

Determinants of oral hygiene behavior: a study based on the theory of planned behavior

Yvonne A.B. Buunk-Werkhoven^{1,2,3}, Arie Dijkstra¹ and Cees P. van der Schans⁴

¹Department of Social Psychology, University of Groningen, Groningen, The Netherlands, ²Dutch Dental Hygienists Association, The Netherlands, ³Center for Dentistry and Oral Hygiene, UMC Groningen, The Netherlands, ⁴Research and Innovation Group in Health Care and Nursing-Hanze University, Applied Sciences, Groningen, The Netherlands

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Abstract – Objective: The aim of this study was to develop an index for oral hygiene behavior (OHB) and to examine potential predictors of this actual behavior based on the theory of planned behavior (TPB). Measures of oral health knowledge (OHK) and the expected effect of having healthy teeth on social relationships were included too. **Material and methods:** Using an Internet questionnaire, 487 participants were asked about actual OHB, attitudes (ATT), social norms (SN), perceived behavioral control (PBC), OHK, and expected social outcomes (ESO). Based on a Delphi method involving oral health professionals, a new index for OHB was developed, including tooth brushing, interdental cleaning, and tongue cleaning. **Results:** Regression analysis revealed that the TPB variables (ATT, SN, and PBC) and OHK explained 32.3% of the variance in self-reported OHB. **Conclusion:** The present findings indicate that socio-psychological consequences play a role in oral health care.

Key words: behavioral science; oral hygiene; prevention; psychosocial aspects of oral health

Yvonne A.B. Buunk-Werkhoven, p/a Department of Social Psychology, University of Groningen, Grote Kruisstraat 2/1, 9721 TS Groningen, The Netherlands
Tel.: +31(0) 6518 73389
Fax: +31(0) 5036 34581
E-mail: yvonne@apbuunk.com

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Professionals in oral health care have recognized that assessments of oral health and oral hygiene outcomes are of great importance for developing oral health care interventions. Oral self-care practices based on personal choice may be considered an important aspect of OHB. Therefore, individual beliefs and attitudes (ATT) toward this behavior have an important role in oral health care. The relevance of the behavioral sciences for modifying individual OHB has been shown since the early seventies and from that moment the behavioral and social sciences were definitively linked with dentistry in the Fédération Dentaire International's publication of *Social Sciences and Dentistry* (1). For instance, researchers successfully applied Social Learning Theory (2) to predict the levels of oral health behavior (3). In line with this study, the relationship between psychosocial variables and oral health behavior has been examined in several other studies. Moreover, there is consensus on the applicability and effectiveness of health behavior models in individual oral health behavior change (4–7).

Health models and health behavior theories have been applied to oral health care in several studies. For example, the theory of reasoned action (TRA) (8) has been used to predict patients' tooth brushing and dental flossing behavior in a sample of 131 first-year psychology students (9). Results from this study showed that attitude and subjective norm accounted for 32% of the variance in intention to brush at least twice a day and 30% of the variance in intention to floss frequently. In addition, intention explained 27% of the variance in brushing behavior and 37% of the variance in flossing behavior. However, self-efficacy expectations (10) as an additional measure for control in the study among students (9) failed to improve the prediction. In contrast, in a study including 39 participants, it was shown that addition of self-efficacy variables to the TRA did increase the explained variance in brushing and flossing behavior (11). Moreover, data on 81 college students in the context of a regimen of daily brushing and flossing showed the importance of perceived behavioral control (PBC) (12). According to the findings of a

study among 214 participants, adequate OHB (tooth brushing and the use of interdental cleaning aids) was associated with an individual's attitude toward oral health –'clean teeth' and 'fresh breath'– and with the perceived influence of 'important others', such as the dentist, family, and friends (13).

The findings of these earlier studies based on social cognitive models show that ATT, subjective norms, and self-efficacy or PBC are the determinants of oral health behavior. For two reasons, however, this so called 'state-of-the-art' with regard to oral health behavior is not satisfactory. First, in several studies, intention to perform oral health behavior instead of actual OHB was predicted. Although intention is the strongest psychological predictor of behavior, meta-analyses show that it accounts for only about 22% of behavior (14, 15). In addition, the meta-analysis findings show that although changes in intention may lead to changes in behavior, the effects are mostly weak to moderate (16). Therefore, interventions based on determinant studies in which principally intention was predicted can be expected to have some limited efficacy. A second limitation of the above-mentioned studies on oral health behavior is that simple and, according to oral hygiene standards and based on the worldwide consensus of oral health professionals, incomplete measures of actual OHB were used.

