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## Examining the Relationship of Physical and Mental Health with Oral Health Concerns among Rhode Island High School Students

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### Abstract

**Background:** Our study was conducted to assess the prevalence of three oral health concerns among Rhode Island (RI) adolescents by evaluating the effects of physical and mental health on adolescent oral health and determining whether the patterns vary by age, sex, and race/ethnicity.

**Methods:** We used the 2019 RI Youth Risk Behavior Survey (YRBS), a random sample of 1,613 high school students. Weighted multivariable logistic regression models were used to assess the relationship of regular physical activity, dietary consumption, BMI, and mental health with experiencing mouth pain, self-consciousness/embarrassment about their teeth/mouth, and not having a recent dental check-up, controlling for age, gender, and race/ethnicity.

**Results:** Poor mental health was significantly associated with all three oral health outcomes. Adolescents who felt sad/hopeless for two weeks or longer had a significantly greater likelihood of mouth pain (Adjusted OR [AOR]=2.06, 95% CI=1.32, 3.20), feeling self-conscious about their teeth/mouth (AOR=3.05, 95% CI=1.63, 5.70), and not having had a recent dental check-up (AOR=2.16, 95% CI=1.22, 3.82).

**Conclusions:** Adolescents with mental health concerns were more likely to experience mouth pain, feel self-conscious about their teeth/mouth, and not have a recent dental check-up. Interprofessional collaboration is essential to address adolescent oral health concerns.

**Keywords:** Adolescents; Dental health; Mental health; Oral health concerns; Physical health; Rhode Island

### Introduction

Dental decay is the most prevalent, non-communicable illness globally [1], constituting a considerable health risk to everyone's oral and systemic health [1]. Like most chronic diseases, dental caries are influenced by numerous genetic, environmental, and behavioral risk factors [2]. Dental decay is brought on by sugary foods interacting with microorganisms, primarily *Streptococcus mutans*, which breaks down sugars to create an acidic environment in the mouth and demineralize tooth enamel [3]. While often treated with fillings and root canals, untreated caries can cause tooth loss, acute pain, and aesthetic concerns, as well as systemic issues and even fatalities [4].

The risk of dental caries is particularly high throughout adolescence [5], when teenagers engage in high sugar consumption [2,5]. Diets with a high sugar content are often addictive and have been linked to binge eating [6]. Additionally, since adolescents typically spend more time outside their homes, they are often tempted by advertisements or peers to consume sugary snacks, engage in unhealthy activities, and avoid nutritious food. Parents are also monitoring adolescents' dietary choices less frequently. Furthermore, adolescents frequently engage in body image comparisons, in person and on social media, making them more likely to suffer eating disorders that can lead to malnutrition [7]. Inadequate nutrition can alter saliva composition and decrease salivary output, thereby increasing susceptibility to caries [2]. Conversely, obesity has also been linked to caries [2]. Malnourished or obese adolescents often have low levels of essential nutrients, such as calcium, phosphate, and vitamin D, which are necessary for healthy teeth [8]. Problems such as discoloration, decay, and crooked or missing teeth can lead to self-consciousness about appearance, when smiling or speaking. Pain in the oral cavity and missing teeth can also result in difficulties in diction, eating, sleeping, and swallowing, which can lead to further declines in self-esteem [9]. Thus, oral health can have a profound effect on adolescent socialization and quality of life.

Few studies have examined the relationship between physical activity, oral health, and systemic health [10]. However, one study showed that physically active adolescents are more likely to brush their teeth twice daily than less physically active adolescents [10]. Healthy adolescents may be more motivated to improve their personal appearance, gain peer approval, and exhibit good oral hygiene [11]. Moreover, inadequate physical activity may result in a lifestyle with greater media exposure and poor dietary habits [12]. Approximately one-third of the commercials on children's channels are related to food and drink products, with 95% of those items regarded as cariogenic [12]. Given the shared risk factors for caries and obesity, analogous psychological pathways may connect TV viewing, low physical activity, and cavities among adolescents.

Body Mass Index (BMI), a measure of a person's weight in relation to height, is often used to determine whether a person is underweight, normal weight, or overweight [13]. However, BMI is not always an accurate indicator of a person's overall health, as it does not consider factors such as muscle mass or body composition [14]. High BMI in adolescents has been correlated with a reduction in motor abilities and lower physical fitness, as excess weight impedes physical activities [13]. Obesity has also been linked to a decreased saliva flow rate and increased dental caries, adding to obesity's deleterious impact on oral health [15]. Inflammatory mediators have been hypothesized to contribute to the hypofunction of salivary glands in obese people [15]. However, salivary glands may also be affected by stress hormones linked to the hypothalamic-pituitary-adrenal axis, which may negatively influence salivary gland function [15]. More importantly, reduced salivary flow can create a clinically significant oral imbalance and generate more caries and other problems [16].

