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ORIGINAL ARTICLE

Knowledge about caries and erosive tooth wear is confused among Norwegian high school students

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ABSTRACT

Objectives: This study investigated differences in high school students' subjective and objective knowledge- and concerns about preventing caries and/or erosive tooth wear and the associations between these variables.

Materials and methods: A survey was conducted among students at 16 high schools in Norway. The survey included a range of fact-based questions to measure objective knowledge about caries and erosive tooth wear, as well as questions about students' perceptions of his/her own knowledge (subjective knowledge) and concerns about preventing the two conditions.

Results: There were small differences in subjective knowledge about caries and erosive tooth wear among the 784 students who completed the survey ($p < .01$). However, students scored significantly higher on objective knowledge about caries (mean 2.99) than about erosive tooth wear (mean 1.45), $p < .01$, and seemed to confuse the two conditions. By contrast, students scored significantly worse on questions about beverages' potential to cause caries (mean 5.18) than to cause erosive tooth wear (mean 6.30), $p < .001$. Finally, objective knowledge about caries was positively associated with subjective knowledge about caries, but corresponding associations could not be found for erosive tooth wear.

Conclusions: Knowledge about caries and erosive tooth wear seemed to be confused among Norwegian high school students.

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Erosive tooth wear; dental erosion; caries; knowledge

Introduction

The prevalence of caries has decreased dramatically in the Western world over the last three to four decades and although the levels of decayed, missing and filled teeth (DMFT) vary from country to country, levels have dropped significantly in a range of countries [1,2]. In Norway, the number of caries-free 12-year-olds has increased from 18.9% in 1985 to 63.5% in 2019 [3,4]. This improvement has been driven by an increased understanding of the risk factors of caries. These include nutritional factors, mainly associated with intake of foods and drinks with high amounts of sugar, oral hygiene factors, including frequency of tooth brushing and flossing, use of fluoride and regular visits to dental professionals for cleaning and removal of plaque and caries [3,5].

In contrast, the prevalence of other oral conditions has increased over the last decades. A systematic review estimated the prevalence of erosive tooth wear to 30.4% in the permanent teeth of children and adolescents (95%CI 23.8–37.0%) [6]. The meta regression analysis included 22 studies from across the world representing 23,012 children. The levels ranged from 7.2 to 74%, and both index type used, and sample size had significant effects on prevalence. Effects of geographic location and dietary- and cultural habits have to be further studied. In Norway, two studies have reported prevalences of 59% [7] and 38% [8] among 16–18-year-olds ($n = 795$) and 16-year-olds ($n = 392$), respectively. In contrast to caries, which is a result of bacteria-induced degradation of enamel, erosive tooth wear is induced by chemical loss of mineralized tooth substance caused by exposure to acids that are not derived from oral bacteria in a process called dental erosion [9]. Erosive tooth wear further differs from caries in that it cannot be prevented by good oral care habits such as brushing and flossing or by preventative procedures such as cleaning at the dental office. While sugar is the main food component causing caries, acidic drinks and foods, and particularly carbonated beverages, constitute the main risk factor for erosive tooth wear [10–14]. Other factors, such as genetic factors, intrinsic factors (e.g. eating disorders or gastroesophageal reflux), low salivary flow and buffer capacity, have also been associated with increased risk of erosive tooth wear (reviewed in literature [15,16]). Several studies have shown that youth consume large amounts of acidic beverages [17 + 19 (Melbye)]. A recent study by Melbye et al. [18] found that more than 25% of participants in a survey of Norwegian high school students between 16 and 19 years ($n = 850$) drink soda with or without sugar every day.

