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Modelling community, family, and individual determinants of childhood dental caries

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This cross-sectional study empirically tested a theoretical model of pathways and inter-relationships among community, family, and individual determinants of childhood dental caries in a sample of 630, 6-year-old children from the Netherlands. Children's decayed, missing, and filled teeth (dmft) scores were extracted from dental records. A validated parental questionnaire was used to collect data on sociodemographic characteristics, psychosocial factors, and oral hygiene behaviours. Data on neighbourhood quality were obtained from the Dutch Central Bureau of Statistics. Structural equation modelling indicated that the model was valid after applying a few modifications. In the revised model, lower maternal education level was related to poorer family organization, lower levels of social support, lower dental self-efficacy, and an external dental health locus of control. These, in turn, were associated with poorer oral hygiene behaviours, which were linked to higher levels of childhood dental caries. In addition, lower maternal education level and poorer neighbourhood quality were directly associated with higher caries levels in children. This model advances our understanding of determinants of childhood dental caries and the pathways in which they operate. Conception of these pathways is essential for guiding the development of caries-preventive programmes for children. Clues for further development of the model are suggested.

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Historically, biological and behavioural risk factors have been the major focus of researchers exploring the causes of childhood dental caries. In recent years, empirical attention has shifted towards investigating the broader social context in which children's oral health behaviours are shaped and biology is affected, known as the underlying social determinants of childhood dental caries (1, 2). To date, there is a substantial body of scientific literature demonstrating that the social and economic conditions in which children are born, grow, and live have a fundamental impact on their dental health status (3, 4). Evidence is also starting to emerge on the important role of parental and familial psychosocial factors in children's caries experience, such as parents' dental attitudes and beliefs, and parental stress (5–7).

Most research into the determinants of childhood dental caries has concentrated on predicting the direct effects of single factors on children's caries experience, often after controlling for other factors in multiple regression analysis (8). The problem with this approach is that the interplay among various socio-economic, psychosocial, behavioural, and biological factors is not explored. Moreover, it does not clarify the operational pathways through which these factors collectively affect children's caries levels. Yet, conception of these pathways is necessary for guiding public health policy and for providing direction for caries-preventive interventions.

In recent years, several theoretical models have been developed that conceptualize the influences on various oral health outcomes (9–12). These models suggest a multilevel approach to investigating oral health, and describe interlinking causal pathways between a broad range of determinants, rather than direct causal pathways. Furthermore, a number of empirical studies have utilized structural equation modelling to model causal pathways between a range of social, psychological and (bio-) behavioural factors and their relationship with several oral health outcomes. Structural equation modelling is a statistical technique that permits simultaneous testing of inter-relationships among a number of variables using sample data, thereby making this a useful technique for testing and modifying conceptual models.

A small number of these studies have empirically modelled the factors that are specific to the development of childhood dental caries. The multidimensional model of Litt *et al.* (13) demonstrated that the development of childhood dental caries was partly determined by mutans streptococci levels, which were influenced by the child's cariogenic diet, which was, in

turn, predicted by parents' dental self-efficacy. Other factors that accounted for children's caries experience were parents' dental knowledge, life stress, education level, and ethnicity. In another model described by Nelson *et al.* (14), maternal enabling factors during a child's early life, such as cognitive abilities and education, were associated with maternal coping and levels of stress, which subsequently affected a child's dental attendance and oral health behaviours in later adolescence. Three other models also documented the contribution of psychosocial factors, such as sense of coherence, health locus of control (LoC), self-esteem, and social support, in understanding oral health outcomes (15–17). However, in these respective studies oral health outcomes referred to children's oral health-related quality of life or to oral health behaviours, oral functional status, and quality of life of adolescents.

