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Early caries predicts low oral health-related quality of life at later age

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Abstract

Oral health-related quality of life (OHRQOL) is the perceived impact of one's own oral health on daily life. Oral diseases influence children's OHRQOL directly, but OHRQOL might also be related to oral health experiences from the past. We investigate the relation between dental caries at the age of 6 with OHRQOL assessed at the age of 10. This study was conducted within the Generation R Study, a population-based prospective cohort study. Caries experience was assessed with the decayed, missing and filled teeth -index (dmft) at a median (90% range) age of 6.09 (5.73-6.80). OHRQOL was assessed with a short form of the Child Oral Health Impact Profile at the children's age of 9.79 (9.49-10.44). In total, n= 2833 children participated in this study, of which n= 472 (16.6%) had mild caries (dmft 1-3) and n= 228 (8.0%) had severe caries (dmft >3).

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Role of authors

Lea Kragt substantially contributed to the conception and design of the manuscript, contributed to the acquisition, analysis and interpretation of data, drafted the manuscript, gave final approval and agrees to be accountable for all aspects of the work in ensuring that questions relating to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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The higher the dmft-score at the age of 6, the lower the OHRQOL at the age of 10 ($p < 0.001$). The children with severe caries at the age of 6 had significant higher odds to be in the lowest OHRQOL quartile at the age of 10 (OR=1.69; 95% CI=1.17-2.45). Our study highlights the importance of oral health during childhood, because those who get a compromised start to oral health are much more likely to follow a trajectory which will lead to poor oral health (-related quality of life) later. OHRQOL is not only related to current oral health experiences, but also to oral health experiences from the past.

Keywords

Caries; childhood; longitudinal study; quality-of-life; prognosis

Introduction

Oral health-related quality of life (OHRQOL) is the perceived impact of one's own oral health on daily life and has commonly been defined as 'people's comfort when eating, sleeping and engaging in social interaction; their self-esteem; and their satisfaction with respect to their oral health' [USDHHS, 2000]. Whereas OHRQOL had a difficult position in research for a long time, recently its use has enormously increased. Nowadays the scientific community is fully aware of the importance of OHRQOL for evidence-based dentistry. OHRQOL is subjective and multidimensional, encompassing the physical and psychological health state as well as the functioning in social interaction [Sischo and Broder, 2011]. Thus, the concept as such is very suitable to measure the perceived oral health of individuals.

Determinants of OHRQOL have been widely investigated, but are not yet understood in detail. Most research on determinants of OHRQOL is guided by the conceptual model of Wilson and Cleary [Wilson and Cleary, 1995]. This model distinguishes between characteristics of the individual (e.g. self-esteem), characteristics of the environment (e.g. socio-economic position (SEP)) and clinical factors (e.g. caries), that influence OHRQOL. Determinants of OHRQOL are mainly investigated in cross-sectional studies. Psychosocial factors like self-esteem or sense of coherence and environmental factors like SEP seem positively correlated with OHRQOL [Baker et al., 2010; Kumar et al., 2014]. Clinical factors are negatively correlated with OHRQOL [Barbosa et al., 2016; Guedes et al., 2016]. The most important clinical factor in oral health research is the diagnosis of caries. Caries experience in childhood has a prevalence of 60 -90 % worldwide and is a strong predictor for later caries experience and other oral diseases [Isaksson et al., 2013; Mejre I et al., 2014; Skeie et al., 2004].

However, all of the different individual, environmental and clinical factors, including caries, do not directly explain much of the variation in children's OHRQOL as shown in cross sectional studies. This raises the question, whether OHRQOL might also be related to oral health experiences from the past. Longitudinal research about different determinants on OHRQOL is scarce. The existing longitudinal literature mainly focusses on the evaluation of dental treatments, but does not investigate the longitudinal influence of disease and its related experiences on OHRQOL [Abanto et al., 2015; Silvola et al., 2016]. However, age

emerged consistently as a crucial determinant of OHRQOL [Bönecker et al., 2014] and OHRQOL decreases with increasing age [Jokovic et al., 2005; Martins-Junior et al., 2013; Pulache et al., 2016].

