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The association of subjective orthodontic treatment need with oral health-related quality of life

Lea Kragt[1,4], **Vincent Jaddoe**[2,3,4], **Eppo Wolvius**[1,4], and **Edwin Ongkosuwito**[1,4]

[1]Departments of Oral & Maxillofacial Surgery, Special Dental Care and Orthodontics, Erasmus University Medical Centre, Rotterdam, The Netherlands [2]Department of Epidemiology, Erasmus University Medical Centre, Rotterdam, The Netherlands [3]Department of Paediatrics, Erasmus University Medical Centre, Rotterdam, The Netherlands [4]Department of The Generation R Study Group, Erasmus University Medical Centre, Rotterdam, The Netherlands

Abstract

Objectives—The existing body of evidence reports an inconsistent association between subjective and objective orthodontic treatment need. The concept of oral health-related quality of life (OHRQoL) might help to explain the differences in subjective and objective orthodontic treatment need. Our aim was to investigate the association of subjective orthodontic treatment with OHRQoL in children.

Methods—This cross-sectional study was embedded in the Generation R Study, a population-based prospective cohort study. OHRQoL and subjective orthodontic treatment need were assessed by parental questionnaires. Questionnaire items were individually compared among children with no, borderline and definite subjective orthodontic need. The association between subjective orthodontic treatment need and OHRQoL was investigated in multivariate regression analysis with weighted least squares. Differences by sex and levels of objective orthodontic treatment need were evaluated.

Results—In total, 3774 children were included in the analysis. Children with borderline subjective orthodontic treatment need and those with definite subjective orthodontic treatment need had significantly poorer OHRQoL based on the fully adjusted model (adjusted regression coefficient [aβ]= -0.49, 95%CI: -0.75, -0.30; [aβ]= -1.58, 95%CI: -1.81, -1.58, respectively). The association between subjective orthodontic treatment need and OHRQoL was stronger in girls than in boys and stronger in children with objective orthodontic treatment need than in those with none.

Conclusions—OHRQoL is poorer in children with subjective orthodontic treatment need. This has not been investigated before in such a large-population based study and clearly offers an explanation for the lack of concurrence between objective and subjective orthodontic treatment need.

Correspondence to L Kragt, P.O Box 2040, 3000CA Rotterdam, The Netherlands, Tel: 010-7043413, fax: 010 - 704 46 45, l.kragt@erasmusmc.nl.

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Keywords

Dental health perceptions; orthodontics; oral health-related quality of life; public health

Introduction

In 2013, a Dutch oral health report stated that 60% of young adults have had orthodontic treatment1. Reasons for providing orthodontic treatment are based on prevention of oral diseases and improvement of aesthetics2. The need for orthodontic treatment comes either subjectively from the patient or objectively from the care provider. The existing body of evidence shows a highly inconsistent association between subjective and objective orthodontic treatment need3.

The concept of oral health-related quality of life (OHRQoL) was introduced in the orthodontic literature to help understand differences in subjective and objective orthodontic treatment need4, 5. Quality of life measures assess the impact of health on social, emotional and functional aspects of life6. OHRQoL measures the particular impact of oral conditions in terms of oral symptoms, functional limitations, emotional and social wellbeing on daily life7. Thus, OHRQoL measures aim to capture subjective oral health in a more standardized way, so that they can augment traditional measures of oral health8. Naturally, various oral disorders influence OHRQoL. Whereas many studies have focused on the association between objective orthodontic treatment need and OHRQoL, the association between OHRQoL and subjective orthodontic treatment need has rarely been investigated. However, this is of particular importance as treatment decisions are often for a big part influenced by what patients and their parents want.