However, the knowledge and awareness about erosive tooth wear seem to be limited. Verploegen and Schuller [19] showed that there is a gap in knowledge about erosive

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tooth wear in young adults. They found that only half (52%) of the participants in their study ($n = 331$) were aware of the causes of dental erosion (i.e. intake of acidic foods and beverages), and even fewer (42%) were aware of the consequences of dental erosion [19]. In a study on Chinese students, students in general had weak knowledge about erosive tooth wear, and even dental students had only moderate knowledge about the condition [20]. Furthermore, in a study on dental students and practitioners in Yemen, only half of the respondents had in-depth knowledge about erosive tooth wear [21]. In a Norwegian study, Skudutyte-Rysstad et al. [22] found that only 56% of youth with diagnosed erosive tooth wear were aware that they had the condition, and although 88% reported that they had heard about erosive tooth wear, their actual knowledge was not measured. Moreover, a qualitative study of children and adolescents found that knowledge about the effect of acidic drinks on teeth was confused [23]. In a study on Chinese adults, 71% had never heard about erosive tooth wear, and 53% confused erosive tooth wear with caries [24].

Within the field of consumer psychology, it is common to differentiate between subjective and objective knowledge. Objective knowledge is often described as *actual or fact-based* knowledge [25], whereas subjective knowledge constitutes an individual's *perceptions* of his/her own knowledge about a topic [26]. A recent study by Melbye et al. [18] showed that Norwegian students lack objective knowledge about erosive tooth wear and that this lack of objective knowledge is associated with a more frequent consumption of acidic beverages. Given the high national and international awareness about the risk factors of caries for many decades [3], we were interested in investigating whether Norwegian adolescents have more knowledge about caries than about erosive tooth wear, and whether there is a large discrepancy between subjective and objective knowledge for the two conditions. Thus, in this study, we aimed to map differences in high school students' knowledge about erosive tooth wear and caries and describe associations between subjective and objective knowledge for the two conditions.

Materials and methods

Participants and procedures

A survey was conducted in 16 high schools in Rogaland County, Norway. Students aged 15–20 were recruited, forming a convenience sample of 793 participants completing the questionnaire. After reviewing the data, nine observations were excluded because of high age (>20). Thus, the final sample consisted of 784 students in which 41% were female and 85% were of Norwegian or Nordic ancestry. Forty-eight percent attended general studies, 43% attended vocational study programmes and 9% attended other study programmes. The average age was 15.9 years (SD 1.05). Teams of dental hygienists, dentists and/or community nurses recruited participants to fill out a two-page questionnaire by standing in stalls at the high schools. The questionnaire was developed based on a previous questionnaire about erosive tooth wear and intake of acidic drinks [18] and included items about subjective knowledge (two items), objective knowledge (six items) and concern about prevention (one item) of caries and erosive tooth wear. The exact wording of all items is presented in Table 1. The questionnaire also included items on the potential of different beverages to induce caries and/or erosive tooth wear (11 items) and some sociodemographic questions (gender, age, ethnicity and study programme), presented in Table 2. The items were identical for the two conditions, except for exchanging the words 'caries' with 'erosive tooth wear'. Response options for the knowledge and concern measures were provided on a 5-point Likert scale: totally disagree (1), somewhat disagree (2), neutral/neither agree nor disagree (3), somewhat agree (4) and totally agree (5). For questions about the damage potential of different beverages to cause caries and/or erosive

Table 1. Results from factor analysis of items measuring subjective- and objective knowledge about caries and erosive tooth wear.

	Factor			
Study items	1	2	3	4
Caries can be prevented by flossing**	0.77			
I know what caries is*	0.77			
Initial caries can be stopped by proper dental hygiene**	0.76			
Caries can be prevented (avoided) by brushing your teeth after consumption of food and beverages**	0.71			
Bacteria is an important cause of caries**	0.67			
I know how caries occurs*	0.66			
Caries can be prevented by drinking milk after intake of food and drink**		0.79		
Erosive tooth wear can be prevented by drinking milk after intake of food and drink**		−0.71		
Caries can be prevented by drinking water after intake of food and drink**		−0.67		
Erosive tooth wear can be prevented by drinking water after intake of food and drink**		−0.56		
Initial erosive tooth wear can be stopped by proper dental hygiene**			0.80	
Bacteria is an important cause of erosive tooth wear**			0.77	
Erosive tooth wear can be prevented by flossing**			0.59	
Erosive tooth wear can be prevented (avoided) by brushing your teeth after consumption of food and beverages**			0.48	
I know how erosive tooth wear occurs*				−0.92
I know what erosive tooth wear is*				−0.90
α	0.84	0.05	0.70	0.90
R^2	0.35	0.11	0.08	0.07

Items about subjective knowledge (two items for both caries and erosive tooth wear) are marked*, while items about objective knowledge (four items for both caries and erosive tooth wear) are marked**. Factor loadings, variance explained (R^2) and Cronbach's alpha (α) are presented.

