reduce the capacity for prevention.

This paper asks a systems level question: which interacting drivers most strongly shape adolescent oral health outcomes in the United States, and what leverage points are realistic within school, family, and community settings? Rather than treating cavities as a single cause problem, the paper treats adolescent oral health as an outcome of connected domains: diet and sugar timing, fluoride exposure and preventive behaviors, access to preventive dental services, social determinants and health literacy, and biology mediated by the oral microbiome.

This paper examines adolescent oral health through a systems lens, with a focus on dental caries as a prevalent and preventable chronic condition. It synthesizes evidence across biological, behavioral, and structural drivers, including dietary sugar exposure, fluoride availability, oral hygiene routines, microbiome dynamics, stress and sleep, and access to preventive care. By mapping connections and feedback loops among these factors, the analysis highlights leverage points for prevention in homes, schools, and clinical settings, and identifies equity relevant barriers that shape risk and outcomes.

### Background and Burden of Disease

National Center for Health Statistics analyses illustrate the broader burden of caries during adolescence. In a NCHS Data Brief using NHANES 2015 to 2016, Eleanor Fleming and Joseph Afful estimate that 53.8% of youth aged 12 to 19 had experienced total dental caries (treated or untreated) and 13.4% had untreated caries (Fleming and Afful, 2018).

Adolescence is a distinct developmental period. Teens increase autonomy over food choices, spend more time outside the home, and often experience time pressure that disrupts routines. Many also begin orthodontic treatment, which can complicate plaque control. Puberty related

hormonal changes can increase gingival inflammation, and stress related behaviors such as frequent snacking, energy drink use, or skipping bedtime routines can shift caries risk.

Oral health outcomes depend not only on whether a teen sees a dentist, but also on whether preventive services are delivered. The CDC emphasizes that dental sealants prevent about 80% of cavities in back teeth for two years after placement and can continue protecting for up to four years (CDC, 2024). Sealants therefore represent a high impact intervention for adolescents because most cavities in permanent teeth develop on molars. Yet sealant access is uneven, particularly when school based sealant programs are absent or when preventive dental visits are difficult to schedule.

Disparities are also sustained by uneven access to the dental workforce. On its oral health equity pages, the CDC notes that tens of millions of Americans live in dental health professional shortage areas (CDC, 2024). Shortage areas increase travel time and waitlists and can push care toward crisis visits rather than prevention. In systems terms, this creates a reinforcing loop: delayed care leads to painful experiences, which increases avoidance, which further delays care.

## Methods

This paper is a structured literature review and systems synthesis. Sources were selected to represent three types of evidence: surveillance datasets describing prevalence and disparities, evidence summaries of preventive interventions, and conceptual reports on social determinants and oral health inequities. Surveillance sources prioritized CDC Oral Health Surveillance products and NHANES analyses. Preventive intervention evidence included CDC summaries and systematic reviews on fluoridation and sealants. The review also used behavioral

surveillance data on sugar sweetened beverage intake from CDC's Youth Risk Behavior Survey (YRBS) materials (CDC, 2022).

Each source was coded into systems categories: exposures (sugar frequency, fluoride), behaviors (brushing routines, dental attendance), structural constraints (insurance, provider supply, transportation), psychosocial context (stress, health literacy, fear), and biologic susceptibility (microbiome, saliva, host inflammation). Organizing evidence this way supports identification of feedback loops and leverage points rather than listing risk factors without showing connections.

#### A Systems View of Adolescent Oral Health

At the biological level, caries develops when demineralization outpaces remineralization. Acidic byproducts created when bacteria metabolize sugars lower plaque pH and dissolve enamel minerals. Saliva and fluoride can repair early damage, but frequent sugar exposure and inadequate fluoride shift the balance toward net mineral loss.

Yet the same biochemical process can occur in very different social contexts. A student may understand that soda increases cavity risk, but if soda is cheap, heavily marketed, and available daily at school or nearby stores, the system is shaped toward repeated exposure. Similarly, a student may own toothpaste but still skip nighttime brushing if they arrive home late from activities and fall asleep immediately, or if stress and low sleep undermine self regulation. For example, a student might drink a sugary coffee in the morning, a soda at lunch, and an energy drink after school. This repeated exposure increases acid production and raises the risk of tooth decay.