In the literature, objective orthodontic treatment need is assessed using clinical oral health features, such as with the dental health component (DHC) of the index of orthodontic treatment need (IOTN), or based on aesthetic impairments, such as with the IOTN aesthetic component (AC). Studies on the association between objective orthodontic treatment need and OHRQoL have shown weak and inconclusive associations between objective orthodontic treatment need and OHRQoL5, 9–12. Subjective orthodontic treatment need has been inconsistently assessed in a small number of existing studies. Some studies used OHRQoL as a surrogate for subjective orthodontic treatment need13, 14. However, OHRQoL can be distinguished from subjective need, since OHRQoL is a dynamic concept that results from the interaction between health, social and contextual factors7. Also, different studies have equated aesthetic impairment and subjective orthodontic treatment need13–15. However, there is little evidence for this assumption and it might be wrong, because, for example, having a worse IOTN-AC score does not implicitly mean having more perceived treatment need. In addition, dental attractiveness, which can be one of the reason for subjective orthodontic treatment need, is not necessarily associated with OHRQoL13, 14, 16, 17. Though never evaluated, still the children with more aesthetic impairment might show a stronger association between subjective orthodontic treatment need and OHRQoL than children with less aesthetic impairment. In summary, little is known about the association between subjective orthodontic treatment need and OHRQoL.

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Accordingly, the aim of this study was to quantify the association between subjective orthodontic treatment need, not assessed by an objective index but a simple question, and OHRQoL. In particular, we were interested in whether subjective orthodontic treatment need in children is associated with poorer OHRQoL independent of their objective orthodontic treatment need. The secondary aim of this study was to see whether the association between subjective orthodontic treatment need and OHRQoL varied by sex or different degrees of objective orthodontic treatment need.

Methods

This cross-sectional study was embedded in the Generation R Study, a population-based prospective cohort study that previously has been described in detail18. The study protocol and its conduct were in accordance with the guidelines of the Declaration of Helsinki and approved by the Medical Ethical Committee of the Erasmus MC, University Medical Centre Rotterdam (MEC-2012-165). Participating parents have given written informed consent before the data collection in children had started (n=7393). Information on children's OHRQoL was given by the parents of 3796 children (51.3%), of whom 3774 (51.0%) also provided subjective orthodontic treatment need.

Subjective orthodontic treatment need was assessed in parental questionnaires with the question: "Do you think your child needs braces?". The response to the question was given by the mothers on a five-point Likert scale from strongly disagree to strongly agree. For the analysis subjective orthodontic treatment need was categorized into: 'No subjective orthodontic treatment need' for children whose mothers strongly or somewhat disagreed with the statement. 'Borderline subjective orthodontic treatment need' for children whose mothers did not agree but also did not disagree with the statement and 'Definite subjective orthodontic treatment need' for children whose mothers somewhat or strongly agreed with the statement.

OHRQoL was measured with the COHIP-ortho19. The COHIP-ortho is a questionnaire addressed to parents measuring OHRQoL of the child with 11 questions, covering the different domains of oral health, including social-emotional wellbeing, functional wellbeing and school and peer interaction (Appendix Table S1) 19. These questions were answered on a five-point Likert scale (never, almost never, sometimes, fairly often, almost all the time). The responses scored from 1 to 5, and were finally summed for each individual. The total overall score of the COHIP-ortho ranges from 0 to 55 and higher scores correspond to higher OHRQoL. Missing values in the responses to the OHRQoL questionnaire (COHIP-ortho) were replaced by the personal mean score of the remaining answers to the questions, as proposed by researchers who used the original version of the COHIP20. If more than 30% of the answers were missing, the participant was excluded from the analysis.

The association between children's subjective orthodontic treatment need and OHRQoL is most likely influenced by other factors, and so the following parental characteristics were considered as covariates: maternal educational level (low, high), household income (<2000€, 2000-3200€, >3200€) and ethnicity (Dutch, other Western, non-Western) as indicators for social economic status (SES); and the following children's characteristics were considered

as covariates: sex, age and objective orthodontic treatment need. Objective orthodontic treatment need was assessed with the dental health component (DHC) and aesthetic component (AC) of the IOTN. The IOTN was assessed from photographic and radiographic records of the children (median (90% range) age 9.78 (9.49 - 10.45)). Assessment of the IOTN on a combination of photographic and radiographic records has been validated previously21. After 6 months, 10% of the photographs were reassessed to calculate the intra-rater reliability (linear weighted K = 0.84).

