The WhiteTeeth app

The development and evaluation of a smartphone app for promoting oral health behavior and oral hygiene in adolescent orthodontic patients

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CHAPTER 2

Psychosocial correlates of oral hygiene behaviour in people aged 9 to 19 A systematic review with meta-analysis

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ABSTRACT

Objectives: This systematic and meta-analytic review aimed to quantify the association of psychosocial correlates with oral hygiene behaviour among 9- to 19-year olds.

Methods: A systematic search up to August 2015 was carried out using the following databases: PubMed, PsycInfo, Embase, CINAHL and Web of Science. If necessary, authors of studies were contacted to obtain unpublished statistical information. A study was eligible for inclusion when it evaluated the association between the psychosocial correlates and oral hygiene behaviour varying from self-reports to clinical measurements, including plaque and bleeding scores. A modified New Castle Ottawa Scale was applied to examine the quality of the included studies.

Results: Twenty-seven data sets (*k*) presented in 22 publications, addressing nine psychosocial correlates, were found to be eligible for the meta-analysis. For both tooth brushing and oral hygiene behaviour, random effect models revealed significant weighted average correlation (r_+) for the psychosocial factors: 'intention', 'self-efficacy', 'attitude' (not significant for tooth brushing), 'social influence', 'coping planning' and 'action planning' (r_+ ranging from 0.18 to 0.57). Little or no associations were found for: 'locus of control', 'self-esteem' and 'sense of coherence' (r_+ ranges from 0.01 to 0.08).

Conclusions: The data at present indicates that 'self-efficacy', 'intention', 'social influences', 'coping planning' and 'action planning' are potential psychosocial determinants of oral health behaviour. Future studies should consider a range of psychological factors that have not been studied, but have shown to be important psychosocial determinants of health behaviours, such as 'self-determination', 'anticipated regret', 'action control' and 'self-identity'. Effectiveness of addressing these potential determinants in order to induce behaviour change should be further examined by intervention trials.

Abbreviations: CI, confidence interval; CMA, Comprehensive Meta-Analysis Software; OHB, oral hygiene behaviour; OR, Odd Ratio; HAPA, Health Action Process Approach model; IM, Intervention Mapping; PBC, perceived behavioural control; *r*, correlation; r_+, weighted average correlation; TPB, Theory of Planned Behaviour.

INTRODUCTION

Despite great global improvements in oral health during the 21st century, oral diseases remain a major health problem [1, 2]. According to the WHO report, dental caries affects approximately 60-90% of children and the vast majority of adults in developed countries [2]. The performance of adequate oral hygiene is important in the prevention of oral diseases, yet a large proportion of the population fails to sufficiently adopt or maintain adequate oral hygiene behaviour [3,4]. Adolescence in particular can be a time of increased caries activity and periodontal disease due to a decline in the quality of oral hygiene behaviour [5,6]. There is an urgent need for effective programs to improve oral hygiene behaviour in this age group.

A systematic review of interventions in adolescents concluded that behavioural interventions to promote oral health of adolescents had limited success and alternative approaches of oral health promotion should be explored [7]. There is increasing recognition that interventions should be guided by the Intervention Mapping (IM) protocol; however, none of oral health promotion programmes regarding adolescents have used the IM protocol for its development [8]. According to the IM protocol, intervention development starts with the analysis of the health problem including the identification of the determinants related to the problem and the specific health-related behaviour [8]. This is based on the assumption that it is possible to change health behaviour by targeting the determinants of this behaviour (the causal mechanism of behaviour), thus leading to an improvement of the health outcome [9].

Of these determinants, psychosocial factors have been identified as important modifiable determinants of behaviour [10, 11]. In adults, a systematic review demonstrated that interventions targeting psychosocial factors led to changes in oral hygiene behaviour [11]. Until now, behavioural interventions regarding adolescents have, however, rarely targeted psychosocial determinants [7]. This explains why these interventions had limited success. Therefore, insight into psychosocial factors is necessary to design evidence-based oral health interventions. No review has so far attempted to summarise the existing evidence regarding all psychosocial factors related to oral hygiene behaviour.

The purpose of this study is to analyse the associations between psychosocial factors and oral hygiene behaviours by a systematic and meta-analytic review. The research question states: 'what are the associations between psychosocial factors and oral hygiene behaviour among people aged 9 to 19?' We decided to limit our study to this age group, since previous meta-analysis have shown that psychosocial factors in young people are different from those in adults [12]. The cut-off point of the age of 9 was chosen, because children aged 9 years and older are supposed to practice oral hygiene behaviour independently without parental supervision [13].

METHODS

Data sources and search strategy

This systematic and meta-analytic review is reported in consistent with MOOSE guidelines [14]. The following databases were searched from inception up to 24 August 2015: PubMed, Embase, Ebsco/PsycInfo, Ebsco/CINAHL and ISI/Web of Science. All languages were accepted. The comprehensive search strategy was designed in collaboration with health sciences librarian (JS and JK). As psychosocial factors can be reported by studies that apply social-cognitive models to explain or predict behaviour, social-cognitive models were included as search terms to create a sensitive and complete search. Search terms (including synonyms and closely related words) were first chosen and used as index terms or free-text words in Pubmed (Table 1). Consequently, the search strategy was adapted and optimised for all consulted databases (available on request). Manual cross-referencing of bibliographies was carried out. Additionally, we utilised indexing sources to retrieve subsequent relevant articles that have cited the included publications [15].

Eligibility criteria

A study was eligible for inclusion if it described the association between psychosocial correlates and oral hygiene behaviour of healthy children with a mean age in the range of 9 to 19. We defined the dependent variable 'oral hygiene behaviours' as oral self-care behaviours which impact or have the potential to impact the oral health of an individual. We included indices of oral hygiene behaviour, if the outcome encompasses one of more oral hygiene behaviours such as tooth brushing, interdental cleaning, fluoride use and flossing behaviour. Studies reporting oral health behaviours like dental visits and sugar consumption were only included if this behaviour was studied in combination with the oral hygiene behaviours mentioned above. Measurement of oral hygiene behaviour could vary from self-report to clinical measurements. The clinical measurements included plaque and gingival indices indirectly measuring the quality oral home care behaviours, a proxy measure of behaviour.

