Modelling Health Belief Predictors of Oral Health and Dental Anxiety Among Adolescents Based on the Health Belief Model: A Cross-Sectional Study

Bilu Xiang
University of Hong Kong
Hai Ming Wong (wonghmg@hku.hk)
The University of Hong Kong https://orcid.org/0000-0003-3411-6442
Antonio P. Perfecto
University of Hong Kong
Colman P.J. McGrath
University of Hong Kong

Research article

Keywords: Dental anxiety, Health Belief Model, path analysis, oral health behavior, oral health, adolescent

DOI: https://doi.org/10.21203/rs.3.rs-31032/v1

Abstract

Background: A vicious cycle exists between dental anxiety, oral health behaviors and oral health status. Based on previous research, psychological factors of the Health Belief Model (HBM) are associated with oral health behaviors and oral health, and are likely involved in this cycle. However, little is known about the relationship between HBM factors and dental anxiety of adolescents. The purpose of this cross-sectional study was to investigate the relationship between health belief factors, oral health and dental anxiety based on the constructs of the HBM.

Methods: 1207 Grade 2 students from 12 secondary schools in Hong Kong were randomly selected and measured for the decayed, missing and filled permanent teeth (DMFT) index. Data for oral health behaviors, HBM constructs and dental anxiety were collected using questionnaires. The hierarchical entry of explanatory variables into logistic regression models estimating prevalence odds ratios (POR) were analyzed and 95% confidence intervals (95% CI) for DMFT and dental anxiety were generated. Path analysis was used to evaluate the appropriateness of the HBM as predictors for oral health behaviors, DMFT and dental anxiety.

Results: Based on the full model analysis, individuals with higher perceived susceptibility of oral diseases (POR: 1.33, 95% CI: 1.14-1.56) or girls or whose mother received higher education level were likelier to have a DMFT≥1, while those with higher perceived severity (POR: 1.31, 95%CI: 1.09-1.57), flossing weekly, DMFT≥1 or higher general anxiety level statistically increases the possibility of dental anxiety. The results from path analysis indicated that stronger perceived susceptibility, greater severity of oral diseases, less performing of oral health behaviors and a higher score of DMFT were directly related to increased dental anxiety level. Other HBM variables, such as perceived susceptibility, self-efficacy beliefs, cues to action and perceived barriers, might influence dental anxiety through oral health behaviors and caries status.

Conclusions: Clarifying the propositional structures of the HBM can help the future design of cognitive-behavioral therapy in reducing dental anxiety and preventing dental caries.

Background

A vicious cycle of dental anxiety, oral health behavior and oral health status has been hypothesized [1]. Multifaceted socio-economical and psychosocial aspects are involved in the onset of dental anxiety [1]. A 3-year cohort study demonstrated the crucial role of Decayed Missing Filled Teeth (DMFT) scores in the development of dental anxiety [2]. Psychological factors such as personality traits or attachment patterns are also important in the development and persistence of dental anxiety [3, 4]. Children with low psychological functioning tend to have higher levels of dental anxiety and increased social problems [3]. Moreover, self-rated oral health status can trigger dental anxiety which is mediated by certain cognitive vulnerabilities, such as threat or disgust [5]. Signs of depression and anxiety in adolescents [4], as well as higher psychological distress [6], are highly correlated to dental anxiety.

Dental anxiety among youth is a common problem in dental practice. The prevalence of dental anxiety among adolescents ranges from 9.4% to 19% [7]. Adolescence is a transitional phase from childhood to adulthood, with biological and psychological developmental changes occurring, such as social-networking [8]. In a retrospective study, 22% of respondents reported that their dental anxiety emerged in adolescence [9]. In establishing their health-related behavior and attitudes, dental avoidance in adolescents has the potential to influence their oral health in the short-term and long-term [10].

The Health Belief Model (HBM) is a theory which posits that one engages in particular health behaviors based on his belief towards susceptibility to illness and severity, and the perception that there are more benefits over barriers to taking action against illness [11, 12]. Previous research has found that the HBM can predict tooth brushing, flossing and dental visit behaviors [13, 14]. In addition, studies have demonstrated that stronger self-efficacy beliefs and greater perceived severity of oral diseases were related to increased tooth brushing frequency, which in turn was associated with better oral health status [15]. The HBM has also been applied in mental health and anxiety relief contexts [16]. Nevertheless, we are unaware of studies investigating the importance of HBM variables in oral health and dental anxiety contexts.

The objectives of the study were (a) to identify psychological factors contributing to oral health and dental anxiety based on the HBM and (b) to explore the direct and indirect associations of the HBM factors on oral health and dental anxiety via oral health behaviors among Hong Kong adolescents. To the best of our knowledge, this is the first study employing a theoretical model to explore HBM constructs involved in dental anxiety via oral health behaviors and oral health status. A well-known conceptual model of influences on health-related behaviors has been described by Janz and Becker et al [17]. Based on the previous model, we hypothesized that oral health beliefs (as conceptualized by HBM) involving higher susceptibility, greater severity, more barriers, fewer perceived benefits and weaker self-efficacy, would be associated with increased dental anxiety scores directly or indirectly through oral health behaviors and oral health status.

