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# The association between adolescent mental health and oral health behavior: The Luxembourg Health Behavior in School-Aged Children study

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Oral health remains a global health problem. Mental health has been linked to oral health behavior. However, studies among adolescents in high-income countries are limited. This study aimed to investigate the association between adolescent mental health and well-being with regular toothbrushing. We used data from the 2018 Luxembourg Health Behavior in School-Aged Children study ( $n = 7,561$ ;  $n = 3,896$  [51.5%] girls; mean [standard deviation] age = 14.9 [2.1] years). Multiple logistic regression analyses were performed to assess the associations of self-reported stress levels, life-satisfaction, somatic health complaints, and psychological health complaints with regular toothbrushing ( $\geq 2$  daily). Analyses were adjusted for gender, age, family affluence, family structure, migration background, daily sugar consumption, smoking behavior, and general health. 70.5% of the adolescents regularly brushed their teeth. Adolescents who reported higher levels of stress (odds ratio [OR], 95% confidence interval [CI]; 0.97 [0.95;0.99] per one-point increase), low life-satisfaction (OR = 0.92 [0.89;0.95] per one-point increase), and psychological health complaints (OR = 0.95 [0.91;0.99] per complaint) were less likely to regularly brush their teeth. No association was found between somatic health complaints and regular toothbrushing (OR = 1.00 [0.94;1.06] per complaint). Adolescents with poor mental health and well-being are less likely to regularly brush their teeth and may have an increased risk for oral diseases. Interventions focused on lifestyle modification in adolescents with mental health problems should include regular toothbrushing to prevent dental caries and other oral diseases.

## KEYWORDS

oral health & hygiene, toothbrushing, epidemiology, mental health, adolescence, health promotion

## Introduction

Toothbrushing is the most effective oral hygiene method and a major modifiable risk factor for oral diseases (1, 2). Oral diseases, which are mostly preventable, are an important global health problem affecting more than 3.5 billion people (3, 4). They may have a significant impact on the individual's daily life. Oral diseases have been

related to pain, chronic diseases, poorer general health, reduced quality of life and well-being, and problems with eating, chewing, and communication because of missing, discolored or damaged teeth (5). The loss of productivity caused by reduced school, work and household activities places a large burden on the society (5). Untreated dental caries is the most prevalent disease worldwide according to the Global Burden of Disease 2019 (6). In 2015, 573 million children had untreated dental caries (7). The prevalence of untreated caries in permanent teeth peaks during adolescence (15–19 years), affecting almost one in two adolescents (8). Oral health behavior during adolescence is crucial for the prevention of dental caries and other oral diseases and forms the basis of oral health behavior throughout adulthood. During adolescence, many behaviors that can affect oral health, including toothbrushing, are established (9).

Studies have shown an association between mental health and oral health among adults. A meta-analysis including 334,503 participants has shown an association of common mood and anxiety disorders and dental phobia, with dental caries and tooth loss (10). Furthermore, symptoms of depression and anxiety have been related to lower frequency of toothbrushing (11). Evidence for a relationship between mental health and oral health among adolescents is more limited. Research conducted in mainly low- and middle-income countries has related poor mental health to inadequate toothbrushing among adolescents. The World Health Organization (WHO) recommends toothbrushing twice daily with fluoride-containing toothpaste (2, 12). Poor mental health, including anxiety, no close friends, loneliness, depression, symptoms of post-traumatic stress disorder, suicidal ideation and suicide attempt, has been related to irregular toothbrushing among adolescents (13–18). However, contrasting results have been reported. Loneliness, suicidal ideation, sadness, and anxiety were not related to regular toothbrushing among African and Asian adolescents (14–17).

Only two studies in high-income countries have reported on the association of mental health and well-being with toothbrushing (19, 20). Finnish adolescents who reported symptoms of social phobia and generalized anxiety disorder were less likely to regularly brush their teeth compared to adolescents without these symptoms (19). Life-satisfaction was related to regular toothbrushing in the French Health Behavior in School-Aged Children (HBSC) study (20). However, both European studies did not adjust for important confounders like sugar consumption and smoking behavior (3).