Given these limitations, and because of the precisely optimal self-care OHB as recommended by oral health professionals and the lack of a complete measure of this behavior, the present study was aimed at developing a new measure of actual oral hygiene behavior (OHB) and immediately investigating its social cognitive determinants, using the theory of planned behavior (TPB) (17, 18). Notable, in this study we focused exclusively on transparent OHB, and not on intention to perform behavior, such as just tooth brushing and flossing frequency.

A much more elaborate index for OHB was used in this study. It is well known among oral health professionals that optimal self-care OHB is not simply a matter of daily removal of dental plaque by 'just tooth brushing and flossing'. Flossing is often neglected, and tooth brushing is often not done in the way it should be done (11). Optimal OHB concerns some other behaviors in addition to just accurate tooth brushing and flossing. Although the notion that there is little evidence about the meaningfulness of all the detailed components, the American Dental Associations, ADA (19)

recommends a daily regimen of at least brushing (using a soft toothbrush, brushing for at least 2 min twice a day; once after breakfast and once before going to sleep, brushing softly/ without pressure, brushing stepwise by making small strokes –sort of massage– near the gum), thorough interdental cleaning (i.e., use of floss, tooth sticks, or interdental brushes at least once a day), and using fluoride containing toothpaste and tongue cleaning. Thus, to assess actual OHB completely and adequately, it is important to include all tooth brushing details and additional self-care OHB in a measure of OHB.

The TPB, which is the model most often used to map the psychological causes of health behaviors, was used to predict the psychological determinants of OHB. The predictive utility of the TPB has been supported in investigations of a wide range of behaviors. It has been reported in two meta-analytic reviews (14, 15) that the psychological factors identified using the TPB accounted for averages of 34% (14) and 27% (15) of the variance in behaviors. The TPB includes three psychological factors as independent determinants of behavioral intention, which in turn influences subsequent behavior:

- attitude (a person's positive or negative feelings about a given behavior, for example, 'I hate brushing my teeth twice a day, and cleaning interdentally at least once a day');
- subjective norm (the belief that specific important persons think that one should or should not perform a given behavior, for example, 'My parents think that I should brush my teeth twice a day, and use interdental aids at least once a day');
- perceived behavior control (a person's perception of his/ her capabilities to perform a behavior, for example, 'I think I will be able to brush my teeth twice a day, and use interdental aids at least once a day').

Overall, for OHB, the TPB suggests that the more positive the attitude toward oral self-care practices, the stronger the social norms (SN), and the higher the perceived behavior control, the more likely it is that an individual will perform an optimal OHB. However, this behavior is quite complex and entails a number of specific behaviors. Therefore, to develop and test the new measure of OHB, the present cross-sectional study was aimed at testing a potential social cognitive determinant of this specific OHB, namely social outcomes. Therefore, in addition to the above-mentioned three factors defined using the TPB, a measure of social

outcomes of oral health was added to the model. Health-related concerns are probably not the only motive for oral self-care. Study reports suggested that behaviors which may promote health are often performed for reasons other than improvements in general health; for example, tooth brushing may be engaged in to look more attractive (20). Indeed, as noted in a review of the literature on physical attractiveness, oral health may have an important, although often neglected, effect on a person's appearance. According to Sugiyama, from an evolutionary point of view, '...strong, even white teeth provide a constellation of cues to health, developmental history, masticatory efficiency, and genotypic quality, and are thus predicted to be attractive' (21, p. 310). In a similar vein, it has been suggested that unhealthy teeth are perceived as negatively affecting a person's image (22). In the present research, therefore, we assessed not only the perceived health consequences of oral hygiene self-care but also the perceived social consequences, i.e., how healthy teeth might affect a person's interpersonal interactions. According to the TPB model, individuals make rational decisions based in part on their oral health knowledge (OHK). In addition, people who have assimilated OHK and experienced some control over their personal oral health are more likely to adopt OHB (13, 23); therefore, this OHK variable was assessed too (Fig. 1).