The relationship between childhood caries and OHRQOL at school-age has not yet been investigated in such a large cohort study. Research on the effect of caries treatment has shown, that patients perceive improved OHRQOL after treatment. However, treatment cannot shift the OHRQOL level as high as the OHRQOL level of caries free children [de Paula et al., 2015].

In this study, we relate dental caries at the age of 6 with OHRQOL assessed at the children's age of 10, whether they were treated or not.

Material and Methods

Design and cohort

The present study was embedded in the Generation R Study, a population-based prospective cohort study from fetal life onwards, which was initiated to identify early environmental and genetic determinants of growth, development and health. The Generation R Study has been previously described in detail [Jaddoe et al., 2012; Kruithof et al., 2014]. The Generation R Study has been conducted in accordance with the World Medical Association Declaration of Helsinki and all study phases have been approved by the Medical Ethical Committee of the Erasmus Medical Centre, Rotterdam, The Netherlands (MEC-2012-165). The present study has been performed in compliance with the STROBE guidelines.

All pregnant women living in Rotterdam with an expected delivery date between April 2002 and January 2006 were invited to participate in the study. In the study phase from 5 years onwards n=6690 visited the research center. Participants with missing information on caries at the age of 6 or OHRQOL at the age of 10 were excluded from this study. A detailed flowchart for the participants selection is presented in figure 1.

Caries experience

The decayed, missing and filled teeth index (dmft) was used to assess dental caries in the 6-year old children [WHO, 2013]. The dmft-score of each child was obtained from intraoral photographs taken by trained nurses and dental students. Before taking photographs, the children brushed their teeth and the teeth were dried with a cotton roll. The images were taken with one of the two intraoral cameras, the Poscam USB intra-oral (Digital Leader PointNix) and Sopro 717 (Acteon) autofocus camera. Both cameras had a resolution of 640x480 pixels and a minimal scene illumination of f 1.4 and 30 lx. The whole dentition was captured with 10 photographs. The photographs were judged by one pediatric dentist (intra-rater reliability K=0.95) and a second calibrated pediatric dentist judged 10% of the photographs (inter-rater reliability of K =0.62). Scoring dental caries per tooth on intraoral photographs has been described elsewhere with a high sensitivity (85.5%) and specificity (83.6%) compared to ordinary oral examination [Elfrink et al., 2009]. If one or more primary teeth were not able to be judged on the photographs, no dmft score was given.

Generally, the dmft-score ranges from 0 to 20. For the analysis, the dmft-index was categorized into three groups: caries free children (dmft = 0), children with mild caries experience (dmft-score = 1 -3) and children with severe caries experience (dmft-score > 3). The cut-off for the categorization was based on the mean dmft-score of five-year-old Dutch children (mean±sd: 1.6±2.5) and was also used in other studies [Pulache et al., 2016; Schuller et al., 2013].

Oral health-related quality of life

OHRQOL of the children was assessed at children's age of 10 by parental questionnaires with a shortened form of the Child Oral Health Impact Profile (COHIP) [Kragt et al., 2015]. This COHIP had 11 items, which covered the following domains of OHRQOL: oral symptoms, functional well-being, emotional well-being, school and peer interaction (appendix Table A.1). The questions referred to the oral health-related experiences in the last 3 month and were answered on a 5-point Likert scale: never (5 points), almost never (4 points), sometimes (3 points), often (2 points), and always (1 point). OHRQOL was scored by the sum of the answers with each question having the same weight. One item was positively formulated and therefore reversed to ensure that the highest score reflected the best possible OHRQOL. The final range of the COHIP score was 11.0 -55.0. Participants that missed answers on more than 3 items were excluded from the analysis. For participants that missed up to three answers, missing values were replaced by the mean answer score based on the remaining items. OHRQOL was not normally distributed and because transformation of the data did not lead to useable results, we decided to categorize OHRQOL into quartiles (appendix Table A.2). In the descriptive Table 1 we present data on OHRQOL as median with 90% range. The median indicates the OHRQOL value which would separate the study population into two equally sized groups. The 90% range indicates the range of OHRQOL scores in which 90% of the children fall.