Table 1. Search strategy (in Pubmed)

#1	(((correlat*[tiab] OR predict*[tiab] OR factor[tiab] OR factors[tiab] OR determinant*[-tiab] OR "cognition"[Mesh] OR cogniti*[tiab]) AND (dental behavio*[tiab] OR oral health behavio*[tiab] OR oral hygiene behavio*[tiab] OR dental health behavio*[tiab])))
#2	(action planning[tiab] OR action control*[tiab] OR "intention"[Mesh] OR intention*[tiab] OR perceived social pressure*[tiab] OR "internal external control"[Mesh] OR "Attitude to Health"[Mesh] OR "Self Concept"[Mesh] OR preintention*[tiab] OR postintention*[tiab] OR outcome expectanc*[tiab] OR perceived behavioral control*[tiab] OR perceived behavioural control*[tiab] OR self efficac*[tiab] OR positive outcome expectanc*[tiab] OR perceived risk*[tiab] OR risk perception*[tiab] OR health perception*[tiab] OR attitude*[tiab] OR oral health knowledge[tiab] OR belief*[tiab] OR anticipated regret*[tiab] OR social norm*[tiab] OR expected social outcome*[tiab] OR social influence*[tiab] OR self-esteem[tiab] OR cues to action*[tiab])
#3	(parental behavior*[tiab] OR parental behaviour*[tiab] OR parental style*[tiab] OR modeling*[tiab] OR modelling*[tiab] OR perceived susceptibilit*[tiab] OR perceived vulnerabilit*[tiab] OR social cognitive theor*[tiab] OR theory of reasoned action*[tiab] OR ASE model*[tiab] OR planned behavio*[tiab] OR protection motivation theor*[tiab] OR transtheoretical model*[tiab] OR precaution adoption process*[tiab] OR health belie*[tiab] OR reinforcement sensitivity theor*[tiab] OR injunctive norm*[tiab] OR descriptive norm*[tiab] OR subjective norm*[tiab] OR stages of change[tiab])
#4	(home care dental devices[MeSH Terms] OR floss*[tiab] OR dental compliance[tiab] OR tooth brushing[tiab] OR tooth brushing[tiab] OR interdental cleaning OR interdental brush* OR dental brush* OR oral hygiene[MeSH Terms] OR oral hygiene[tiab] OR dental hygiene[-tiab] OR oral health behavior*[tiab] OR dental behavior*[tiab] OR oral health behaviour*[-tiab] OR dental behaviour*[tiab] OR ((oral health[tiab] OR dental health[tiab]) AND (health behavior[MeSH Terms] OR health behavior*[tiab] OR health behaviour*[tiab] OR compli-an*[tiab] OR patient compliance[MeSH Terms] OR sugar sweetened beverage*[tiab] OR "Energy Drinks"[Mesh] OR energy drink*[tiab] OR "Fluorides"[Mesh] OR fluorid*[tiab] OR "Diet"[Mesh] OR diet[tiab] OR diets[tiab] OR "intention"[Mesh])))
#5	(child*[tw] OR schoolchild*[tw] OR adolescen*[tw] OR pediatri*[tw] OR paediatr*[tw] OR boy[tw] OR boys[tw] OR boyhood[tw] OR girl[tw] OR girls[tw] OR girlhood[tw] OR youth[tw] OR youths[tw] OR teen[tw] OR teens[tw] OR teenager*[tw] OR puberty[tw])
#6	((#1 OR #2 OR #3) AND #4 AND #5)

[Mesh] = Medical subject headings; [tiab] = words in title OR abstract; [tw] = words in title, abstract, MeSH, other terms

Furthermore, in the event of several publications reporting the outcomes on an identical group of participants, only the most recent publication was included. Studies were excluded, when the study population was exposed to an intervention prior to measurement. In case of an intervention study, data from the baseline measurement prior to the intervention or no-treatment control group was included. Only literature in English, Dutch, and German was included. Qualitative studies, reviews, expert opinion, conference proceedings and case studies were excluded.

Study selection

The study selection was performed in two stages. In the first stage, two persons (JS and EW) independently read the title and abstract of potentially relevant articles against the eligibility criteria. If the abstract contained insufficient information for the decision on whether to include or exclude, the full-text article was obtained and reviewed before a decision was made. In the second stage, full-text articles were obtained and the same two persons independently applied the eligibility criteria to confirm the final selection. If necessary, a third reviewer (PE) was consulted to resolve disagreements or the authors of the included studies were contacted to verify eligibility. Consensus was reached in 100% of the cases.

Data extraction

Two authors (JS and PE) performed the data extraction using a predefined data extraction form. Information was extracted from each included study on authors and year of publication, setting, country, description of the study population (sample size, age and gender), study design, psychological theory or behavioural model used for the design of the study, used definition and measurement of the oral hygiene behaviour under study, the psychosocial correlates assessed, and the reported effect sizes. In addition, we contacted authors of studies to obtain unpublished statistical information or for clarification. To ensure comparability of the psychosocial correlates across studies, measures of the correlates were coded based on actual operationalisations presented in Table 2, rather than the name that the concepts were given in the articles. The psychosocial correlates and outcomes of the included studies were coded so that higher scores indicated greater engagement in oral hygiene behaviour.

Quality assessment of the included studies

The reviewers (JS and EW) independently assessed the methodological quality of the selected articles with a method adapted from Elyasi et al. (2015), which was based on a modified Newcastle-Ottawa Scale [28, 29]. As one item with regard to controlling for confounders was inapplicable, this item was skipped. For cross-sectional studies, a quality score was based on five items of the following categories: group selection, outcome and exposure. For cohort studies, two items were added: duration and adequacy of follow-up. A maximum score of five points for cross-sectional studies and seven points for prospective studies represented the highest methodological quality. Discrepancies between the assessors were resolved via discussion with third reviewer (PE) until reaching a consensus. The report of this procedure is available on request from the corresponding author.