Overview of present research

The first aim of this study was to develop a new, elaborate index for desirable OHB. An initial inventory was made of all behaviors identified as relevant for oral hygiene self-care. The final index was constructed on the basis of a Delphi method.

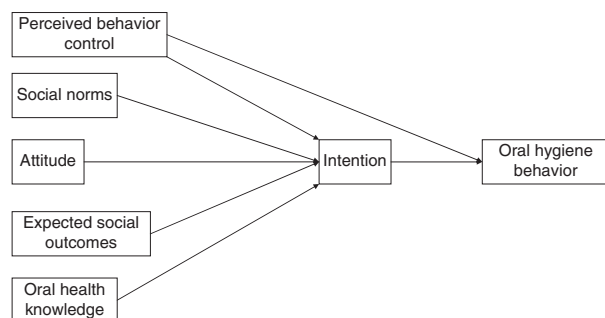


Fig. 1. Model theory of planned behavior, including expected social outcomes and oral health knowledge.

The second aim of the present study was to examine the relevant predictors of OHB as assessed using the new index. These predictors were the variables specified in the TPB. As mentioned before, a measure of expected social outcomes (ESO) of having healthy teeth and a measure of OHK were also used as predictors.

Materials and methods

Permission for this cross-sectional study was obtained from the ethical committee of the Faculty of Behavioral and Social Sciences, University of Groningen, and the study was conducted according to universal ethical principles.

Procedure

From 31st October 2005 (the start of 'National Brushing Week 2005') to 19th December 2005, the questionnaire was administered to a convenient sample of the Dutch population. The questionnaire was published on the Internet, and subjects were invited via several websites concerning general and oral health to fill in the questionnaire. During 'National Brushing Week 2005', radio audiences in the Groningen region were informed through an interview on the local radio station, and about 150 dental and dental hygienist practices in all provinces in the Netherlands were informed by e-mail about the online research. In addition, about 200 dentists and dental hygienists received posters and flyers to hand out to their patients to invite them to participate in this study. For students, participation announcements were placed on intranet and in student newspapers of the University of Groningen and of Hanze University Applied Sciences Groningen.

To check whether people had answered the questionnaire more than once, they were asked to mention their postal code. In the Netherlands, each street and generally each side of a street has a unique postal code. If someone answered the questionnaire with the same postal code as a previous respondent, to be on the safe side, he or she was excluded from the sample.

Development of measures of oral hygiene behavior (OHB)

For the preliminary version of the OHB part of the questionnaire, relevant items concerning OHB were defined by the first author based on the literature and on her experience as a dental

hygienist. A two-round Delphi method (24) to identify the experts' views on a broader range of relevant OHB was then carried out. In the first round, the list of items was submitted to the dental professionals of the Center for Dentistry and Oral Hygiene, *Hanze University, Applied Sciences, Groningen, Department of Oral Health Care*, University Medical Center Groningen, University of Groningen, with the request to evaluate this list and to mention additional relevant behaviors. A total of 12 experts, including one dietician, three dentists, one PhD student in dentistry, two professors in dentistry, and five dental hygienists, participated in this round. They added a number of oral hygiene-related behaviors, many on a specific level, for example, breastfeeding, use of cleaners for prosthesis, use of stain-removers, thumb-sucking, pencil-chewing, etc. For the final OHB questionnaire, the oral health behaviors were clustered into subcategories: personal oral (home) care (e.g., frequency of tooth brushing, use of fluoride-enriched toothpaste, tongue cleaning) and professional dental health care (e.g., frequency of dental check-up or dental hygienist visits). A group of two dentists, one PhD student in dentistry, and four dental hygienists (who work as lecturers in the *Department of Oral Health Care*) evaluated the relevance of these clusters. There was concerning the quality a degree of consensus among the experts on these clusters of oral hygiene-related behaviors.

The final set of most relevant oral hygiene behaviors (28 items) was included in the digital questionnaire for 'Research on Oral Health Care 2006'. Items concerning, for example, personal oral (home) care practices were evaluated by determining the percentages of responses on all these items. For the participants who responded, there was low positive response of a number of items, so these items were removed from further consideration; for instance, 74% never used mouth spray and 98% never used medical bandage or cocktail sticks for interdental cleaning.