Covariates

The following variables were considered to influence the association between dental caries at the age of 6 years and OHRQOL assessed at the age of 10: child's gender, ethnicity and age at answering the COHIP, socio-economic status (SES) measured as maternal education level (high vs. low), family income (< 2400€ vs. ≥ 2400€) and marital status of the mother (single vs partnership). Information of these potential covariates was collected by questionnaires at the children's age of 6. Furthermore, we considered following oral health (-behavior) variables as potential confounders: tooth-brushing frequency (once a day vs twice or more a day), dental visits in the last year (yes vs. no) and malocclusion at the age of ten. Malocclusion was assessed with the Dental Health Component of the Index of Orthodontic Treatment Need (IOTN-DHC). The IOTN-DHC was assessed from photographic and radiographic records taken at children's age of 10. This method has been described elsewhere [Kragt et al., 2016].

Data analysis

Statistical analysis were performed using the statistical package for social sciences (SPSS) for Windows, version 21 (IBM SPSS Inc, Chicago, IL, USA). Figures were created in Microsoft Word and Microsoft Excel (Microsoft Office Professional Plus 2010).

Characteristics of the study population were explored with frequency tables and cross-tabulations stratified by caries experience at the age of 6 years. Differences in sample characteristics between children with and without dental caries at the age of 6 years were evaluated with Chi-square tests and Mann -Whitney-U tests.

Multinomial logistic regression was used to investigate the association between dental caries at the age of 6 and OHRQOL at the age of 10. We built 3 different models. The first model was the crude model only adjusted for gender and age. The second model was additionally adjusted for SEP and the third model took additionally oral health behavior into account. We only included those socioeconomic factors, that were statistically significant different between children with and without caries experience. We performed a test for trend analysis by treating the categorized variable as a continuous term. We also tested for interaction effects gender, ethnicity as well as orthodontic treatment need with caries, but none of them were significant. For all analyses a p-value < 0.05 was considered to be statistically significant. In order to reduce potential bias associated with missing data, we performed multiple imputation of missing covariates by generating 5 independent datasets using the Markov Chain Monte Carlo method, assuming no monotone missing pattern [Sterne et al., 2009]. This method takes into account the uncertainty of the imputed values to generate new datasets based on a fully conditional specified model. Imputations were based on the relationship between all variables considered to be included in the models, determinant and outcome were not imputed. We present effect estimated based on the pooled datasets. However, we also conducted a sensitivity analysis in the original data set (appendix Table A. 3).

Non-response analysis

The children included in this study were compared to the children excluded from the study. Children with missing data on dmft-index or OHRQOL score differed from children without missing these data on all covariates except for gender, tooth brushing frequency, malocclusions presence and OHRQOL (p-values > 0.05, appendix Table A.4).

Results

Sample characteristics

In total, n = 2833 children participated in this study. The median(90%range) OHRQOL of the children at the age of 10 was 50.00 (42.00 - 53.00), with a minimum score of 29.0 (prevalence: 0.1%) and a maximum score of 55.0 (prevalence: 0.9%). In Table 1 the maternal and child characteristics of the study population are presented by caries experience. In total, 24.7% (n =700) of the children experienced dental caries at the median (90%range) age of 6.09 (5.73 - 6.80), of which 32.6% (n = 228) had a dmft-score > 3. Mothers of children with dental caries were lower educated (p-value <0.001) had a lower household income (p-value < 0.001) and were more often of non-European origin (p-value <0.001). Child characteristics, as gender, age and oral health behavior did not differ between children with dental caries and children without dental caries. Children with caries at the age of 6 had significantly lower OHRQOL scores at the age of 10 compared to the children that were caries free at the age of 6 (p-value <0.001).

