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Applying World Dental Federation Theoretical Framework for Oral Health in a General Population

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ABSTRACT

Introduction: The World Dental Federation (FDI) has recently proposed a new definition and theoretical framework of oral health. The theoretical framework includes 4 main components and describes the relationships amongst them. In 2020, an international work group proposed the minimum Adult Oral Health Standard Set (AOHSS) of variables to measure oral health, which was mapped onto the FDI's theoretical framework. By using an empirical data set, the proposed variables in the AOHSS and the potential interactions amongst the components of the FDI's theoretical framework can be tested. The purpose of this research was to investigate structural relations of the components of the FDI's theoretical framework of oral health based on data from a general adult population.

Methods: Data from a previously conducted Swedish cross-sectional study focusing on oral health were utilised (N = 630; women, 55.2%; mean age, 49.7 years [SD, 19.2]). Variable selection was guided by the AOHSS. Structural equation modeling was used to analyse relationships amongst the components of the FDI's theoretical model (core elements of oral health, driving determinants, moderating factors, and overall health and well-being).

Results: The Oral Health Impact Profile (OHIP)-14, xerostomia, and aesthetic satisfaction had statistically significant direct effects on overall health and well-being ($p < .05$). Driving determinants and moderating factors had statistically significant direct effects on all core elements of oral health ($p < .05$) except aesthetic satisfaction ($p = .616$). The predictors explained 24.1% of the variance of the latent variable overall health and well-being. Based on several indices, the proposed model showed acceptable model fit.

Conclusions: The FDI's theoretical framework can be used to describe different components of oral health and the relationship amongst them in an adult general population. Further research based on the FDI's theoretical framework in other populations and settings is needed to explore complex interactions and possible relationships that form oral health and to investigate other or additional important social determinants.

Introduction

Oral diseases are a significant public health concern, affecting over 3.5 billion individuals globally.[1,2] Furthermore, the social gradient of oral health is strong and persistent.[2] In order to describe oral health and explore pathways and inequalities of oral health, several frameworks have been developed. Instead

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of a biomedical approach focusing on oral diseases and treatment,[3] frameworks reflecting more complex interactions, including a biopsychosocial perspective, have been suggested.[4-7]

The World Dental Federation's (FDI's) theoretical framework of oral health builds on the World Health Organisation's Commission on Social Determinants of Health report and includes individual, environmental, and social determinants of oral health through a life course. A central part of the FDI's framework, the core elements of oral health, refers to progression, impact, and severity of diseases and conditions as well as the abilities, functions, and capacities related to oral health. In addition, the framework includes these components: overall health and well-being, moderating factors, and driving determinants (Figure 1). Altogether, the framework describes oral health status, the connection to overall health and well-being, and elements that can determine or affect how an individual scores their oral health, as well as factors that can affect it.[8]

Only a few studies have explored potential clinician- and patient-reported measures to reflect the components of the FDI's theoretical framework.[9,10] A collaboration between the International Consortium for Health Outcomes Measurements and the FDI presented the minimum Adult Oral Health Standard Set (AOHSS) of variables to describe oral health. It includes perspectives from both oral health professionals and patients and contains 31 patient-centred outcome and case mix concepts reflecting the FDI's multifaceted definition and framework. The AOHSS is intended to be used in different settings and geographic locations for both clinical dentistry and in research, which allows flexibility in data collection whilst maintaining the possibility of comparisons amongst groups.[10] To date, the AOHSS has not been tested with empirical data regarding potential interactions amongst the components of the FDI's framework. Ahonen et al.[9] explored potential measures which could be used to describe the core elements of oral health, and the results were in line with the AOHSS. By using structural equation modeling (SEM), it is possible to investigate relationships amongst the components of the FDI's framework, as SEM provides a possibility to investigate multiple complex interrelationships amongst variables simultaneously.[11,12] The aim of this study was to investigate structural relations of the components of the FDI's theoretical framework of oral health based on data from a general Swedish adult population. The following relationships were hypothesised:

a. Driving determinants and moderating factors have a direct effect on the core elements of oral health.
b. Core elements of oral health have a direct effect on overall health and well-being.
c. Driving determinants and moderating factors have a direct effect on overall health and well-being.

In addition, indirect effects of driving determinants and moderating factors on overall health and well-being mediated by core elements of oral health were hypothesised.