The connection between mental health and oral health in adolescents is well-established. Mental health problems, including stress, anxiety, depression, and obsessive-compulsive disorders, can lead to self-neglect and poor oral hygiene that involve forgetting to brush and floss, cavities, gum disease, and bruxism (teeth grinding) [17]. Furthermore, oral health problems, such as tooth pain can lead to further stress, anxiety, and depression in adolescents, creating a vicious cycle of poor oral and mental health that is exacerbated by xerostomia (dry mouth) arising from antidepressant use [18]. Thus, healthcare providers should be aware of the connections between dental and mental health issues. Depressed individuals have been found to have a 20-30% higher likelihood of losing all of their teeth [18]. Poor nutrition and oral hygiene, excessive sugar consumption, substance abuse involving tobacco, alcohol, or psychostimulants, and financial or other hindrances can exacerbate such adolescents' oral health problems [18]. The National Institutes of Health recommends that a comprehensive assessment of individuals with severe mental illness include an oral health evaluation and that mental health clinicians and dentists closely collaborate to overcome psychosocial and financial barriers to care [19].

The Youth Risk Behavior Surveillance System (YRBSS) gathers population-based data and monitors various health-related behaviors among American youth [20], including inadequate physical activity and poor dietary habits. Since oral health is frequently neglected along with overall health [21], it is necessary to evaluate the effects of physical and mental health on the dental health of Rhode Island (RI) high school students. The objectives of this study are to: (1) assess the prevalence of oral health concerns among RI adolescents; (2) evaluate the effects of physical and mental health on adolescent oral health; and (3) determine whether the patterns vary by age, sex, and race/ethnicity. Although the YRBSS gathers a limited amount of data for RI, the system provides significant insight into the relationships among adolescents' oral, physical, and mental health.

## Methods

### Study Design and Participants

RI biennially conducts the Youth Risk Behavior Survey (YRBS), a component of the national YRBSS. A random cross-sectional sample of RI's public, charter, special education, alternative, and vocational high schools (grades 9-12) is selected to participate. Prior to survey administration, parent permission procedures are followed, including informing parents that their child's participation is voluntary [22]. Students complete an anonymous 99-item self-administered paper-and-pencil survey in their classrooms during one class period [23]. Since issues such as remote learning, limited opportunities for physical activity, increased mental health problems, and decreased access to dental care may have occurred during the COVID-19 pandemic, this study utilizes the 2019 YRBS.

### Measures

#### Oral Health Concerns

We examined three primary oral health outcomes in this study: teeth/mouth pain, self-consciousness/embarrassment because of teeth or mouth, and no recent dental check-up. The survey questions, response options, and analytic coding for these measures are available in the Supplementary Table.

### Other Measures

We examined three measures of physical health: dietary consumption, physical activity, and BMI. We also examined one measure of mental health: persistent feelings of sadness or hopelessness. We additionally examined students' age, sex, race, and ethnicity. The survey questions, response options, and analytic coding for these measures are available in the Supplementary Table.

### Statistical Analysis

All statistical analyses were performed on weighted data to account for the complex sampling design of the YRBS. Descriptive statistics were computed for all independent variables. Three logistic regression models were run to predict the likelihood of adolescents experiencing each oral health concern (mouth pain, self-consciousness, and lack of a recent dental check-up). First, unadjusted models were run to relate the sociodemographic, physical health, and mental health measures to each outcome. Then, adjusted models were run, including all sociodemographic measures, physical activity, BMI, mental health, and all dietary measures that were significant in the unadjusted models. R version 2022.12.0+353 was used in conducting all analyses. This study did not require Institutional Review Board approval as only secondary anonymized data were used for the analyses.

### Results

There were 1,613 adolescents who participated in the 2019 RI YRBS; 292 (18.1%) had missing data on one or more measures and were excluded, yielding an analytic sample of 1,321. Approximately 10% of RI adolescents were aged 14 years or younger (9.6%), 24.8% were 15 years old, 24.8% were 16 years old, 23.1% were 17 years old, and 17.7% were 18 years or older (Table 1). Half were male (49.5%) and half were female (50.5%). Over 60% identified as white (61.6%), 7.9% identified as Black, 23.1% identified as Hispanic, and 7.3% identified as other race(s). Half (50.5%) of RI adolescents reported having experienced mouth pain in the past year, 21.8% expressed feeling self-conscious about their teeth and mouth in the past year, and 20.6% had not had a recent dental check-up (Table 2).