A well-known conceptual model of influences on children's oral health outcomes is that described by Fisher-Owens *et al.* (9). This comprehensive model suggests that genetic and biological factors, the social and physical environment, health behaviours, and dental and medical care, influence children's oral health at community, family, and individual levels. It provides a framework for research and draws on a solid foundation of public health literature and oral health research. Yet, the model does not specify the exact pathways by which factors are linked to children's oral health outcomes. Therefore, the present study modelled plausible pathways and inter-relationships among community, family, and individual determinants of childhood dental caries under the conceptual model of Fisher-Owens and coworkers (Fig. 1). This theoretical model was inclusive of those determinants identified in previous research as important factors influencing children's caries experience (18–20). Pathways between factors were based on previous conceptual and empirical models, suggesting that social and environmental determinants impact on oral health outcomes via mediating psychosocial factors, which, in turn, affect behaviours and lifestyle practices (10, 14, 15). In the model, the mother's education level (an indicator of socio-economic status), ethnicity, and neighbourhood quality are inter-related and are suggested to impact on parental and familial psychosocial factors, including family functioning in the dimension of organization, social support, dental self-efficacy, and dental health LoC. These, in turn, are postulated to affect oral hygiene behaviours, which directly influence childhood dental caries. The aim of this study was to test the validity of this theoretical model in a sample of 6-year-old children from the Netherlands, using structural equation modelling. In the event of poor validity of the model, a further objective was to explore whether modifications to the model, the framework of Fisher-Owens *et al.* (9), would improve its validity.

Material and methods

The study participants were 6-year-old children from six large paediatric dental centers located in various socio-economic regions in the Netherlands. Six-year-olds were chosen to study the determinants of childhood dental caries, because enough time had passed for caries to develop in the deciduous teeth and most permanent teeth had not yet erupted. A total of 1,169 children were selected using simple random sampling (response rate = 53.9%; $n = 630$). This study was part of a project for which a power calculation indicated that a sample of 594 children was required (18). According to MacCollum *et al.* (21), this sample size would be adequate to evaluate data-model fit of a model with 12 degrees of freedom (d.f.) and a power of 0.80 for an $\alpha < 0.05$-level test associated with the root mean square error of approximation (RMSEA). Parents reported 'no interest' or 'being too busy' as the main reasons for non-participation. The mother's education level and the proportion of mothers of Dutch origin were significantly lower in the non-participant group compared with the participant group.

Of the 630 children (325 boys and 305 girls) who participated in the study, the mean age was 6.0 ± 0.3 years. A large proportion of children ($n = 278$, 44.2%) had immigrant parents. Common ethnicities were Moroccan, Turkish, and Surinamese. Three-hundred and thirty-three (51.9%) children were caries free [decayed, missing, and filled teeth (dmft) score = 0]. Of those children with dental caries (dmft ≥ 1), the mean ± SD dmft score was 4.7 ± 3.1 (range, 1–14).

Data collection

Data were collected between June 2011 and March 2012. An informative letter about the study and a questionnaire

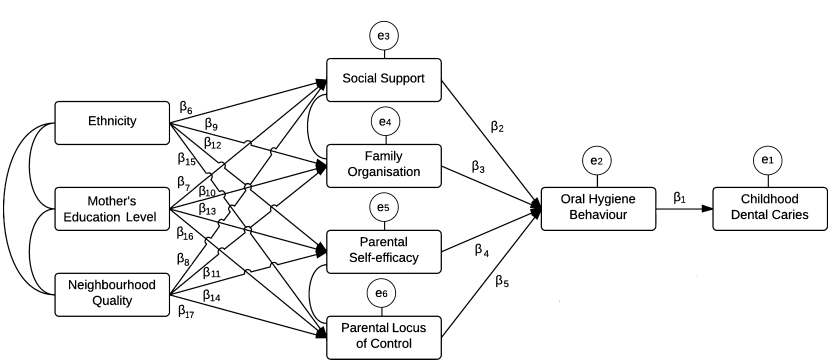

Fig. 1. Schematic illustration of the theoretical model. Connecting lines imply that variables are associated. Values in circles represent unexplained variance of variables. β1 to β17 represent standardised path coefficients and e1 to e6 represent unexplained variance.

were mailed to the home address of the selected children. Parents were asked to complete and return the questionnaire and to provide written consent to use their child's clinical dental health records from the paediatric dental centers. Non-respondents were sent a first reminder by mail after 3 weeks; if they failed to respond they received a second reminder by telephone after a further 3 weeks. The Medical Ethics Committee of the Vrije Universiteit Amsterdam provided consent for the implementation of this study.