The above studies suggest that adolescent mental health is related to oral health behavior. However, the association between adolescent mental health and well-being with oral health behavior in high-income countries needs further investigation. The aim of this study was to investigate the association between adolescent mental health and well-being with regular toothbrushing in Luxembourg. Because socio-demographic differences among adolescents have been reported in relation to

both mental health and toothbrushing (21), it was investigated whether potential associations of mental health and well-being with toothbrushing differ by gender, age, and family affluence.

## Materials and methods

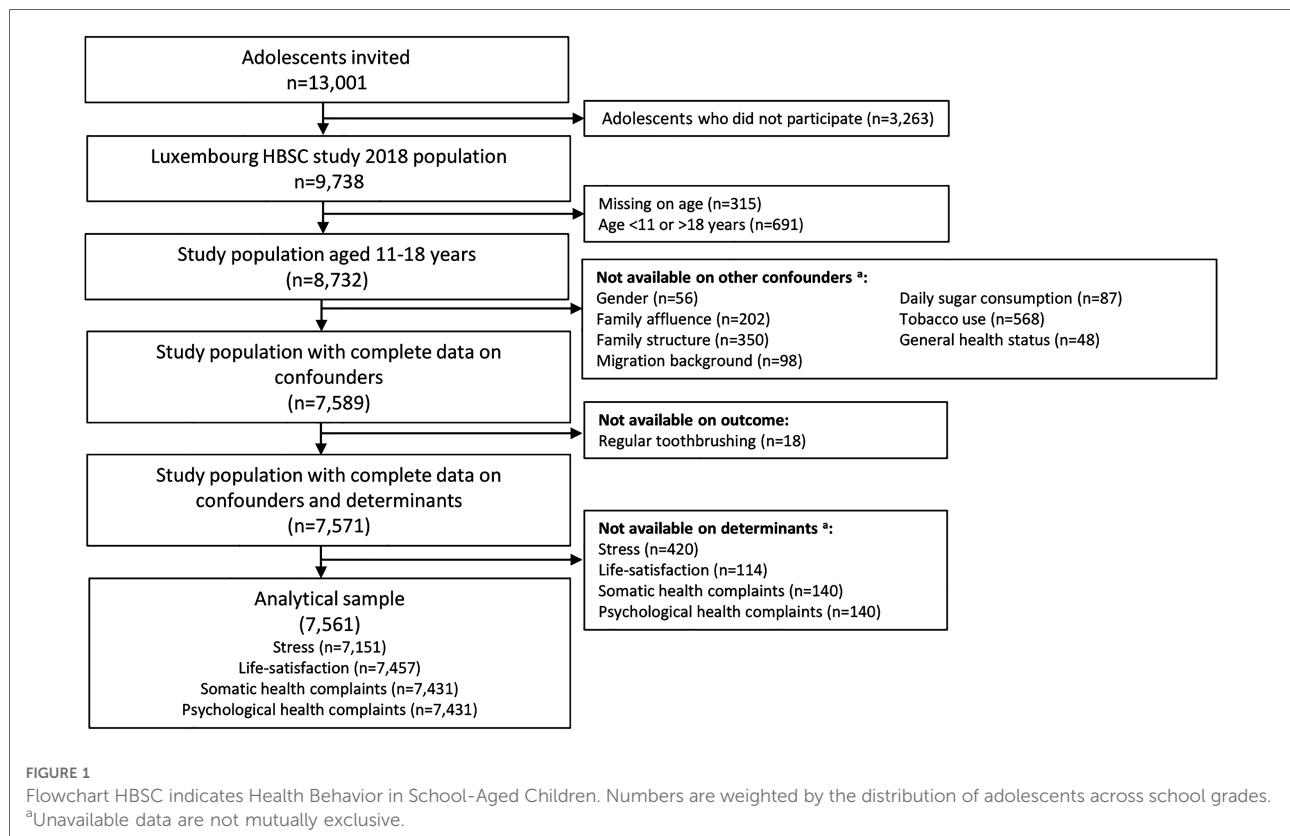
### Study population and design

Data from the 2018 wave of the Luxembourg Health Behavior in School-Aged Children (HBSC) study were used. The HBSC study is a World Health Organization (WHO) collaborative cross-national survey study that is conducted every four years across 50 countries and regions in Europe, Asia, and North America. The rationale and methodology of the 2018 Luxembourg HBSC study have been described previously (21). In brief, the study collected nationally representative data from adolescents aged 11–18 years old. Primary and secondary school classes were selected at random as primary sampling units. Schools that did not teach according to the national curriculum and special needs schools were excluded from sampling. Students from special needs schools were not surveyed because it could not be ensured that they would be able to complete the questionnaire without assistance. Schools that teach according to international curricula were excluded because these students are taught in different languages. This would have made the survey very time-consuming and would have made it possible to identify students retrospectively. Data were collected using paper–pencil questionnaires. Ethical approval was granted by the Comité National d’Ethique de Recherche (CNER, Avis N201711/02) and the Ethics Review Panel of the University of Luxembourg (ERP 17–059 HBSC 2018). All participants and parents were informed about the study and the right to refuse participation. Parents gave opt-out written consent.

**Figure 1** shows the flowchart of the study sample. 13,001 adolescents were invited to participate, of whom 9,738 participated (74.9%). Adolescents with missing data on the age variable ( $n = 315$ ) or who were too young or too old to participate ( $n = 691$ ) were excluded. Data on other confounders were missing in 1,143 adolescents and toothbrushing data were incomplete in 18 participants. Exclusion of adolescents with unavailable stress ( $n = 420$ ), life-satisfaction ( $n = 114$ ), and health complaints ( $n = 140$ ) data, resulted in a total study sample of  $n = 7,561$  participants. Our analytical sample ranged between  $n = 7,457$  and  $n = 7,151$  participants, depending on the assessed mental health variable.

### Mental health and well-being

The shortened 4-item version of the Cohens’ Perceived Stress Scale-4 (PSS-4) was used to assess general perceived