Student Characteristics		Total Sample (n=1321) N (%)*
Sociodemographics		
Age	14 years and younger	171 (9.6)
	15 years	408 (24.8)
	16 years	323 (24.8)
	17 years	254 (23.1)
	18 years and older	165 (17.7)
Gender	Male	641 (49.5)
	Female	680 (50.5)
Race/ethnicity	Non-Hispanic White	710 (61.6)
	Non-Hispanic Black	90 (7.9)
	Hispanic any race	394 (23.1)
	Non-Hispanic other	127 (7.3)

\*Unweighted N; weighted percent

**Table 1:** Student characteristics, Rhode Island, 2019.

	Student Characteristics	Total Sample (n=1321) N (%)*
<b>Oral Health Concern</b>		
Mouth pain	Did not experience mouth pain	655 (49.5)
	Experienced mouth pain	666 (50.5)
Self-conscious	Not self-conscious about mouth	1030 (78.2)
	Self-conscious about mouth	291 (21.8)
Timing of most recent dental check-up	Dental check-up within 12 months	1036 (79.4)
	Dental check-up more than 12 months	285 (20.6)
<b>Physical Health</b>		
<b>Dietary Consumption</b>		
Green salad	0 servings per week	564 (41.7)
	1+ servings per week	757 (58.3)
Carrots	0 servings per week	709 (52.1)
	1+ servings per week	612 (47.9)
Potatoes	0 servings per week	535 (38.7)
	1+ servings per week	786 (61.3)
Other vegetables	< 1 serving per day	1015 (75.5)
	1+ servings per day	306 (24.5)
Water	0-3 glasses per day	874 (66.4)
	4+ glasses per day	447 (33.6)
Sugar-sweetened beverages	0 glasses per week	267 (20.3)
	1+ glasses per week	1054 (79.7)
Fruit juice	0-1 glasses per day	1177 (89.5)
	2+ glasses per day	144 (10.5)
Regular physical activity (60+ minutes per day)	0-4 days per week	765 (56.9)
	5+ days per week	556 (43.1)
Body Mass Index (BMI)	Not overweight or obese	933 (71.4)
	Overweight	198 (14.4)
	Obese	190 (14.3)
<b>Mental Health</b>		
Feeling sad or hopeless	2 weeks or less in the last 12 months	882 (68.0)
	More than 2 weeks in the last 12 months	439 (32.0)
*Unweighted N; weighted percent		

**Table 2:** Prevalence of self-reported oral health concerns and their correlates among Rhode Island adolescents, 2019.

More than half (58.3%) of RI adolescents reported eating green salad 1+ times per week, 47.9% ate carrots 1+ times per week, 61.3% ate potatoes at least once per week, and 24.5% ate 1+ servings of other vegetables per day. One-third (33.6%) drank 4+ glasses of water per day, while 79.7% consumed 1+ glasses of sugar-sweetened beverages (SSBs) per week, and 10.5% consumed 2+ glasses of fruit juice per day. Less than half (43.1%) engaged in 60+ minutes of physical activity 5+ days per week. The majority (71.4%) were not overweight or obese, 14.4% were overweight, and 14.3% were obese. Lastly, one in three (32.0%) reported feeling sad or hopeless for two weeks or more in the last 12 months.

Females were significantly more likely than males to report feeling self-conscious about their teeth/mouth (26.6% vs. 16.9%,  $p=0.001$ ) (Table 3). Males were more likely than females to have not had a recent dental check-up (23.6% vs. 17.6%,  $p=0.02$ ). Finally, adolescents identifying as non-Hispanic Black were the most likely to have not had a recent dental check-up (white: 14.0%; Black: 36.0%; Hispanic: 30.4%; other race(s): 28.2%;  $p < 0.0001$ ).

