Community Dent Oral Epidemiol 2015; 43; 9–16

Community Dentistry and Oral Epidemiology

Impact of lifestyle factors on caries experience in three different age groups: 9, 15, and 21-year-olds

Elise Dusseldorp[1,2], Mascha Kamphuis[1,3] and Annemarie Schuller[1,4]

[1]TNO Leiden, The Netherlands, [2]Mathematical Institute, Leiden University, Leiden, the Netherlands, [3]Stichting JGZ Zuid Holland West, Zoetermeer, The Netherlands, [4]Center for Dentistry and Oral Hygiene, University Medical Center Groningen, Groningen, The Netherlands

Dusseldorp E, Kamphuis M, Schuller A. Impact of lifestyle factors on caries experience in three different age groups: 9, 15, and 21-year-olds. Community Dent Oral Epidemiol 2015; 43: 9–16. © 2014 John Wiley & Sons A/S. Published by John Wiley & Sons Ltd

Abstract – *Objectives:* To study the impact of lifestyle factors on dental caries experiences in addition to the effect of demographic characteristics at the ages of 9, 15, and 21 years. *Methods:* The data were obtained from the study 'Oral health in children and adolescents in the Netherlands'. Data were collected through questionnaires and a clinical oral examination. Because the DMFS count data were highly skewed with a peak at zero, the negative binomial hurdle model was used for the analyses. The first part of the hurdle predicted the probability of having caries experience or not, and the second part predicted the degree of caries experience. *Results:* For the 9- and 15-year-old age groups, the breakfast frequency per week was related with having caries experience, while the frequency of brushing teeth per day was related with the degree of caries experience. In addition, the number of food and drinks consumed per day was important for the younger age group. These relations were not found in the 21-year-olds age group. *Conclusions:* Findings of this study suggest that components to promote structure and regularity, including having breakfast and the number of food and drink moments, may be important to include in programs to prevent dental caries in children.

Key words: caries; dental health promotion; early childhood caries; health promotion

Elise Dusseldorp, TNO, Leiden, The Netherlands
Tel.: +31 (0)88 866 61 10
e-mail: elise.dusseldorp@tno.nl

Submitted 4 October 2013; accepted 28 July 2014

Despite improvements over the past decades, caries is still the most common chronic childhood disease in the Netherlands, as in many other countries in the world (1). In 2005, 56% of the 5-year-olds had experienced caries in their primary teeth (2). Dental caries affects quality of life in children (3, 4) as well as body weight and growth (4).

Associations between dental caries or oral health-related behavior and lifestyle factors have been described in several studies. For example, research has shown that toothbrushing frequency is associated with getting up in time, having breakfast, and the time of going to bed [in 14- and 15-year-olds; (5)], and eating breakfast was found to be the greatest predictor of toothbrushing twice a day (6). In addition, relations were found between caries and frequency of snacking (7), between caries and being physically inactive, having a higher consumption of snacks and sweetened drinks (8, 9), and between caries and skipping breakfast (8, 10). Bruno-Ambrosius et al. showed that skipping breakfast and irregular meal frequency was related to dental caries in 12- to 15-year-olds (11). This study also found that among 12- to 15-year-olds, in contrast to the other studies, snacks, soft drinks and sweets, as well as

doi: 10.1111/cdoe.12123

toothbrushing habits had no significant influence on caries development (11).

All the mentioned lifestyle factors are related to structure and regularity. It goes without saying that prevention programs for dental caries should be directed at changing lifestyle factors. Most of the above-mentioned studies analyzed the impact of lifestyle factors or a group of lifestyle factors separately, and included only one age group [except for (12) and (13)]. However, it is useful to know whether these lifestyle contributions on dental caries vary across age groups. This will make it possible to target the content of the prevention programs to specific age groups. In addition, to better understand how prevention programs for dental caries can be improved, it is valuable to determine the contribution of lifestyle factors adjusted for demographic characteristics, such as ethnicity, gender, and educational level. As lifestyle factors are influenced by cultural and environmental aspects (which are indicated partially by demographic characteristics), it is useful to understand the influence of lifestyle factors on dental caries over and above the influence of demographic variables. Therefore, the central research questions of this study were as follows: Which lifestyle factors, adjusted for the effect of demographic factors, have an impact on dental caries experiences? Do these factors vary between 9-, 15-, and 21-year-olds?