Associations between dental caries and OHRQOL

In Table 2 the results of the multinomial logistic regression models illustrating the differences on OHRQOL between children without caries and with mild or severe dental caries at the age 6 are presented. Based on the crude model children with a mild dmft-score were 1.33 times and children with a severe dmft-score were 2.05 times more likely to be in the lowest OHRQOL quartile (mean±sd = 43.6±2.7) at the age of 10 compared to children that were caries free at the age of 6. After adjustment for SES, these associations between the children with a mild dmft-score and the lowest OHRQOL quartile lost significance (OR = 1.24 95%CI = 0.94 - 1.64), but for the children with a severe dmft-score the associations remained significant (OR = 1.69 95% CI = 1.17 - 2.45).

Although the association between mild or severe dmft-index and the 2nd and 3rd OHRQOL quartile (mean±sd = 48.2±0.8 resp. 50.0±0.0) were not statistically significant, a clear trend was visible and confirmed with the test for trend analysis. Thus, the higher the dmft-score at the age of 6, the lower the OHRQOL score at the age of 10 in all models ($p < 0.001$). However, in figure 2 it is shown that the actual differences in median OHRQOL scores among the 3 groups (caries free = 50.0 (43.0-53.0), mild = 49.0 (41.0-53.0) and severe caries = 49.0 (40.0-53.0)) are rather small.

Oral health related behavior was not associated with dental caries, nor with OHRQOL. Accordingly adjustment for oral health related behavior had no effect on the association between dental caries at the age of 6 and OHRQOL at the age of 10, as can be seen in the small differences in effect estimates between model 2 and model 3.

Discussion

The results of our study showed that caries experience at the age of 6 and OHRQOL at the age of 10 are inversely related. Especially children with severe caries at the age of 6 are significantly more likely to have lower OHRQOL at the age of 10 compared to children without caries experience at the age of 6. Based on our results, we highly endorse the importance to target oral health prevention strategies at young children.

Several previous studies assessed the influence of caries on OHRQOL. Comparison with our results is difficult, because most of the studies have a cross-sectional design, use a different OHRQOL measure or investigate the effect of treatment instead of disease. Nevertheless, caries had an impact on OHRQOL cross-sectionally assessed [Correa-Faria et al., 2016]. Effect estimates of these studies indicated consistently a 3-fold increased risk for lower OHRQOL in children with dental caries compared to children without dental caries (relative risk (RR) = 2.97 (1.61–5.47) [Martins-Junior et al., 2013]; RR = 2.74 (2.02–3.72) [Kramer et al., 2013]; RR = 3.81 (2.66–5.46) [Abanto et al., 2011]. Because of the large time interval between the caries assessment and OHRQOL assessment in our study, we expected a weaker association compared to the previous cross-sectional studies. Also because one other study showed an RR = 1.4 (1.1–1.7) for the relationship between untreated dental caries at the age of 6 (dmft-score > 3) and OHRQOL at the age of 12 [Peres et al., 2009]. Similarly in our study, children with a dmft-score > 3 at the age of 6 were 1.69 times more likely to be in the lowest OHRQOL quartile at the age of 10 compared to children with a dmft-score = 0. The

effect sizes in our study need to be interpreted carefully, because they do not show the actual decrease in OHRQOL but the likelihood to be in the lowest OHRQOL quartile of our particular study population. The absolute decrease in OHRQOL is rather small as we showed in figure 2. Small effect sizes are a common problem in quality of life research, because there is always a tendency towards high scores [Raat et al., 2005]. No consensus exists about the minimal clinical difference of the OHRQOL measure we use, however this might also be less relevant as children with caries experience at the age of 6 have a systematic lower OHRQOL at the age of 10.