Statistical analyses used Statistical Package for Social Sciences (IBM SPSS statistics) version 21, SPSS Inc, Chicago, IL, USA. Characteristics of the participants were summarized and stratified by sex. Differences between males and females were investigated with chi-square tests and Mann-Whitney-U-tests. Mean scores for the individual items of the COHIP-ortho in the group of unsure and definite orthodontic treatment need were separately compared with the mean scores for the individual questions of the no subjective orthodontic treatment need group. To evaluate the differences in the mean item scores between these groups, Cohen's effect sizes were calculated. Following Cohen's suggestions, effect sizes of 0.2 were considered small, 0.5 were considered medium and 0.8 were considered large22. Differences between the groups were evaluated with the Mann-Whitney-U test ($p < 0.05$). Furthermore, weighted least square (WLS) linear regression models were calculated with subjective orthodontic treatment need as the determinant and the summary score for OHRQoL as the outcome. We used WLS regression models, because of the heteroscedasticity in the OHRQOL data. In multivariate WLS regression analysis with (potential) confounders (child's age and sex (crude model), child's ethnicity and other indicators of socio-economic status (Model 1) and finally orthodontic characteristics (Model 2) were added. The selection of covariates into the model was based on the current orthodontic literature and significant associations between covariates with both subjective orthodontic treatment need and OHRQoL. We also performed a test for trend analysis by treating the categorized variable (subjective orthodontic treatment need) as a continuous term. We tested for differences in the association of subjective orthodontic treatment need and OHRQoL between girls and boys and children with and without objective orthodontic treatment need based on either the IOTN-DHC or the IOTN-AC by including interactions terms in the model. For all variables, significant interactions were present (Table 3). Significant differences in the associations between the strata were evaluated with a test for heterogeneity. For all analyses, a p value < 0.05 was considered to be statistically significant.

Missing values for covariates were handled with multiple imputation by using the Markov Chain Monte Carlo method. Objective orthodontic treatment need had the largest amount of missing data (IOTN-AC (22.9 %), IOTND-DHC (20.3%), Table 4). We generated 5 independent datasets with a fully conditional specified model and we present the pooled effect estimates (β (95% Confidence intervals (CI)). Rubin's rules were applied for pooling of the effect estimates23. We generated 5 independent datasets because the pooled effect estimates did not change with more imputations and because based on Rubin's rules the relative efficiency of 5 imputed datasets appeared sufficient, namely higher than 95.6% in case of 22.9% missing data23. Imputations were based on the associations between all variables used in this study, but the main determinant (subjective orthodontic treatment need) and outcome (OHRQOL) were not imputed22. Finally, we also conducted a sensitivity

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analysis in the original dataset. The obtained effect estimates (β(95%)) of the sensitivity analysis were comparable with the pooled effect estimates on the relation between subjective and objective orthodontic treatment need (Appendix, Table S2).

To evaluate potential selection bias, children with missing data on OHRQOL and subjective orthodontic treatment need (n=3619) were compared to those without missing data on OHRQOL and subjective orthodontic treatment need (n=3774). Data on OHRQOL and subjective orthodontic treatment need were more often missing in children from parents with lower socio-economic status (for all socio-economic indicators p value < 0.001, Table 4).

Results

In Table 1, the characteristics of the study sample are presented. In total, 3774 children were included in the final analysis, of whom 1767 (46.8%) had definite subjective orthodontic treatment need, 958 (25.4%) were unsure about their orthodontic treatment need and 1049 (27.8%) did not perceive any subjective orthodontic treatment need. Boys had slightly higher OHRQoL and perceived less orthodontic treatment need than girls. These differences between boys and girls were significant (p <0.001).