Dental health status

Children's dental health data were obtained from personal dental health records obtained from the paediatric dental centers. The dental status of children's primary dentition was extracted using data from the latest dental visit. The dmft score was calculated by adding the numbers of decayed, missing (because of caries), and filled teeth. Enamel caries lesions were not included.

A self-administered parental questionnaire was used to collect sociodemographic, psychosocial, and behavioural data.

Oral hygiene behaviours

The questionnaire included four questions on oral hygiene behaviours, including toothbrushing frequency ('three or more times a day', 'twice a day', 'once a day', or 'less than once a day'), the age that brushing was started ('less than 1 year old', '1–2 years old', '2–3 years old', or 'older than 3 years'), frequency of supervised toothbrushing ('always', 'often', 'sometimes', or 'never') and frequency of rebrushing by a parent ('always', 'often', 'sometimes', or 'never'). For each question the most favourable answer option was coded as '1' and the least favourable answer option was coded as '4'. A total oral hygiene score was computed, generating scores ranging from 4 to 16, with higher scores indicating poorer oral hygiene.

Family organization and social support

Family organization and social support were assessed using the Gezinsvragenlijst (GVL, translation 'Family Questionnaire'), a validated psychometric measure to assess family functioning and the quality of family relationships (18, 22). Family organization refers to the degree of structure, routines, and assignment of roles in the family, as well as the family's ability to resolve problems. Examples of items of this construct are: 'In our home, the tasks (work, household) are clear and definite distributed' and 'In our family, it is important that you stick to rules and agreements'. Social support relates to the extent to which the family can rely on support from people in their social environment. Examples of items measuring this construct include: 'We regularly visit or do things together with friends or acquaintances' and 'For jobs or advice we can count on support from family or friends'. Both dimensions contained nine items, each of which was responded to on a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree'. Responses to the nine items were summed, generating scores from 9 to 45, with higher scores indicating poorer family organization and poorer social support.

Parental dental self-efficacy and dental health LoC

The questionnaire items on dental self-efficacy and dental health LoC were taken from a validated questionnaire developed by Pine *et al*. (11). Dental self-efficacy refers to parents' confidence in their ability to engage in healthy oral-hygiene practices for their child. Examples of items of this construct include: 'When our child is tired, it can be a struggle to brush his/her teeth' and 'It is not worth it to battle with our child to brush his/her teeth twice a day'. Dental health LoC is defined as parents' belief in their ability to control the dental health of their child: health-external persons interpret health as dependent on outside forces (e.g. relying on luck or chance, or genetics), whereas health-internal persons believe that health is determined by one's own behaviour. Examples of items measuring this construct are: 'No matter what we do, our child is likely to get tooth decay' and 'It is just bad luck if our child gets tooth decay'. Exploratory factor analysis with varimax rotation yielded a five-item scale for dental self-efficacy and a four-item scale for dental health LoC. Each item was measured on a five-point Likert scale, ranging from 'strongly agree' to 'strongly disagree'. A total score was computed for dental self-efficacy and dental health LoC, ranging from 5 to 25 and 4 to 16, respectively. Higher scores reflected a lower dental self-efficacy and a more external LoC.

Mother's education level and ethnic background

The question related to the mother's highest completed level of education contained seven answer options: 'university', 'further education (higher level)', 'secondary school (higher level)', 'further education (lower level)', 'secondary school (lower level)', 'elementary school', or 'no education', and responses were coded from 1 to 7, respectively. The ethnicity variable classified children as 'native' if the mother of the child was born in the Netherlands or as 'immigrant' if the mother was a first-generation immigrant from any other country.