The result of our study should be seen in the light of several limitations. Mothers of children who were included in the study were on average higher educated, had a higher household income and had more often an European background than those of children who were excluded. This could have led to a selection bias, if the association between caries and OHRQOL differed between those excluded and included, but this seems unlikely. We do not distinguish between the effect of treated and untreated dental caries on later OHRQOL, as was done by Peres et al [Peres et al., 2009]. As we assessed the dmft-index at one time, misclassification of treated and untreated caries would have been likely, because there is no consensus among dentists how to treat dental caries in the primary dentition and treatment could have taken place shortly after the dmft assessment. Furthermore, for our research question dental treatment was less important, because we were interested in the effect of early caries experience on OHRQOL later in life. Finally, the assessment of dental caries from intraoral photographs might be generally limited, since oral examination is the gold standard and intraoral photographs have been validated to perform moderately for the clinical diagnosis of dental caries, but suitable for scientific studies [Elfrink et al., 2009; Gimenez et al., 2015]. Therefore, the assessment of dmft indices in this study might be affected by a non-differential measurement error leading to misclassification and underestimation of the association between dental caries and OHRQOL. We also did not adjust our analysis for dental caries at the time point of OHRQOL assessment, because these data were not available. At the time point of OHRQOL assessment the children were 10 years old and thus having a transitional dentition, which would have limited the reliability of the dmft-index. Although our analyses were adjusted for SES and oral health behavior, residual confounding might have occurred. Nevertheless, the present study is the first one worldwide evaluating the longitudinal relationship of caries with OHRQOL in a large population-based prospective cohort study among $n = 2833$ children. The prospective design of the study is most suitable to evaluate long term effects of caries, as caries is still a highly prevalent disease during childhood [WHO, 2012].

We have two theoretical explanations for the present results. First, the strong relationship between caries experience at the age of 6 and OHRQOL at the age of 10 could be based on the fact that caries experience at young age is a strong predictor for later caries. Different studies have shown that the main risk factor for dental caries is previously experienced caries [Declerck et al., 2008; Mejre et al., 2014; Skeie et al., 2006]. In this case, the caries assessment at the age of 6 could be seen as a proxy for caries at the age of 10 and our effect estimates are mediated by the cross-sectional relation between dental caries and OHRQOL. Our trend results have supported this hypothesis, because the higher the dmft-score at the age of 6, the lower OHRQOL at the age of 10. Secondly, the strong relationship between

caries experience at the age of 6 and OHRQOL at the age of 10 could be rather based on psychological factors. Children with severe caries at a young age remember their bad experiences and therefore still have impaired OHRQOL later in life. Dental caries affects OHRQOL via pain perception [Guedes et al., 2016; Ortiz et al., 2014; Peres et al., 2009]. Although the effect of negative dental experiences on dental anxiety has been contradictory [Eli et al., 1997; Rojas-Alcayaga et al., 2015], dental anxiety in turn is strongly related with lower OHRQOL [Barbosa et al., 2016; Carlsson et al., 2015]. Furthermore, it is likely that OHRQOL is strongly related to personal perceptions of oral health, as it is designed to measure psychological wellbeing related to the oral health status. The personal perception of one's oral health is formed by experiences [McGrath et al., 2004]. Most likely, our results show a mixture of the longitudinal and cross-sectional influences of caries on OHRQOL. Further studies could focus on the individual effects of both, longitudinal and cross-sectional effects of caries experience separately on OHRQOL.

This research gives insight into longitudinal influences of clinical factors, as caries, on OHRQOL and subsequently promotes oral health prevention strategies for young children. Our study highlights the importance to promote good oral health during childhood, because those who get a compromised start to oral health are much more likely to follow a trajectory which will lead to poor oral health (-related QOL) later. The development of risk factors, like unhealthy habits or socio-economic disadvantage, tend to persist and increase through life and need to be tackled as early as possible. Multicomponent interventions targeting at individual level determinants, family level determinants and environmental determinants of poor oral health in childhood should be designed, as it is known from other public health areas that those multi-component interventions are most effective [van Sluijs et al., 2007].

In conclusion, dental caries at the age of 6 can be seen as a predictor for lower OHRQOL at the age of 10. Whether this association exists because children with former caries experience do also have more caries later in childhood or because the experiences of dental caries at a young age have caused a longitudinal impairment of OHRQOL needs further research.

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Fig. 1.

Flowchart of study selection. COHIP= Child Oral Health Impact Profile, OHRQOL = Oral health related quality of life.