Student Characteristics	Experienced mouth pain		p-value	Felt self-conscious about teeth/mouth		p-value	Timing of most recent dental check-u		p-value
	No N (%)	Yes N (%)		No N (%)	Yes N (%)		≤12 months N (%)	>12months N (%)	
<b>Sociodemographics</b>									
Age			0.5			0.26			0.1
14 years and younger	86 (50.4)	85 (49.6)		136 (78.7)	35 (21.3)		144 (84.8)	27 (15.2)	
15 years	197 (48.6)	211 (51.4)		315 (78.5)	93 (21.5)		334 (83.0)	74 (17.0)	
16 years	170 (54.1)	153 (45.9)		249 (76.4)	74 (23.6)		246 (77.2)	77 (22.8)	
17 years	118 (45.1)	136 (54.9)		191 (74.9)	63 (25.1)		194 (78.2)	60 (21.8)	
18 years and older	84 (49.4)	81 (50.6)		139 (84.3)	26 (15.7)		118 (76.1)	47 (23.9)	
Gender			0.15			0.001			0.02
Male	340 (52.4)	301 (47.6)		533 (83.1)	108 (16.9)		488 (76.4)	153 (23.6)	
Female	315 (46.6)	365 (53.4)		497 (73.4)	183 (26.6)		548 (82.4)	132 (17.6)	
Race/ethnicity			0.79			0.83			<.0001
Non-Hispanic White	347 (48.9)	363 (51.1)		550 (77.7)	160 (22.3)		616 (86.0)	94 (14.0)	
Non-Hispanic Black	45 (48.6)	45 (51.4)		71 (79.3)	19 (20.7)		58 (64.0)	32 (36.0)	
Hispanic any race	199 (50.2)	195 (49.8)		307 (78.5)	87 (21.5)		270 (69.6)	124 (30.4)	
Non-Hispanic other	64 (53.1)	63 (46.9)		102 (80.9)	25 (19.1)		92 (71.8)	35 (28.2)	
*Unweighted N; weighted percent									

**Table 3:** Self-reported oral health concerns by sociodemographic characteristics among Rhode Island adolescents, 2019\*.

**Mouth Pain**

Drinking 1+ glasses of SSBs per week was significantly associated with higher odds of experiencing mouth pain in the unadjusted model (Unadjusted Odds Ratio [UOR]=1.32, 95% Confidence Interval [CI]=1.02, 1.70) (Table 4). Adolescents who experienced feeling sad or hopeless for two weeks or longer had a significantly greater likelihood of mouth pain (UOR=2.08, 95% CI=1.51, 2.85).

	Experienced mouth pain		Felt self-conscious about teeth/mouth		Dental check-up more than 12 months ago	
Student characteristics	Unadjusted OR 95% CI	Unadjusted OR 95% CI	Unadjusted OR 95% CI	Adjusted OR 95% CI	Unadjusted OR 95% CI	adjusted OR 95% CI
<b>Sociodemographics</b>						
Age	1.03 (0.91, 1.16)	1.03 (0.84, 1.27)	0.95 (0.83, 1.09)	0.95 (0.77, 1.18)	1.14 (0.999, 1.31)	1.11 (0.91, 1.36)
<b>Gender</b>						
Male (ref)	1	1	1	1		1
Female	1.26 (0.91, 1.75)	1.17 (0.74, 1.85)	1.78 (1.33, 2.38)	1.48 (0.94, 2.34)	0.69 (0.51, 0.94)	0.59 (0.38, 0.94)
<b>Race/Ethnicity</b>						
White (ref)	1		1	1		1
Non-White	0.94 (0.76, 1.17)		0.92 (0.69, 1.22)	0.86 (0.57, 1.29)	2.77 (1.82, 4.22)	2.59 (1.52, 4.42)
<b>Physical Health</b>						
<b>Dietary consumption</b>						
<b>Green salad</b>						
0 servings per week (ref)	1		1		1	
1+ servings per week	1.18 (0.89, 1.55)		1.02 (0.64, 1.61)		0.90 (0.80, 1.003)	
<b>Carrots</b>						
0 servings per week (ref)	1		1			
1+ servings per week	1.18 (0.79, 1.76)		0.91 (0.65, 1.26)		0.89 (0.66, 1.20)	
<b>Potatoes</b>						
0 servings per week (ref)	1		1		1	
1+ servings per week	1.06 (0.77, 1.46)		1.07 (0.82, 1.41)		0.88 (0.70, 1.11)	
<b>Other vegetables</b>						
< 1 serving per day (ref)	1		1		1	
1+ servings per day	0.92 (0.69, 1.21)		0.99 (0.60, 1.64)		1.03 (0.72, 1.48)	
<b>Water</b>						
0-3 glasses per day (ref)	1		1	1	1	
4+ glasses per day	0.86 (0.65, 1.13)		0.73 (0.55, 0.98)	0.71 (0.49, 1.02)	1.05 (0.68, 1.60)	
<b>Sugar-sweetened beverages</b>						
0 glasses per week (ref)	1	1	1		1	
1+ glasses per week	1.32 (1.02, 1.70)	1.35 (0.93, 1.96)	1.34 (0.94, 1.92)		0.96 (0.66, 1.40)	
<b>Fruit juice</b>						
0-1 glasses per day (ref)	1		1		1	1
2+ glasses per day	0.91 (0.58, 1.42)		0.83 (0.50, 1.40)		1.92 (1.34, 2.77)	1.66 (0.87, 3.18)
<b>Regular physical activity (60+ minutes per day)</b>						
0-4 days per week (ref)	1	1	1	1	1	1
5+ days per week	0.92 (0.78, 1.09)	1.05 (0.77, 1.41)	0.74 (0.57, 0.96)	0.93 (0.62, 1.41)	0.70 (0.49, 0.99)	0.79 (0.50, 1.24)
<b>BMI</b>						
Not overweight or obese (ref)		1	1	1	1	1
Overweight	1.28 (0.81, 2.02)	1.31 (0.75, 2.28)	0.98 (0.60, 1.62)	1.00 (0.51, 1.94)	0.95 (0.56, 1.62)	0.91 (0.38, 2.18)
Obese	1.25 (0.92, 1.70)	1.26 (0.80, 1.97)	0.93 (0.70, 1.23)	0.97 (0.57, 1.65)	1.66 (0.997, 2.78)	1.34 (0.67, 2.67)
<b>Mental Health</b>						
<b>Feeling sad or hopeless</b>						
2 weeks or less in the last 12 months (ref)	1	1	1	1	1	1
More than 2 weeks in the last 12 months	2.08 (1.51, 2.85)	2.06 (1.32, 3.20)	3.21 (2.15, 4.80)	3.05 (1.63, 5.70)	2.07 (1.40, 3.07)	2.16 (1.22, 3.82)