Methods

Description of data

Data for this study were obtained from a previously conducted Swedish project on oral health in the population over time. Data were collected every 10 years from 1973 by using a repeated cross-sectional design. In each data collection wave, a random selection of 130 participants in each age group (5, 10, 15, 20, 30, 40, 50, 60, 70, and 80 years) from one region were invited to participate. The participants were invited to participate in a clinical and a radiographic examination as well as to respond to a questionnaire. Information regarding the previous project has been reported elsewhere.[9,13-15] In this study, data from the 2013 wave were utilised and only the adult age groups (≥20 years of age) were included (N = 630).

Variables

The selection procedure was guided by the AOHSS and a study by Ahonen et al.[9] As Ni Riordain et al. mapped the measures in the AOHSS (eg, dental caries, sugar

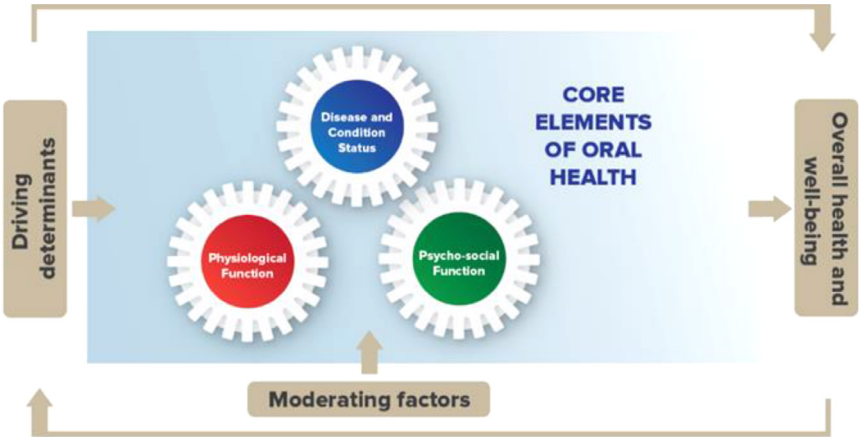

Fig. 1 – The World Dental Federation's theoretical framework of oral health (adapted with permission from the American Dental Association).

consumption, and age) into 3 of the components of the FDI's framework,[10] this illustration guided the selection. Variables in the current data set and the AOHSS were compared for optimal matching. Some variables had to be modified to fit the model (Table 1). The final selection represents the 4 components of the FDI's theoretical framework.

The Patient-Reported Outcome Measurement (PROM) included was the abbreviated Oral Health Impact Profile (OHIP-14), which previously has demonstrated good validity and reliability.[16,17] The additive score for OHIP-14 was used. Periodontal disease staging was classified into 5 stages.[18] Caries staging[13] and missing teeth were included as continuous measures. The data set included 10 questions to reflect the current aesthetic satisfaction, and an additive score was obtained by summarising the response for each item. Age groups corresponded to the date of birth given in the AOHSS.

Visible plaque index (PLI; %) was included as a continuous variable.[19] Sugar consumption was reflected by 2 questions. Three questions were merged into interdental cleaning. Level of education was based on the highest level of completed education, fairly comparable to the International Standardized Classification of Educations (ISCED 2011) education programmes.[20]

To reflect the question and response options in the AOHSS, the free-text response from the question "Which disease/condition do you have?" was used. The response options were divided into the proposed medical conditions in the AOHSS, and 2 response options were added. Three additional measures from the data set were included: "Do you think your state of health prevents you from doing things you want to do?" "How do you assess your overall state of health?" "How do you perceive your health compared to others of your age?" (See Table 1.)

Description of statistical analysis

By using the FDI's theoretical framework[8] as a basis for hypothesised relationships, we used SEM to assess direct and possible mediating effects.