Systems thinking adds a time dimension. Untreated decay can cause pain that disrupts sleep, and sleep disruption can increase cravings for high sugar foods and caffeinated drinks. Pain can also reduce participation in school, which can raise stress and crowd out preventive routines. In the opposite direction, a preventive dental visit that provides sealants and supportive counseling can reduce new cavities, lowering fear and increasing the likelihood of future visits, which reinforces prevention.

Finally, systems thinking emphasizes that some interventions are more equitable than others. Population level strategies such as community water fluoridation provide benefits without requiring a teen to have time, money, or transportation. In contrast, interventions that rely solely on individual behavior change can inadvertently widen disparities if they are easier to adopt for higher resource households.

Figure 1 (text representation): Sugar intake → acid production → enamel damage → pain → disrupted routines → increased sugar intake

#### Driver 1: Sugar Sweetened Beverages and the Food Environment

Sugar sweetened beverages are a major contributor to frequent sugar exposure because they are easy to consume quickly and repeatedly. CDC data shows that many high school students consume sugary drinks one or more times per day (CDC, 2022).

#### Driver 2: Fluoride as a Population Level Prevention Tool

Fluoride reduces caries risk through multiple mechanisms, including strengthening enamel and supporting remineralization. Community water fluoridation can reduce tooth decay by about 25% (CDC, 2024).

### Driver 3: Sealants and School Based Prevention

Dental sealants are one of the strongest evidence based strategies for preventing cavities in permanent molars. Research shows disparities in sealant use, with lower access among higher risk populations (Patel et al., 2024).

### Driver 4: Access to Care, Insurance, and Navigation

Emergency department visits for dental pain are often preventable and reflect gaps in access to care (ASTDD, 2016).

### Driver 5: Social Determinants, Stress, and Health Literacy

Social and economic conditions influence access to care, health behaviors, and oral health outcomes.

### Driver 6: Biology and the Oral Microbiome

Biological factors such as saliva, enamel composition, and oral bacteria influence cavity development.

### Conclusion

Adolescent oral health outcomes reflect a connected system, not a single behavior. Factors such as sugar intake, fluoride exposure, access to care, stress, and the oral microbiome all interact to shape outcomes over time. A systems perspective highlights that prevention is most effective when multiple factors are addressed together rather than in isolation. Strategies such as community water fluoridation, school-based sealant programs, improved access to preventive care, and healthier school environments can reduce risk at a population level. At the same time, increasing health literacy and providing practical tools can help adolescents build consistent habits and make informed decisions. By combining individual, community, and

policy-level approaches, oral health prevention can become more effective, more accessible, and more equitable.

**Sources:**

<sup>1</sup> Centers for Disease Control and Prevention. (2024). *Oral Health Surveillance Report*. CDC.

<https://www.cdc.gov/oralhealth>

<sup>2</sup> Fleming, E., & Afful, J. (2018). *Prevalence of Total and Untreated Dental Caries Among Youth Aged 2–19 Years*. National Center for Health Statistics.

<https://www.cdc.gov/nchs>

<sup>3</sup> Centers for Disease Control and Prevention. (2022). *Youth Risk Behavior Survey Data Summary & Trends Report*. CDC.

<https://www.cdc.gov/healthyyouth/data/yrbs>

<sup>4</sup> World Health Organization. (2015). *Guideline: Sugars Intake for Adults and Children*. WHO.

<https://www.who.int/publications>

<sup>5</sup> Centers for Disease Control and Prevention. (2024). *Community Water Fluoridation Basics*. CDC.

<https://www.cdc.gov/fluoridation>

<sup>6</sup> Patel, M., et al. (2024). *Disparities in Dental Sealant Use Among Adolescents*. Journal of Public Health Dentistry.

<sup>7</sup> Association of State and Territorial Dental Directors. (2016). *Emergency Department Visits for Non-Traumatic Dental Conditions*. ASTDD.

<https://www.astdd.org>

<sup>8</sup> Peres, M. A., Macpherson, L. M., Weyant, R. J., et al. (2019). Oral diseases: A global public health challenge. *The Lancet*, 394(10194).

[https://doi.org/10.1016/S0140-6736\(19\)31146-8](https://doi.org/10.1016/S0140-6736(19)31146-8)