Table 2. Descriptive analysis and paired samples *t*-tests for all single items and condensed variables.

Item	Caries			Erosive tooth wear				Paired-samples *t*-test		
	n	Mean	SD	*n*	Mean	SD	Sig.(2-tailed)	Cohen's d	*t*-Value	df
I know what caries/erosive tooth wear is*	779	0.82	0.29	779	0.73	0.31	<0.001	0.27	7.41	773
I know how caries/erosive tooth wear occurs*	770	0.72	0.30	772	0.70	0.31	0.021	0.084	2.31	757
I am concerned about preventing caries/erosive tooth wear***	768	0.79	0.28	761	0.74	0.28	<0.001	0.19	5.15	745
Caries/erosive tooth wear can be prevented (avoided) by brushing your teeth after consumption of food and beverages**	769	0.77	0.28	768	**0.33**	0.30	<0.001	0.85	23.32	753
Caries/erosive tooth wear can be prevented by flossing**	761	0.79	0.28	769	**0.40**	0.31	<0.001	0.82	22.51	746
Caries/erosive tooth wear can be prevented by drinking milk after intake of food and drink	763	**0.47**	0.28	758	0.57	0.28	<0.001	−0.21	−5.81	739
Caries/erosive tooth wear can be prevented by drinking water after intake of food and drink	774	0.63	0.28	768	0.62	0.28	0.267	0.040	1.11	758
Bacteria is an important cause of caries/erosive tooth wear**	763	0.73	0.27	756	**0.40**	0.29	<0.001	0.74	20.12	738
Initial Caries/erosive tooth wear can be repaired/stopped by proper dental hygiene (such as brushing)**	748	0.79	0.28	773	**0.37**	0.31	<0.001	0.90	24.40	736
Which of the following beverages can induce caries/erosive tooth wear:										
Soda with sugar****	779	0.72	0.45	779	0.77	0.42	0.01	−0.10	−2.78	778
Soda without sugar****	779	**0.38**	0.49	779	0.64	0.48	<0.001	−0.51	−14.23	778
Energy drink****	779	0.64	0.48	779	0.80	0.40	<0.001	−0.29	−7.97	778
Juice****	779	0.38	0.49	779	0.74	0.44	<0.001	−0.57	−15.90	778
Smoothie****	779	0.28	0.45	779	0.42	0.49	<0.001	−0.22	−6.06	778
Iced coffee****	779	0.53	0.50	779	**0.37**	0.48	<0.001	0.31	8.65	778
Coffee****	779	**0.33**	0.47	779	**0.33**	0.47	0.96	0.00	0.05	778
Tea****	779	**0.39**	0.49	779	**0.40**	0.49	0.64	−0.02	−0.46	778
Milk****	779	0.17	0.38	779	**0.64**	0.48	<0.001	−0.79	−21.93	778
Water with flavour****	779	**0.50**	0.50	779	0.32	0.47	<0.001	0.30	8.31	778
Tapped water****	779	**0.86**	0.35	779	**0.85**	0.35	0.78	0.01	0.28	778
Subjective knowledge (2 items)*	781	1.53	0.55	783	1.42	0.59	<0.001	0.19	5.27	779
Concern about prevention (1 item)***	768	0.79	0.28	761	0.74	0.28	<0.001	0.19	5.15	745
Objective knowledge (4 items)**	783	2.99	0.92	784	1.48	0.87	<0.001	1.00	28.12	782
Damage potential of beverages (11 items)****	779	5.18	1.88	779	6.30	2.10	<0.001	−0.58	−16.18	778