Table 2. Brief definitions of psychosocial correlates

Variable(s)	Brief definition
Action planning	Participants' plan regarding when, where, and how to perform OHB [16].
Coping planning	Participants' anticipation of barriers that might threaten the implementation of the OHB and participants imagination of ways to overcome them [16].
Intention to practice OHB	Participants' motivation in the sense of his or her conscious decision to exert effort to perform the OHB in the future [17].
Perceived Behavioural Control #	Participants' expectancy that the performance of the behaviour is within his/her control and the participants' perception of the extent to which performance of the behaviour is easy or difficult. 'Perceived behavioural control' is determined by beliefs concerning factors that inhibit or facilitate performance of the behaviour and the perceived power of these factors [17, 47].
• Self-efficacy	Participants' confidence in their ability to perform behaviour [18].
• Perceived Self-efficacy	Participants' beliefs about one's abilities to successfully perform OHB [18].
Social influences	Participants' experiences of pressure that they receive from important others to perform, or not to perform, behaviour. Social influences can be subdivided into 'subjective norm' and 'descriptive norm' [47].
• Subjective norms (or injunctive norm)	Participants' perception whether significant others or peers think he/she should engage in the behaviour and the participants motivation to comply with those expectations [17].
• Descriptive norms	Participants' perceptions of significant others' attitudes towards OHB and/or OHB [19].
Attitude	Participants' positive or negative evaluation of what it would be like for them to perform OHB. Evaluations of behaviour are determined by beliefs that the behaviour will produce a certain outcome ('outcome expectancies') [17].
• Affective beliefs	Participants' beliefs about considering tooth brushing for affective reasons.
• Perceived barriers	Participants' beliefs about the likelihood of negative consequences of their OHB.
• Perceived benefits	Participants' beliefs about the likelihood of positive consequences of their OHB.
• Cognitive beliefs	Participants' beliefs about considered tooth brushing for cognitive reasons.
• Response-efficacy	Participants' belief in the effectiveness of performing oral hygiene behaviour in preventing oral diseases.
Self-esteem	Participants' overall emotional evaluation of individual's worth and respect for oneself, encompasses beliefs and affect [20, 21].
Locus of control	Participants' beliefs about whether the events affecting their life are causally related to their own behaviour (internal control) or being determined by outside forces, over which the individual has little or no control (external control) [22].
Sense of coherence	Participants' ability to cope with life stress and his/her ability to find an appropriate solution in the face of challenges (mastery orientation) and to stay healthy [23].
Risk perception*	
• Perceived susceptibility	Participants' beliefs about the extent to which they are personally at risk of oral diseases [24].
• Perceived vulnerability	Participants' beliefs about how serious gum and dental diseases would be for them [24].
Life satisfaction*	Participants' perceptions of how they experience their life in terms of being lonely and happy [25].
Depression vulnerability*	Participants' feelings of sadness or hopeless that have caused participants stopped doing usual activities [26].
Health perception*	Participants' perception whether they perceive themselves as healthy or unhealthy [27].

The concept of 'perceived behaviour control' is conceptually related to 'self-efficacy'; * For variables denoted by the sign * applies that these variables were excluded from the analysis, since only one independent correlation (k<1) was available; OHB= Oral hygiene behaviour.

Statistical procedure

Meta-analyses were undertaken using Comprehensive Meta-Analysis (CMA) software (Version 2.0). A weighted average correlation (r_+) and its 95% confidence interval (CI) was calculated per psychosocial correlate and oral hygiene behaviour (range: -1.0 to +1.0) using Fisher's Z-transformations [30]. Pearson and Spearman correlation coefficients (r) were used as the effect size for analyses. When the Odds Ratio (OR) was reported instead of the correlation coefficient, CMA converted the crude OR to a correlation coefficient. CMA computed the oral hygiene behaviour outcome by combining the independent variables of each included study and calculating a mean effect size. Random effects models were chosen due to the heterogeneity across studies caused by various operationalisations of outcomes. Only bivariate analyses were synthesized because multivariate analyses were incommensurable over studies as the studies adjusted for different confounders in their models. This resulted in exclusion of two articles from the analysis [31, 32]. Meta-analyses were only performed if data of two or more independent correlations were available (k > 1). This latter resulted in the exclusion of one study from the analysis [27]. If a study reported an effect size for boys and girls, but not for mixed gender, a mean effect size

was computed by CMA. Heterogeneity analyses, *Q* and I^2 statistics, were conducted to determine whether the variation among correlations was greater than chance [33, 34]. Additionally, subgroup analyses were conducted to test if the study designs (cross-sectional vs. prospective) could explain the observed heterogeneity among effect sizes. If the mixed-effect models revealed significant differences, the results of cross-sectional and prospective design were separately reported. By contrast, if the mixed-effect models revealed nonsignificant differences, a combined effect size was reported to serve as a summary. To assess the extent of publication bias, we calculated the Rosenthal's fail-safe number (FSN), which estimates the number of studies with null findings necessary to nullify the significant weighted effect [35]. A larger FSN value indicates a more robust weighted average effect size. As a rule of thumb, it has been suggested that the recommended tolerance is $5k + 10$, where k is the number of studies retrieved [35]. FSN could only be calculated when $k>2$. If the FSN is larger than the recommended tolerance, then the results are robust [35].

RESULTS

Study selection

Figure 1 shows the flow diagram presenting the selection process of the included articles. After removing duplicates, a total of 3548 unique articles were found by searching the databases. Screening on title and abstract led to retention of 203 potentially relevant articles. Reading on full-text resulted in exclusion of 179 publications. The flow diagram displays a summary of the excluded papers and the reasoning behind their exclusion. The final sample contained 31 unique data sets (k) reported in 24 articles [20, 21, 25-27, 31,32, 36-52].