Materials and methods

Study sample

The data used in this paper were obtained from the study 'Oral health in children and adolescents in the Netherlands'. The objective of the original study was to describe the oral health status and the preventive dental behaviors of 9-, 15-, and 21-year-olds (14). The participants were living in four medium-sized cities in the Netherlands. In each city, simple random samples for the 9- and 15-year-olds were drawn from the Municipal Joint Health Services (called GGDs in the Netherlands) and the sample for the 21-year-olds was taken from the files of the Municipal Population Records. Both institutes had continuously updated addresses of the inhabitants of their municipality. The sampling methods are described earlier (15). The project was approved under the Personal Data Protection Act (no. m1383077).

Adolescents and/or the parents received a letter describing the purpose of the study. Informed consent to participate in the clinical examination was signed and returned by those authorized to do so (parental authorization). People who did not respond were contacted at home by a person who emphasized the importance of the study. In case of noncontact, a maximum of three contact attempts were made. Individuals who refused to participate were asked to fill out a nonresponse questionnaire, with questions including demographic characteristics and oral health habits.

Data collection

The data collection consisted of a questionnaire and a clinical oral examination. The questionnaire was filled out by a parent of the 9-year-olds and by the 15- and 21-year-olds themselves. The questionnaire measured demographic variables (ethnicity and educational level) and children's dental attendance, oral self-care, and dental anxiety. The clinical assessment consisted of visual inspection of the teeth and the registration of caries lesions and any subsequent treatment (restoration or extraction). No X-rays were taken to avoid exposure to radiation. The study protocol is written in Dutch and available on request. Clinical examinations were performed by four calibrated dentists in a Mobile Oral Health Facility. To evaluate interexaminer agreement, 11% of the participants (all ages) were re-examined by a second examiner. The Pearson correlation between raters for the dmfs and DMFS was 0.96, the intracluster coefficient was 0.98. The interexaminer agreement was considered to be satisfactory based on these results.

Outcome measures

The DMF score was used to describe caries experience (16). The DMF score is the sum of decayed (D), missing (M), and restored (F, filled) surfaces (S; resulting in DMFS) or teeth (T; resulting in DMFT). Uppercase letters refer to permanent teeth, lowercase letters to primary teeth. In 1987, the Dutch dental field of epidemiologists agreed that the DMFS index should be calculated on the basis of 28 dental elements, third molars excluded (17). For the 9-year-olds the dmfs index was used, for the other two age groups, the DMFS index was used. There was little DMF in the premolars and second molars in 15-year-olds as the time elapsed between the eruption of the premolars and the second permanent molars and the moment of this clinical examination was quite short. This time is expected to be too short to detect caries visually without the use of X-rays. Therefore, in addition,

an alternative index (DMFSalt) based on just the DMF of the first permanent molars was calculated for 15-year-olds.

Demographic characteristics

The socioeconomic status (SES) of the 21-year-olds and the mothers of the 9-year-olds was based on the highest level of completed education in accordance with the classification of Statistics Netherlands. For the 15-year-olds, the classification was based on a combination of the current level of education for youngsters still at school or the highest level of completed education for youngsters who had finished their education. Level of education was divided into low and high, based upon the intellectual challenges offered by the Dutch education system. High education was defined as senior general secondary education (HAVO) or higher. All other education was defined as low education.

Ethnicity was defined as mother being born in the Netherlands (referred to as natives) versus being born abroad (referred to as immigrants).

Lifestyle factors

The following lifestyle factors were measured by the questionnaire: Frequency of brushing teeth per day, frequency of having breakfast per week, and frequency of food and drinks per day (Table 1). The table shows the answer categories and the categories for data analysis.

Dichotomization of the variables 'brushing teeth' and 'food and drinks' were based on nationally accepted recommendations in the Netherlands (www.ivorenkruis.nl).