Mean and standard deviation (SD) are reported for all study items and variables for caries and erosive tooth wear, in addition to significance level (Sig (2-tailed)), effect size (Cohen's *d*), *t*-value and degrees of freedom (df) for the paired-samples *t*-test performed for each pair of items. Maximum score for each item was 1. The two items included in the sum score variable *subjective knowledge* are marked*, the four items included in the sum score variable *objective knowledge* are marked**, the item for *concern about prevention* is marked with***, while the eleven items included in the total score for *damage potential of beverages* are marked****. For items where the answers to statements are considered to be wrong or the answer to be no, the mean score is marked in bold italics.

tooth wear, response options were: 'No damage to teeth', 'Caries', 'Erosive tooth wear', 'Both caries and erosive tooth wear' and 'Don't know'. The questionnaire was pre-tested on eight representatives from the population of interest, and revisions were made based on their feedback. Neither personal identifiers nor sensitive information were collected in the survey.

Statistical analyses

Analyses were conducted using IBM SPSS Statistics for Windows, Version 27.0. Factor analysis was performed to investigate the factor structure of the 16 knowledge items. Hair et al.'s [27] recommendations were used to assess whether our data were suitable for factor analysis, that is, the presence of several correlation coefficients >0.30, a Kaiser–Meyer–Olkin value (KMO) ≥0.60 and a significant Bartlett's test ($p < .01$). Factor loadings ≥0.40 were used as criteria for convergent validity, whereas cross loadings `0.40 were used as criteria for discriminant validity [27]. The Kaiser criterion (eigenvalue >1) and oblique rotation were used to determine the factor structure of the data. Cronbach's alpha and corrected item-total correlation (CITC) were computed to evaluate internal consistency. A Cronbach's alpha ≥0.70 was considered good [28], and the threshold for CICT was set to >0.3. Items with Likert scale response options (i.e. knowledge and concern items) were scored with one point for fully right answers (totally agree/disagree), and the score was reduced stepwise until a score of zero was reached for totally wrong answers (totally agree/disagree). For items about the damage potential of different beverages, one point was given for right answers and zero points for wrong answers for caries and erosive tooth wear. Based on the results from factor analysis, sum scores were calculated for the knowledge items for both caries and erosive tooth wear, creating the condensed variables *subjective knowledge* (two items) and *objective knowledge* (four items). Sum scores were also calculated for the items measuring the damage potential of beverages to induce caries and/or erosive tooth wear, creating the variables *damage potential of beverages* (11 items) for both caries and erosive tooth wear. Both single items and

condensed variables are presented in Table 2. Paired-samples *t*-tests were performed on each pair of caries/erosive tooth wear items, as well as for the condensed variables *subjective knowledge, objective knowledge* and *damage potential of beverages*. Probability values (*p*) less than .05 were considered significant. Effect sizes were calculated using Cohen's *d* to reveal relevant differences between the two groups, where values >0.2 were considered a small effect, >0.5 a moderate effect and >0.8 a large effect [29, pp. 284–287].

Multiple linear regressions were subsequently run to investigate associations between *objective knowledge*, *subjective knowledge, damage potential* and *concern about prevention* for both caries and erosive tooth wear. More specifically, three models were tested: in the first model (model 1), we tested whether objective knowledge about caries was associated with *subjective knowledge* and *concern about prevention* of caries; in the second model (model 2a), we tested whether *objective knowledge* about erosive tooth wear was associated with *subjective knowledge* and *concern about prevention* of erosive tooth wear. Lastly, in the third model (model 2b), we tested whether *objective knowledge* about erosive tooth wear could be explained by *objective knowledge* about caries. The three models were adjusted for sociodemographic variables (gender, age, ethnicity and field of study). Preliminary analyses were performed to test for violations of normality and linearity. Cut-off values were set to ± 3 and ± 8 for skewness and kurtosis, respectively [30]. Bivariate correlations were used to test for multicollinearity between independent variables included in regression analyses. A cut-off value of ≥0.80 for multicollinearity was used, as proposed by Haerens et al. [31].