Study characteristics

Table S1 (see the Appendix) presents the characteristics and cumulative score of the methodological quality assessment of all studies selected for the systematic review. For cross-sectional studies, the quality assessment scores range from three to five points. Prospective studies scores range from five to six points. Across the studies, the quality scores vary in three items, namely information about the nonrespondents, validation of measurement of the psychosocial factors and assessment of the outcome. The included articles were published from 1972 onwards. Selected studies were conducted in seventeen different countries, located in: Europe (k=15), North America (k=3), South America (k=1), Africa (k=1), Asia (k=8) and Oceania (k=3). In total, the studies sampled 104288 participants. The majority of the studies (k=25) focused on self-reported tooth brushing frequency. Five data sets focused on self-reported oral hygiene behaviour, which comprised a set of different activities. Finally, the remaining data sets focused flossing frequency (k=9) and/or plaque score (k=3). Twenty-nine data sets were cross-sectional in design, including papers that presented baseline results of a longitudinal study. Six data sets were prospective in design. Only 39% of the studies based their research on a behavioural theory, the remaining 61% of the studies did not refer to a specific theoretical framework. The most dominant theoretical framework used for the design in the included studies (25%) was the 'Theory of Planned Behaviour' [17].

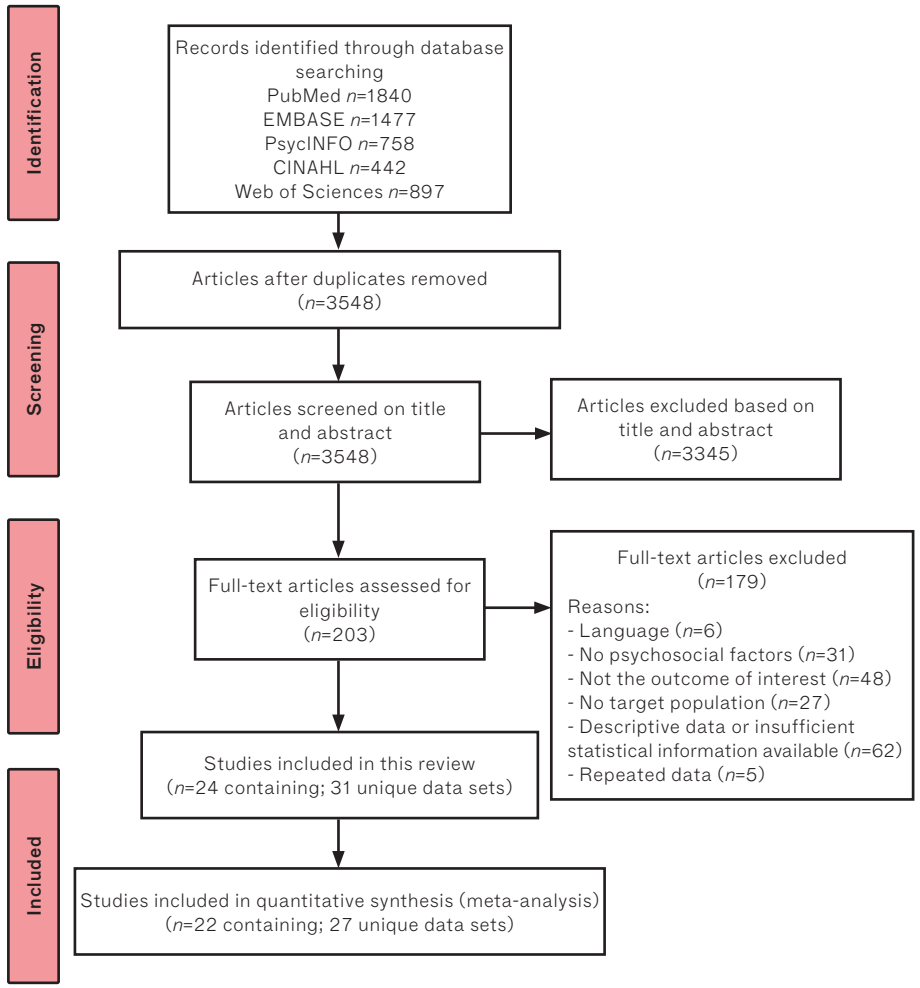

Fig.1. Results of search strategy and screening procedure

Synthesis of results

Twenty-seven unique data sets reported in 22 publications were included in quantitative synthesis (meta-analysis) [20, 21, 25-27, 36-52]. Meta-analyses were performed for the most frequently reported outcome: tooth brushing and for a combined oral hygiene behaviour outcome, which combined various oral hygiene behaviours. The results of the meta-analyses and the heterogeneity analyses for the psychosocial correlates of tooth brushing are presented in Table 3, and for oral hygiene behaviour, in Table 4. The majority of the heterogeneity tests were significant (Table 3 and 4). Nine psychosocial

Table 3. Samples weighted average correlations, confidence intervals and heterogeneity analyses for the psychosocial correlates of tooth brushing

Variable	total n	*k*	r_+	95% CI	Heterogeneity	
					Q	I^2
Coping planning	1682	2	0.57	[0.54; 0.60]	8.2*	87.8
Action planning	1682	2	0.47	[0.37; 0.56]	6.9*	85.5
Intention	2784	4	0.43	[0.16; 0.64]	122*	97.5
PBC/Self-efficacy	3202	5	0.36	[0.17; 0.52]	127.3*	96.9
Social influences	1533	2	0.32	[0.27; 0.37]	2.6	62.3
Attitude	4217	3	0.18	[-0.04; 0.39]	61.7*	96.7
Self Esteem	12193	7	0.08	[.0.05; 0.10]	32.4*	81.5
Sense of Coherence	2244	3	0.04	[-0.01; 0.09]	2.9	31.5
Locus of Control	5583	6	0.04	[0.02; 0.05]	12.5*	59,9

Note. Total n= total sample size across all the included studies; *k*= number of independent correlations, which contains prospective and cross-sectional data; r_+ = sample-weighted average correlation; CI = confidence interval; *Q* between-study heterogeneity, expressed as a Chi-square statistic; I^2 between-study heterogeneity, expressed as percentage of variation attributable to heterogeneity rather than chance; PBC= Perceived Behavioural Control.* When *p* <0,10, correlations are heterogeneous.

correlates were addressed across the included studies. These correlates include the following: coping planning, action planning, intention, self-efficacy/perceived behavioural control, social influences, attitude, sense of coherence, self-esteem and locus of control. The results of the meta-analysis for each psychosocial correlate of tooth brushing are described next in order of strength.