The new index for OHB (eight items), a method for assessing and evaluating actual oral self-care practices of individuals and population groups, was constructed using the most applicable items, such as tooth brushing (frequency, time of brushing, measures of force, duration in minutes, method, and use of fluoride toothpaste), interdental cleaning (use of floss, tooth sticks, interdental brushes), and tongue cleaning. Based on the author's experience and the relevant literature,

weights (generally based on worldwide consensus for what is relatively most important) were assigned to all these items. A new Delphi-method round, involving the same group dentists and dental hygienists, was then performed to evaluate the index and the weights. An adequate level of consensus was once again reached among the experts, and consequently only minor modifications to the index and the weights were necessary (see Table 1).

Development of measures of determinants concerning OHB

Index for oral health knowledge (OHK). Oral health knowledge refers to the degree to which a person has sufficient or insufficient knowledge of oral health issues. Based on the literature and on the author's own experience, a short list of relevant questions about oral health issues was compiled; this was examined by two other lecturers of the Dept. of Oral Health Care. The index consisted of a number of items to reveal the status of the individual's OHK. Because of a too small number of dichotomy items, this index was not considered a valid scale. However, the face validity of the index for OHK was acceptable.

Expected social outcomes and TPB variables. In addition to a test of the new index for OHB, a measure of social outcomes of oral health was developed in the same manner as described for OHK. The ESO scale of having healthy teeth included six items. The scales used for measuring the three TPB variables (ATT, SN, and PBC) were constructed according to Ajzen (17).

Questionnaire

General part of the questionnaire. The initial questionnaire included 122 items divided into seven parts, including a few demographic questions on matters such as gender, age, nationality, education, and marital status. Level of education was categorized as low, medium or high. In the Netherlands, low educational level refers to vocational training, medium level to advanced vocational training, and high level to college/university training. These and other items about dental history, experiences, and dental health status were open-ended, multiple choice, or to be answered on bipolar adjective rating or Likert scales.

Oral hygiene behavior. Oral hygiene behavior was measured using the new index for OHB (eight items with respect to tooth brushing, interdental cleaning and tongue cleaning). For example, the

Table 1. Index for oral hygiene behavior (OHB index): Values ('weights') and percentage per item, $N = 487$

Items	Values	Weight	Percent
Frequency of tooth brushing	'Twice a day' or 'more than 2 times a day'	2	82.8
	'Once a day'	1	16.4
	'Not every day'	0	0.8
Moments of tooth brushing	Three times or more a day, including 'After dinner in evening' and 'Before going to sleep'	4	42.7
	Twice a day		
	'Morning after breakfast' and 'Before going to sleep'	3	15.9
	'Morning before or after breakfast' and 'Noon'	2	16.2
	'Morning before breakfast' or 'Noon' and 'Before going to sleep'	2	19.5
	'After dinner in evening' and 'any other moment' or all combinations	1	5.8
	Once a day		
	'Before going to sleep'	1	9.7
Measure of force of tooth brushing	'Any other moment' than 'Before going to sleep'	1	6.4
	Softly ('1, 2, 3')	2	25.1
	Softly/Forcefully ('4, 5')	1	63.7
Duration of tooth brushing	Forcefully ('6, 7')	0	11.3
	'2 min' or '3 min'	2	65.7
	'Longer than 3 min' or 'One minute'	1	28.1
Method of tooth brushing	Shorter than 'One minute'	0	6.2
	'Bass-method'	2	17.5
	'Horizontal movement' or 'Combination of methods'	1	39.1
Fluoride toothpaste	'Vertical movement' or 'Circular movement'	0	43.1
	'Toothpaste with fluoride'	1	76.0
Interdental cleaning	'Toothpaste without fluoride' or other alternatives	0	24.0
	'At least once a day' floss and/or tooth sticks and/or interdental brushes	2	26.7
Tongue cleaning	'Not every day' interdental cleaning	1	54.8
	'Never' interdental cleaning	0	18.5
	'Every day'	2	20.5
	'Sometimes'	1	45.0
	'Never'	0	34.5

item 'I brush my teeth as follows:' was supported by pictures showing different brushing methods. After the item scores were assigned weights, the item values were calculated and a sum score was computed. The sum OHB score on this index could range from 0 to 16. A high sum score indicated a high level of self-care OHB.