^ Measure not included in adjusted model

**Table 4:** Unadjusted and adjusted models of oral health concerns for Rhode Island adolescents, 2019.

Adolescents who experienced feeling sad/hopeless had significantly higher odds of experiencing mouth pain, controlling for sociodemographics and physical health (Adjusted Odds Ratio [AOR]=2.06, 95% CI=1.32, 3.20).

### **Self-Conscious/Embarrassed About Teeth/Mouth**

Females were more likely to feel self-conscious compared to males (UOR=1.78, 95% CI=1.33, 2.38). Adolescents who consumed 4+ glasses of water per day had significantly lower odds of feeling self-conscious (UOR=0.73, 95% CI=0.55, 0.98). Adolescents who engaged in regular physical activity for 60+ minutes per day 5+ days per week were significantly less likely to feel self-conscious (UOR=0.74, 95% CI=0.57, 0.96). Adolescents who experienced feeling sad/hopeless for two weeks or longer had a significantly greater likelihood of mouth pain (UOR=3.21, 95% CI=2.15, 4.80) and a significantly higher likelihood of feeling self-conscious about their teeth or mouth when controlling for sociodemographics and physical health (AOR=3.05, 95% CI=1.63, 5.70).

### **Recent Dental Check-up**

Compared to males, females had a significantly lower likelihood of not having had a recent dental check-up (UOR=0.69, 95% CI=0.51, 0.94); that is, females were more likely than males to have had a dental check-up in the past 12 months. Non-white adolescents were found to have a significantly higher likelihood of not having had a recent dental check-up compared to white adolescents (UOR=2.77, 95% CI=1.82, 4.22). Drinking 2+ glasses of fruit juice per day was significantly associated with higher odds of not having had a recent dental check-up (UOR=1.92, 95% CI=1.34, 2.77). Finally, adolescents who experienced feeling sad/hopeless for two weeks or longer were twice as likely to not have had a recent dental check-up (UOR=2.07, 95% CI=1.40, 3.07).

In the adjusted model, females were less likely than males to have not had a recent dental check-up (AOR=0.59, 95% CI=0.38, 0.94). Non-whites had significantly higher odds of not having had a recent dental check-up compared to white adolescents when controlling for age, gender, physical health, and mental health (AOR=2.59, 95% CI=1.52, 4.42). Adolescents who felt sad/hopeless had higher odds of not having had a recent dental check-up (AOR=2.16, 95% CI=1.22, 3.82).

### **Discussion**

Among the three oral health concerns, mouth pain was the most prevalent, with half of all adolescents reporting mouth pain at least once in the past year. Adolescents frequently experience mouth discomfort due to normal changes in their teeth (e.g., wisdom teeth migration) or self-neglect and unhealthy eating. Bacterial plaque may cause swollen gums or medications may cause gingival overgrowth, resulting in pain and sensitivity, thereby hindering proper dental hygiene [24]. Many adolescents undergo orthodontic treatments to correct alignment issues, causing further pain and discomfort. In the U.S., 15.1% of children aged 0-20 years had orthodontic appointments in 2013 [25]. It is also quite common for adolescents to suffer from dental trauma: 18% of those aged 12-15 and 22% of those aged 16-19 experienced fractures to their permanent incisors [19]. Males often suffer more dental trauma than females, possibly due to their greater involvement in contact sports, which can cause broken teeth and fractured jaws. However, the trend is shifting as females increase participation in contact sports [19]. These injuries can result in considerable pain and require immediate dental treatment to prevent damage.