Action planning

A significant weighted average correlation of 0.47 was observed for action planning with tooth brushing (*k*=2; *p*<0.001). Mixed-effect models showed significant moderate effects, which indicate that the study design accounted for the heterogeneity in the overall distribution (*Q*-value=7.9; *p*=0.005). Prospective studies reported stronger correlations for action planning on tooth brushing (r_+=0.57; *p*<0.001; *k*=2) than for cross-sectional studies (r_+=0.35; *p*<0.001; *k*=2).

Coping planning

Tooth brushing frequency was found to be related positively to 'coping planning' with a r_+ of 0.57 (*k*=2; *p*<0.001).

Table 4. Samples weighted average correlations, confidence intervals, and heterogeneity analyses for the psychosocial correlates of oral hygiene behaviour

Variable	total n	*k*	r_+	95% CI	Heterogeneity	
					Q	I^2
Intention	4774	7	0.46	[0.29; 0.60]	141.9*	95.8
PBC/Self-efficacy	3966	10	0.44	[0.33; 0.54]	174.1*	94.8
Coping Planning	1842	3	0.43	[0.18; 0.63]	60.8*	96.7
Social influences	2296	5	0.32	[0.28; 0.36]	9.1	45.5
Action planning	1843	3	0.31	[0.05; 0.53]	59.6*	96.6
Attitude	9700	11	0.23	[0.15; 0.30]	119.5*	91,6
Sense of Coherence	2244	3	0.06	[0.02; 0.10]	1.6	37.1
Self Esteem	12193	7	0.05	[0.02; 0.07]	28.6*	79.0
Locus of Control	5583	6	0.01	[0.00; 0.02]	3.6	43.7

Note. Total n= total sample size across all the included studies; *k*= number of independent correlations, which contains prospective and cross-sectional data; r_+ = sample-weighted average correlation; CI = confidence interval; Q between-study heterogeneity, expressed as a Chi-square statistic; I^2 between-study heterogeneity, expressed as percentage of variation attributable to heterogeneity rather than chance; PBC= Perceived Behavioural Control.* When *p* <0,10, correlations are heterogeneous

Intention
A significant weighted average correlation of 0.43 was observed for intention with tooth brushing (*k*=4; *p*=0.002; FSN=410).

Self-efficacy or perceived behavioural control
The average weighted correlation between 'self-efficacy' or 'perceived behavioural control' and tooth brushing was estimated at 0.36 (*k*=5; *p*<0.001; FSN=625).

Social influences
A significant weighted average correlation of 0.32 was observed for social influences with tooth brushing (*k*=2; *p*<0.001).

Attitude
The weighted average correlation between attitude and tooth brushing was estimated at 0.18 (*k*=3), which was not significant (*p*=0.109).

Sense of Coherence
A nonsignificant pooled correlation for sense of coherence and tooth brushing was observed (r_+=0.04; *k*=3; *p*=0.092).

Self-esteem
Self-esteem had a negligible association with tooth brushing in the analysis (r_+=0.08; *k*=7; *p*<0.001; FSN=235).

Locus of Control
The average weighted correlation between locus of control and tooth brushing was estimated at r_+=0.04 (*k*=6; *p*=0.001; FSN=13).

Analysis for the outcome oral hygiene behaviour revealed significant positive weighted average correlations for the variables: 'intention' (r_+= 0.46; *k*=7; *p*<0.001; FSN=1000), 'self-efficacy (r_+= 0.44; *k*=10; *p*<0.001; FSN=2441), 'coping planning' (r_+=0.43; *k*=3; *p*=0.001; FSN=374), 'social influences' (r_+= 0.32; *k*=5; *p*<0.001; FSN=272), 'action planning' (r_+= 0.31; *k*=3; *p*=0.021; FSN=210), 'attitude' (r_+=0.23; *k*=11; *p*<0.001; FSN=984), 'sense of coherence' (r_+= 0.06; *k*=3; *p*=0.008.; FSN=2), 'self-esteem' (r_+= 0.05; *k*=7; *p*=0.001; FSN=84). A nonsignificant pooled correlation was observed between 'locus of control' and oral health behaviour (r_+=0.01; *k*=6; *p*=0.144) (Table 4).

DISCUSSION

The present systematic and meta-analytic review of 27 unique data sets aimed to identify psychosocial determinants of oral hygiene behaviour in young people aged 9 to 19. A higher tooth brushing frequency was observed among those with higher 'intention', 'social influences', 'self-efficacy', 'action planning' and 'coping planning', which suggests that these factors are potential psychosocial determinants of tooth brushing. The pooled correlations found for 'intention', 'social influences' and 'self-efficacy' for tooth brushing are in accordance with a previous meta-analysis regarding to other types of health behaviour, for example physical activity and diet behaviours [53]. Little or no associations were found for the factors: 'locus of control', 'self-esteem' and 'sense of coherence'. Our findings indicated that more commonly studied psychosocial factors (e.g. 'locus of control', 'sense of coherence' and 'self-esteem') were less likely to be associated with tooth brushing, whereas factors that illustrated a strong association were relatively understudied (e.g. 'action planning' and 'coping planning'). In addition, it is noteworthy that none of the included studies examined determinants such as 'self-

determination', 'anticipated regret', 'action control' and 'self-identity' that have found to be important in explaining health behaviours [54-56]. Future studies should test for these determinants to advance in the field.