Methods

Participants and Sampling

The study was approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB) (IRB HKU: UW18–029). We hypothesized the prevalence of dental anxiety in the adolescent population as 19.5% based on previous studies [7]. The percentage frequency of the estimated dental anxiety was set at 19.5% with confidence limits of ± 2.5% and a significant level set at 5%. The sample size was calculated for 965 subjects. Accounting for an 85% response rate, 1136 subjects were required for recruitment. A list of government-funded secondary schools was retrieved from the official website of the Education Bureau, Hong Kong Special Administrative Region (http://www.edb.gov.hk). All secondary schools were coded respectively in the list of their district area (there were four districts of the Hong Kong SAR, i.e. New Territories West, New

Territories East, Kowloon and Hong Kong Island). Three schools were randomly selected from each of the four districts using the bowl method, given that there were approximately 100 Grade 2 students in each secondary school. The inclusion criterion included every Grade 2 student from the 12 invited schools. Students with severe systemic diseases, physical, or psychological disabilities were excluded. All eligible adolescents in the participating schools were approached. Written informed consents from parents were obtained prior to their child's participation. The data were collected through self-reported questionnaires and clinical oral examinations from September 2018 to November 2018.

Measures

The questionnaire was filled by participants under the supervision of the teacher-in-charge in order to prevent student interaction and maintain data integrity. Age and the gender of participants were requested. The following oral health-related behaviors were measured: frequency of tooth brushing (1. Less than twice a day; 2. Twice or more a day), flossing frequency (1. Never or less than once a week; 2. Once or more a week), sugar consumption (1. Several times a week or daily; 2. Rare) and dental visits (1. No regular dental visit; 2. Have an annual dental visit). Each beneficial behavior scored 1 while discouraged behavior scored 0. The oral health behavior (OHB) score was calculated by summing up the scores of the four beneficial behaviors (ranged from 0–4), with a higher score indicating a higher level of oral health behavior.

The constructs of the HBM were measured using the OHBQAHBM, which consists of 35 items related to 6 interrelated components of the HBM; Perceived Susceptibility (2 items), Perceived Benefits (7 items), Perceived Barriers (6 items), Cues to Action (3 items), Perceived Severity (7 items) and Self-efficacy (10 items) [18]. Each item was scored on a scale from 1–5 points and the average score for each subscale was calculated thereby representing the individual's belief towards that specific component. For each subscale, a higher average score indicates a stronger feeling towards its corresponding component.

Dental anxiety was assessed using the Modified Child Dental Anxiety Scale consisting of 8 questions [19]. Responses were scored from 1–5 points, giving a total score of 8–40. A higher score indicates a higher dental anxiety level. A score under 20 indicates no dental anxiety while a score equaling 20 or higher is indicative of dental anxiety [20]. General anxiety levels were measured using the Chinese version of the Generalized Anxiety Disorder–7 [21]. A 7-item self-rating questionnaire, each item is scored 0–4 points, giving a total range from 0 to 28. A higher score indicates a higher general anxiety level.

Two trained and calibrated dentists conducted dental examinations in schools using dental mirrors with added lights and Community Periodontal Index probes. Dental caries diagnosis was determined according to the criteria of WHO [22]. DMFT (number of decayed, missing, and filled teeth due to caries) score was calculated. To avoid measurement bias, the clinical examinations were performed unannounced in advance. 10% of children from each school were randomly selected and re-examined on the same day. Acceptable intra- and inter-examiner reliability was achieved (kappa = 0.90–0.94).

Data Analysis

The percentage of missing values of the questionnaire was 0.3–7.0%. For eligible participants, an MCAR (missing completely at random) analysis in SPSS was undertaken to test whether data were missing at random. The p-value for the MCAR analysis were all > 0.05, signifying that our data were missing completely at random. The expectation maximization algorithm was used to replace the missing values with predicted values.

Correlation tests confirmed weak associations among the HBM factors, oral health and dental anxiety (Spearman's Rho correlation range 0.1–0.4). Variables were not excluded due to collinearity. Using bivariate analyses, prevalence, corresponding confidence intervals, and p-values were generated using the 'cross-tabulations' approach in SPSS. Blocks of explanatory variables were entered into a binary logistic regression model using a hierarchical methodology, as predicated by our conceptual model (Figure 1). The dependent variable of these models were DMFT ≥ 1 or DMFT = 0 and the existence of dental anxiety. The HBM construct factors were entered into Model 1, with the main effects presented as prevalence odds ratio and 95% confidence interval (95% CI). The modifying factors were entered into Model 2 and oral health behaviors entered into Model 3. For DMFT, the full model (Model 4) comprised all factors. For dental anxiety, DMFT was entered into Model 4 and general anxiety entered into Model 5. The full model (Model 6) for dental anxiety comprised all factors. It is important to note that the full model was built based on *a priori* selection of covariates according to the conceptual model (Figure 1) as opposed to covariate selection based upon bivariate statistics. The degree of attenuation was calculated by the 1–[ln (adjusted OR)/ln (unadjusted OR)] formula [23]. A normality distribution test for general anxiety score, DMFT and HBM variables was used. Since the data were not normally distributed, a Mann-Whitney U test was used to compare the median between groups with dental with and without anxiety. The chosen level of significance was $p < 0.05$ (two-tailed). The above mentioned statistical analysis was conducted using SPSS 25.0.