The model comprised 6 observed and 2 latent variables. The observed variables were aesthetic satisfaction, decayed filled surfaces (DFS), xerostomia, missing teeth, periodontal classification, and OHIP-14. The 2 latent variables were (1) overall health and well-being (indicators: chronic conditions, perceived health, perceived health compared to other of same age, and state of health prevents you from doing things you want) and (2) driving determinants and moderating factors (indicators: age, education, regularly interdental cleaning, PLI, drinking sugar-containing beverages between meals, and eating or drinking between meals). We estimated the sample size based on Westland's[21] sample size for SEM based on anticipated effect size (.03) and number of latent variables (n = 2) and indicators (n = 10). The recommended sample size for power 0.9 with probability level $\alpha = 0.05$ was N = 119. It was decided that all cases would be considered for inclusion, but as some participants did not respond to the questions regarding sex (n = 9) and/or age (n = 2), they were removed (Table 2). Before the SEM analysis, data were controlled regarding missing values. Little's missing completely at random (MCAR) test showed that data were not missing completely at random, $\chi^2 = 35.0$, $df = 14$, $p < .01$. We assumed the data were missing at random, as it could be presumed that missing data could be related to other observed variables, and not due to factors such as unwillingness to respond.[22] Missing data were then imputed by using the full information maximum likelihood (FIML) method. Before constructing the model, the correlation coefficients (Pearson's *r* and Spearman's Rho) were estimated, and variables with a statistically significant correlation coefficient r/rho >.20 were considered for inclusion.[23]

The model was estimated using the FIML method. To investigate direct and indirect effects (mediation) and as the multivariate assessment of normality showed non-normal distribution, bootstrap analysis was performed using 5000 bootstrap samples, with 95% confidence intervals.[11] The following indices were used to evaluate model fit: the absolute fit index χ^2; the goodness-/badness-of-fit indices root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR); and the incremental fit indices: comparative fit index (CFI) and Tucker-Lewis index (TLI). Due to the χ^2 test tendency to be oversensitive in larger samples, the χ^2 test was presumed to be significant. The relative χ^2 value was therefore estimated (satisfactory if value of <3).[11,24] A satisfactory model fit was considered if CFI and TLI >.90, RMSEA <.08 (confidence interval between .05 and .08), and SRMR <.09.[11,24] The statistical significance level was $p < .05$.

Statistical analyses were performed in IBM SPSS Statistics for Windows[25] and IBM SPSS AMOS[26] version 27, respectively.

Ethical considerations

The study from which data were obtained[13,14] was approved by the Regional Ethical Board in Linköping, Sweden, prior to data collection (ref. no. 2012/191-31). The rules of the Declaration of Helsinki[27] were applied.

Results

Data from 621 adults were included in the SEM analysis. The mean age was 49.7 (SD, 19.2), and 343 (55.2%) were female. Most of the participants had an educational level of completed primary and secondary school or higher (79.2%; Table 2).

One model was constructed based on the FDI's theoretical framework (Figure 2). The model showed acceptable fit except for the χ^2 test, but the relative χ^2 was considered acceptable. The effects of all predictors on overall health and well-being and core elements of oral health were examined with both statistically significant and nonsignificant results. Together, the predictors explained 24.1% of the variance of the latent variable overall health and well-being. Three of the core elements of oral health (OHIP-14, xerostomia, and aesthetic satisfaction) had statistically significant direct effects on overall health and well-being, −.321 ($p < .001$), .209 ($p < .001$), and −.112 ($p = .023$), respectively (Table 3).

Except for aesthetic satisfaction ($p = .616$), the latent variable driving determinants and moderating factors had statistically significant direct effects of all core elements of oral

Table 1 – Summary of included measures regarding differences and modifications of questions and response options and reporting source.

AOHSS outcomes/case mix concepts	Item in data set	Response options in data set	Alteration	Reporting source
Core elements of oral health				
Food alteration Ability to speak Productivity Self-confidence Social participation Oral pain Ability to eat	OHIP-14	Very often, fairly often, Sometimes, hardly ever, Never	Additive score, continuous	Patient
Caries staging	DFS	Continuous, n		Clinician
	Number of missing teeth	Continuous, n		
Periodontal disease staging	Classification according to the severity of periodontal diseases experience	Score, 1-5		Clinician
Dry mouth experience	Do you feel dry in your mouth?	Never, occasionally, often, always		Patient
Aesthetic satisfaction	Appearance of your face	Score from 0–10	Additive score, continuous	Patient
	Appearance of your profile	Score from 0–10		
	Appearance of your mouth	Score from 0–10		
	Appearance of your teeth	Score from 0–10		
	Shape of your teeth	Score from 0–10		
	Colour of your teeth	Score from 0–10		
	Appearance of your gums	Score from 0–10		
	Whole appearance of your face, mouth, and teeth	Score from 0–10		
Moderating factors				
Date of birth	Age group	20, 30, 40, 50, 60, 70, or 80 years		Patient
Driving determinants				
Level of education	Which educational level applies to you?	Score, 1–6*		Patient
Sugar consumption	How many times/day do you eat or drink something between your main meals?	0-9, more than 10		Patient
	Do you drink a soft drink, energy drink, or lemonade/juice between meals?	Every day, often (several times a week), sometimes, never		
Oral hygiene	Do you regularly (every day) use interdental brushes?	Yes, no	Categorised: 1-8†	Patient
	Do you regularly (every day) use toothpicks?	Yes, no		
	Do you regularly (every day) use dental floss?	Yes, no		
Visible plaque	PLI	Continuous, %		Clinician
Overall health and well-being				
Chronic medical condition	Do you think your state of health prevents you from doing things you want to do?	Not at all, partly, greatly		Patient
	How do you assess your overall state of health?	Good, average, bad		
	How do you perceive your health compared to others of your age?	Better, similar, worse		
	Which disease or condition?	Free text	Categorised: 1-7‡	