Compared to males, female exhibited greater self-consciousness/embarrassment about their teeth/mouth. Social and cultural expectations may further impact this trend. Since their teeth and smile are considered integral to their appearance, females develop a heightened awareness of them. Any perceived oral imperfections can undermine self-confidence. One study has highlighted the significance of dental aesthetics as a crucial component of oral health and a prerequisite to adolescents maintaining a satisfactory social life [26]. Usually, adolescents strongly desire social connections, and poor dental health can reduce socialization.

Further analysis of the 2019 YRBS data revealed that non-white adolescents were more prone to not having received a recent dental check-up. Adolescents identifying as Black, other race(s), or Hispanic had comparable rates, all of which were higher than those of white adolescents. One study showed that structural factors and socioeconomic disparities play a role in the dental health inequities faced by minorities [27]. There is extensive documentation of disparities in oral health literacy (OHL) levels based on race/ethnicity and socioeconomic status [28]. OHL is the ability to comprehend basic oral health information and make informed decisions. Many who identify as Black and individuals with lower levels of education have been found to have limited OHL levels [28]. Valdez et al. focused on racial/ethnic minority communities, revealing that their beliefs and attitudes towards oral health can significantly influence their management of dental health [29]. For example, Mexican-Americans perceive many staple foods as not containing high amounts of sugar (e.g., high carbohydrate foods, ketchup, sweet rolls) [30]. Consequently, social, familial, and peer influences within diverse ethnic minorities can positively or negatively impact their dental literacy and affect their understanding of oral health, their ability to access health information and services, and ultimately their OHL. Reducing oral health disparities and promoting oral health have been proven to be critically dependent on OHL, along with income, insurance, and access to care [27].

Since the 2019 YRBS data indicated that approximately 50% of white and non-white students in RI reported experiencing mouth pain, it can be hypothesized that adolescents, regardless of race, engage in a high level of sugar consumption and suffer from a higher incidence of poor dental health and/or could be undergoing painful orthodontic procedures or wisdom tooth migration. Additionally, one in five RI adolescents felt self-conscious about the appearance of their teeth and mouth, a percentage that did not significantly vary across racial/ethnic groups, suggesting that adolescents are generally concerned with their appearance.

Adolescents with mental health concerns were more likely to experience mouth pain, feel self-conscious about their teeth and mouth, and not have had a recent dental check-up. The RI KIDS COUNT reported that 38% of RI high school students surveyed in the YRBS felt sad or hopeless for two or more weeks [31]. Addressing adolescent mental health concerns is crucial for averting more severe issues. Although the findings revealed a connection between oral and mental health, the data's cross-sectional nature makes it impossible to establish causality. It is plausible that poor mental health affects people's perception of their oral cavity, their survey responses, and their ability to maintain proper oral health, and that the three issues are linked due to unmeasured variables such as the family's income level.

Mental health is a key predictor of adolescents' oral health because anxiety and depression can significantly impact dental care experiences and oral health [32]. When mental health issues are not properly addressed, it can lead to avoidance of dental visits, difficulty following dentists' recommendations, and poor oral hygiene [32]. Mental health professionals should confirm that adolescents have a dental care provider for preventive treatment and specialized referrals. Educating dental care providers and pediatricians on the connection between adolescent mental and oral health issues may better equip them to identify signs of adolescent mental distress. Therefore, pediatricians, dentists, and parents should work together to develop a more comprehensive approach to adolescent health and dental care. It is important for healthcare professionals to educate parents and adolescents on the links between diet, dental care, and mental health, so as to improve health outcomes.

Schools offer an exceptional opportunity to promote both oral and general health, as they facilitate the participation of parents, students, and the community in health promotion [33]. Oral health education should emphasize the importance of regularly engaging in dental hygiene, such as brushing and flossing and eating fewer unhealthy foods. Traditionally, the school's oral health promotions prioritized disease prevention and the adoption of healthy dental behaviors, but achieved limited long-term efficacy [33]. Instead, interventions that emphasize regular dental hygiene and proper nutrition are more effective at improving oral health [33], along with workshops that effectively teach oral hygiene. For instance, group toothbrushing sessions with fluoride toothpaste can help students practice brushing and flossing while fostering healthy social norms. School-based programs can also advance oral health equity, providing vulnerable adolescents with access to preventative services [34]. In the current study, adolescents who consumed greater quantities of water were less inclined to feel self-conscious about their teeth. This result could be attributed to their reduced consumption of SSBs or the benefits of water fluoridation in the reduction of caries. Therefore, schools should also provide refillable water bottles and conveniently-located water refill stations. Overall, a school-based oral health curriculum should encourage healthy dietary habits and dental disease management, and school newsletters and parent-teacher conferences should remind parents to maintain their adolescents' oral health and inform them of the location of low-cost or free dental clinics.