Table 2 shows the mean COHIP-ortho item scores of the children with no perceived orthodontic treatment need, borderline perceived orthodontic treatment need and definite perceived orthodontic treatment need. Children with borderline perceived orthodontic treatment need had lower scores than children with no perceived need for the items about ‘crooked teeth’, ‘discolored teeth’ and ‘bleeding gums’. Children with definite orthodontic treatment need showed lower scores than children without perceived orthodontic treatment need on all items except ‘pain’, ‘bad breath’ and ‘attractiveness’. Most of the effect sizes were small except for the item ‘crooked teeth’ in the borderline perceived and definite orthodontic treatment need groups (d=0.36, p ≤0.001; d=0.98, p ≤0.001) as well as the item ‘anxious’ in the definite perceived orthodontic treatment need group (d=0.34, p ≤0.001).

In Table 3 the findings of the regression model for subjective orthodontic treatment need and total COHIP scores are shown. In contrast to children without subjective orthodontic treatment need, children with borderline orthodontic treatment need as well as children with definite subjective orthodontic treatment need had significant lower total COHIP scores after adjustments for SES and objective orthodontic treatment need (adjusted regression coefficient [aβ]= -0.49, 95%CI:-0.75, -0.30; [aβ]= -1.58, 95%CI:-1.81, -1.58, respectively). The trend estimates for the association between subjective orthodontic treatment need and total COHIP scores were significant (p <0.001).In the group without subjective orthodontic treatment need, girls had generally lower total COHIP scores than boys (Appendix Table S4/ S5). In addition, the effect of definite subjective orthodontic treatment need on OHRQoL was significantly stronger in girls than in boys ([aβ]= -1.93, 95%CI: -2.27, -1.60 and [aβ]= -1.27, 95%CI: -1.58, -0.96, respectively, p <0.001).

The associations between subjective orthodontic treatment need and OHRQoL stratified by objective orthodontic treatment need are also presented in Table 3. After stratification by objective orthodontic treatment need based on the IOTN-AC, the association between

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subjective treatment need and total COHIP scores was stronger in children with an IOTN-AC >5 for the borderline and the definite subjective need group than in children with an IOTN-AC ≤5 (p value =0.024). Similarly, after stratification by objective orthodontic treatment need based on the IOTN-DHC, the association between definite subjective treatment need and total COHIP scores was stronger in children with an IOTN-DHC >3 than in children with an IOTN-DHC ≤3 (p =0.039). In contrast, the association between borderline perceived subjective treatment need and total COHIP score was significantly stronger in children with an IOTN-DHC ≤3 ([aβ]= -0.57, 95%CI:-0.85, -0.30) than in children with an IOTN-DHC >3 ([aβ]= -0.42, 95%CI:0.02, -0.85).

Discussion

Our study findings suggest that subjective orthodontic treatment need is associated with poor OHRQoL. We showed that more subjective orthodontic treatment need is associated with poorer OHRQoL in children with and without objective orthodontic treatment need and that this association is stronger in girls than in boys. Considering these marked associations, .subjective orthodontic treatment need is not solely related to objective orthodontic treatment need, but also related to OHRQoL. And thus, OHRQoL offers an explanation for the lack of concurrence between objective and subjective orthodontic treatment need.