A first look at the distribution of the variable 'breakfast' showed that most 9-year-olds had breakfast every day, while the majority in the older age groups had breakfast 5 days a week (most probably the weekdays). For the analyses, the scores were therefore reduced into two categories, which were different for the age groups. For the 9-year-olds, this was 'not every day' versus 'every day'. For the 15- and 21-year-olds, this was 'not every weekday' versus 'every weekday'.

Data analysis

The distributions of the dmfs and DMFS indices were much skewed and some outliers were detected at the positive end (i.e., some children with an extreme caries experience). These were: for the 9-year- olds, one observation with a dmfs > 30; for the 15-year-olds, three observations with a DMFS > 30, and four with a DMFSalt > 10; for the 21-year-olds, two with a DMFS > 50. Appendix A (see online supplementary material) shows the distributions of the caries indices with and without outliers. All distributions show a high peak at zero, that is, many children had no caries experience.

To inspect univariate differences between children with (i.e., dmfs > 0 or DMFS > 0) and without caries experience (i.e., dmfs = 0 or DMFS = 0) in distributions of the demographic characteristics and lifestyle factors, chi-square tests (for categorical variables) or independent *t*-tests (for continuous variables) were used. These analyses were performed in SPSS, version 20 (18).

To assess the impact of lifestyle factors on *dental caries experience*, adjusted for the effect of demographic characteristics, the negative binomial hurdle model was applied (19), using dmfs (or DMFS) as outcome. For outcome distributions with an excessive number of zeros, recommended models

Table 1. Overview of operationalizations of the lifestyle factors

Item in questionnaire	Answer categories	Categories for data analysis
Frequency of brushing teeth	0 Never 1 Sometimes but not every day 2 Once a day 3 Twice a day 4 More than twice a day	0 Less than twice a day 1 At least twice a day
Frequency of having breakfast	0 Never 1 Less than once a week 2 Once a week 3 Two to four times a week 4 Five to six times a week 5 Every day	For 9-year-olds: 0 Not daily 1 Daily For 15- and 21-year-olds 0 Not every weekday 1 Every weekday
Frequency of food and drinks per day in addition to the three main meals (excluding sugar-free coffee, tea, water)	Continuous variable asked for morning, afternoon, evening and night.	0 Maximum 7 times daily 1 More than 7 times daily

are the zero-inflated negative binomial model or the negative binomial hurdle model (20, 21). The performance of the zero-inflated model is as good as that of the hurdle model, but the coefficients of the hurdle model have a nicer and less misleading interpretation (21, 22). The hurdle model consists of a logistic regression component that estimates whether a child experiences caries or not (i.e., dmfs = 0 versus dmfs > 0), and a truncated count component that estimates the degree of caries experience for those persons with caries experience. The first component was estimated with a binomial model, and the second with a negative binomial. For the binomial model, the exponential of the regression coefficient represents the odds ratio (OR). For the negative binomial, the exponential of the coefficient represents the rate ratio (RR), that is, the relative change in the degree of caries with a unit increase in the predictor. For each age group, two hurdle analyses were performed differing in the set of predictors that were included either only the demographic factors were entered in the analysis, or all demographic and lifestyle factors were entered. Because part of these predictor variables overlap, the two models are called nested models and the increase in fit was tested with a likelihood ratio test. In this way, the impact of the group of lifestyle factors in addition to the demographic factors could be tested.

The hurdle analyses were performed with and without the outliers. For the 9- and 15-year- olds, the significance results were dependent on whether outliers were included or not. Because the outliers had such an impact, the outliers were excluded from the final hurdle analyses. The hurdle analyses were performed using the R-package pscl (23) in the R software environment, version 3.0.2 (24). The likelihood ratio tests were performed using the R-package lmtest (25).

Results

For the different age groups (9-, 15-, and 21-years) 1746, 1915, and 3745 were invited to participate in the study. Table 2 shows the response rates. The main reasons for not taking part in the study were lack of interest in the study or no time to participate. Other less frequently mentioned reasons were illness, anxiety, language problems, or inaccessibility. The response rates were quite low. It was therefore important to perform nonresponse analysis (9-year-olds $n = 98$, 15-year-olds $n = 118$, and 21-year-olds $n = 311$) to describe possible selection bias. It was concluded from the nonresponse analyses that the responders had some worse oral health and worse oral health habits that could result in a too negative description of the situation (15).