Oral health knowledge. This index for OHK consisted of 16 items to reveal the status of the individual's oral health knowledge. Some examples are, 'For teeth maintenance, it doesn't matter how many times I eat during a day, as long there is no sugar in the food', 'A gum inflammation can disappear by itself', 'To prevent caries, I have to brush especially on the crown covers', 'The older you get, the more your teeth color', 'Gum bleeding is a sign of a periodontal disease', 'When brushing one's teeth it is important to put little pressure on the tooth-brush', and 'The more often I brush my teeth on a day, the better it is for my teeth'. All items were scored with 1 = *yes* or 0 = *no*, and a sum score was computed, so that a total OHK score was formed

for each respondent (ranging from 0 to 16). The higher the total score, the higher the individual's knowledge of oral health issues.

Expected social outcomes. Expected social outcomes (ESO) of having healthy teeth included six items (Cronbach's $\alpha = 0.82$), i.e., 'People judge each other in part on the basis of their teeth', 'In social contacts well maintained teeth are important', 'It is embarrassing when someone has badly maintained teeth', 'Someone's teeth are important for the first impression he or she makes', 'I appreciate it when people with whom I socialize have well maintained teeth', and 'In social contacts fresh breath is important' Responses varied from 1 = *disagree* to 5 = *agree*, and a sum score (ranging from 6 to 30) was computed by summing up scores on all six items that measured the concept ESO.

Variables of TPB and focal oral hygiene behavior

In accordance with the TPB, the respondents' ATT, SN, and PBC of the focal OHB were assessed using

a total of 17 items. The focal OHB was described as 'brushing your teeth twice a day (once after breakfast and once before going to sleep, using a soft-bristled toothbrush and fluoride containing toothpaste; brushing softly/ without pressure for at least 2 min; brushing stepwise by making small strokes –sort of massage– near the gum, along the inside and the outside, and on the jackdaw areas. In addition to the tooth brushing, daily interdental cleaning, (i.e., the use of floss, tooth sticks, or interdental brushes at least once a day), and tongue cleaning is also recommended'.

Attitude

Attitudes (ATT) toward this focal OHB were measured using nine-worded statements in a semantic differential format ($\alpha = 0.83$). The respondents indicated on 7-point scales how they evaluated this advised OHB, on the dimensions 1 = *unimportant* to 7 = *important*, 1 = *unpleasant* to 7 = *pleasant*, and so on: *unhealthy–healthy*, *negative–positive*, *annoying–not annoying*, *not useful–useful*, *boring–exciting*, *painful–painless*, and *stupid–smart*. A sum score for respondents' ATT was constructed by adding the nine items (ranging from 9 to 63). Higher scores indicate a more positive attitude.

Social norms

To assess SN toward OHB, the respondents rated the perceived opinions of seven different significant others with respect to taking better care of their teeth, e.g., 'my dentist', 'my dental hygienist', 'the dental nurse', 'my partner', 'my family (parents, brothers, and sisters)', 'my friends', and 'my colleagues'. Because of near nonresponse on the items concerning 'my dental hygienist' and 'the dental nurse', these two items were removed from the scale. Thus, the final 7-point scale for SN was based on five items instead of the original seven items ($\alpha = 0.92$). A sum score on this SN scale varied from 5 to 35.

Perceived behavioral control

Perceived behavioral control (PBC) was measured using a sum score constructed from three items ($\alpha = 0.71$), e.g., 'If I wanted to, I could take care of my teeth as described', which was answered with endpoints 1 = *don't agree* to 5 = *agree*, 'I find it difficult or easy to take care of my teeth based on the daily OHB', with the endpoints 1 = *difficult* to 5 = *easy*, and 'I am able to take care of my teeth as described', which was answered with endpoints 1 = *don't agree* to 5 = *agree*. The sum score for

respondents' PBC was constructed by adding the three items (ranging from 3 to 15).