The main strength of the present study is the large and ethnically diverse study sample obtained from a population-based cohort study, which was designed to be representative for the general population in the Netherlands. However, the study findings should also be seen in the light of several limitations. Non-response analysis showed a higher proportion of children without information on OHRQoL or subjective orthodontic treatment need had parents of lower socio-economic status. This might have caused selection bias if the association between subjective orthodontic treatment need and OHRQoL would be different in included and excluded participants. However, because we have no information on subjective orthodontic treatment need and OHRQoL in the non-responding subsample, this is difficult to ascertain. Another drawback of our study is that in this study OHRQoL and subjective orthodontic treatment need of the children was assessed by asking the parents, thus we assumed that parents are a valid proxy for children's reports. This assumption was based on several studies that found parents to be good proxies for children's OHRQoL24–26. Still, we cannot exclude an information bias including a social desirability bias. In addition, we also had no information whether children already had started their orthodontic treatment or not which also might have contributed to an information bias in the main determinant. In the Netherlands, parents and dentist start to concern with orthodontic treatment need around the children's age of nine, but it is rather uncommon that children start their orthodontic treatment so early. However, if they have started they were definitely still in orthodontic treatment need, which we assessed and included in the analysis. Furthermore, a limitation of our study is that the IOTN was assessed from radiographic and photographic records due to logistic reasons in such a large cohort study as the Generation R study. This method is less valid than direct oral examination and might also have introduced some misclassification of participants' orthodontic treatment need. However, this method has been shown to be sufficiently valid for research21. Objective orthodontic treatment need

was assessed with the IOTN. This measure was chosen because it was developed solely based on the opinion of orthodontists27. In this way, the analysis would be adjusted only for professional based objective orthodontic treatment need. The use of other orthodontic measures such as the Dental Aesthetic Index (DAI), might have been problematic, because this Index not only covers objective orthodontic treatment need, but also social norms. Subjective orthodontic treatment need as well as OHRQoL are both influenced by social norms. Consequently, the use of the DAI to adjust the analysis might have resulted in a weaker association between subjective orthodontic treatment need and OHRQoL. In line with this, a recent meta-analysis showed that the association between objective orthodontic treatment need assessed with the DAI and OHRQoL is highly heterogeneous, whereas this association assessed with the IOTN is not28. Finally, like in every observational study, our study findings might be affected by residual confounding, although we were able to minimize confounding of the study findings by constructing fully adjusted models including indicators for socio-economic status and objective orthodontic treatment need.

In agreement with Kok et al. (2004), we think that aesthetics are limited in their ability to reflect subjective need for orthodontic care14. For example, subjective orthodontic treatment need can arise when friends wear braces or when the opinion is influenced by the recommendation of the dentist. Furthermore, children with a similar dental aesthetic impairment do not necessarily perceive the same subjective orthodontic treatment need. Nevertheless, based on the stratification analysis, the association between subjective orthodontic treatment need and OHRQoL seemed indeed stronger in children with more dental aesthetic impairment. Next to this, our analysis showed that children with an IOTN-DHC ≤3 do perceive more impact of borderline subjective orthodontic treatment need on OHRQoL than children with an IOTN-DHC >3. Most likely, these are the children who are more aware of their dentition and feel more impairment due to minor malocclusions. In this way, they could be a source for the divergent association between subjective and objective orthodontic treatment need reported by other authors3. Whether the perceived impairment due to minor malocclusions is related to conditions like Body Dysmorphic Disorder (as suggested by several researchers) might be possible, but is probably not the case, given that it is a rare condition12, 29.

The sex differences shown in the present study reflect the dynamic, context-specific character of OHRQoL. Based on the literature we expected general poorer OHRQoL in girls13, 16. Surprisingly, the association between definite subjective orthodontic treatment need and OHRQoL was stronger in girls, whereas the association between borderline subjective orthodontic treatment need and OHRQoL was stronger in boys. In line with another study, this suggests that females might be more conscious about their appearance, but boys might be more aware of their malocclusions16, 30. At the age of 9, girls might already be more aware of themselves and how they come across, compare themselves more with their friends and feel more pressure to be like their peers, for example by wanting braces. We saw in the sex specific item analysis that the effect of subjective treatment need on items about bullying and pronunciation was stronger in girls than in boys (Appendix, Table S3/S4), and those items belong to the peer interaction domain of OHRQoL31. Differences between girls and boys regarding the experience of oral health and its impacts on OHRQoL have been reported in 12 year old children26. Another study performed in

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adults showed that women perceive both the negative and positive impacts of oral health on OHRQoL more intensely32, and a recently published study found that OHRQoL was worse in girls than in boys after a 3-year follow-up, whether they were orthodontically treated or not33. Thus, although sex differences in oral health research are insufficiently investigated yet, it is generally accepted that girls and boys differ in psychological variables as how they perceive themselves34. Still, these different studies suggests that the association between subjective orthodontic treatment need with OHRQoL should be investigated at different ages and over time, also with regard to the differences between boys and girls, before valid conclusion can be drawn.