Table 2. Response rates for the three age groups

	9-year-olds $N = 1746$ n (%)	15-year-olds $N = 1915$ n (%)	21-year-olds $N = 3745$ n (%)
Completed questionnaires	541 (31)	612 (32)	486 (13)
Clinical examinations	541 (31)	555 (29)	486 (13)
Both: Completed questionnaires and clinical examinations	436 (25)	574 (30)	449 (12)

About half of the 9- and 15-year-olds had caries experience (dmfs > 0 or DMFS > 0) (Table 3, 54.5% and 51.9%, respectively), compared with more than three-quarters of the 21-year-olds (Table 3, 77.5%). For all age groups, the percentage of children with caries experience was higher in the less educated group than in the well-educated group (Table 3). In addition, the percentage of children with caries experience was significantly higher for the immigrants compared with natives for the younger age groups (Table 3). With regard to the lifestyle factors, the percentage of children with caries experience (dmfs > 0) was much higher for the 9-year-olds who did not have breakfast every day compared with the ones who did have breakfast every day (80.6% versus 51.9%; $P = 0.001$, Table 3); furthermore, this percentage was much higher among the 15-year-olds who had breakfast <5 days a week compared with those who have breakfast 5 days or more per week (67.5% versus 49.6%; $P = 0.003$ for DMFS, and 58.4% versus 39.8%; $P = 0.002$ for DMFSalt, Table 3). In addition, a significant effect of brushing teeth was shown for the 15-year-olds while for the 9-year-olds an effect of frequency of food and drinks was evident (Table 3). Overall, the differences in demographic characteristics and lifestyle factors between children with and without caries experience were larger for the younger age groups (9-year-olds and 15-year-olds) than the older age group (21-year-olds; see Table 3).

The likelihood ratio tests of the hurdle model including the demographic and lifestyle factors compared with the hurdle model including the demographic factors only, showed that the group of lifestyle factors had a significant effect on dental

Table 3. The percentage of children with caries experience are given per category of each demographic characteristic and lifestyle factor. For 9-year-old children, caries experience in primary teeth is given (dmfs) while for 15- and 21-year-olds, caries experience in permanent teeth (DMFS and/or DMFSalt) is given. Results of chi-square tests are shown for differences between the groups without and with caries

	9-year-olds			15-year-olds					21-year-olds		
Variable	*n*	dmfs > > 0	*P*	*n*	DMFS > 0	*P*	DMFSalt > 0	*P*	*n*	DMFS > 0	*P*
Education level (mother or child)											
Low	215	61.4%	**0.003**	257	57.6%	**0.018**	49.8%	**0.001**	103	85.4%	**0.023**
Middle/High	215	47.0%		315	47.6%		36.2%		324	74.7%	
Sex											
Male	237	55.3%	0.740	243	52.3%	0.885	43.2%	0.671	174	76.4%	0.666
Female	203	53.7%		333	51.7%		41.4%		266	78.2%	
Ethnicity											
Immigrants	74	67.6%	**0.010**	94	63.8%	**0.012**	53.2%	**0.017**	74	77.0%	0.901
Native	361	51.2%		476	49.6%		39.9%		363	77.7%	
Brushing teeth											
Less than twice a day	91	62.6%	0.074	141	59.6%	**0.036**	49.6%	**0.039**	133	79.7%	0.457
Twice or more a day	347	52.2%		435	49.4%		39.8%		306	76.5%	
Having breakfast											
Not every day (or <5)	36	80.6%	**0.001**	77	67.5%	**0.003**	58.4%	**0.002**	94	84.0%	0.082
Every day (or ≥5 days)	401	51.9%		498	49.6%		39.8%		344	75.6%	
Food & drinks per day											
More than 7	35	77.1%	**0.005**	182	51.6%	0.930	44.0%	0.553	144	77.8%	0.842
Maximum of 7	400	52.3%		392	52.0%		41.3%		286	76.9%	
Total group	440	54.5%		576	51.9%		42.2%		440	77.5%	