stress (22). Participants were asked how unpredictable, uncontrollable, and overloaded their lives were during the last month, e.g., “How often have you felt confident about your ability to handle your personal problems?”. Items were scored on a 5-point Likert scale with a total score range from 0 to 16. The internal consistency of the scale in this sample was satisfactory (Cronbach’s alpha = 0.57).

Life-satisfaction was measured using the Cantril Ladder (23, 24). Participants rated how they feel about their life on a visual analogous scale ranging from 0 (worst possible life) to 10 (best possible life). The Cantril scores were reversed so a higher score indicates lower life-satisfaction.

Subjective psychosomatic health complaints were assessed using the self-reported HBSC-Symptom Checklist (25, 26). The frequency of four somatic complaints (headaches, abdominal pain, backache, and dizziness) and four psychological complaints (feeling low, irritability, nervousness, and sleeping difficulties) during the last six months were assessed. Scores on somatic and psychological complaints ranged between 0 and 4.

## Regular toothbrushing

Adolescents were asked how often they brush their teeth. This question was developed by the HBSC network to

measure dental care. A dichotomous variable was created to compare adolescents who brush their teeth at least 2 times a day and those who brush their teeth less often. This dichotomization is based on the recommendation of the WHO (2).

## Confounders

Adolescents reported their gender and year and month of birth. Socioeconomic status was assessed through the 6-item HBSC Family Affluence Scale (27). Relative family affluence was categorized into low (lowest 20%), medium (medium 60%) and high (highest 20%). Adolescents were asked about the people with whom they lived in their main or only home. Adolescents living with both parents were identified and compared to those with other family structures. Migration background was assessed by country of birth of the participant and their parents, and categorized into native, first-generation immigrant or second-generation immigrant. The frequency of sweets and soft drink consumption was assessed. Participants who consumed sweets and/or soft drinks daily were identified and compared to those who did not consume sweets and/or soft drinks daily. Participants were asked how often they used tobacco over the past 30 days. This question was adapted by the HBSC network from

the 1975 Monitoring the Future project (28) and the 1995 European School Survey Project on Alcohol and other Drugs (29). A dichotomous variable was created to identify adolescents who used tobacco during the past 30 days (yes/no). Participants were asked to rate their general health on a four-point Likert-scale (poor, fair, good, and excellent) (30). In line with previous studies from the HBSC network, response options were dichotomized into those who reported their health as excellent or good and those who reported their health as fair or poor (31).