Our study is of clinical relevance in orthodontics, oral epidemiology and community dentistry. The findings contribute to understanding the importance of orthodontic treatment for the young population in terms of quality of life. Our findings give an indication for why boys might be less compliant with treatment, to be specific because they have generally higher OHRQoL. In this way, our findings can support an effective communication between patient and orthodontist. Furthermore, the regression analysis, in combination with the item analysis, showed that subjective orthodontic treatment need is associated with poorer OHRQoL, first independent of objective orthodontic treatment need, and second especially affecting OHRQOL on the social-emotional and functional domain. Thus, whereas the provision of orthodontic treatment nowadays is largely based on oral health factors such as susceptibility to caries or dental trauma or functional problems such as temporomandibular disorders or difficulties with chewing, subjective problems such as avoiding to smile or to speak lie in the social-emotional domain and are those which were in the present study particularly associated with poorer OHRQoL and subjective orthodontic treatment need. Therefore, our findings are also relevant for health education and policy decisions, especially in representing the patient's perspective. Finally, this study helps understanding the importance of OHRQoL as outcome measure in the orthodontic practice as well as Health Service Research.

In summary, we conclude that OHRQoL is poorer in children with subjective orthodontic treatment need. This has not been investigated before in such a large-population based study and clearly offers an explanation for the variability between objective and subjective orthodontic treatment need. Further research should not only focus on the association between subjective orthodontic treatment need and OHRQOL in populations of different ages, but also investigate in more detail the role of personal and environmental factors other than sex, such as socio-economic status, on the association between OHRQoL, subjective orthodontic treatment need and malocclusions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of the study sample by sex (n=3774)

Characteristics	**Boys n= 1873**	**Girls n=1901**	**p value***
Age in years			
Median (range)	9.8 (9.5-10.4)	9.9 (9.5-10.5)	0.643
Ethnicity [a] (%)			
Dutch	1278 (68.2)	1295 (68.1)	
Other western	147 (7.8)	180 (9.4)	
Non-western	438 (23.4)	413 (21.7)	0.135
Maternal education level [a]			
Low	619 (33.0)	615 (32.3)	
High	1143 (61.0)	1158 (60.9)	0.782
Household income[a] (%)			
< 2000	321 (17.1)	298 (15.7)	
2000-3200	552 (29.5)	535 (28.1)	
> 3200	877 (46.8)	936 (49.2)	0.230
IOTN-DHC[a] (%)			
2	578 (30.6)	541 (28.5)	
3	364 (19.4)	392 (20.6)	
4	428 (22.9)	443 (23.3)	
5	128 (6.8)	135 (7.1)	0.449
IOTN-ac[a] (%)			
≤ 5	1045 (55.8)	1018 (53.5)	
> 5	394 (21.0)	451 (23.7)	0.049
OHRQoL			
Median (range)	50.0 (43.00-53.00)	49.0 (42.00-53.00)	< 0.001
Subjective treatment need (%)			
No	565 (30.2)	484 (25.5)	
Borderline	498 (26.6)	460 (24.2)	
Yes	810 (43.2)	957 (50.3)	<0.001

*Based on chi square test for categorical variables and t-test or Mann –Whitney U for continuous variables

[a]May not add up to 3774, because of missing values: Maternal education: 6.3 %; Ethnicity : 0.6%; IOTN: 21.9 %; Household income: 6.7%, IOTN-DHC: 20.2%; IOTN-AC: 22.9%