To explore the relationship between HBM variables, general anxiety, OHB and DMFT, a path analysis was performed using AMOS 22.0. In this model, oral hygiene beliefs were posited to be related to dental anxiety both directly and indirectly through oral health behaviors and oral health status. If the p-value of the chi-square statistics (χ^2) exceeded 0.05, the hypothesized path analysis was retained. The model fit was evaluated using multiple fit indices, such as the comparative fit index (CFI), goodness-of-fit index (GFI), Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA) and the standardized root mean squared residual (SRMR). Cut-offs to consider the model a good fit to the data were CFI > 0.90, TLI > 0.90, RMSEA < 0.06 and SRMR< 0.08 [24].

Results

Sample Characteristics

Of the 1207 eligible participants, 1159 participated in clinical examinations and returned questionnaires (response rate = 96%). The mean age of the participants was 14.32 ± 0.68 and the proportion of girls were 46.6%. The prevalence of dental anxiety among Hong Kong adolescents was 40.5%. Nearly half of

adolescents (45.0%) had a DMFT ≥ 1 (Table 1). 67.9% adolescents brushed their teeth at least twice a day, but only 20.3% flossed weekly. Most adolescents (81.7%) consumed sugar every week and less than a quarter (23.3%) had annual dental visitation plans. A high proportion of adolescents with DMFT ≥ 1 were girls with highly educated parents who had stronger perceived susceptibility of oral diseases and more perceived barriers towards performing OHB (Table 1). Dental anxiety among participants was associated with being a girl, lower flossing rates, higher sugar consumption rates, DMFT ≥ 1, stronger perceived susceptibility, stronger perceived severity, lower self-efficacy and higher general anxiety levels (Table 1).

Table 1
The relationship between dental anxiety and oral health behaviors, oral health status, HBM variables and general anxiety.

Variable	Total group	DMFT=0	DMFT≥1	OR (95% CI)	No dental anxiety	Dental anxiety	OR (95% CI)
Gender %							
Boys	618 (53.4)	369 (57.9)	250 (47.9)	1	388 (56.6)	225 (48.2)	1
Girls	540 (46.6)	268 (42.1)	272 (52.1)	1.50 (1.19-1.89)*	298 (43.4)	242 (51.8)	1.40 (1.11-1.77)*
Father's education level %							
Elementary school	84 (7.8)	39 (6.6)	45 (9.3)	1	49 (7.7)	35 (8.0)	1
High school	741 (68.7)	400 (67.3)	341 (70.3)	0.74 (0.47-1.16)	446 (69.8)	293 (67.0)	0.92 (0.58-1.45)
College or above	254 (23.5)	155 (26.1)	99 (20.4)	0.55 (0.34-0.91)*	144 (22.5)	109 (24.9)	1.06 (0.64-1.75)
Mother's education level %							
Elementary school	128 (11.7)	54 (8.9)	74 (15.0)	1	74 (11.4)	54 (12.2)	1
High school	740 (67.5)	410 (67.9)	330 (66.9)	0.59 (0.40-0.86)*	444 (68.2)	294 (66.4)	0.91 (0.62-1.33)
College or above	229 (20.9)	140 (23.2)	89 (18.1)	0.46 (0.30-0.72)*	133 (20.4)	95 (21.4)	0.98 (0.63-1.52)
Monthly family income %							
HK$15,000 or below	183 (18.1)	91 (16.3)	92 (20.3)	1	106 (17.8)	77 (18.6)	1
	688	383	305	0.79	408	279	0.94

HK$15,001 -50,000	(67.9)	(68.5)	(67.2)	(0.57-1.09)	(68.3)	(67.2)	(0.68-1.31)
HK$50,001 or above	142 (14.0)	85 (15.2)	57 (12.6)	0.66 (0.43-1.03)	83 (13.9)	59 (14.2)	0.98 (0.63-1.53)
Tooth brushing behaviors %							
Once a day or less often	372 (32.1)	201 (31.6)	171 (32.8)	1	210 (30.6)	159 (34.0)	1
Twice or more a day	787 (67.9)	436 (68.4)	351 (67.2)	0.95 (0.74-1.21)	476 (69.4)	308 (66.0)	0.86 (0.67-1.10)
Flossing behavior %							
Never or less than once a week	924 (79.7)	503 (79.0)	421 (80.7)	1	530 (77.4)	392 (83.9)	1
At least once a week	235 (20.3)	134 (21.0)	101 (19.3)	0.47 (0.67-1.20)	155 (22.6)	75 (16.1)	0.65 (0.48-0.89)*
Sugar consumption %							
Rare or less than once a week	212 (18.3)	509 (79.9)	438 (83.9)	1	141 (20.6)	69 (14.8)	1
Several times a week or daily	947 (81.7)	128 (20.1)	84 (16.1)	1.3 (0.97-1.78)	545 (79.4)	398 (85.2)	1.50 (1.09-2.05)*
Annual dental visit %							
No	889 (76.7)	478 (75.0)	411 (78.7)	1	520 (75.8)	363 (77.7)	1