Note. Statistically significant results (i.e., $P < .05$) are shown in bold face.

caries experience for the 9-year-olds [$\Delta\chi^2(6) = 23.7$; $P < 0.001$], and the 15-year-olds [$\Delta\chi^2(6) = 14.1$; $P = 0.03$; this effect concerned DMFSalt], not for the 21-year-olds. The parameter estimates of the hurdle models including all factors (i.e., the demographic and lifestyle factors) were further inspected. The two parts of the hurdle models are shown separately (Tables 4 and 5). With regard to the first part that predicts having caries experience, none of the effects of the lifestyle factors was for all three age groups significant (Table 4). The effect of one lifestyle factor, frequency of having breakfast per week, was for two age groups significant the 9-year-olds and the 15-year-olds. And one lifestyle factor, frequency of food and drinks per day, showed a significant effect for the 9-year-olds. The remaining lifestyle factor, brushing teeth, showed no significant effect in any of the age groups. For the 9-year-olds, those not having breakfast every day were three times more likely to have caries experience than those having breakfast every day (adjusted OR = 3.4, Table 4) and those having more than seven food and drink moments a day were about three times more likely to have caries experience than those having seven or less of such eating & drinking moments (adjusted OR = 2.8, Table 4). For the 15-year-olds, those not having breakfast every day were about two times more likely to have caries experience than those having breakfast every day (adjusted OR = 1.7, Table 4). For the 21-year-olds no significant effect was found for any of the lifestyle factors.

With regard to the second part of the hurdle model that predicts the degree of caries experience for those having caries experience, one lifestyle factor (i.e., frequency of brushing teeth) showed a significant effect (Table 5). This significant effect was found for two age groups: the 9-year-olds and 15-year-olds (for the latter age group, the effect related to the alternative measure for caries experience, DMFSalt). For both the 9-year-olds and 15-year-olds with caries experience, the predicted degree of caries experience (indicated by dmfs or DMFSalt) for those brushing their teeth less than twice a day is 1.43 (or 1.45) higher than for those brushing their teeth twice a day (Table 5); in other words, those brushing their teeth less than the norm show on average a 43–45% increase in degree of caries compared with those brushing according to the norm. Again, for the 21-year-olds no significant effect was found for any of the lifestyle factors.

Discussion and conclusion

In this study, we studied which lifestyle factors, adjusted for the effect of demographic factors, have an impact on dental caries experiences, and the

Table 4. Effect of lifestyle factors on caries experience adjusted for the effect of demographic characteristics. Results are shown of the first part (i.e., the logistic regression component) of the hurdle model that predicts the probability of having caries experience

	9-year-olds $n = 426$ dmfs > 0		15-year-olds $n = 563$ DMFS > 0		15-year-olds $n = 562$ DMFSalt > 0		21-year-olds $n = 414$ DMFS > 0	
Predictors	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Education level[a]: low versus middle/high	1.63*	1.10, 2.42	1.37	0.97, 1.93	1.59**	1.13, 2.25	1.80	0.98, 3.33
Sex: male versus female	1.07	0.72, 1.60	0.98	0.70, 1.38	1.03	0.73, 1.46	0.88	0.54, 1.41
Ethnicity: immigrants versus. native	1.72	0.98, 3.01	1.53	0.95, 2.46	1.36	0.85, 2.17	0.93	0.50, 1.74
Brushing teeth: less than twice versus twice or more	1.26	0.77, 2.08	1.37	0.92, 2.05	1.33	0.89, 1.98	1.03	0.61, 1.74
Having breakfast[b]: not every day versus every day	3.37**	1.41, 8.02	1.72*	1.00, 2.94	1.75*	1.04, 2.93	1.38	0.74, 2.59
Food & drinks: more than 7 versus 7 or less	2.78*	1.21, 6.40	0.92	0.64, 1.32	1.04	0.72, 1.51	1.03	0.63, 1.68

CI, confidence interval; OR, odds ratio, adjusted for the effect of the other predictors in the model.
[a]For the 9-year-olds, the education level of mother was used, and for the 15- and 21-year-olds, the education level of the child.
[b]The categories of having breakfast were operationalized in the following way: For the 9-year-olds, not every day versus every day was used; for the 15- and 21- year-olds, less than 5 days a week versus 5 days a week or more was used.
*$P < 0.05$; **$P < 0.01$.