AOHSS, Adult Oral Health Standard Set; OHIP-14, Swedish version of the abbreviated Oral Health Impact Profile; DFS, decayed filled surfaces; IDB, interdental brushes; TP, toothpicks; DF, dental floss; PLI, plaque index; CVD, cardiovascular disease; DM, diabetes mellitus.

* Academic degree, upper secondary school (3-4 years), upper secondary school (2 years), folk high school, elementary/grade school, elementary/grade school (<6 years).

† Yes (IDB, TP, & DF), yes (TP & DF), yes (IDB & DF), yes (IDB & TP), yes (IDB), yes (TP), yes (DF), no.

‡ No reported chronic condition, CVD, DM, respiratory disease, cancer, other, 2 chronic conditions, >2 chronic conditions.

Table 2 – Description of characteristics of study population.

Measure	Total (N = 621)
Age (missing n = 2), M (SD)	49.7 (19.2)
Education, n (%)	
Academic degree	213 (34.3)
Upper secondary/vocational school (3–4 years)	181 (29.1)
Upper secondary/vocational school (2 years)	82 (13.2)
Independent adult education	16 (2.6)
Primary and secondary school	65 (10.5)
Primary school	56 (9.0)
Primary school (<6 years)	8 (1.3)
OHIP-14 (missing n = 125), M (SD)	65.7 (6.5)
Dry mouth experience, n (%)	
Never	209 (33.7)
Occasionally	348 (56.0)
Often	52 (8.4)
Always	12 (1.9)
Aesthetic satisfaction (missing n = 107), M (SD)	54.5 (14.4)
Periodontal staging (missing n = 8), n (%)	
Healthy/almost healthy	192 (30.9)
Gingivitis	176 (28.3)
Alveolar bone loss <1/3	174 (28.0)
Alveolar bone loss 1/3–2/3	52 (8.49)
Alveolar bone loss >2/3 and furcation involvement and/or angular bony defects	19 (3.1)
DFS, M (%)	29.3 (24.1)
Missing teeth, M (%)	3.05 (5.3)
Eating/drinking between meals (missing n = 29), M (SD)	2.9 (1.6)
Drinking sugar-containing beverages between meals, n (%)	
Never	259 (41.7)
Sometimes	299 (48.1)
Often (several times a week)	44 (7.1)
Every day	19 (3.1)
Visual plaque (PLI), M (%)	15.7 (8.9)
Interdental cleaning (missing n= 24), n (%)	
Regular interdental cleaning (interdental brushes, toothpicks, and/or dental floss)	284 (47.6)
No regular interdental cleaning	313 (52.4)
State of health prevents you from doing things you want, n (%)	
Not at all	444 (71.5)
Partly	151 (24.3)
Greatly	26 (4.2)
Assessment of overall state of health, n (%)	
Good	460 (74.1)
Average	142 (22.9)
Bad	19 (3.1)
State of health compared to others your age, n (%)	
Better	195 (31.4)
Similar	379 (61.0)
Worse	47 (7.6)
Reported disease or condition, n (%)	
No reported chronic condition	415 (66.8)
Cardiovascular disease	58 (9.3)
Diabetes mellitus	24 (3.9)
Respiratory disease	24 (3.9)
Cancer	17 (2.7)
Other	70 (11.3)
2 chronic conditions	11 (1.8)
More than 2 chronic conditions	2 (0.3)

OHIP-14, Swedish version of the abbreviated Oral Health Impact Profile; DFS, decayed filled surfaces; PLI, plaque index.

health, xerostomia, periodontal classification, missing teeth, OHIP-14, and DFS, .120 ($p = .004$), .516 ($p < .001$), .485 ($p = .001$), .176 ($p < .001$), and .761 ($p = .001$), respectively. Additionally, we examined possible mediation, but no statistically significant mediation effect was found ($p = .380$; Table 3).