Apart from tooth brushing, we examined whether our findings were consistent for combined oral health behaviour outcome. Generally, the findings were comparable, with exception of 'coping planning' and 'action planning', which showed lower correlations for the combined outcome. The differences between tooth brushing and oral hygiene behaviours for these variables could potentially be explained through to the nature of the behaviour, as the oral hygiene behaviour outcome includes flossing. Flossing is a more complex task, which might require other skills affected by other psychosocial factors. Another reason might be measurement bias, as the method of measuring the psychosocial constructs differed between the studies, that is single items or a more refined assessment tool of five items.

The most frequently used theory for the design of the studies was the 'Theory of Planned Behaviour' (TPB). Nonetheless, the TPB is not without its limitations as highlighted in a recent critique by Sniehotta and his colleagues [57]. They state that TPB does not account for all of the variance in intentions and behaviour. Our findings do suggest that determinants other than TPB variables ('social influences', 'attitude', 'perceived behavioural control' and 'intention') could be relevant to explain oral hygiene behaviour, such as 'action planning' and 'coping planning'. Hence, alternative theories that focus for instance on these and other self-regulatory processes (e.g. Health Action Process Approach [16]), might improve the understanding of tooth brushing or oral hygiene behaviours as well as provide better means for behavioural change.

Prior to discussions of the practical implications, several strengths and limitations should be acknowledged. Random effects models were chosen due to the heterogeneity across studies. This heterogeneity may have been due to different operationalization of the variables, mixed gender, mixed cultures and different definitions of the outcomes across the included studies. As the majority of the studies demonstrated results for mixed gender, it was not possible to test moderation of psychosocial factors with oral hygiene behaviour by gender of participants. However, one of the included studies noticed differences between genders in the psychosocial correlates of oral hygiene behaviour, namely 'locus of control' and 'self-esteem' [21]. Therefore, gender should be given consideration in future studies. In general, the reliance on the availability of published results is a limitation. Studies that show negative or insignificant results are less likely to be published. Therefore, an overestimation of the robustness of the effect sizes may occur due to publication bias. Additional analysis (FSN) was performed to assess the extent of publication bias. All significant effect sizes showed FSN larger than the recommended tolerance, which indicate robust results. Another limitation is the lack of a validated assessment tool to measure the quality of the included studies.

Although no validated checklist exists to assess the risk of bias of the included studies [58], we did measure the quality of their studies by a modified NOS assessment tool adapted by Elyasi et al. (2015) [28]. The majority of the included studies scored low on the outcome measurement, as they assessed oral hygiene behaviour by self-report. It is reasonable to expect inaccuracy of self-reported measures [59]. An attempt should be made to obtain objective measurements of oral hygiene behaviour. Modern technology provides novel ways of collecting reliable data about a person's behaviour, for example registration of behaviour by an electric toothbrush with Bluetooth connectivity. The final limitation is that most studies have used cross-sectional designs, which means that evidence for these correlates to be determinants is somewhat hypothetical [10, 57]. A next step to verify the causal role of these psychosocial factors is to examine them in studies using more complex longitudinal or experimental designs.

The practical implication of the present review is that oral health promotion could be improved by targeting the following potential determinants: 'intention', 'social influences', 'self-efficacy', 'coping planning' and 'action planning'. Two notions should be considered: existing oral health promotion interventions for adolescents rarely targeted these factors, which could explain the generally limited success of oral health promotion programmes [7] and preliminary evidence of intervention studies that have targeted (some of) these determinants have indeed shown that this may result in improved oral hygiene behaviour [4, 40, 60-64].

Behaviour change interventions need to incorporate methods directly targeting these potential determinants. Various methods have previously been defined in relation to these determinants [65]. One could think of skill building as a method to enhance 'self-efficacy' [65]. Skill building compromises the following activities: (i) providing instruction, (ii) demonstrating the behaviour and (iii) guiding practice with feedback and reinforcement [65]. To achieve 'intention' formation, a method might include goal setting, that is prompting planning what a person will do, including a definition of goal-directed behaviours that result in the target behaviour [65]. With regard to 'action planning' and 'coping planning' enhancement, methods might include implementation intentions, that is prompting making if-then plans [65, 66, 67]. A practical application for this method is the use of volitional help sheets [68]. To change 'social influences', a method could be providing information about what others think about the persons' behaviour and whether others will approve or disapprove any proposed behavioural change [65].

In conclusion, this systematic and meta-analytic review highlights the importance of psychosocial factors as potential determinants in explaining oral hygiene behaviour among pre-adolescents and adolescents. In addition, the review identifies various gaps in the literature: (i) psychosocial factors that appear to be the most important received relatively little attention, for instance 'action planning' and 'coping planning';

(ii) psychosocial factors: 'self-determination', 'anticipated regret', 'action control' and 'self-identity' that have found to be important in explaining health behaviours and have not been studies in relation to oral health in young people; and (iii) the quality of the study design requires improvement. There is a need for prospective or experimental research. Apart from these improvements, future research should include objective measurement of oral hygiene behaviour. Finally, this review discussed practical implications to optimize and design evidence-based interventions to promote oral hygiene behaviour.