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Table 2

COHIP-ortho scores by question for children with unsure or definite subjective orthodontic treatment need versus no subjective orthodontic treatment need (n=3774)

	COHIP-ortho mean scores per question (mean ± standard deviation)				
Questions	**No subj need**	**Unsure subj need**	**Effect size[a]**	**Definite subj need**	**Effect size [a]**
Pain	4.8 (0.5)	4.8 (0.5)	0.02	4.8 (0.5)	0.02
Crooked teeth	4.8 (0.6)	4.5 (0.8)	0.36**	3.8 (1.2)	0.98**
Discolored teeth	4.7 (0.7)	4.6 (0.8)	0.13**	4.5 (0.9)	0.22**
Bad breath	4.5 (0.8)	4.5 (0.8)	0.05	4.8 (0.9)	0.07
Bleeding gums	4.7 (0.6)	4.7 (0.6)	0.08*	4.6 (0.8)	0.22**
Eating foods	4.9 (0.4)	4.9 (0.4)	0.00	4.8 (0.5)	0.15*
Anxious	4.8 (0.6)	4.7 (0.6)	0.05	4.5 (0.9)	0.34**
Speaking	5.0 (0.1)	5.0 (0.2)	0.00	5.0 (0.3)	0.14**
Bullied	5.0 (0.3)	5.0 (0.2)	0.04	4.9 (0.4)	0.15**
Attractiveness	1.8 (1.2)	1.8 (1.2)	0.02	1.8 (1.1)	0.00
Pronunciation	5.0 (0.3)	5.0 (0.3)	0.04	4.9 (0.5)	0.16**

[a]Cohens effect size (d) for differences between either No subjective need and borderline subjective need or No subjective need and definite subjective need. p values are based on Mann Whitney U test for differences in mean scores * ≤ 0.05, **≤ 0.001

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Table 3

The association between subjective orthodontic treatment need and OHRQoL analyzed overall, stratified by gender and both IOTN components

	Oral health related quality of life score						
	Total	**Sex**		**IOTN-DHC**		**IOTN-AC**	
	(n= 3774)	**Boys (n= 1873)**	**Girls (n= 1901)**	**DHC ≤ 3 (n=2129)**	**DHC > 3 (n=1645)**	**AC ≤ 5 (n=2275)**	**AC > 5 (n=1499)**
No need	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Borderline need (β (95% CI))							
Crude [a]	-0.51 (-0.74, -0.27)	-0.59 (-0.90, -0.27)	-0.42 (-0.77, -0.07)	-0.60 (-0.89, 0.31)	-0.30 (-0.77, 0.17)	-0.49 (-0.77, -0.21)	-0.55 (-1.03, -0.06)
Adjusted b	-0.53 (-0.75, -0.30)	-0.57 (-0.86, -0.27)	-0.51 (-0.85, -0.17)	-0.58 (-0.85, 0.31)	-0.42 (-0.87, 0.03)	-0.47 (-0.74, -0.21)	-0.64 (-1.12, -0.17)
Adjusted [c]	-0.49 (-0.71, -0.27)	-0.52 (-0.82, -0.23)	-0.49 (-0.82, -0.15)	-0.57 (-0.85, -0.30)	-0.42 (-0.85, 0.02)	-0.45 (-0.72, -0.19)	-0.64 (-1.11, -0.17)
Definite need (β (95% CI))							
Crude [a]	-1.76 (-1.99, -1.53)	-1.43 (-1.74, -1.12)	-2.13 (-2.46, -1.80)	-1.45 (-0.89, -0.31)	-1.78 (-2.21, -1.36)	-1.50 (-1.80, -1.19)	-1.88 (-2.31, -1.45)
Adjusted b	-1.76 (-1.98, 1.55)	-1.41 (-1.71, -1.12)	-2.18 (-2.50, -1.86)	-1.46 (-1.75, -1.17)	-1.86 (-2.25, -1.47)	-1.50 (-1.79, -1.21)	-1.93 (-2.33, -1.53)
Adjusted [c]	-1.58 (-1.81, -1.34)	-1.27 (-1.58, -0.96)	-1.93 (-2.27, -1.60)	-1.45 (-1.73, -1.16)	-1.80 (-2.19, -1.41)	-1.44 (-1.74, -1.13)	-1.81 (-2.24, -1.38)
p for trend [d]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
p for interaction [e]		0.001		0.039		0.024	