Results

Factor analysis

The 16 knowledge items were subjected to factor analysis (FA). Correlation matrices were inspected, and many coefficients above 0.3 were found. Kaiser-Meyer-Olkin (KMO) was 0.845, and Bartlett's test of sphericity was statistically significant (<0.01), indicating that the dataset was suitable for factor analysis. Four factors with eigenvalues above 1 were revealed, explaining 35, 11, 8 and 7% of the variance, respectively (Table 1). The two items on subjective knowledge about caries loaded on factor 1, together with four items on objective knowledge about caries. Factor 2 consisted of two sets of corresponding items on objective knowledge about caries and erosive wear. Four items on objective knowledge about erosive tooth wear loaded on factor 3, while the two items about subjective knowledge about erosive tooth wear loaded on factor 4. Internal consistency reliability was good for factors 1 and 4 (Cronbach's alpha >0.8) and respectable for factor 3 (Cronbach's alpha 0.7). The four items in factor 2 lacked internal consistency (Cronbach's alpha 0.05) and were excluded from further analyses. The sum scores for the four items on objective knowledge about caries in factor 1 and for the four items on objective knowledge about erosive tooth wear in factor 3, created the condensed variables *objective knowledge – caries* and *objective knowledge – erosive tooth wear*. The two items on subjective knowledge about caries in factor 1 and for the two items on subjective knowledge about erosive tooth wear in factor 4, created the condensed variables *subjective knowledge – caries* and *subjective knowledge – erosive tooth wear*.

Descriptive analyses and paired-samples t-tests

Mean scores and standard deviations for all items are presented in Table 2. Paired-samples *t*-tests revealed that students reported having slightly higher *subjective knowledge* about caries (mean 1.53, SD 0.55) than erosive tooth wear (mean 1.42, SD 0.59; t [779] = 5.27, $p < .01$), but the effect size was very small (Cohen's d 0.19). However, the students scored significantly higher on *objective knowledge* about caries (mean 2.99, SD 0.92) than on erosive tooth wear (mean 1.48, SD 0.87; t [782] = 28.12, $p < .01$), with large effects (Cohen's *d* 1.00). By contrast, the students scored significantly worse on the *damage potential of beverages* to cause caries (mean 5.18, SD 1.88) than to cause erosive tooth wear (mean 6.30, SD 2.10; t [778] = −16.18, $p < .001$), with medium effects (Cohen's d −0.58), although there were larger in-between variations for these items (Table 2).

The distribution of the sum scores for the variables *subjective knowledge – caries/tooth wear, objective knowledge – caries/tooth wear* and *damage potential of beverages* to cause caries and/or erosive tooth wear are presented in Figure 1. Scores for *subjective knowledge* were similarly distributed for caries and erosive tooth wear (Figure 1A). The differences in the variables objective knowledge – caries/erosive tooth wear was visualised as a shift toward the right for caries compared to erosive tooth wear (Figure 1B). By contrast, differences in the sum scores for damage potential of different beverages to cause caries and/or erosive tooth wear were observed as a shift towards the left for caries compared to erosive tooth wear (Figure 1C).

Regression analyses

Three multiple linear regressions revealed how *objective knowledge* was associated with *subjective knowledge* and *concern about prevention* for caries and/or erosive tooth wear. In the first model, significant and strong positive associations were found between the dependent variable *objective knowledge – caries* and the independent variables *subjective knowledge – caries*, *concern about prevention – caries* and *damage potential of beverages – caries* (F (7, 735) = 87.73, $p < .01$), explaining 45.5% of the variance in the data (Table 3). By contrast, in the two models using *objective knowledge – erosive tooth wear* as a dependent variable, we found significant but negative associations between the dependent variable and the independent variables *subjective knowledge – erosive tooth wear*, *concern about prevention – erosive tooth wear* (Models 2a and 2b) and *objective knowledge – caries* (Model 2b) (Table 3). There was a unique but weak positive association between *objective knowledge – erosive tooth wear* and the independent variable *damage potential of beverages – erosive tooth wear* ($\beta = 0.087$, $p = .012$, Model 2a). Variances