## Statistical analyses

Analyses were performed using IBM SPSS version 27. Multiple logistic regression analyses were used to assess the associations of mental health and well-being with regular toothbrushing. Analyses were adjusted for gender, age, family affluence, family structure, migration background, daily sugar consumption, smoking behavior, and general perceived health. The data were weighted by the distribution of adolescents across school grades. Accordingly, the distribution of the adolescents across school grades in the weighted sample was in line with the distribution in the population. To test whether the associations differ among gender, age, and family affluence, interactions of sociodemographic factors with mental health and well-being on regular toothbrushing were tested. A 2-sided *P*-value <0.05 was considered statistically significant.

## Results

### General characteristics of the study sample

**Table 1** shows the general characteristics of the study sample. Participants had a mean age of  $14.9 \pm 2.1$  years and 51.5% were girls. Regular toothbrushing was reported in 70.5% of the participants and most adolescents had good health (87.7%).

### Associations of mental health and well-being with regular toothbrushing

The associations of mental health and well-being with regular toothbrushing are presented in **Table 2**. Adolescents who reported higher stress levels were less likely to regularly brush their teeth (odds ratio [OR], 95% confidence interval [CI]; 0.97 [0.95;0.99], *p* = 0.001 per one-point increase in stress level). Furthermore, a one-point increase in low life-satisfaction was associated with lower odds for regular

toothbrushing (OR = 0.92 [0.89;0.95], *p* < 0.001). No association was found between somatic health complaints and regular toothbrushing (OR = 1.00 [0.94; 1.06], *p* = 0.969 per increase in the number of complaints), while there was an association between psychological health complaints and regular toothbrushing (OR = 0.95 [0.91;0.99], *p* = 0.019 per increase in the number of complaints).

**TABLE 1** Characteristics of the study sample.

Variable	Statistic
<b>Socio-demographics</b>	
Age (years)	14.9 ± 2.1
Being girl, <i>n</i> (%)	3,896 (51.5)
Family affluence, <i>n</i> (%)	1,659/4,390/1,512
High/Medium/Low	(21.9/58.1/20.0)
Living with both parents, <i>n</i> (%)	5,088 (67.3)
Migration background, <i>n</i> (%)	2,227/3,722/1,613
None/Second generation/First generation	(29.4/49.2/21.3)
<b>Mental health and well-being</b>	
Stress (PSS-4 score)	6.8 ± 3.0
Low life-satisfaction (Cantril score) <sup>a</sup>	8 [7; 9]
Somatic health complaints (number of complaints)	0 [0; 1]
Psychological health complaints (number of complaints)	1 [0; 2]
<b>Oral health behavior</b>	
Toothbrushing ≥2daily, <i>n</i> (%)	5,334 (70.5)
<b>Confounders</b>	
Daily sugar consumption, <i>n</i> (%)	2,858 (37.8)
Current smoker, <i>n</i> (%)	979 (12.9)
Good health, <i>n</i> (%)	6,630 (87.7)

*n* = 7,561. Data are presented as mean ± standard deviation, number (percentage), or median [interquartile range] as appropriate. Study sample is weighted by the distribution of adolescents across school grades.

<sup>a</sup>Cantril scores are reversed so a higher score indicates lower life-satisfaction.