Finally, a longitudinal study is needed to further assess adolescents' oral health and monitor trends over time. Factors, such as genetics, lifestyle, and environmental and financial conditions, can influence adolescent oral health. By monitoring a cohort of adolescents over an extended period, changes in oral health and behaviors can be observed. A longitudinal design will allow for a better understanding of adolescents' dental health which is not possible with a cross-sectional study, and it is also crucial to guiding policies and interventions to promote oral health in this susceptible population.

## **Limitations**

Although the YRBS is a valuable source of data for comprehending adolescent behaviors, it has limitations. First, it only surveyed adolescents who attend public school and, therefore, it is not indicative of all individuals in this age group. Second, 18.1% of the respondents to the 2019 YRBS study failed to answer all of the survey questions, thereby disqualifying their data. Students may have chosen not to answer questions because they considered them too invasive of their privacy or did not have time to complete the survey. Third, RI Black and Hispanic students experienced a higher suspension rate (46%) during the 2018-2019 academic year [35]. These adolescents may engage in riskier behaviors than their peers, but the YRBS could not include them if they were not in school during the survey's administration. Additionally, the YRBS is susceptible to selection bias since it depends on voluntary participation. Not all schools or students participate in the survey, which can limit its generalizability. Moreover, the YRBS employs self-reported student data, which might be affected by social desirability or recall bias and cause students to underreport or overreport behaviors, resulting in imprecise estimates of the prevalence of health-risk behaviors [23]. It is worth noting that YRBS data analyses rely on cross-sectional surveys, which can only establish an indication of association and not causality. Finally, it is crucial to acknowledge that the YRBS solely addresses the potential impact of caries rather than detects them. The data reflected the adolescents' subjective perception of their teeth and did not constitute an objective assessment of their dental health. Despite these limitations, the YRBS is currently the only reliable source for monitoring trends in RI adolescent oral health and recognizing areas for public health intervention.



## Conclusions

Healthcare professionals need to have the training and resources to recognize dental health problems, understand the relationships among oral, mental, and physical health, and be able to provide relevant referrals to adolescents and their parents. Since maintaining good oral health is crucial for adolescents' overall well-being, oral health providers need to consider mental health as a factor in their patients' care, and mental health professionals need to provide referrals to dentists. Interprofessional collaboration can identify and remove barriers preventing adolescents from receiving dental care.