Yes	270 (23.3)	159 (25.0)	111 (21.3)	0.81 (0.62-1.08)	166 (24.2)	104 (22.3)	0.90 (0.68-1.19)
Variable	Total group	DMFT = 0	DMFT ≥ 1	p	No dental anxiety	Dental anxiety	***p***
Perceived susceptibility (Mean ± SD)[a]	2.65 ± 0.92	2.51 ± 0.91	2.82 ± 0.88	<0.001	2.57 ± 0.92	2.76 ± 0.88	< 0.001
Perceived severity (Mean ± SD)[a]	3.71 ± 0.88	3.73 ± 0.89	3.67 ± 0.86	0.24	3.65 ± 0.90	3.81 ± 0.82	< 0.01
Perceived benefits (Mean ± SD)[a]	3.68 ± 0.59	3.68 ± 0.59	3.67 ± 0.58	0.54	3.67 ± 0.61	3.69 ± 0.54	0.60
Perceived barriers (Mean ± SD)[a]	2.27 ± 0.76	2.21 ± 0.75	2.35 ± 0.77	0.001	2.21 ± 0.76	2.37 ± 0.75	< 0.001
Cues to action (Mean ± SD)[a]	2.11 ± 0.91	2.10 ± 0.90	2.13 ± 0.94	0.90	2.12 ± 0.93	2.10 ± 0.89	0.82
Self-efficacy (Mean ± SD)[a]	3.47 ± 0.99	3.50 ± 1.00	3.42 ± 0.99	0.27	3.55 ± 0.99	3.34 ± 0.99	< 0.001
General anxiety score (Mean ± SD)[a]	4.81 ± 5.16	-	-	-	3.62 ± 4.65	6.56 ± 5.39	< 0.001
Variable	Total group	DMFT = 0	DMFT ≥ 1	OR (95% CI)	No dental anxiety	Dental anxiety	OR (95% CI)
Oral health (DMFT) %							
DMFT = 0	637 (55.0)	-	-	-	398 (58.0)	235 (50.3)	1

DMFT ≥ 1	522 (45.0)	-	-	-	288 (42.0)	232 (49.7)	1.36 (1.08-1.73)*

*Note. P-value < 0.05

[a]Note. Mann-Whitney U test was used given non-normal distribution.

For an unadjusted model of HBM variables, every increase of one unit in perceived susceptibility resulted in 1.44 times the odds for DMFT ≥ 1 (Table 2, Model 1). The addition of modifying factors to HBM variables attenuated the effect of perceived susceptibility on DMFT by 16% (Table 2, Model 2), while the addition of oral health behavior variables to HBM variables attenuated the odds by 10% (Table 2, Model 3). A strong perceived susceptibility persisted as a risk indicator for DMFT ≥ 1 in the final model, which included all covariates. In the full model, the odds of perceived susceptibility was attenuated by 22% (Table 2, Model 4). In addition, girls and low education level of mothers were also significantly associated with DMFT ≥ 1 in the full model (Table 2, Model 4).

Table 2
Multivariable models evaluating risk indicators for DMFT ≥ 1 among adolescents

	Model 1 (POR, 95% CI)	Model 2 (POR, 95% CI)	Model 3 (POR, 95% CI)	Model 4 (POR, 95% CI)
Perceived susceptibility	1.44 (1.25-1.65)*	1.36 (1.16-1.59)*	1.39 (1.21-1.61)*	1.33 (1.14-1.56)*
Perceived severity	1.00 (0.87-1.15)	0.94 (0.80-1.11)	1.01 (0.87-1.16)	0.94 (0.80-1.11)
Perceived benefits	0.98 (0.79-1.20)	1.05 (0.83-1.33)	0.97 (0.79-1.20)	1.05 (0.83-1.33)
Perceived barriers	1.16 (0.97-1.39)	1.16 (0.95-1.42)	1.15 (0.95-1.39)	1.17 (0.94-1.46)
Cues to action	0.96 (0.84-1.10)	1.00 (0.86-1.17)	0.98 (0.85-1.13)	1.02 (0.80-1.11)
Self-efficacy	1.02 (0.89-1.15)	1.00 (0.87-1.16)	1.01 (0.88-1.16)	1.00 (0.86-1.17)
Sex				
Boy	-	1	-	1
Girl	-	1.63 (1.25-2.12)*	-	1.65 (1.25-2.20)*
Father's education level				
Elementary school	-	1	-	1
High school	-	0.76 (0.46-1.25)	-	0.72 (0.43-1.19)
College or above	-	0.66 (0.37-1.21)	-	0.63 (0.34-1.15)
Mother's education level				
Elementary school	-	1	-	1
High school	-	0.58 (0.38-0.89)*	-	0.60 (0.39-0.92)*
College or above	-	0.56 (0.32-0.98)*	-	0.55 (0.32-0.98)*
Family income per month				
HK$15,000 or below	-	1	-	1
HK$15,001 -50,000	-	1.00 (0.69-1.43)	-	1.01 (0.70-1.46)

HK$50,001 or above	-	1.01 (0.61-1.68)	-	1.04 (0.62-1.74)
Tooth brushing behavior				
Once a day or less often	-	-	1	1
Twice or more a day	-	-	0.96 (0.73-1.28)	0.92 (0.67-1.27)
Flossing behavior				
Never or less than once a week	-	-	1	1
At least once a week	-	-	0.99 (0.73-1.35)	1.01 (0.71-1.42)
Sugar consumption				
Rare or less than once a week	-	-	1	1
Several times a week or daily	-	-	1.23 (0.69-1.26)	1.10 (0.76-1.60)
Annual dental visit				
No	-	-	1	1.07 (0.76-1.51)
Yes	-	-	0.93 (0.69-1.26)	
−2 Log likelihood	1558	1261	1508	1222
Nagelkerke R^2	0.042	0.072	0.042	0.074

Note: *p < 0.05

In the unadjusted model, the increase in perceived susceptibility, perceived severity, perceived barriers and decrease in self-efficacy significantly resulted in a higher chance of dental anxiety (Table 3, Model 1). In the full model, only perceived severity remained significantly associated with dental anxiety. The odds of perceived severity and dental anxiety was 1.31, which was attenuated by 14% (Table 3, Model 6). The addition of modifying factors increased the effect of perceived severity by 4%, while general anxiety attenuated it by 19% (Table 3, Model 2&5). In addition, flossing behavior, DMFT and general anxiety were also associated with dental anxiety in the full model (Table 3, Model 6).