Neighbourhood quality

Data on neighbourhood quality were obtained from the Dutch Central Bureau of Statistics (CBS) (23). The neighbourhood was defined based on postal code area. The CBS determined the quality of the neighbourhood on the basis of 49 indicators, which measured the following six underlying dimensions: housing, public space, public facilities, demographics, social cohesion, and safety. The CBS subsequently classified neighbourhood quality into four categories – 'very positive', 'positive', 'moderately positive', and 'moderate', which were coded 1 to 4, respectively.

Statistical analysis

Structural equation modelling was used to test the fit of the theoretical path model, using R version 2.14.2 (R Foundation for Statistical Computing, Vienna, Austria: package lavaan, Rosseel (24). Structural equation modelling is a statistical technique that integrates factor analysis and multiple regression analysis and permits the simultaneous testing of inter-relationships among a number of potentially interdependent variables (25). The main *a-priori* hypotheses were (Fig. 1):

(i) Childhood dental caries = β_1·oral hygiene behaviour + e_1,
(ii) Oral hygiene behaviour = (β_2·social support) + (β_3·family organization) + (β_4·parental self-efficacy) + (β_5·parental LoC) + e_2,
(iii) Social support = (β_6·ethnicity) + (β_7·mother's education level) + (β_8·neighbourhood quality) + e_3,
(iv) Family organization = (β_9·ethnicity) + (β_{10}·mother's education level) + (β_{11}·neighbourhood quality) + e_4,
(v) Parental self-efficacy = (β_{12}·ethnicity) + (β_{13}·mother's education level) + (β_{14}·neighbourhood quality) + e_5, and
(vi) Parental LoC = (β_{15}·ethnicity) + (β_{16}·mother's education level) + (β_{17}·neighbourhood quality) + e_6.

Preliminary analysis

Before testing the path model, the questionnaire items of the measurement models for social support, family organization, dental self-efficacy, and dental health LoC were each evaluated in terms of internal consistency and acceptability of the factor structure using confirmatory factor analysis. An acceptable factor structure of a variable allows this variable to be tested in the path model as a manifest variable using the total score of a subscale, as opposed to including each specific questionnaire item of the variable in the path model.

To verify whether the factors that were included in the theoretical model were indeed determinants of childhood dental caries in the study sample, associations between each model variable (continuous and discretized) and the dmft score were first univariately tested using Pearson correlation and the Kruskal–Wallis test, respectively.

Path analysis

All variables in the theoretical path model were included as continuous variables, except for the dichotomous variable ethnicity. The variables social support, family organization, dental self-efficacy, and dental health LoC referred to the total score of each subscale. The univariate distributions of all variables in the theoretical path model (except for ethnicity) were checked for normality, using standard errors of $\sqrt{(6/N)}$ and $\sqrt{(24/N)}$ to evaluate the skewness and kurtosis values, respectively. Because of the presence of non-normally distributed variables, the path model was evaluated first using square-root-transformed variables and second by using the corrections of Satorra & Bentler (26) (i.e. robust estimates of goodness-of-fit indices and standard errors). As both methods produced similar fit, this paper will report Satorra–Bentler-adjusted standardized path coefficients of non-transformed variables. The following goodness-of-fit measures were examined to determine the adequacy of model fit to the data: the RMSEA, the standardized root mean square residual (SRMR), the comparative fit index (CFI), and the chi-square/d.f. ratio and its probability value. Root mean square error of approximation and SRMR values of less than 0.06 are considered to indicate good fit, and values of less than 0.08 reflect adequate fit (27). Comparative fit index values greater than 0.95 indicate good fit (27). A non-significant chi-square value reflects good fit. However, it should be noted that the chi-square value is sensitive to sample size. With large samples, models are more likely to be significant, and substantively trivial discrepancies can lead to rejection of an otherwise satisfactory model. Therefore, the chi-square statistic should not be the sole basis for determining model fit (28).