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## References

1. Giacaman RA, Fernández CE, Muñoz-Sandoval C, et al. (2022) Understanding dental caries as a non-communicable and behavioral disease: Management implications. *Front Oral Health* 3: 764479.
2. Kumar S, Kroon J, Lalloo R, et al. (2017) Relationship between body mass index and dental caries in children, and the influence of socio-economic status. *Int Dent J* 67: 91-97.
3. Colak H, Dülgergil CT, Dalli M, et al. (2013) Early childhood caries update: A review of causes, diagnoses, and treatments. *J Nat Sci Biol Med* 4: 29-38.
4. Kim JK, Baker LA, Davarian S, et al. (2013) Oral health problems and mortality. *J Dent Sci* 8: 10.1016/j.jds.2012.12.011.
5. Majewski RF (2001) Dental caries in adolescents associated with caffeinated carbonated beverages. *Pediatr Dent* 23: 198-203.
6. Al-Zahrani A, Al-Qahtani M, Al-Barti M, et al. (2022) Dietary Determinants of Dental Caries Prevalence and Experience in Saudi School-children: Frequency versus Quantity. *ScientificWorldJournal* 2022: 5447723.
7. Banu A, Şerban C, Pricop M, et al. (2018) Dental health between self-perception, clinical evaluation and body image dissatisfaction - a cross-sectional study in mixed dentition pre-pubertal children. *BMC Oral Health* 18: 74.
8. Alshihri AA, Rogers HJ, Alqahtani MA, et al. (2019) Association between Dental Caries and Obesity in Children and Young People: A Narrative Review. *Int J Dent* 2019: 9105759.
9. Kaur P, Singh S, Mathur A, et al. (2017) Impact of Dental Disorders and its Influence on Self Esteem Levels among Adolescents. *J Clin Diagn Res* 11: ZC05-ZC08.
10. Virtanen JI, Muikku T, Similä T, et al. (2019) Physical activity, BMI and oral health behaviour among adolescents: Finnish School Health Promotion Study. *Eur J Public Health* 29: 296-302.
11. Baskaradoss JK, Tavares M, Al-Mulla F, et al. (2022) Association between Frequency of Toothbrushing and Metabolic Syndrome among Adolescents: A 5-Year Follow-Up Study. *Int J Environ Res Public Health* 19: 508.
12. Zeng X, Sheiham A, Sabbah W (2014) The association between dental caries and television viewing among Chinese adolescents in Guangxi, China. *BMC Oral Health* 14: 138.
13. Ding C, Jiang Y (2020) The Relationship between Body Mass Index and Physical Fitness among Chinese University 9Students: Results of a Longitudinal Study. *Healthcare (Basel)* 8: 570.
14. Nuttall FQ (2015) Body Mass Index: Obesity, BMI, and Health: A Critical Review. *Nutr Today* 50: 117-128.
15. Modéer T, Blomberg CC, Wondimu B, et al. (2010) Association between obesity, flow rate of whole saliva, and dental caries in adolescents. *Obesity (Silver Spring)* 18: 2367-2673.
16. Diaz-Arnold AM, Marek CA (2002) The impact of saliva on patient care: A literature review. *J Prosthet Dent* 88: 337-343.
17. Hudson J (2021) How mental health affects oral health. *BDJ Student* 28: 21-23.
18. Kisely S (2016) No Mental Health without Oral Health. *Can J Psychiatry* 61: 277-282.
19. Bethesda (MD): National Institute of Dental and Craniofacial Research (US) (2021) Oral Health in America: Advances and Challenges: Executive Summary.
20. Youth Risk Behavior Surveillance System (YRBSS) (2022) Centers for Disease Control and Prevention.
21. Berg P, Coniglio D (2006) Oral health in children overlooked and undertreated. *JAAPA* 19: 40, 42, 44 passim.

22. Youth Risk Behavior Survey. State of Rhode Island: Department of Health, 2022.
23. Underwood JM, Brener N, Thornton J, et al. (2020) Overview and Methods for the Youth Risk Behavior Surveillance System - United States, 2019. *MMWR Suppl* 69: 1-10.
24. Tungare S, Paranjpe AG (2023) Drug Induced Gingival Overgrowth. In: StatPearls. Treasure Island (FL): StatPearls Publishing.
25. Pellegrino A, Vendetti T, Jackson T, et al. (2018) Oral Health Concerns and Connections to Mental Health among Rhode Island High School Students, 2017. *R I Med J* 101: 56-59.
26. Lawal FB, Fagbule OF, Lawal TA, et al. (2022) “Oral health as an important milieu for social and mental health”: Perspectives of adolescents emerging from a qualitative study. *Front Oral Health* 3: 879144.
27. Como DH, Duker LIS, Polido JC, et al. (2019) The Persistence of Oral Health Disparities for African American Children: A Scoping Review. *Int J Environ Res Public Health* 16: 710.
28. Baskaradoss JK (2018) Relationship between oral health literacy and oral health status. *BMC Oral Health* 18: 172.
29. Valdez R, Spinler K, Kofahl C, et al. (2022) Oral Health Literacy in Migrant and Ethnic Minority Populations: A Systematic Review. *J Immigrant Minority Health* 24: 1061-1080.
30. Maupome G, Aguirre-Zero O, Westerhold C (2015) Qualitative description of dental hygiene practices within oral health and dental care perspectives of Mexican-American adults and teenagers. *J Public Health Dent* 75: 93-100.
31. Children’s Mental Health in Rhode Island. Rhode Island KIDS COUNT, 2022.
32. Tiwari T, Kelly A, Randall CL, et al. (2022) Association Between Mental Health and Oral Health Status and Care Utilization. *Front Oral Health* Feb 7: 732882.
33. Benzian H, Garg R, Monse B, et al. (2017) Promoting Oral Health through Programs in Middle Childhood and Adolescence. In: Bundy DAP, et al. (Editors). *Child and Adolescent Health and Development* (3rd Edition). Washington (DC): The International Bank for Reconstruction and Development / The World Bank.
34. Gargano L, Mason MK, Northridge ME (2019) Advancing Oral Health Equity Through School-Based Oral Health Programs: An Ecological Model and Review. *Front Public Health* 7: 359.
35. 2020 Rhode Island Kids Count Factbook. Providence, RI: Rhode Island KIDS COUNT.