Table 3
Multivariable models evaluating risk indicators for dental anxiety among adolescents

	Model 1 (POR, 95% CI)	Model 2 (POR, 95% CI)	Model 3 (POR, 95% CI)	Model 4 (POR, 95% CI)	Model 5 (POR, 95% CI)	Model 6 (POR, 95% CI)
Perceived susceptibility	1.20 (1.04-1.38)*	1.23 (1.05-1.43)*	1.19 (1.03-1.37)*	1.17 (1.02-1.35)*	1.15 (0.99-1.33)	1.16 (0.98-1.37)
Perceived severity	1.37 (1.17-1.59)*	1.39 (1.17-1.65)*	1.37 (1.17-1.60)*	1.37 (1.18-1.59)*	1.29 (1.10-1.51)*	1.31 (1.09-1.57)*
Perceived benefits	1.06 (0.86-1.31)	1.12 (0.89-1.43)	1.04 (0.84-1.30)	1.06 (0.86-1.32)	1.05 (0.84-1.31)	1.08 (0.84-1.39)
Perceived barriers	1.31 (1.09-1.57)*	1.25 (1.01-1.53)*	1.29 (1.06-1.57)*	1.30 (1.08-1.56)*	1.29 (1.07-1.56)*	1.17 (0.93-1.48)
Cues to action	0.93 (0.81-1.08)	0.95 (0.81-1.11)	0.95 (0.82-1.09)	0.94 (0.81-1.08)	0.97 (0.84-1.12)	0.99 (0.84-1.17)
Self-efficacy	0.84 (0.74-0.96)*	0.80 (0.69-0.92)*	0.87 (0.76-1.01)	0.84 (0.74-0.96)*	0.91 (0.79-1.04)	0.92 (0.78-1.09)
Sex						
Boy	-	1	-	-	-	1
Girl	-	1.42 (1.08-1.85)*	-	-	-	1.26 (0.94-1.69)
Father's education level						
Elementary school	-	1	-	-	-	1
High school	-	0.95 (0.58-1.58)	-	-	-	1.04 (0.61-1.77)
College or above	-	1.24 (0.68-2.26)	-	-	-	1.26 (0.67-2.37)
Mother's education level						
Elementary school	-	1	-	-	-	1
High school	-	1.04 (0.68-1.59)	-	-	-	1.15 (0.73-1.82)

College or above	-	1.13 (0.65-1.97)	-	-	-	1.55 (0.86-2.80)
Family income per month						
HK$15,000 or below	-	1	-	-	-	1
HK$15,001-50,000	-	1.09 (0.76-1.57)	-	-	-	1.13 (0.77-1.67)
HK$50,001 or above	-	1.02 (0.62-1.70)	-	-	-	0.93 (0.55-1.59)
Tooth brushing behavior						
Once a day or less often	-	-	1	-	-	1
Twice or more a day	-	-	0.91 (0.68-1.21)	-	-	0.82 (0.59-1.15)
Flossing behavior						
Never or less than once a week	-	-	1	-	-	1
At least once a week	-	-	0.74 (0.54-1.02)	-	-	0.66 (0.45-0.95)*
Sugar consumption						
Rare or less than once a week	-	-	1	-	-	1
Several times a week or daily	-	-	1.41 (1.01-1.96)*	-	-	1.13 (0.77-1.67)
Annual dental visit						

No	-	-	1	-	-	1
Yes	-	-	1.08 (0.79-1.46)	-	-	1.01 (0.70-1.45)
	Model 1 (POR, 95% CI)	Model 2 (POR, 95% CI)	Model 3 (POR, 95% CI)	Model 4 (POR, 95% CI)	Model 5 (POR, 95% CI)	Model 6 (POR, 95% CI)
Oral health						
DMFT=0	-	-	-	1	-	1
DMFT≥1	-	-	-	1.28 (1.00-1.63)*	-	1.34 (1.01-1.79)*
General anxiety	-	-	-	-	1.11 (1.08-1.14)*	1.11 (1.08-1.14)*
−2 Log likelihood	1512	1245	1456	1508	1441	1151
Nagelkerke R^2	0.051	0.066	0.059	0.055	0.129	0.146

Note:*p < 0.05

Path Analysis Modeling

After deleting several insignificant paths, the final model is depicted in Figure 2 and as shown, the model was well fitted (TLI = 0.99; CFI = 1.00; RMSEA = 0.01; SRMR = 0.01; $\chi2$ = 13.60; df = 11; p = 0.26). Regarding the direct effect, a significant path was noted from general anxiety to dental anxiety (β = 0.44, p<0.01). Consistent with this hypothesis, higher perceived susceptibility (β = 0.56, p = 0.03) and greater perceived severity (β = 0.72, p<0.01) were associated with greater dental anxiety. Significant direct paths were also found to OHB from perceived susceptibility (β = −0.07, p<0.05), self-efficacy (β = 0.20, p<0.01), perceived barriers (β = −0.25, p<0.01) and cues to action (β = 0.08, p = 0.02). Regarding the direct effects of OHB and DMFT on dental anxiety, both were significant (β = −0.74, p<0.01; β = 0.28, p = 0.02).