Results

Measurement models

Goodness-of-fit measures indicated a good factor structure of the measurement models for family organization, dental self-efficacy, and dental health LoC (Table 1). The fit of the measurement model for social support was not optimal (CFI = 0.92, RMSEA = 0.11, and SRMR = 0.05); therefore, testing of the study model required some discretion in the interpretation of path model parameters related to social support. Internal consistency of variables ranged from Cronbach's $\alpha = 0.62$ to $\alpha = 0.89$.

Univariate associations

All variables in the theoretical path model were univariately associated with dmft scores (Table 2). In Table 2, variables were discretized and the mean ± SD dmft score per category is presented. The continuous total scores of oral hygiene behaviour, family organization, social support, dental self-efficacy and dental health LoC (as included in the path model) were also significantly associated with dmft, with correlations ranging from $r = 0.15$ to $r = 0.26$ (results not shown).

Path model

Analysis of the theoretical path model (Fig. 1) indicated poor fit: CFI = 0.89, RMSEA = 0.10 (90% CI: 0.08–0.12), SRMR = 0.07, and χ^2/d.f. ratio = 111.14/14 ($P < 0.001$). The model was subsequently modified according to the following steps. First, regression coefficients demonstrated that none of the paths with ethnicity were statistically significant when the mother's education level was also included in the model. This implied that excluding ethnicity from the model could help model fit. The rationale for excluding ethnicity is in line with previous studies that have demonstrated no differences in dental caries experience among minority ethnic groups of the same socio-economic status (29), which suggests that the inclusion of ethnicity as a variable for childhood dental caries may not be relevant.

Second, inspection of the standardized residual matrix revealed that the ill fit of the model was partially caused by the omission of two paths: one path between mother's education level and childhood dental caries; and one path between neighbourhood quality and childhood dental caries. Furthermore, the paths linking neighbourhood quality to family organization, social support, dental self-efficacy, and dental health LoC were not statistically significant, which also indicated that a path between neighbourhood quality and childhood dental caries, instead of paths linking neighbourhood quality to psychosocial factors, would

Table 1

Fit statistics (confirmatory factor analysis) and internal consistency for social support, family organization, dental self-efficacy, and dental health locus of control

Statistic	Social support	Family organization	Dental self-efficacy	Dental health locus of control
CFI	0.92	0.95	0.99	1.00
RMSEA (90% CI)	0.11 (0.10–0.12)	0.06 (0.05–0.07)	0.02 (<0.01–0.06)	<0.01 (<0.01–0.06)
SRMR	0.05	0.04	0.02	0.01
χ^2/d.f. ratio (*P*-value)	(215.10/27) (<0.001)	84.95/27 (<0.001)	5.83/5 (0.32)	1.02/2 (0.60)
Cronbach's α	0.89	0.78	0.62	0.64

CFI, comparative fit index; d.f., degrees of freedom; RMSEA (90% CI), root mean square error of approximation and the 90% CI; SRMR, standardized root mean square residual.
CFI values greater than 0.95 indicate good fit. RMSEA and SRMR values of less than 0.06 are considered to indicate good fit, and values of less than 0.08 reflect adequate fit. A non-significant chi-square value reflects good fit.

Table 2

Distribution of the mean decayed, missing, and filled teeth (dmft) score by model variables