Discussion

This study aimed to investigate structural relations of the components of the FDI's theoretical framework of oral health by utilizing data from a general adult Swedish population. At present, this is the first time the FDI's framework has been tested with empirical data from a general population, as far as is known. The proposed model shows the possibility and the importance of including both clinician-and patient-reported measures. The predictors explained 24.1% of the variance of the latent variable overall health and well-being, showing that the included variables are important but also that other factors contribute to a great extent. The model showed acceptable fit, and by that the possibility to use the FDI's definition and framework to describe components of oral health and the relationship amongst them in this population and setting. The final model also corresponded to Listl's 7 tentative key outcomes regarding perceived and physical oral health.[28]

Relationships amongst driving determinants and moderating factors and core elements of oral health

Both clinician- and patient-reported measures were included as indicators for the latent variable driving determinants and moderating factors. Except for aesthetic satisfaction, this latent variable had statistically significant small to strong direct effects on all variables representing core elements of oral health. The hypothesised relationships in the proposed model could therefore be argued to be confirmed.[10] In relation to a life course perspective of oral health, the cumulative effect of social determinants and progression of oral disease probably have an impact on the oral health–related quality of life to a great extent.[29] Therefore, age becomes an important factor for the outcome of oral health.

As a part of socioeconomic position,[30,31] educational level can be considered an important social determinant of oral health. The suggested case mix concept in the AOHSS "financial burden of care" would be relevant to include as it considers whether the individual had to put off dental care due to financial reasons.[10] However, this question was not covered in the data set. It would have been optimal to include several measures to capture more structural, socioeconomic, or environmental determinants to further elucidate the importance of other than individual factors related to behaviour, for example, dietary habits and oral hygiene. As oral health has been neglected in the process of improving health for all,[1,32,33] comparing oral health amongst or within populations on different levels could be a way to highlight the importance of oral health for both patients and stakeholders outside the dental community.