Table 5. Effect of lifestyle factors on caries experience adjusted for the effect of demographic characteristics. Results are shown of the second part of the hurdle model predicting the degree of caries experience

	9-year-olds dmfs		15-year-olds DMFS		15-year-olds DMFSalt		21-year-olds DMFS	
Outcome Predictors	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Education level[a]: low versus middle/high	1.32*	1.02, 1.71	1.86**	1.41, 2.46	1.61**	1.19, 2.18	1.23	0.89, 1.69
Sex: male versus female	1.05	0.82, 1.34	1.00	0.76, 1.33	1.05	0.78, 1.42	1.13	0.86, 1.49
Ethnicity: immigrants versus native	1.35*	1.00, 1.82	1.71**	1.22, 2.40	1.59*	1.11, 2.27	1.28	0.89, 1.85
Brushing teeth: <twice versus twice or more	1.43*	1.08, 1.89	1.07	0.78, 1.47	1.45*	1.04, 2.02	1.16	0.85, 1.59
Having breakfast[b]: not every day versus every day	1.22	0.84, 1.76	0.91	0.62, 1.32	0.86	0.59, 1.28	1.17	0.84, 1.65
Food & drinks: more than 7 versus 7 or less	0.97	0.65, 1.44	0.92	0.68, 1.24	0.78	0.56, 1.08	1.03	0.77, 1.37

RR, rate ratio, that is, the exponential of the regression coefficient; CI, confidence interval.
[a]For the 9-year-olds, the education level of mother was used, and for the 15- and 21-year-olds, the education level of the child.
[b]The categories of having breakfast were operationalized in the following way: For the 9-year-olds, not every day versus every day was used; for the 15- and 21- year-olds, <5 days a week versus 5 days a week or more was used.
*$P < 0.05$; **$P < 0.01$.

possible variation through the ages of 9, 15, and 21 years.

A significant impact of lifestyle factors (brushing teeth, having breakfast, and eating, and drinking moments) in addition to demographic characteristics (sex, education and being immigrant) was found for the 9- and 15-year-old age groups, but not for the 21-year-olds. Although effects on caries through feeding practices, such as between meal snacking, were summarized in a recent review (26), having breakfast was not specifically studied in this review. For the 9- and 15-year-old age groups in our study, not having breakfast was shown to have an impact on having caries experience, while not brushing teeth twice a day was shown to have an impact on degree of caries experience. Both effects were adjusted for the effect of demographic characteristics. A plausible explanation of this finding could be that having breakfast is an indication of regularity in life, including regular moments for brushing teeth. In addition, having breakfast means there is probably less need for snacks during the day so that the number of eating moments remains lower. Some of these findings were also found in previous studies. Levin and Currie. (6) and Macgregor et al. (5), both found that having breakfast was a predictor for tooth-brushing twice a day. The study by Bruno-Ambrosius (11) showed a negative effect of not having breakfast on dental caries in 12-year-old

children. However, they showed that toothbrushing habits had no significant influence on caries development.

In our study, the number of food and drinks consumed per day only had an impact on caries experience in primary teeth of 9-year-olds. There were no other studies that operationalized the number of eating moments as we did in our study. In the Netherlands, the nationally recommended maximum frequency of food and drinks consumption per day is seven. From our study, we can underline that this number of eating moments is an appropriate cutoff for recommendations.

There were no significant effects of lifestyle factors for 21-year-olds: none of the included lifestyle factors had an impact on having caries experience (yes or no) or on the degree of caries experience, regardless of the adjustment for the effect of demographic characteristics. An explanation for this could be that after several years the influence of lifestyle factors on dental caries is 'overruled' by the decay in the teeth themselves. Several studies only showed the relation between lifestyle factors and dental decay for young children (5–7, 11). However, Sanders et al. (26) showed interrelatedness of oral and general risk behaviors and sociodemographic associations in people older than 18 years (age group 18–92 years with mean 43.7 years). They did not, however, include the frequency of breakfast or the frequency of brushing teeth in their study.