Fig. 2. Median (90%range) oral-health related quality of life (OHRQOL) scores of 10-year old children with no caries at the age of 6 (healthy, n= 2133), children with a dmft-score = 1-3 at the age of 6 (mild caries, n = 472) and children with a dmft-score >3 at the age of 6 (severe caries, n = 228). *p-value = 0.03, **p-value = < 0.001. p-values based on Mann-Whitney-U test

Table 1

Sample characteristics of the study population stratified by caries experience (n=2833)

Characteristics		dmft = 0	dmft > 0	p -value
		n=2133	n=700	
<i>Maternal characteristics</i>				
Educational level				
	Low	124	92	
	High	1925	560	< 0.001
	Missing (%)	4.0	6.9	
Household income				
	< 2400€	396	213	
	2400€	1574	414	< 0.001
	Missing (%)	7.6	10.4	
Ethnicity				
	European	1691	447	
	Non-European	434	250	< 0.001
	Missing (%)	0.4	0.4	
Marital status				
	Single	167	53	
	Partnership	1851	607	0.842
	Missing (%)	5.4	5.7	
<i>Child characteristics</i>				
Gender				
	Boys	1065	334	
	Girls	1068	366	0.309
	Missing (%)	0.0	0.0	
Age				
	at caries assessment	5.97 [5.73 - 6.65]	6.03 [5.76 - 7.19]	< 0.001
	at OHRQOL assessment	9.78 [9.48 - 10.43]	9.87 [9.52 - 10.55]	0.086
	Missing (%)	0.0	0.0	
Toothbrush frequency				
	Once per day	408	135	
	Twice or more per day	1595	501	0.641
	Missing (%)	6.0	9.1	
Dental visits last year				
	Yes	1888	611	
	No	122	30	0.188
	Missing (%)	5.7	8.4	
Malocclusion at age 9				
	Present	1138	294	
	Absent	653	239	< 0.001

Characteristics		dmft = 0	dmft > 0	p -value
		n=2133	n=700	
OHRQOL	Missing (%)	16.0	23.9	
		49.00 [40.00 - 53.00]	48.00 [37.00 - 52.00]	< 0.001
	Missing (%)	0.0	0.0	

Numbers are absolute values for categorical variables or median [90% range] for continuous variables, missing values are given in percentages. p values are based on chi-square tests for categorical variables or Mann-Whitney-U tests for continuous variables. dmft = decayed, missing and filled teeth; OHRQOL = oral health related quality of life;

Table 2

Association between dmft and oral health related quality (n=2833)

		Oral health related quality of life				
		Highest Quartile	Mid highest Quartile	Mid-lowest Quartile	Lowest Quartile	
		n	1100	341	868	524
		mean±sd	51.6±1.0	50.0±0.0	48.2±0.8	43.6±2.7
Caries measure			OR [95%CI]	OR [95%CI]	OR [95%CI]	Pfor trend*
Dmft = 0 (n = 2133)			Ref	Ref	Ref	
dmft = 1-3 (n = 472)	Model 1		1.33 [0.82 - 1.58]	1.17 [0.92 - 1.49]	1.33 [1.01 - 1.76]	
	Model 2	reference	1.16 [0.83 - 1.62]	1.18 [0.93 - 1.51]	1.24 [0.94 - 1.64]	
	Model 3		1.14 [0.82 - 1.60]	1.16 [0.91 - 1.49]	1.21 [0.91 - 1.61]	
dmft > 3 (n = 228)	Model 1		0.94 [0.57 - 1.56]	1.23 [0.87 - 1.73]	2.05 [1.44 - 2.94]	< 0.001
	Model 2	reference	1.02 [0.61 - 1.72]	1.27 [0.90 - 1.82]	1.69 [1.17 - 2.45]	0.002
	Model 3		0.98 [0.60 - 1.65]	1.19 [0.83 - 1.70]	1.48 [1.02 - 2.16]	0.017

OR = odds ratios; CI = confidence interval; odds ratios are estimated using multinomial logistic regression models. Model 1 is adjusted for child's gender and age; model 2 is additionally adjusted for socio-economic indicators and model 3 is additionally adjusted for oral health behavior and orthodontic treatment need; dmft = decayed, missing and filled teeth ; *p-value for trend calculated by adding the dmft variable treated continuous term to the model