**TABLE 2** Associations of mental health and well-being with regular toothbrushing.

	Regular toothbrushing (≥2 daily) OR (95% CI)	<i>P</i> -value
Stress (PSS-4 score)	0.97 (0.95; 0.99)	0.001
Low life-satisfaction (Cantril score) <sup>a</sup>	0.92 (0.89; 0.95)	<0.001
Somatic health complaints (per 1 complaint)	1.00 (0.94; 1.06)	0.969
Psychological health complaints (per 1 complaint)	0.95 (0.91; 0.99)	0.019

*n* = 7,151 (stress); *n* = 7,457 (life-satisfaction); and *n* = 7,431 (somatic and psychological health complaints). Results represent the odds for regular toothbrushing per one point increase in score or health complaint. OR indicates odds ratio; CI, confidence interval. Analyses are adjusted for age, gender, family affluence, family status, migration background, sugar consumption, smoking behavior, and general perceived health and weighted by the distribution of adolescents across school grades.

<sup>a</sup>Cantril scores are reversed so a higher score indicates lower life-satisfaction.

TABLE 3 Analyses stratified by socio-demographics.

	Regular toothbrushing ( $\geq 2$ daily) OR (95% CI)	P-value
<b>Stress</b>		
Girls ( $n = 3,896$ )	0.97 (0.94; 0.99)	0.012
Boys ( $n = 3,455$ )	0.97 (0.95; 0.99)	0.012
Age 11-14 years ( $n = 3,508$ )	0.96 (0.93; 0.99)	0.002
Age 15-18 years ( $n = 3,374$ )	0.98 (0.95; 1.00)	0.061
Normal family affluence ( $n = 4,100$ )	0.98 (0.95; 1.00)	0.046
Low family affluence ( $n = 1,377$ )	0.98 (0.95; 1.02)	0.310
High family affluence (1,425)	0.93 (0.89; 0.98)	0.002
<b>Low life-satisfaction<sup>a</sup></b>		
Girls ( $n = 3,841$ )	0.92 (0.88; 0.96)	<0.001
Boys ( $n = 3,300$ )	0.92 (0.88; 0.96)	<0.001
Age 11-14 years ( $n = 3,696$ )	0.91 (0.87; 0.94)	<0.001
Age 15-18 years ( $n = 3,491$ )	0.93 (0.89; 0.98)	0.003
Normal family affluence ( $n = 4,265$ )	0.92 (0.88; 0.96)	<0.001
Low family affluence ( $n = 1,454$ )	0.92 (0.87; 0.98)	0.005
High family affluence (1,475)	0.91 (0.84; 0.98)	0.018
<b>Somatic health complaints</b>		
Girls ( $n = 3,828$ )	1.00 (0.92; 1.09)	0.946
Boys ( $n = 3,307$ )	0.97 (0.88; 1.07)	0.564
Age 11-14 years ( $n = 3,697$ )	0.99 (0.90; 1.08)	0.771
Age 15-18 years ( $n = 3,474$ )	0.99 (0.91; 1.08)	0.855
Normal family affluence ( $n = 4,269$ )	1.02 (0.94; 1.11)	0.684
Low family affluence ( $n = 1,462$ )	0.98 (0.87; 1.11)	0.761
High family affluence (1,474)	0.97 (0.84; 1.14)	0.733
<b>Psychological health complaints</b>		
Girls ( $n = 3,828$ )	0.93 (0.88; 0.99)	0.028
Boys ( $n = 3,297$ )	0.95 (0.89; 1.01)	0.107
Age 11-14 years ( $n = 3,698$ )	0.91 (0.86; 0.97)	0.005
Age 15-18 years ( $n = 3,472$ )	0.98 (0.92; 1.04)	0.419
Normal family affluence ( $n = 4,266$ )	0.95 (0.89; 1.00)	0.058
Low family affluence ( $n = 1,471$ )	0.96 (0.88; 1.05)	0.326
High family affluence (1,474)	0.95 (0.85; 1.06)	0.338

$n = 7,151$  (stress);  $n = 7,457$  (life-satisfaction); and  $n = 7,431$  (somatic and psychological health complaints). Results represent the odds for regular toothbrushing per one point increase in score or health complaint. OR indicates odds ratio; CI, confidence interval. Analyses are adjusted for age, gender, family affluence, family status, migration background, sugar consumption, smoking behavior, and general perceived health and weighted by the distribution of adolescents across school grades. <sup>a</sup>Cantril scores are reversed so a higher score indicates lower life-satisfaction.