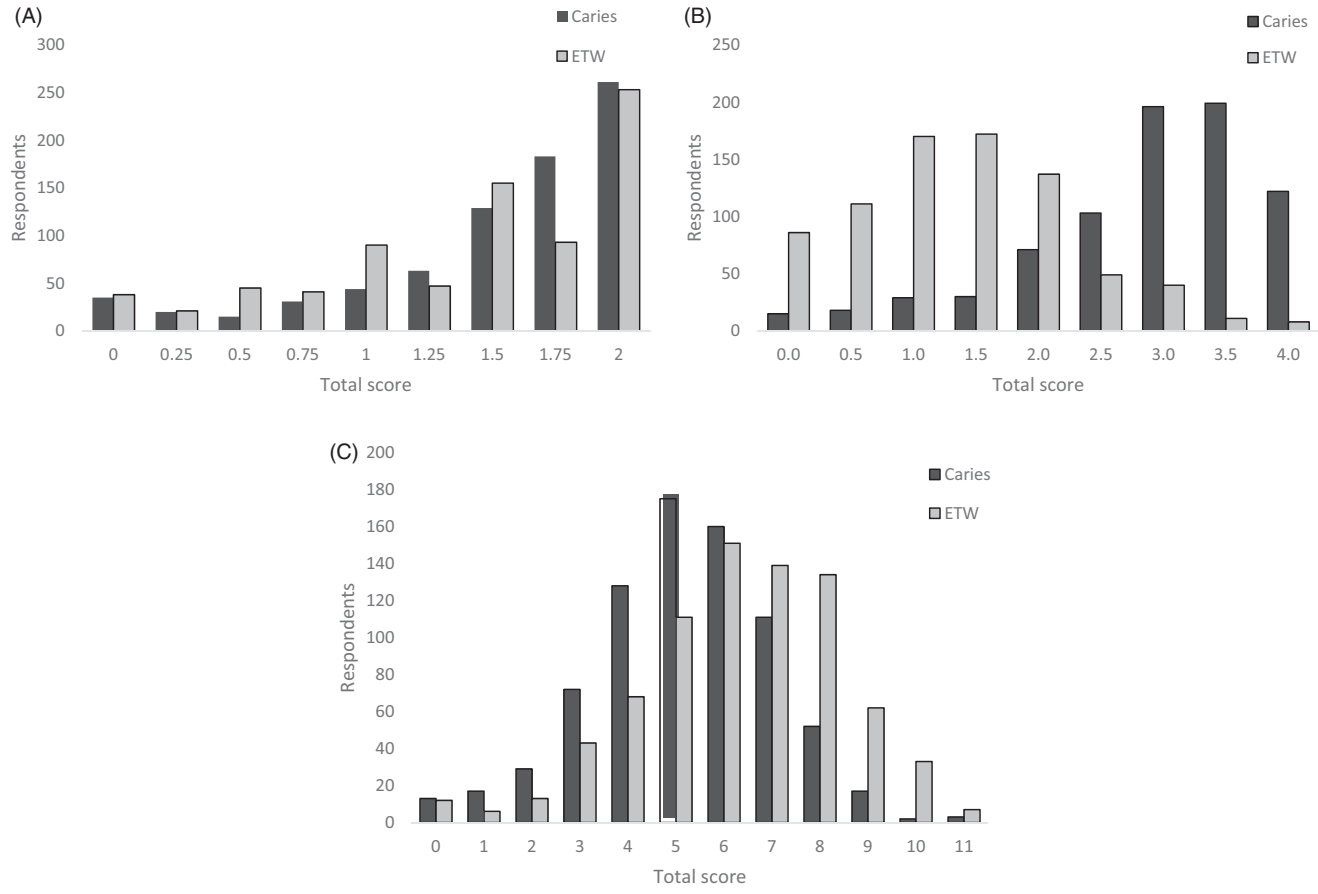

Figure 1. Distribution of sum scores for the variables *subjective knowledge, objective knowledge and damage potential of beverages* to cause caries and/or erosive tooth wear.

Table 3. Regression models assessing associations between subjective and objective knowledge, and concern about prevention for the two conditions caries and erosive tooth wear[a].