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APPENDIX A

Table S1. Characteristics of the included studies

Study, country, design, (quality assessment score)	Sample (number, gender, age)	Psychosocial correlates (Theoretical framework)	The independent correlations with 95% CI per oral hygiene behaviour outcome
Aleksejuniene et al.2012[36] Lithuania; Cross-sectional study (4 points)	n=235 [a]; mix [b] aged 12-13 years	1. Locus of control (internal) 2. Locus of control (external)	Plaque score (IQP-index) 1. 0.02(-0.11;0.15) 2. -0.06(-0.18;0.07) Self-reported tooth brushing frequency 1. na. 2. 0.11(-0.24;0.01)
Ayo-Yusuf et al. 2009[26]* South Africa; Prospective study (18 months) (6 points)	n= 526; mix mean age(SD) in years=14.4 (1.5)	1. Sense of coherence 2. Depression vulnerability** 3. Attitude 4. Intention (I-Change Model)	Self-reported tooth brushing frequency 1. 0.02(-0.07;0.11) 2. 0.13(0.05;0.21) 3. 0.05(-0.04;0.14) 4. 0.08(-0.01;0.16)
Cinar et al. 2009[37]* Finland; Cross-sectional study (4 points)	n=338; mix aged 10-12 years	1. Self-efficacy	Self-reported tooth brushing frequency 1. 0.22(0.11;0.32)
Cinar et al. 2009[37]* Turkey; Cross-sectional study (3 points)	n=611; mix aged 10-12 years	1. Self-efficacy	Self-reported tooth brushing frequency 1. 0.28(0.20;0.35)
Dorri et al. 2010[38]* Iran; Cross-sectional study (4 points)	n=911; mix mean age(SD) in years=12,4 (0.8) range=11-16 years	1. Sense of coherence (Salutogenic model)	Self-reported tooth brushing frequency 1. 0.09(0.03;0.15)

Freire et al. 2001[39]* Brazil; Cross-sectional study (3 points)	n=664; mix 15 year olds	1. Sense of coherence (Salutogenic model)	Self-reported tooth brushing frequency 1. 0.01(-0.07;0.08) Plaque score (index of Silnes & Löe) 1. 0.03(-0.05;0.10)
Gholami et al. 2014[40]*; Iran; Cross-sectional study (4 points) nested within a prospective study (1 month) (6 points)	n=156; F aged 11-15 years mean age(SD) in years= 12,5 (1,1)	1. Intention 2. Self-efficacy 3. Action planning 4. Coping planning (HAPA constructs)	Self-reported flossing frequency cross (n=156) pros (n=89) 1. 0.65(0.55; 0.73) 0.34(0.15; 0.51) 2. 0.72(0.64; 0.80) 0.38(0.19; 0.55) 3. 0.09(-0.24; 0.07) -0.01(-0.21; 0.20) 4. 0.04(-0.12; 0.20) -0.03(-0.28; 0.12)
Honkala et al. 2007[25] * Kuwait; Cross-sectional study (3 points)	n=1826; mix; Mean age: 11.9 years (SD ±1.3); age range=11-13 years	1. Self-esteem 2. Life-satisfaction**	Self-reported tooth brushing frequency 1. 0.12(0.08;0.17) 2. 0.10(0.05;0.14) Self-reported flossing frequency 1. 0.16(0.12;0.20) 2. 0.04(0.00;0.08)
Kallestal et al. 2006[20] Sweden; 2 cross-sectional studies within the same study group (4 points)	n=2836; mix mean age in '97 = 14 years mean age in '99 = 16 years	1. Self-esteem 2. Attitude	Self-reported tooth brushing frequency cross cross 1. 0.02(-0.12;0.15) 0.16(-0.05;0.36) 2. 0.11(0.06;0.17) 0.06(0.00;0.11)
Kamalikhah et al. 2015[41]* Iran; Cross-sectional study (4 points)	n=652; mix; mean age: 16,3 years (SD ±1.02);	1. Self-efficacy 2. Attitude	Self-reported flossing frequency 1. 0.48(0.42;0.54) 2. 0.24(0.16;0.31)

Koerber et al. 2006[42]* United States of America; Cross-sectional study (4 points)	n=575; mix mean age=10.8 years	1. Social influences 2. Self-esteem 3. Self-efficacy (Mixed models - social learning contructs)	Self-reported tooth brushing frequency 1. 0.34(0.27;0.41) 2 0.16(0.08;0.24) 3. 0.12(0.12;0.28)
Macgregor et al. 1997[21] Study 1 England; Cross-sectional study (3 points)	n=18158; f/m age range=12-13 years	1. Self-esteem 2. Locus of control	Self-reported tooth brushing frequency 1 0.03(0.02;0.05) 2. 0.02(0.00;0.03) Self-reported flossing frequency 1. 0.00(-0.02;0.02) 2. -0.01(-0.03;0.01)
Macgregor et al. 1997[21] Study 2 England; Cross-sectional study (3 points)	n=4736; f/m age range=13-14 years	1. Self-esteem 2. Locus of control	Self-reported tooth brushing frequency 1. 0.06(0.03;0.08) 2. 0.02(-0.01;0.04) Self-reported flossing frequency 1. -0.01(-0.03;0.03) 2. -0.03(-0.06;0.00)
Macgregor et al. 1997[21] Study 3 England; Cross-sectional study (3 points)	n=15492; f/m age range=14-15 years	1. Self-esteem 2. Locus of control	Self-reported tooth brushing frequency 1. 0.08(0.06;0.09) 2. 0.04(0.03;0.06) Self-reported flossing frequency 1. 0.01(-0.01;0.02) 2. -0.01(-0.03;0.01)