## Socio-demographic differences

Several interactions of mental health and well-being with sociodemographic factors on regular toothbrushing were found. Table 3 shows the associations of stress, low life-satisfaction, and psychosomatic health complaints with regular toothbrushing stratified by sex, age, and family affluence. Stress, low life-satisfaction, and psychosomatic health complaints showed an interaction with age on regular toothbrushing ( $p$ -interaction = 0.023,  $p$ -interaction = 0.016, and  $p$ -interaction = 0.003, respectively). Stronger associations were observed in adolescents aged 11–14 years compared to

adolescents aged 15–18 years (stress: OR = 0.96 [0.93;0.99],  $p = 0.002$  vs. OR = 0.98 [0.95;1.00],  $p = 0.061$ ; low life-satisfaction: OR = 0.91 [0.87;0.94],  $p < 0.001$  vs. OR = 0.93 [0.89;0.98],  $p = 0.003$ ; and psychological health complaints: 0.91 [0.86;0.97],  $p = 0.005$  vs. OR = 0.98 [0.92;1.04],  $p = 0.419$ ). Although the difference in the associations between the younger and older subgroups was marginal (<10%), the associations of stress and psychological health complaints with regular toothbrushing in the older age group became non-significant.

An interaction with high family affluence on regular toothbrushing was found for stress ( $p$ -interaction = 0.041). Slightly stronger associations were found in adolescents with a

high family affluence (stress: OR = 0.93 [0.89;0.98],  $p = 0.002$ ) compared to adolescents with a normal family affluence (stress: OR = 0.98 [0.95;1.00],  $p = 0.046$ , [Table 3](#)).

Other interactions of stress, low life-satisfaction, somatic health complaints, and psychological health complaints with gender, age, and family affluence on regular toothbrushing were non-significant.

## Discussion

This study aimed to investigate whether adolescents' mental health and well-being is associated with regular toothbrushing in a high-income country. Adolescents who experienced higher levels of stress, lower levels of life-satisfaction, and more psychological health complaints were less likely to regularly brush their teeth. Somatic health complaints did not decrease the likelihood for regular toothbrushing. Differences in sociodemographic characteristics were observed, in which associations were more pronounced in younger adolescents compared to older adolescents. In addition, adolescents with high family affluence who experience higher stress levels were less likely to regularly brush their teeth than those with normal family affluence.

The current findings are in line with a previous Finnish study that found an association of social phobia and elevated anxiety levels with regular toothbrushing (19). Furthermore, our results are in line with a French study that observed an association of low life-satisfaction and with regular toothbrushing (20). Our results extend these findings by observing that the association of mental health and well-being is independent of important confounders like daily sugar consumption and smoking behavior. Furthermore, this study found that the association between mental health and oral health is already evident in subtle markers of poor mental health and well-being, i.e., subjective continuous measures of stress, life-satisfaction, and health complaints were used, instead of dichotomous markers of for example high or low depression. This underscores the importance of regular toothbrushing over the whole continuum of mental health and well-being.

More qualitative and longitudinal studies are needed to investigate the mechanisms underlying the association of poor mental health and well-being with irregular toothbrushing. One explanation for irregular toothbrushing is that adolescents with mental health problems have less motivation to regularly brush their teeth due to their mental state (32), i.e., adolescents with symptoms of apathy and stress might be less motivated to follow the recommendation for toothbrushing twice a day. There are also social factors that motivate toothbrushing. Clean teeth look attractive, create a feeling of freshness and strengthen one's self-confidence (33). A reduction in social contacts may reduce the motivation for regular toothbrushing. Aside from motivation, adolescents with a mental disease who receive pharmacological treatment have an increased risk for dental caries and oral diseases due to side-effect of their medication. A decrease or increase in

salivation, taste problems, and abnormal involuntary movements have been related to dental caries and other oral diseases (34). Longitudinal research may provide more insights into the direction of the association between mental health and regular toothbrushing.