Dependent variable	Model 1: objective knowledge - caries β	Model 2a: objective knowledge - erosive tooth wear β	Model 2b: objective knowledge – erosive tooth wear β
Gender	0.004	−0.029	−0.037
Age	0.025	0.016	0.037
Nationality	0.024	−0.073*	−0.070*
Study program	−0.030	−0.096	−0.122***
Subjective knowledge – caries	0.349***		
Concern about prevention – caries	0.402***		
Damage potential of beverages – caries	0.056*		
Subjective knowledge – erosive tooth wear		−0.097*	−0.024
Concern about prevention – erosive tooth wear		−0.375***	−0.284***
Damage potential of beverages – erosive tooth wear		0.087*	0.082*
Objective knowledge – caries			−0.301***
R^2	0.455	0.200	0.269

[a]Regression analyses were performed using the sum score items displayed in Table 2.
Objective knowledge – caries was used as the dependent variable in model 1, while *Objective knowledge – erosive tooth wear* was the dependent variable in model 2a and 2b. Model 2b further assessed whether *objective knowledge* about caries could explain *objective knowledge* about erosive tooth wear. Regression coefficients (β) and variance explained (R^2) are presented for each model. *<0.05, ***<0.001.

explained for Models 2a and 2b were 20.0% (F (7, 729) = 26.04, $p < .001$) and 26.9%, respectively (F (8, 728) = 33.42, $p < .001$).

Discussion

The main finding in this study is that there is a major discrepancy between subjective- and objective knowledge about erosive tooth wear and concern about preventing this condition among high school students. This is in contrast to subjective- and objective knowledge about caries and concern about preventing caries, where there was a strong positive correlation between these variables. In fact, there was a significant negative correlation between *objective knowledge about erosive tooth wear* and *concern about preventing erosive tooth wear* and *objective knowledge about caries*, suggesting that students confuse the two conditions and how to prevent them. This is supported by descriptive statistics which showed that a large portion of students believed that hygiene measures could protect against erosive tooth wear. It is, for example, disturbing that more than half of the students believed that erosive tooth wear could be prevented by brushing teeth after eating or drinking. Since Norwegian high school students have reported a substantial intake of acidic drinks [18], there seem to be a need for increased knowledge and awareness about this condition among youth.

Our results showed that students performed better in determining which beverages that has potential to induce erosive tooth wear than they did in determining which beverages may induce caries. This is an important finding because frequent consumption of acidic beverages is the main extrinsic cause of erosive tooth wear. In line with our findings, Verploegen and Schuller [19] found that young adults (20–25-year olds) in the Netherlands lacked knowledge about erosive tooth wear. However, participants in their study generally scored higher on questions regarding the dental erosion potential of different beverages than the participants in our study. This might be due to the age difference between the two samples surveyed. Another explanation might be that Verploegen and Schuller [19] asked exclusively about erosive tooth wear (i.e. no questions addressed caries). Accordingly, the addition of questions related to caries in the present study might have confused the students, resulting in their lower scores.

Our results are interesting because several studies have shown that erosive tooth wear occurs independently of caries and general dental hygiene. Maharani et al. [32] found that erosion lesions were correlated with frequency of soft drink intake, but not with frequency of tooth brushing or caries experience. Erosive lesions, however, correlated positively with educational level and dental knowledge of the parents [32]. Chu et al. [24] found that erosive tooth wear neither correlated with caries experience nor with frequency of tooth brushing. This indicates that what is typically considered to be oral health-promoting behaviour, such as dental hygiene routines and regular dental visits, does not prevent erosive tooth wear. Verploegen and Schuller [19] found that individuals with higher levels of education and who previously had received or searched for information about dental erosion had a significantly higher level of knowledge about erosive tooth wear, emphasizing the need for more and targeted information to youth about this condition.

One strength of our study is that it included a relatively large sample, increasing the power of the statistical tests applied. However, the students were recruited in common areas in schools during their free time, and this might have skewed the representation. Furthermore, the study had a cross-sectional design, which does not allow for causal inferences.

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Disclosure statement

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