Variable	*n*	Range of the total score of the questionnaire subscale	Mean dmft score (95% CI)	*P**
Oral hygiene behaviour†				
Excellent	159	4–5	1.3 (0.9–1.6)	<0.001
Good	148	6	1.8 (1.3–2.3)	
Fair	180	7–8	2.5 (2.0–3.0)	
Poor	115	9–16	3.4 (2.7–4.1)	
Parental self-efficacy†				
Very high	213	5–8	1.4 (1.1–1.8)	<0.001
Moderately high	130	9–10	2.0 (1.5–2.5)	
Moderately low	131	11–12	2.8 (2.2–3.4)	
Very low	136	13–25	3.1 (2.4–3.7)	
Parental locus of control†				
Mainly internal	74	4–6	1.6 (0.9–2.3)	<0.001
Somewhat internal	189	7–8	1.7 (1.3–2.1)	
Somewhat external	176	9–10	2.0 (1.5–2.4)	
Mainly external	177	11–20	3.1 (2.5–3.6)	
Family organization‡				
Normal	434	9–17	1.9 (1.6–2.2)	<0.001
Subclinical	134	18–20	2.3 (1.8–2.9)	
Clinical	42	21–45	4.2 (3.0–5.5)	
Social support‡				
Normal	461	9–21	1.9 (1.7–2.2)	0.02
Subclinical	80	22–24	2.9 (2.2–3.7)	
Clinical	72	25–45	2.9 (2.0–3.7)	
Mother's education level				
University	83	–	1.3 (0.7–1.9)	<0.001
Further education (higher level)	153	–	1.4 (1.0–1.8)	
Secondary school (higher level)	62	–	1.8 (1.1–2.5)	
Further education (lower level)	160	–	2.4 (1.9–2.9)	
Secondary school (lower level)	101	–	2.9 (2.3–3.5)	
Elementary school	38	–	4.0 (2.8–5.2)	
No education	16	–	4.6 (2.3–7.0)	
Ethnicity				
Native	346	–	1.7 (1.4–1.9)	<0.001
Immigrant	274	–	2.9 (2.5–3.3)	
Neighbourhood quality				
Very positive	114	–	1.7 (1.1–2.2)	<0.001
Positive	279	–	1.8 (1.4–2.1)	
Moderately positive	162	–	2.9 (2.3–3.4)	
Moderate	65	–	3.4 (2.6–4.1)	

*Kruskal–Wallis test.
†Discretization of groups based on quartiles.
‡Discretization of groups based on normative cut-off values determined by the original authors of the Gezinsvragenlijst (GVL).

improve model fit. A conceptual rationale for this modification is that the neighbourhood may influence children's caries experience through several other variables that were not included in the model (e.g. environmental factors that may impact on children's dietary behaviours), rather than via the included psychosocial factors that affect children's oral hygiene behaviours (30).

Finally, the standardized residual matrix revealed that the model could be improved by allowing dental self-efficacy to correlate with family organization and social support. The model was revised by applying these modifications (Fig. 2, Table 3). The revised path model yielded a good fit: CFI = 0.95, RMSEA = 0.06 (90% CI: 0.04–0.08), SRMR = 0.04, and χ^2/d.f. ratio = 44.99/12 ($P < 0.001$). In this model, lower maternal education level was related to poorer family organization, lower levels of social support, lower dental self-efficacy, and a more external dental health LoC. These, in turn, were associated with poorer oral hygiene behaviours, which were related to higher levels of childhood dental caries. In addition, lower maternal education level and poorer neighbourhood quality were directly associated with higher caries levels in children. The corresponding numerical solutions were:

(i) Predicted childhood dental caries = (0.19·oral hygiene behaviour) + (0.22·the mother's education level) + (0.13·neighbourhood quality), and

(ii) Predicted oral hygiene behaviours = (0.10·social support) + (0.13·family organization) + 0.36·parental self-efficacy) + (0.05·parental LoC).

All pathways were statistically significant, except for the path between dental health LoC and oral hygiene behaviours ($P = 0.27$). A path between dental health LoC and childhood dental caries would have fit the data better; however, for conceptual reasons it was decided to retain the path between dental health LoC and oral hygiene behaviours. The revised model explained 22.6% of variance in oral hygiene behaviours and 12.6% of variance in childhood dental caries.