The findings of this study should be considered in the context of its methodological strengths and weaknesses. This study included three cohorts with large sample sizes that were representative of the study population. The dataset included both clinical data collected by standardized examinations and data obtained from a questionnaire. However, the design of the study was cross-sectional: The lifestyle factors were measured at the same time as dental caries experience. As a consequence, no causal influences were established. Nonresponse analyses showed some differences between responders and nonresponders, in favor of the nonresponders (i.e., a better oral health and better oral health habits) for all age groups. This resulted possibly in an underestimation of the prevalence of oral health and oral health habits in the study population. Dental caries experiences were not registered using X-ray pictures as this was not allowed by the ethic committee. This means that there may be an underestimation of the absolute number of caries registrations.

The more general lifestyle factors used in this study, having breakfast and number of eating moments, are also known to contribute to childhood obesity or the prevention thereof (1, 8, 11, 27, 28). A significant relation between childhood obesity and dental caries was found in a recent review, although the confounding variables were questioned (29). Another recent study, addressed this association as well, and a surprising direction was found (30) in families with a high socioeconomic status of the mother, a high caries experience was related to a smaller weight increment. In addition, an indication for an association between caries and obesity was found, but results were not significant. Therefore, in our opinion, and also mentioned by Lempert et al. (30), uniformity in preventive messages about the consumption of food and drinks should be strived for.

Conclusion

Lifestyle factors with an impact on dental caries, adjusted for the influence of demographic factors, were found for 9- and 15-year-old children, but not for 21-year-olds. For the two younger age groups, not having breakfast and not brushing teeth twice a day was associated with higher caries experience. In addition, for the younger age group having more than seven food and drink moments a day increased caries experience. Findings of this study suggest that components to promote structure and regularity, including having breakfast and the number of food and drink moments, may be important to include in programs to prevent dental caries in children. Preventive messages about the consumption of food and drinks should be coordinated with different health and oral health professionals.

Acknowledgements

The study 'Oral health in children and adolescents in the Netherlands was financed by the Health Care Insurance Board (Zorginstituut Nederland), Diemen, the Netherlands. This research is free of conflict of interest. The authors gratefully acknowledge Denise Duijster and Stef van Buuren for their helpful comments on earlier drafts of this paper, and Achim Zeileis for his support with the interpretation of the hurdle model.