For indirect effects exerted through OHB and DMFT, perceived susceptibility, self-efficacy beliefs, cues to action and perceived barriers were equal to 0.05 (SE = 0.03, p = 0.03), −0.16 (SE = 0.05, p<0.01), −0.06 (SE = 0.03, p<0.01) and 0.19 (SE = 0.07, p<0.01). The majority of standard errors of the unstandardized parameter estimates were small, indicating that values of the model parameters were estimated accurately.

Discussion

This study suggests that HBM factors are risk indicators for caries and dental anxiety among Hong Kong adolescents. After adjusting for socio-demographic factors and behavior covariates, the association of

perceived susceptibility with DMFT score and perceived severity in relation to dental anxiety was maintained.

We believe that this is the first study to examine the complex predictors regarding oral health and dental anxiety after accounting for the impact of HBM variables in a path analysis model of data. Our findings indicate that oral health beliefs (including HBM constructs) are associated with dental anxiety directly or indirectly via OHB and oral health.

In recent decades, pressure has been placed on therapeutics to reduce patients' anxiety in the long term without pharmacological use [25, 26]. Psychological treatments have displayed better improvement in dental anxiety prevention in the long term compared to the use of pharmaceuticals [27]. In our study, we identified the role of HBM psychological constructs on the severity of dental anxiety. Threat-related perceptions based on past experiences may bring negative expectations of dental treatment and trigger dental phobia [28]. From the perspective of the HBM, threat perceptions are based on two beliefs: perceived susceptibility and perceived severity [29]. Perceived susceptibility refers to the chance of obtaining a disease or a painful state; perceived severity refers to one's belief towards the effect and psychological harm the disease could create [29]. In previous research on preoperative anxiety, perceived severity was a risk factor for increased anxiety levels [30]. In this study, perceived severity and perceived susceptibility were positively correlated with dental anxiety directly.

Other variables from the HBM are able to predict dental anxiety via the oral health behavior path. The HBM theory also proposes that if an individual has sufficient self-efficacy, perceived benefits over barriers, and cues to action, he is more likely to perform a behavior [29]. Dental anxiety is a risk factor for caries in younger children [23] and individuals with poorer oral health practices are correlated with higher dental anxiety levels [31]. Our study results were consistent with previous studies and the HBM variables indicate that they are related to dental anxiety via OHB and caries status.

Limitations

One of the major limitations of our study is the cross-sectional study design of the work. Given the nature of the design, a causal relationship between psychological factors and dental anxiety cannot be determined. Thus, future work is necessary to test this relationship using a longitudinal study design. Another limitation of our study is the use of self-reported measures. It is possible that response bias may limit the effects of our results. The third limitation of our findings is that it may not be generalizable to older adolescents as differences in psychological and physical status exist between early adolescents and late adolescents [32]. Regardless, the importance of the HBM in oral health and disease should be investigated further.

Conclusions

The present study suggests directions and further steps to be taken to reduce dental anxiety and improve oral health status in adolescents. The need for cognitive-behavioral interventions is further evidenced by

the fact that 2/3 of adolescents brushed their teeth as recommended (at least twice a day) but only 20.0% of adolescents flossed weekly. Most adolescents had a high frequency of sugar intakes and did not have plans for annual dental visitation. Moreover, our study found a relatively high prevalence of dental anxiety (40.5%) and DMFT ≥ 1 (45.0%). A high prevalence of dental anxiety has been shown to result in increased dental avoidance and poorer oral health outcomes. Our analysis of dental anxiety and oral health from a cognitive theory model perspective, such as the HBM, provides a clearer explanation for one of the mechanisms involved in oral health and dental anxiety among adolescents. Thus, there is a tangible application for the implementation of theory-based behavioral interventions targetting the promotion of oral health behaviors in schools as an alternative strategy in reducing dental anxiety and prevent oral diseases in adolescents.

List Of Abbreviations

HBM, Health Belief Model; DMFT, missing and filled permanent teeth; POR, prevalence odds ratios; CI, confidence interval; OHB, oral health behavior; CFI, comparative fit index; GFI, goodness-of-fit index; TLI, Tucker-Lewis index; RMSEA, the root mean square error of approximation; SRMR, the standardized root mean squared residual;

Declarations

Ethical approval and consent to participate

The study was approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB) (IRB HKU: UW18–029). The mean age of the participants was 14.32 ± 0.68. Written informed consent from parents were obtained prior to their child's participation.

Consent for publication

Not applicable

Availability of data and material

The datasets used and/or analyzed for the current study are available from the corresponding author on reasonable request.

Competing interest

The authors declare that they have no competing interests.

Funding

The study was financially funded by grants from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. 17115916). The funding body has not influenced the study design, collection, analysis and interpretation of data, or how the manuscript was written.

Authors' contribution

BX: data collection, data analysis and writing of the manuscript. HMW: design of the study and revision of the manuscript. APP: critical review of the data analysis and results. CPJM: critical review of the manuscript. All the authors read and approved the final manuscript.