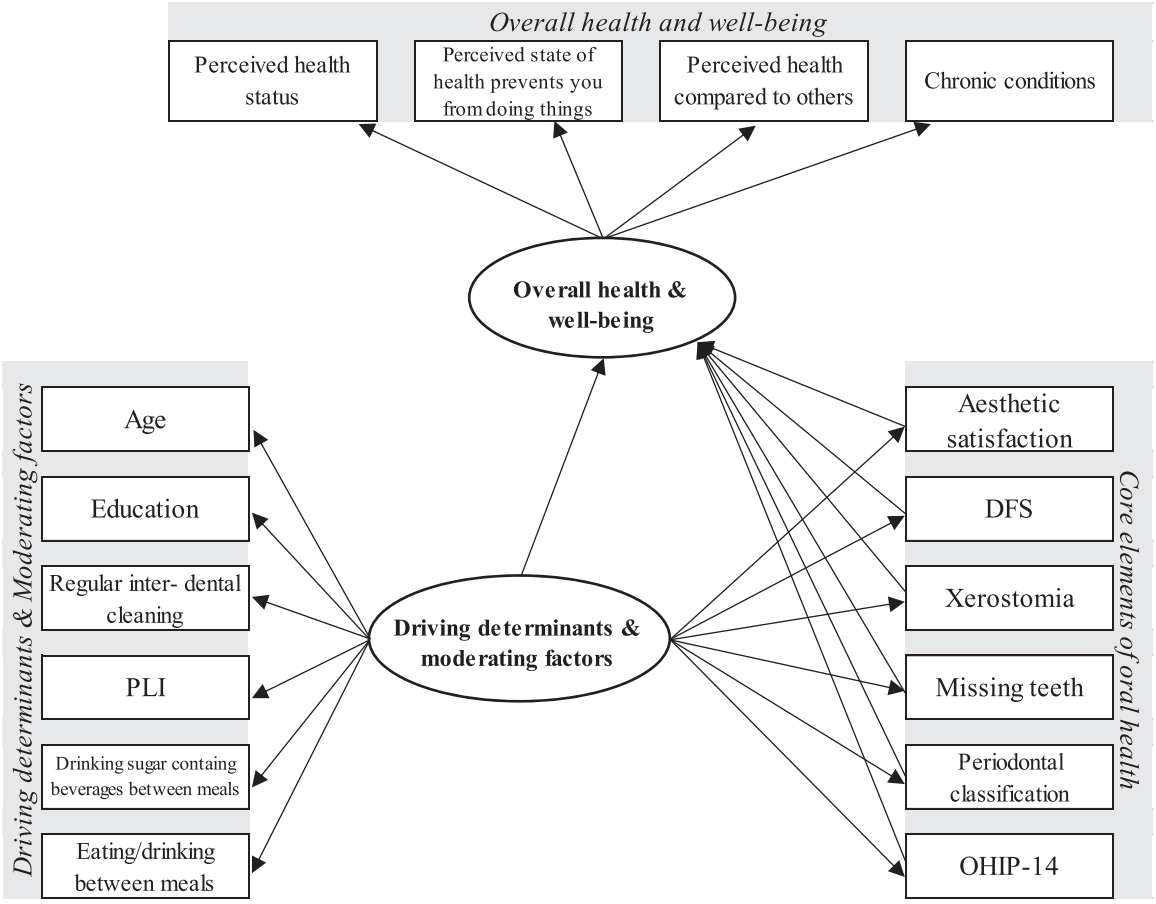

Fig. 2 – Proposed model (error terms omitted); see Table 2 for more details.

Relationships amongst core elements of oral health and overall health and well-being

Three of the included core elements of oral health (xerostomia, aesthetic satisfaction, and OHIP-14) had statistically significant strong to medium-sized direct effects on overall health and well-being. OHIP-14 was used to provide PROMs related to oral function, orofacial pain, and psychosocial impact, which previously have been proposed to be of importance for value-based oral health care.[28] Aesthetic satisfaction could be regarded as a reflection of the psychosocial part of oral health, and thus it also affects the perception of one's health. Previously, aesthetic satisfaction was reported to be of importance both regarding interaction with others and the relationship with function. Furthermore, education, age, and sex were reported to affect the attitude towards the aesthetic aspect.[34] Self-reported experience of xerostomia had a direct effect on overall health and well-being, which is consistent with previous research.[35,36] As studies have shown that the type of medication used and the number of medications can impact the individual's experience of xerostomia,[37,38] medication use could be relevant to investigate further. For both aesthetic satisfaction and dry mouth, having a single question in a clinical setting to highlight the patient's experience to complement a clinical examination could enable further discussion and investigation, if needed.

In our model, one classification of periodontal disease[18] and DFS was used based on the available data set, but there are other or new classification systems[10,39] to capture the progression or severity of disease. However, together with missing teeth, the included measures were regarded as sufficient. Even if tooth loss has previously been reported as an important oral health outcome,[28] a relationship between missing teeth and overall health and well-being could not be seen. However, the number of missing teeth was relatively low in this population, and amongst those aged 40 to 70 years, only 0.3% were previously reported to be edentulous.[13] Affected chewing ability or a visible tooth gap could also influence patients' perspective on missing teeth.[40] Even if the clinician-reported measures did not show direct effects, they are important for planning or evaluating, for example, preventive oral health care or treatments. A combination of clinician- and patient-reported measures could possibly better capture the relationship between oral and overall health and well-being. The multifaceted nature of oral health[8] underlines the importance of bringing in the patient's perspective, which has been highlighted in relation to value-based oral health care.[28] A set of core items can strengthen patient-centred and prevention-oriented oral health care. Together, a combination of clinician-and patient-reported outcomes could enable discussions with a more person-centred approach.

Table 3 – Summary of proposed model test results and standardised direct effects of driving determinants and moderating factors, core elements of oral health, and overall health and well-being in the final model.