[a] adjusted only for age and additional for sex in the overall analysis,

[a] adjusted for age, ethnicity, household income, maternal education and additional for sex in the overall analysis,

[c] adjusted for age, ethnicity, household income, maternal education, additional for sex in the overall analysis as well as the stratification on IOTN-DHC and IOTN-AC; and additional for IOTN-DHC and IOTN-AC in the overall analysis as well as the stratification on sex,

[d] p for trend for the fully adjusted model obtained by treating subjective orthodontic treatment need as continuous term,

[e] obtained from interaction-term entered into the crude model between subjective orthodontic treatment need and gender, resp. IOTN-DHC and IOTN-AC, ref = reference category

Table 4

Non response analysis (n = 7393)

Characteristics	Included n= 3774	Excluded n=3619	p value*
Sex			
Boys (%[1])	1873 (49.6)	1834 (50.7)	
Girls (%[1])	1901 (50.4)	1785 (49.3)	0.374
Missing (%[2])	*0 (0.0)*	*0(0.0)*	
Age in years			
Median (range)	9.78 (9.49 - 10.45)	9.86 (9.56 - 11.12)	< 0.001
Missing (%[2])	*0 (0.0)*	*3252(89.9)*	
Ethnicity (%)			
Dutch (%[1])	2573 (68.6)	1619 (47.7)	
Other western (%[1])	327 (8.7)	247 (7.3)	
Non-western (%[1])	851 (22.7)	1529 (45.0)	< 0.001
Missing (%[2])	*23 (0.6)*	*379(10.5)*	
Maternal education level			
Low (%[1])	1234 (34.9)	1191 (52.1)	
High (%[1])	2301 (65.1)	1093 (47.9)	< 0.001
Missing (%[2])	*239 (6.3)*	*1490(41.2)*	
Household income (%)			
< 2000 (%[1])	619 (17.6)	358 (31.8)	
2000-3200 (%[1])	1087 (30.9)	353 (31.3)	
> 3200 (%[1])	1813 (51.5)	415 (36.9)	< 0.001
Missing (%[2])	*255(6.8)*	*2493(68.9)*	
IOTN-DHC (%)			
2 (%[1])	1119 (37.2)	632 (37.7)	
3 (%[1])	756 (25.1)	380 (22.7)	
4 (%[1])	871 (28.9)	496 (29.6)	
5 (%[1])	263 (8.7)	168 (10.0)	0.185
Missing (%[2])	*765(20.3)*	*1943(53.7)*	
IOTN-ac (%)			
≤ 5 (%[1])	2063 (70.9)	1144 (70.8)	
> 5 (%[1])	845 (29.1)	471 (29.2)	0.940
Missing (%[2])	*866(22.9)*	*2034(56.2)*	
OHRQoL			
Median (range)	50.0 (43.0 - 53.0)	49.0 (44.3 - 54.9)	
Missing (%[2])	*0(0.0)*	*3597(99.4)*	*0.959*

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Characteristics	Included n= 3774	Excluded n=3619	p value*
Subjective treatment-need (%)			
No (%[1])	1049 (27.8)	1 (11.1)	
Borderline (%[1])	958 (25.4)	2 (22.2)	
Yes (%[1])	1767 (46.8)	6 (66.7)	0.429
Missing (%[2])	*0(0.0)*	*3610*	

*Based on chi square test for categorical variables and t-test or Mann –Whitney U for continuous variables.

[1]percentage of available data within the subgroup;

[2]percentage of missing data per subgroup