Acknowledgment

The author would like to thank all the participating adolescents.

Reference

1 Armfield JM, Stewart JF, Spencer AJ. The vicious cycle of dental fear: exploring the interplay between oral health, service utilization and dental fear. BMC Oral Health. 2007;7:1.

2 Thomson W, Poulton R, Kruger E, Davies S, Brown R, Silva P. Changes in self-reported dental anxiety in New Zealand adolescents from ages 15 to 18 years. J Dent Res. 1997;76(6):1287–91.

3 Versloot J, Veerkamp J, Hoogstraten J. Dental anxiety and psychological functioning in children: its relationship with behaviour during treatment. Eur Arch Paediatr Dent. 2008;9 suppl 1:36–40.

4 Stenebrand A, Wide Boman U, Hakeberg M. Dental anxiety and symptoms of general anxiety and depression in 15-year-olds. Int J Dent Hyg. 2013;11(2):99–104.

5 Carrillo-Díaz M, Crego A, Armfield JM, Romero M. Self-assessed oral health, cognitive vulnerability and dental anxiety in children: testing a mediational model. Community Dent Oral Epidemiol. 2012;40(1):8–16.

6 Abrahamsson KH, Berggren U, Carlsson SG. Psychosocial aspects of dental and general fears in dental phobic patients. Acta Odontol Scand. 2000;58(1):37–43.

7 Klingberg G, Broberg AG. Dental fear/anxiety and dental behaviour management problems in children and adolescents: a review of prevalence and concomitant psychological factors. Int J Paediatr Dent. 2007;17(6):391–406.

8 Blakemore SJ, Mills KL. Is adolescence a sensitive period for sociocultural processing? Annu Rev Psychol. 2014;65:187–207.

9 Locker D, Liddell A, Dempster L, Shapiro D. Age of onset of dental anxiety. J Dent Res. 1999;78(3):790–6.

10 Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezeh AC, et al. Adolescence: a foundation for future health. Lancet. 2012;379(9826):1630–40.

11 Green EC, Murphy E. Health belief model. The Wiley Blackwell Encyclopedia of health, illness, behavior, and society. John Wiley & Sons, Ltd. 2014;766–769.

12 Rosenstock IM. Why people use health services. Milbank Q. 2005;83.

13 Kasmaei P, Shokravi FA, Hidarnia A, Hajizadeh E, Atrkar-Roushan Z, Shirazi KK, et al. Brushing behavior among young adolescents: does perceived severity matter. BMC Public Health. 2014;14:8.

14 Lee CY, Ting CC, Wu JH, Lee KT, Chen HS, Chang YY. Dental visiting behaviours among primary schoolchildren: Application of the health belief model. Int J Dent Hyg. 2018;16(2):e88-e95.

15 Anagnostopoulos F, Buchanan H, Frousiounioti S, Niakas D, Potamianos G. Self-efficacy and oral hygiene beliefs about toothbrushing in dental patients: a model-guided study. Behav Med. 2011;37(4):132–9.

16 Langley EL, Wootton BM, Grieve R. The Utility of the Health Belief Model Variables in Predicting Help-Seeking Intention for Anxiety Disorders. Australian Psychologist. 2018;53:291–301.

17 Janz N, Becker MH. The health belief model: a decade later. Health Educ Q. 1984; 11(1):1–47.

18 Xiang B, Wong HM, McGrath CPJ. Validation of a theory-based oral health questionnaires among adolescents. J Dent Res. 2019;98 Spec Iss A:0929 (www.iadr.org).

19 Humphris G, Wong H, Lee G. Preliminary validation and reliability of the modified child dental anxiety scale. Psychol Rep. 1998;83 suppl 3:1179–86.

20 Paryab M, Hosseinbor M. Dental anxiety and behavioral problems: a study of prevalence and related factors among a group of Iranian children aged 6–12. J Indian Soc Ped Prev Dent. 2013;31(2):82–6.

21 Tong X, An D, McGonigal A, Park SP, Zhou D. Validation of the Generalized Anxiety Disorder–7 (GAD–7) among Chinese people with epilepsy. Epilepsy Res. 2016;120:31–6.

22 World Health Organization. Oral Health Surveys: Basic Methods. 4th ed. Geneva: WHO; 1997.

23 Milsom K, Tickle M, Humphris G, Blinkhorn A. The relationship between anxiety and dental treatment experience in 5-year-old children. Br Dent J. 2003; 194(9):503–6.

24 Hu LT, Bentler PM. Cut-off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: a multidisciplinary journal. 1999;6(1):1–55.

25 Bankole O, Aderinokun G, Denloye O, Jeboda S. Maternal and child's anxiety—effect on child's behaviour at dental appointments and treatments. Afr J Med Med Sci. 2002;31(4):349–52.

26 Levitt J, McGoldrick P, Evans D. The management of severe dental phobia in an adolescent boy: a case report. Int J Paediatr Dent. 2000;10(4):348–53.

27 Thom A, Sartory G, Jöhren P. Comparison between one-session psychological treatment and benzodiazepine in dental phobia. J Consult Clin Psychol. 2000;68(3):378–87.

28 Hawton KE, Salkovskis PM, Kirk JE, Clark DM. Cognitive behaviour therapy for psychiatric problems: A practical guide. London: Oxford University Press; 1989.