References

1. Spiegel KA, Palmer CA. Childhood dental caries and childhood obesity. Different problems with overlapping causes. Am J Dent 2012;25:59–64.
2. Poorterman JHG, Schuller AA. Tandheelkundige verzorging Jeugdige Ziekenfondsverzekerden (TJZ): een onderzoek naar veranderingen in mondgezondheid en preventief tandheelkundig gedrag: eindmeting 2005. Amsterdam; Leiden: Academisch Centrum Tandheelkunde Amsterdam; TNO Kwaliteit van Leven; 2006.
3. Low W, Tan S, Schwartz S. The effect of severe caries on the quality of life in young children. Pediatr Dent 1999;21:325–6.
4. Sheiham A. Dental caries affects body weight, growth and quality of life in pre-school children. Br Dent J 2006;25:625–6.
5. Macgregor ID, Balding J, Regis D. Toothbrushing schedule, motivation and 'lifestyle' behaviours in 7,770 young adolescents. Community Dent Health 1996;13:232–7.
6. Levin KA, Currie C. Adolescent toothbrushing and the home environment: sociodemographic factors, family relationships and mealtime routines and disorganisation. Community Dent Oral Epidemiol 2010;38:10–8.
7. Niji R, Arita K, Abe Y, Lucas ME, Nishino M, Mitome M. Maternal age at birth and other risk factors in early childhood caries. Pediatr Dent 2010;32:493–8.
8. Cinar AB, Christensen LB, Hede B. Clustering of obesity and dental caries with lifestyle factors among Danish adolescents. Oral Health Prev Dent 2011;9:123–30.
9. Craig LC, McNeill G, Macdiarmid JI, Masson LF, Holmes BA. Dietary patterns of school-age children in Scotland: association with socio-economic indicators, physical activity and obesity. Br J Nutr 2010;103:319–34.
10. Nagel G, Wabitsch M, Galm C, Berg S, Brandstetter S, Fritz M et al. Determinants of obesity in the Ulm Research on Metabolism, Exercise and Lifestyle in Children (URMEL-ICE). Eur J Pediatr 2009;168:1259–67.
11. Bruno-Ambrosius K, Swanholm G, Twetman S. Eating habits, smoking and toothbrushing in relation to dental caries: a 3-year study in Swedish female teenagers. Int J Paediatr Dent 2005;15:190–6.
12. Chankanka O, Cavanaugh JE, Levy SM, Marshall TA, Warren JJ, Broffitt B et al. Longitudinal associations between children's dental caries and risk factors. J Public Health Dent 2011;71:289–300.
13. Meurman PK, Pienihakkinen K. Factors associated with caries increment: a longitudinal study from 18 months to 5 years of age. Caries Res 2010;44:519–24.
14. Schuller AA, Poorterman JHG, vanKempen CPF, Dusseldorp E, vanDommelen P, Verrips GHW. Kies voor tanden: een onderzoek naar mondgezondheid en preventief tandheelkundig gedrag van jeugdigen. Tussenmeting 2009, een vervolg op de reeks TJZ-onderzoeken. Leiden: TNO; 2011.
15. Schuller AA, van Dommelen P, Poorterman JHG. Trends in oral health in young people in the Netherlands over the past 20 years: a study in a changing context. Community Dent Oral Epidemiol 2014;42:178–84. doi:10.1111/cdoe.12070.
16. Klein H, Palmer CE, Knutson JW. Studies on dental caries: I Dental status and dental needs of elementary school children. Public Health Rep 1938;53:751–65.
17. Schuller AA, Bruers JJ, van Dam BA, Poorterman JH, Gerardu VA, Truin GJ. The restorative care index in children 1. Factors concerning the child. Ned Tijdschr Tandheelkd 2009;116:347–53.
18. IBM Corp. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp; 2011.
19. Mullahy J. Specification and testing of some modified count data models. J Econom 1986;33:341–65.
20. Lewsey JD, Thomson WM. The utility of the zero-inflated Poisson and zero-inflated negative binomial models: a case study of cross-sectional and longitudinal DMF data examining the effect of socio-economic status. Community Dent Oral Epidemiol 2004;32:183–9.
21. Zeileis A, Kleber C, Jackman S. Regression models for count data in R. J Stat Softw 2008;27:1–25.
22. Preisser JS, Stamm JW, Long DL, Kincade ME. Review and recommendations for Zero-inflated count regression modeling of dental caries indices in epidemiological studies. Caries Res 2012;46:413–23.
23. Jackman S. PSCL: Classes and Methods for R Developed in the Political Science Computational Laboratory, Stanford University. R package version 1.04.4. 2012.
24. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2013.
25. Zeileis A, Hothorn T. Diagnostic checking in regression relationships. R News 2002;2:7–10.
26. Sanders AE, Spencer AJ, Stewart JF. Clustering of risk behaviours for oral and general health. Community Dent Health 2005;22:133–40.
27. de Silva-Sanigorski AM, Waters E, Calache H, Smith M, Gold L, Gussy M et al. Splash!: a prospective birth cohort study of the impact of environmental, social and family-level influences on child oral health and obesity related risk factors and outcomes. BMC Public Health 2011;11:505.
28. Cinar B, Murtomaa H. Clustering of obesity and dental health with lifestyle factors among Turkish and Finnish pre-adolescents. Obes Facts 2008;1:196–202.
29. Hayden C, Bowler JO, Chambers S, Freeman R, Humphris G, Richards D et al. Obesity and dental caries in children: a systematic review and meta-analyis. Community Dent Oral Epidemiol 2013;41:289–308. doi: 10.1111/cdoe.12014.
30. Lempert SM, Froberg K, Christensen LB, Kristensen PL, Heitmann BL. Association between body mass index and caries among children and adolescents. Community Dent Oral Epidemiol 2014;42:53–60.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix A. Overview of the distributions of dmfs or DMFS per age group.