Macgregor et al. 1997[21] Study 4 England; Cross-sectional study (3 points)	n=2756; f/m age range=15-16 years	1. Self-esteem 2. Locus of control	Self-reported tooth brushing frequency 1. 0.07(0.03;0.11) 2. 0.07(0.03-0.10) Self-reported flossing frequency 1. -0.05(-0.08;-0.01) 2. -0.04(-0.08;0.00)
Morowatisharifabad et al. 2007[43] Iran; Cross-sectional study (4 points)	n=300; mix mean age (SD) in years= 17,45 ± 0,54 range=17- 19 years old.	1. Perceived self-efficacy 2. Attitude 3. Social influences (Health Promotion Model)	Self-reported oral health behaviour (Brushing and its quality; brushing after consumption of sweets,flossing; use of fluoride mouth wash, and dental visits.) 1. 0.40(0.31;0.50) 2. 0.38(0.27;0.47) 3. 0.28(0.17;0.34)
Pakpour et al. 2012[44] Iran; Cross-sectional study (4 points) nested within a prospective study (1 month) (6 points)	n=721, mix mean age (SD) in years=15.45 (1.18)	1. Intention 2. Attitude 3. Perceived behavioural control 4. Subjective norm 5. Action planning 6. Coping planning (TPB + HAPA constructs)	Self-reported tooth brushing frequency cross pros 1. 0.50(0.44;0.55) 0.70(0.66;0.73) 2. 0.34(0.27;0.40) 0.46(0.40;0.51) 3. 0.53(0.47;0.58) 0.72(0.68;0.75) 4. 0.26(0.19;0.32) 0.34(0.28;0.41) 5. 0.32(0.25;0.38) 0.51(0.45;0.56) 6. 0.51(0.46;0.57) 0.71(0.67;0.74)
Pakpour et al. 2012[45] Iran; Cross-sectional study (4 points) nested within a prospective study (1 month) (6 points)	n=961, mix mean age (SD) in years=15.61 (1.19), range=14-18 years old	1. Intention 2. Perceived behavioural control 3. Action planning 4. Coping planning (TPB + HAPA constructs)	Self-reported tooth brushing frequency cross pros 1. 0.46(0.41;0.51) 0.51(0.46;0.56) 2. 0.34(0.28;0.40) 0.47(0.42;0.52) 3. 0.37(0.31;0.42) 0.64(0.60;0.68) 4. 0.49(0.44;0.54) 0.56(0.52;0.60)

Polk et al. 2014[46] United states of America, prospective study (6 months) (5 points)	n=576; mix aged 9-12 years mean age =10 years	1. Intention	Self-reported tooth brushing frequency 1. 0.50 (0.16;0.73)
Poutanen et al. 2005[47]* Study 1 Finland; Cross-sectional study (4 points)	n=1464; mix aged 11-12 year old	1. Attitude	Self-reported oral health behaviour (brushing, snacking and xylitol chewing gum) 1. 0.17(0.12;0.22)
Poutanen et al. 2005[47]* Study 2 Finland; Cross-sectional study (4 points)	n=673; mix; aged 11-12 year old	1. Attitude	Self-reported oral health behaviour (brushing, snacking and xylitol chewing gum) 0.16(0.08;0.23)
Rise et al. 1998[48] Norway; Prospective study (4 weeks) (4 points)	n=163; mix mean age(SD) in years=15.3 (0.3)	1. Attitude 2. Subjective norm 3. Perceived behavioural control 4. Past behaviour 5. Intention (TPB)	Self-reported flossing frequency 1. 0.17(0.02;0.32) 2. 0.30(0.15;0.43) 3. 0.42(0.29;0.54) 4. 0.45(0.32;0.57) 5. 0.50(0.38;0.61)
Schou et al. 1990[27] Scotland; Cross-sectional study (3 points)	n=4935; f/m 11, 13 &15 year olds.	1. Health perception**	Self-reported tooth brushing frequency 1. 0.13(0.11;0.14)
Smyth et al. 2007[47]* Spain; Cross-sectional study (3 points)	n=1105; mix 12 year olds	1. Attitude (KAB model)	Plaque score (index of Silnes & Löe) 1. 0.11(0.05;0.17)

Tolvanen et al. 2012[50]* Finland; Cross-sectional study (4 points)	n=827; mix 15 &16 year olds	1. Attitude 2. Risk perception** (KAB model)	Self-reported oral health behaviour (tooth brushing, fluoride toothpaste, use of dental floss) 1. 0.35(0.29;0.41) 2. na. (not sign.)
Tran et al. 2006[30] Vanuata Cross-sectional study (3 points)	n=4474;mix age range 11-17 year.	1. Life-satisfaction	Self-reported tooth brushing 1. AOR=0.99(0.85;1.16)
Tran et al. 2006[30] Tonga Cross-sectional study (3 points)	n=1485; mix age range 11-17 year.	1. Life-satisfaction	Self-reported tooth brushing 1. AOR=1.05(0.85;1.28)
Tran et al. 2006[30] Pohnpei, FSM Cross-sectional study (3 points)	n=104; mix age range 11-17 year.	1. Life-satisfaction	Self-reported tooth brushing 1. AOR=1.09(0.69;1.72)
Vakili et al. 2011[51] Iran; Cross-sectional study (4 points)	n=300; mix mean age(SD) in years=16.24 (0.8) age range=15-18 years	1. Self-efficacy 2. Attitude 3. Social influences 4. Intention (Health Promotion Model)	Self-reported oral health behaviour (brushing and its quality, brushing after consumption of sweets, dental visits, flossing, and use of a fluoride mouth wash) 1. 0.53(0.44;0.61) 2. 0.36(0.26;0.45) 3. 0.39(0.29;0.48) 4. 0.32(0.22;0.42)
Verrips et al. 1993[32] the Netherlands Cross-sectional study (4 points)	n=518; mix, 11 year olds.	1. Attitude 2. Descriptive norm (parental)	Self-reported tooth brushing frequency 1. AOR=2.2(1.3;4.0) 2. na.
Williams 1972[52] United States of America; Cross-sectional study (5 points)	n=386; f/m Age: na.; (9th grade students ≈ 14-15 years old)	1. Locus of control (external)	Self-reported tooth brushing frequency 1. 0.07(-0.03;0.18)

Note. cross: cross-sectional data; pros: prospective data; na.: data not available; AOR: Adjusted Odds Ratio; TPB: Theory of Planned Behaviour ; KAB: Knowledge-Attitude-Behaviour ; HAPA: Health Action Process Approach. a:Smallest number of participants in relevant analyses; b:Mix indicates a mixed sample of female (F) and males (M); For the studies denoted by the sign * applies that (additional) data were supplied by the author. For variables denoted by the sign ** applies that these variables were excluded from the analysis, since meta-analyses were only performed if data of two or more independent correlations were available ($k > 1$). The software Comprehensive Meta-Analysis calculated the presented correlations with confidence interval (CI).