29 Orji R, Vassileva J, Mandryk R. Towards an effective health interventions design: an extension of the health belief model. Online J Public Health Inform. 2012;4(3):pii:ojphi.v4i3.4321.

30 Kacel EL, Morgan LS, Pereira DB. The relationship between perceived severity of stressful life events and preoperative anxiety in women undergoing surgery for suspected endometrial malignancy. J Clin Oncol. 2014;32 suppl 15:e20563

31 DeDonnoa MA. Dental anxiety, dental visits and oral hygiene practices. Oral Health Prev Dent. 2012;10(2):129–33.

32 Petersen AC, Leffert N. Developmental issues influencing guidelines for adolescent health research: a review. J Adolesc Health. 1995;17(5):298–305.

Figures

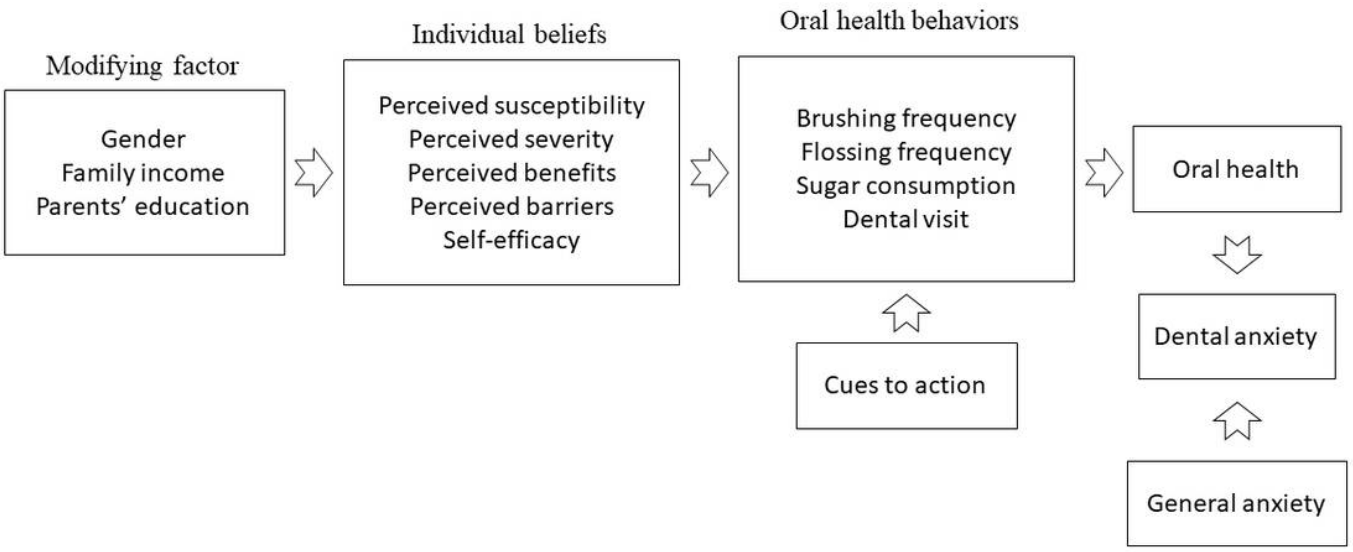

Figure 1

Theoretical model for the study of the health belief model to predict oral health status and dental anxiety (Adapted from Janz & Becker, 1984 [17]).

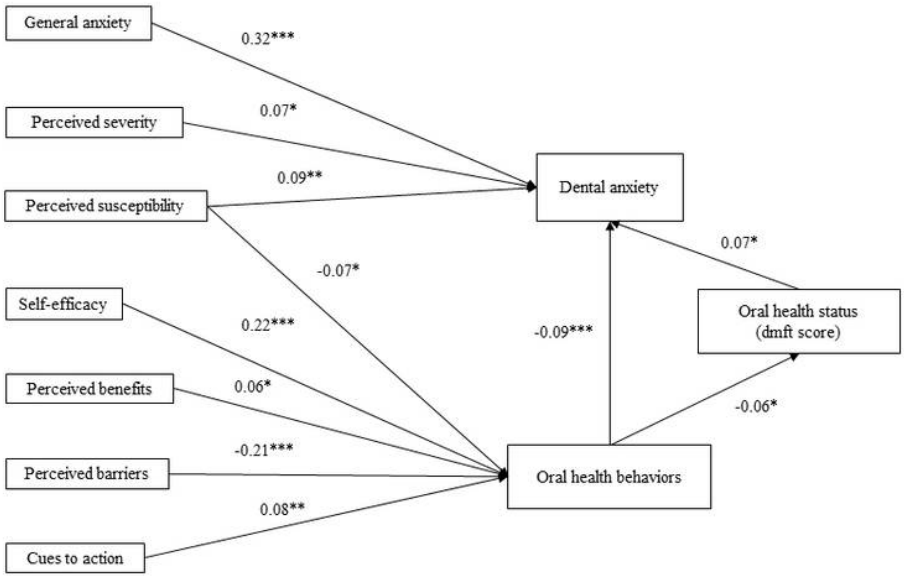

Figure 2

Path analysis of psychological factors as predictors for dental anxiety. Standardized direct path coefficients are presented. Note. Significant differences indicated by ***p < 0.001; ∗∗p < 0.01; ∗p < 0.05.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1.doc