In all three cases, the mean sum scores of each of these scales were assessed via calculation of means, and high sum scores indicated a positive attitude, strong perceived approval from significant others, and a high level of PBC of the focal OHB.

Results

Four hundred and eighty-seven participants were examined; eighty-two percent of the participants were women; 97% were of Dutch nationality; the mean age was 28.4 years [SD = 11.93; (12–67)]. Sixty-five percent of the respondents were unmarried, and 77% had no children. The highest level of education for 42% of the participants was high school; 31% had polytechnic or university level. About a quarter of the group (26%) had a lower level of education. The frequencies in percentages of the items concerning the OHB index are presented in Table 1. The means, standard deviations, and range of the total score on the OHB index were computed, and the distribution of scores was approximately normal. The individual OHB score is an indicator of self-reported oral hygiene self-care practices.

The mean scores with standard deviation, and the range values of the main variables, i.e., ATT, SN, PCB, ESO, and OHK, for the whole sample are presented in Table 2. It can be seen that participant's attitude toward the focal OHB was quite positive. Participants attached much value to positive social outcomes of having healthy teeth, and their knowledge of oral health was also good. Participants reported hardly any pressure from

Table 2. Cronbach's α , Range, Means, and Standard deviation (SD) for the main variables

Variables	Cronbach's α	Range	Mean (SD)
Attitude ^a	0.83	9–63	50.04 (7.12)
Social norms ^b	0.92	5–35	11.39 (6.53)
Perceived behavioral control ^a	0.71	3–15	11.97 (2.47)
Expected social outcomes ^a	0.82	6–30	25.38 (3.56)
Oral health knowledge ^a	–	0–16	12.57 (1.63)
Oral hygiene behavior ^c	–	0–16	10.56 (2.45)

Note. ^a $n = 487$; ^b $n = 421$; ^c $n = 478$.

their social environment to perform this behavior and felt they had considerable control over carrying out the oral hygiene self-care practices. For instance, the reported results of the OHB index showed that two-thirds of the respondents brushed their teeth as recommended by professionals, 2 min twice a day. In addition, 76% used toothpaste with fluoride, the percentage that used interdental cleaning aids at least once a day was just over 25%, and between 20% to 45% cleaned their tongue everyday or sometimes.

In addition, correlational analyses were carried out to establish the direction and magnitude of the associations between the variables (Table 3). OHB was found to correlate positively and significantly with ATT, PBC, ESO, and OHK and negatively and significantly with SN. According to the TPB, subjective norms are positively associated with behavior, but in this study SN are not. All other relations are in the expected directions.

Finally, linear regression analysis was performed to examine the multivariate relationships of the TPB variables and the two additional variables, expected social outcomes and oral health knowledge, with OHB (Table 4). All variables were entered at once. This model proved to be significant and accounted for 32.3% of the variance in self-reported OHB. The TPB variables and OHK emerged as significant predictors of OHB. In these multivariate analyses, ESO was no longer related significantly to OHB.

The finding that ESO was related to OHB in a univariate analysis but not in the multivariate analysis might result from the relationship of ESO with OHB being mediated by one or more of the other independent variables. Generally speaking, the criteria for a potential mediation are that (i) ESO should be significantly related to the mediator, (ii) ESO should be significantly related to OHB in the absence of the mediator, (iii) the mediator should be significantly related to OHB, and (iv) the relationship of ESO with OHB should decrease

Table 4. Linear regression of self-reported oral hygiene behavior (OHB) on the theory of planned behavior variables, expected social outcomes (ESO) and oral health knowledge (OHK)

Determinants	Self-reported OHB Beta	SE Beta
Attitude	0.18*	0.017
Social norms	-0.16*	0.016
Perceived behavioral control	0.30*	0.050
ESO	0.08	0.029
OHK	0.17*	0.061

Note. In total model (* $P < 0.001$). $R^2 = 0.32$ $F(5,415) = 41.02$, $P < 0.001$.

upon addition of the mediator to the model (25). A Sobel test (26) reveals whether a mediator had influenced the relationship of ESO with OHB.