The prevalence and disease burden of highly preventable oral diseases demands for a radical change in the oral health systems and public health policies (7). The current treatment approach in high-income countries, that is characterized by technology, interventions, and specialism, does not deal with the underlying causes of oral diseases (3). Oral health care should not be a luxury and needs to be more integrated in other health care setting, particularly in primary care and mental health care settings. This demands action from academics, clinicians, dental health associations, governments, and international organizations as the FDI World Dental Federation and WHO, to promote oral health and place it back on the public health agenda. The World Health Assembly approved a Resolution on oral health in 2021 that proposes a change from the traditional curative approach towards a preventive approach that includes promotion of oral health behavior within the family, schools and workplaces, and includes timely, comprehensive and inclusive care within the primary care (2). The Resolution also declares the inclusion of oral health within the noncommunicable disease agenda and inclusion of oral health interventions in the universal health coverage programs (2). Promotion of regular toothbrushing is a major step in this. School oral health programs have shown to be effective in the improvement of oral health knowledge, status, and behavior, including frequency of toothbrushing (35). The government of the United Kingdom sets a good example by providing supervised toothbrushing programs in schools (36).

Other easy and inexpensive prevention approaches for oral diseases overlap with cardiovascular risk management, like a reduction in sugar, tobacco, and alcohol consumption. An introduction of sugar tax, restrictions on advertisements of sugary products, the reduction of sugar in existing products, and water fluoridation are recommended (7). Research has shown that adolescent demographics, mental health factors, and oral health behavior are interrelated. Therefore, promotion and intervention strategies should be developed using a multi-faceted approach (37). Clinicians in both primary care and mental health settings should include oral health behavior as part of a healthy lifestyle promotion and facilitate dental referrals if needed. Patients should be stimulated to brush their teeth regularly and clinicians should provide education about oral health behavior, like sugar consumption and smoking behavior. Clinicians should consider the side-effect of pharmacological treatment and advise patients to drink water regularly throughout the day and chew sugar-free chewing gum to reduce the side-effects of reduced salivation (34).

Strengths of this study include its large representative and random sample size, which make the results generalizable to the adolescent population in Luxembourg; the inclusion of both negative and positive mental health factors, which allows investigation into both negative and positive associations with

regular toothbrushing; the adjustment of important behavioral confounders like sugar consumption and smoking behavior; the inclusion of interactions with sociodemographic factors, which consents research into sociodemographic differences; and the comparability of the 2018 data with future 2022 international data, which makes it possible to investigate cross-national changes due to Covid-19 with regards to mental health and oral health behavior.

The current study is limited by its cross-sectional design. Therefore, no conclusions can be drawn about causality. A previous study has observed an association between oral health symptoms and an increased risk of suicide-related factors (38). Although reversed causality cannot be ruled out, the poor oral hygiene in adolescents with poor mental health and well-being is relevant for both disciplines and demands for an integrated health care approach. Furthermore, data is based on self-reports. However, previous research has shown that self-reported toothbrushing frequency is a reliable proxy measure for clinical oral hygiene indices. Gil et al. (39) investigated the associations between oral hygiene measures and dental caries. Results of their study revealed that toothbrushing frequency was a better predictor for dental caries than the Simplified Oral Hygiene Index and the Plaque Index, two clinical measures for oral hygiene.

In conclusion, adolescents with poor mental health and well-being are less likely to brush their teeth regularly and may have an increased risk for oral diseases. Interventions focused on lifestyle modification in adolescents with mental health problems should include regular toothbrushing to prevent dental caries and other oral diseases.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary materials, further inquiries can be directed to the corresponding author/s.

## Ethics statement

The studies involving human participants were reviewed and approved by Ethical approval was granted by the Comité National d'Éthique de Recherche (CNER, Avis N201711/02) and the Ethics Review Panel of the University of Luxembourg (ERP 17-059 HBSC 2018). Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

A.F.J.G: Contributed to conception and design, data analysis and interpretation, and drafted and critically revised the

manuscript. A.H: Contributed to conception and design, data acquisition and interpretation, and critically revised the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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