Discussion

This study modelled pathways and inter-relationships among community, family, and individual determinants of childhood dental caries. The findings of this study provided empirical support for components of the conceptual framework of Fisher-Owens *et al.* of the influences on children's oral health (9). A great strength of this study was that determinants of childhood dental caries were analysed using structural equation modelling, which has the advantage over standard regression techniques in that it allows exploration of complex pathways between the factors that add to caries development, rather than treating all factors as isolated predictors of dental caries. Structural equation modelling thereby yields findings that are more useful for understanding and explaining the mechanisms which contribute to the development of dental caries in children. Of particular relevance is that potential intermediary mechanisms which link social conditions to childhood dental caries were clarified: the findings suggest that it is plausible that the mother's education level indirectly influences children's oral hygiene behaviours, and subsequently children's caries experience, through an impact on inter-related parental and familial psychosocial factors. The results of this study concur with the findings of Nelson *et al.* (14) and Dorri *et al.* (15), who also demonstrated that psychosocial factors mediate the relationship between parental education and oral health behaviours. This study and the findings of Dorri *et al.* indicate that social support is an important psychosocial predictor of oral hygiene behaviours, although in the model of Nelson *et al.*, social support was directly related to levels of dental decay. In line with Litt *et al.* (13), this study demonstrated that parents' dental self-efficacy is another important factor that affects children's caries experience, which acts via an impact on health behaviours. In contrast to their findings, ethnicity did not significantly contribute to the explanation of childhood dental caries in this study sample. This may be a consequence of the different ethnic groups that were represented in both studies

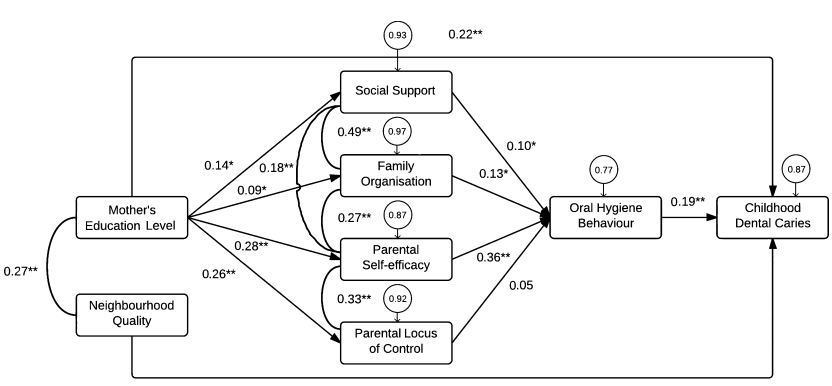

Fig. 2. Revised model with standardized path coefficients in a sample of 6-year-old children from the Netherlands. Standardized path coefficients, $*P < 0.05$, $**P < 0.001$. Arrows imply that a variable has an influence on another variable. Connecting lines imply that variables are associated. Values in circles represent unexplained variance of variables.

Table 3

Standardized and unstandardized path coefficients of the revised model

Effects	Standardized path coefficient (β)	Unstandardized path coefficient	SE	95% CI	*P*	$1-R^2$
Childhood dental caries						
Oral hygiene behaviours	0.19	0.31	0.07	0.18 to 0.44	<0.001	0.87
Mother's education level	0.22	0.43	0.08	0.27 to 0.59	<0.001	
Neighbourhood quality	0.13	0.43	0.14	0.15 to 0.71	<0.01	
Oral hygiene behaviours						
Social support	0.10	0.03	0.01	0.01 to 0.05	<0.001	0.77
Family organization	0.13	0.06	0.02	0.02 to 0.10	0.27	
Dental self-efficacy	0.36	0.21	0.03	0.15 to 0.27	<0.01	
Dental health locus of control	0.05	0.03	0.03	−0.02 to 0.08	0.02	
Social support						
Mother's education level	0.12	0.54	0.16	0.22 to 0.86	<0.001	0.93
Family organization						
Mother's education level	0.08	0.22	0.10	0.02 to 0.42	<0.001	0.97
Dental self-efficacy						
Mother's education level	0.28	0.56	0.08	0.40 to 0.72	0.04	0.87
Dental health locus of control						
Mother's education level	0.26	0.43	0.07	0.30 to 0.56	<0.001	0.82

95% CI, 95% confidence interval of the unstandardized path coefficient; SE, standard error of the unstandardized path coefficient.