In this model, there were three variables that may be considered mediators: (i) SN; that is, the individual's expectations about the importance of oral health in social interactions (ESO) may contribute to the construction of ideas about how others think the individual should behave, (ii) ATT; this idea is theoretically plausible too and means that the individual's expectations about the importance of oral health in social interactions (ESO) may contribute to the person's own beliefs or ideas about having a favorable or unfavorable evaluation or appraisal of this specific OHB, and (iii) PBC; that is, the individual's expectations about the importance of oral health in social interactions (ESO) may enhance the motivation to engage in OHB and thus contribute to the construction of ideas about the person's own abilities to perform the given behavior.

The findings of regression analyses showed that the criteria for mediation were met by all three separate variables. In addition, the Sobel test revealed that the changes for all the variables separately were significant, i.e., the relationship of ESO with OHB decreased upon addition of the mediator. These results show that the relationship

Table 3. Intercorrelations (Pearson's) between the main variables and oral hygiene behavior (OHB) score

Variables	1	2	3	4	5	6
1. Attitude ^a	-					
2. Social norms ^b	-0.34*	-				
3. Perceived behavioral control ^a	0.57*	-0.33*	-			
4. Expected social outcomes ^a	0.33*	-0.18*	0.22*	-		
5. Oral health knowledge ^a	0.11**	-0.09	0.10**	0.14*	-	
6. OHB score ^a	0.42*	-0.35*	0.46*	0.24*	0.22**	-

Note. ^a $n = 487$; ^b $n = 421$. * $P < 0.001$; ** $P < 0.05$.

between ESO and OHB was in part mediated by SN, ATT, and PBC (Table 5).

Apart from these mediations, ESO also had an independent relation with OHB that was independent of SN; ESO and ATT both had a unique relation with OHB. ESO also had an independent relation with OHB that was independent of PBC.

Discussion

The first phase of this cross-sectional study consisted of the development of a new index for oral hygiene behavior (OHB index). The OHB index appears to be a useful method for assessing and evaluating oral hygiene self-care practices of individuals. In contrast to the 4-item oral hygiene scale constructed from self-reported tooth brushing and dental flossing (27), this new OHB index included all brushing details and other potential components of personal oral hygiene regimens, such as the use of tooth sticks, interdental brushes, toothpaste with fluoride (28), and tongue cleaning (29). This new OHB index was used to measure realistic preventive oral hygiene self-care behavior, and given the relatively low number of items, and the substantial variety in the content of the items; the index had a sufficient internal structure, as was apparent from its face validity. Especially note-

worthy is the fact that the total scores in this population were normally distributed; many scales or indices used in the behavioral sciences have a skewed distribution. Underlining the validity of the OHB index, it correlated with all variables of the model of TPB as well as with the variables of ESO and OHK. The real test of a new measurement system such as the OHB index is when it is employed in relation to general oral health and needs to be used in other populations in the Netherlands and abroad (30–33).

In this study, we also determined the predictors and the predictive power of the TPB and two other variables, ESO and OHK related to OHB. Regression analysis indicated that PBC was the best predictor of OHB and explained, together with ATT, SN, and OHK, 32.3% of the variance in self-reported OHB. Different from previous and recent studies, in which social cognitive models were used for the prediction of intention and behavior relevant to oral health (22, 34–39), in the present study, we used actual oral hygiene self-care behavior assessed using the OHB index as focal behavior (cross-sectional rather than prospective measure of behavior), instead of exclusively the intention to brush teeth or to use dental floss. The findings of this study are consistent with evidence from previous research in which was founded that TPB variables accounted for comparable percentages of the variance dental hygiene behavior (i.e., just tooth brushing and flossing) (8). The present results are also consistent with the findings of meta-analyses to investigate a wide range of health behaviors, which have shown that the TPB explains between 27% and 34% of the variance in behavior (14, 15).

Whereas the TPB variables (PBC more than ATT and SN) and also OHK emerged as significant independent predictors of OHB, ESO of having healthy teeth did not independently predict variance in OHB scores. As proposed, the relationship between self-efficacy and outcome expectancies (in this study, PBC and ESO) is that outcome expectancy beliefs affect self-efficacy estimates (10). Because ESO is generally dependent on PBC, it is possible that ESO did not add much to the prediction of behavior (in this study, OHB). The role of particular self-efficacy and ESO in OHB has not been adequately tested. For example, researchers had developed measures of self-efficacy and outcome expectancies in the oral hygiene domain, but did not explore the role of these variables in OHB (40). Also in a qualitative study, the role and formation of perceived self-efficacy in describing

Table 5. Criteria for mediation ESO → OHB to be met

	Beta	SE Beta	R ²	F
ESO → OHB	0.24	0.108	0.06	(1,485) = 29.79
SN as mediator				
ESO → SN	-0.18	0.048	0.03	(1,420) = 13.64
SN → OHB	-0.35	0.112	0.12	(1,420) = 59.56
Attitude (ATT) as mediator				
ESO → ATT	0.33	0.043	0.10	(1,485) = 57.09
ATT → OHB	0.42	0.101	0.18	(1,485) = 105.34
PBC as mediator				
ESO → PBC	0.22	0.044	0.05	(1,486) = 25.59
PBC → OHB	0.46	0.099	0.21	(1,486) = 129.79
Mediation analyses ^a		Beta		Sobel z
ESO → OHB				
With SN as mediator		0.18 (0.24)		3.22
With ATT as mediator		0.12 (0.24)		5.94
With PBC as mediator		0.15 (0.24)		4.87

ESO, Expected social outcomes; OHB, oral hygiene behavior; PBC, perceived behavioral control; SN, social norms.

^aBeta after test for mediation, between parentheses the original β , $P < 0.001$.

and understanding oral health behavior were examined (41). The present results are particularly in line with meta-analyses in which it has been found that PBC is, in general, a strong independent predictor of health behavior (14, 15, 18). In addition, as theorized earlier, the findings of mediational analyses showed that SN, ATT, and PBC mediated between ESO and OHB.

This study has some limitations that need to be addressed in future studies. First, the large proportion of female participants may have biased the results. Because of the selective sample of mainly relatively young, high-educated, unmarried women without children, these findings cannot be considered representative of the population as a whole. As known from past studies, there are apparent differences in OHB across demographic variables (e.g., gender, age, and lifestyle) and socioeconomic status. For instance, women brush their teeth more often than men, and people with a healthy lifestyle use more extra cleaning aids (5, 27, 42, 43). Although this does not imply that the relation between the variables of the TPB differ in different populations, it is recommended that our results be replicated in different groups. In a similar vein, online studies, though, can often be biased, as only highly motivated individuals with strong opinion respond. Another limitation is that some people had answered the questionnaire more than once. However, in the present study, duplication was impossible, because someone who had answered the questionnaire with the same postal code as a previous respondent was excluded from the sample. Recruitment by Internet will have excluded some elderly people who could not fill in the questionnaire too. Thus, we recommend examining our model using written questionnaires among senior citizens, even though Internet use is becoming increasingly common among the elderly. In addition, a more controlled or alternative sampling strategy and implementation of that strategy may be also crucial to ensuring valid results. Finally, TPB may perform differently in different sociocultural contexts; it is, therefore, important to test the applicability of the TPB, for instance, in developmental countries as well (5).

The present study may have several implications, as it provides support for the TPB model in predicting actual OHB as recommended by dental professionals. Our findings are particularly important because we developed an elaborate index for OHB that corresponds closely with what dental professionals consider relevant OHB. Therefore, it is safe to make practical recommendations based

on our research. Our findings suggest that, to increase oral hygiene self-care behavior, interventions should target not only the well-known determinants from the TPB and OHK but especially the target individual's ESO of having healthy teeth.

For instance, to increase individual's motivation to perform optimal OHB, PBC seems to be the most important factor to influence, followed by ATT, OHK, and ESO. All factors had significant association with actual OHB, suggesting both a motivational and a structural educational approach. These findings may not only assist dental associations and dental schools but also dental hygienists in what was refers to as 'the most dignified tasks' of the dentists, i.e., educating patients in oral health and changing patient's oral hygiene habits (44). But also from a theoretical point of view, assessing behavior on a specific level as we did in the present research may contribute to a greater external validity of the findings. In conclusion, while the results of this study need replication in other samples to gauge the generalization of the findings, the expanded TPB model developed in the present research may be a fruitful perspective to guide future research and practice in OHB.

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