(i.e. mainly Hispanic and Black children in the study of Litt *et al*. (13) compared with mainly Moroccan, Turkish, and Surinamese children in this study).

The present study suggested that there is a persistent direct relationship between the mother's education level and childhood dental caries. The same applied to the direct relationship between neighbourhood quality and dental caries in children. Yet, evidently, their influence on children's caries experience must act via a number of intermediary factors, which suggests that important factors were omitted from the present study. For example, neighbourhoods may influence childhood dental caries directly through the availability of (un)healthy foods and access to dental care (30, 31). Indirectly, the degree of safety, social cohesion, and the availability of public resources may affect children's oral health practices via an influence on parents' level of stress, social support, health standards, and sense of positivism (32, 33). Examples of psychosocial factors that may link the mother's education level to childhood dental caries include dental knowledge, maternal depression and anxiety, sense of coherence, and marital quality (5, 16, 34–36). Furthermore, in the present model, the effect of (psycho-) social factors on children's caries levels was assumed to operate via one individual factor, namely oral hygiene behaviour. However, it is well known that dietary behaviours and biological factors are also important in the development of childhood dental caries (37). Therefore, the model could be further developed by adding the aforementioned factors to the model, which will probably increase the model's explanatory power.

A few methodological caveats should be considered when interpreting the findings of this model. The model was tested using a large sample, with considerable variation in the mother's education level and the children's ethnic background, living environment, and dental caries levels. Still, its generalizability is limited because children who did not visit the dentist were not included and the non-response rate was relatively high. Furthermore, this study was cross-sectional with data measured at a single time point. Although variables were modelled in the sequence of their expected operational order, this ordering does not imply a causal effect or provide evidence on the temporal precedence of variables (38). It is important to recognize that reciprocal relationships and feedback loops may exist and that the exact role of variables [e.g. whether they have an indirect (mediating) effect or act as moderators, confounders, or independent factors] should be further investigated (39). Moreover, the effects of variables on childhood dental caries may change over time as families move around, social networks and neighbourhoods change, and families are affected by alterations in life circumstances, stressful events, and natural transitions, such as the ageing of family members (40). Therefore, the measurement of variables at the time of this study may not have been an accurate reflection of the variables over the past years. Finally, the operationalization of contextual factors, including the mother's education level as an indicator of socio-economic status, and neighbourhood quality, had limitations because they were measured as individual attributes, whereas, in fact, they are partial indicators of several life circumstances and events resulting from broader social and economic living conditions (8). The above-mentioned issues may explain why mainly moderate associations between factors were demonstrated in the model. Exploration of the exact role of factors over time, and the determination of causal and reciprocal effects, require future studies that are longitudinal in design. Such studies would allow validation of the present model and enable further development of the model by integrating bio-behavioural pathways and by including additional psychosocial and contextual factors.

The results of this study provide some direction for the development of interventions to prevent childhood dental caries. There is growing recognition that traditional health-promotion methods, solely placing emphasis on changing oral health behaviours through dental health education, are largely ineffective in achieving sustained oral health gains (41). More promising are theory-driven interventions that are underpinned by sound frameworks of oral health determinants. For example, a recent study by Nammontri *et al*. (42) demonstrated that children's gingival health and oral health-related quality of life could be improved by a psychosocial school-based intervention that enhanced children's sense of coherence. The findings of this study imply that parental and familial psychosocial factors, such as parents' self-efficacy and family functioning, may be important components to consider in caries-preventive interventions. Several intervention studies have already demonstrated that the integration of family system components in obesity-prevention programmes, including parenting and family functioning variables, resulted in sustained health-behaviour change and weight loss in obese children (43). Future studies should determine whether efforts to improve parental and familial psychosocial factors also have the potential to prevent childhood dental caries.

In conclusion, this study presented a valid model of the pathways and inter-relationships among community, family, and individual determinants of childhood dental caries. Conception of these pathways is essential for guiding public health policy and for the development of interventions to prevent dental caries in children.

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