Hypothesised relationships	Hypothesis supported
Driving determinants and moderating factors-> Core elements of oral health	Yes
Core elements of oral health->Overall health and well-being	Partly
Driving determinants and moderating factors-> Core elements of oral health-> Overall health and well-being	No

Model fit statistics	Value
χ^2 (p <. 001)	239.302
df	81
Relative χ^2	2.954
CFI	.933
TLI	.900
RMSEA (90% CI)	.056 (.048 to .064)
SRMR	.0597

Effect	B	Bootstrap SE	Bias-corrected CI (95%)	*p* value
Direct effects on overall health and well-being				
- Xerostomia	.209	.050	.106 to .304	**<.001**
- Periodontal classification	.046	.053	−.058 to .147	.383
- Missing teeth	.087	.056	−.020 to .199	.113
- OHIP-14	−.321	.052	−.420 to −.216	**<.001**
- DFS	.053	.078	−.100 to .202	.486
- Driving determinants and moderating factors	.033	.097	−.159 to .230	.762
- Aesthetic satisfaction	−.112	.047	−.201 to −.017	**.023**
Direct effects of driving determinants and moderating factors on core elements of oral health				
- Xerostomia	.120	.040	.043 to .198	**.004**
- Periodontal classification	.516	.030	.455 to .572	**.001**
- Missing teeth	.485	.026	.431 to .533	**.001**
- OHIP-14	.176	.036	.103 to .245	**<.001**
- DFS	.761	.023	.712 to .802	**.001**
- Aesthetic satisfaction	.023	.042	−.064 to .104	.616

df, degrees of freedom; CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardised root mean square residual, OHIP-14, Oral Health Impact Profile.

Limitations

Some reflection must be offered related to the study population and the generalisability of the results. In Sweden, oral health has improved to a great extent during the last 40 years,[13] even if there still are differences in oral health within Sweden. Based on the tax-financed dental system, the accessibility of care is generally good,[41] which probably had an impact on oral health for almost all participants. Furthermore, the participants in the current study were derived from a generally healthy and well-educated population. It is therefore of importance to evaluate the framework in other populations and contexts.

The model showed an acceptable but not perfect fit. Furthermore, not all effects were statistically significant, even if theoretically possible or of clinical relevance, and only one model was derived. The associations that were found to be statistically significant in the present study could be regarded to be of clinical relevance, given the strength of the estimated associations; however, they should be interpreted with consideration of the limitations presented in the study. Notably, the TLI value was somewhat low but was considered acceptable. The possible bidirectional effect between overall health and well-being and driving determinants or core elements of oral health was not investigated, as nonrecursive models are not recommended when using cross-sectional data.[12] Furthermore, model respecification was based on theory and used to a minimum, as it can affect the generalisability of the model.[12] In this sample, the level of current tobacco use was relatively low (<8%) and was not included due to low correlation (<.20). In another context, tobacco use should be considered for inclusion due to the impact on oral health.[42] Other measures should also be considered, especially considering contextual differences amongst countries, for example, educational level and oral health care organisation. Altogether, there is a possibility that alternative models could be more plausible. Measures such as income, access to dental care, and living conditions have previously been highlighted as important social determinants[30] and should therefore be considered in future studies. The model should be viewed as an initial step, and further exploration of the FDI's theoretical framework is suggested.

Implications

This study shows the possibility to use empirical cross-sectional data from a general population to investigate the components and relationships in the FDI's theoretical framework.

Furthermore, it shows that both clinician- and patient-reported measures are relevant to describe the components of the FDI's framework, and variables from the AOHSS can be used to describe oral health. It is suggested that further testing of the framework should be performed using longitudinal data, qualitative methods or, in specific populations, for example, specific general diseases or disorders, with an established (eg, diabetes mellitus) or potential (eg, obstructive sleep apnea) association with oral health.

For clinical settings, this study shows that empirical measures based on expert knowledge and the patient perspective are possible and relevant to include to enable more person-centred oral health care. To understand a persons' oral health, a biopsychosocial approach including the social environment and contextual factors in a person's life should be considered.[7,43] It is suggested that the FDI's framework and the AOHSS are further explored in clinical settings to identify additional important factors of clinical relevance in other populations and settings.

Conclusions

Based on the overall acceptable model fit, it was concluded that the model showed that the FDI's theoretical framework can be used to describe different components of oral health and the relationship amongst them in a Swedish general adult population. OHIP-14, experience of xerostomia, and aesthetic satisfaction had direct effects on overall health and well-being, and driving determinants and moderating factors had direct effects on all core elements of oral health except aesthetic satisfaction. This study supports further research based on the FDI's framework to explore the complex interactions and possible bidirectional relationships that form oral health to enable the inclusion of other or additional important social determinants.

Conflict of interest

None disclosed.

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REFERENCES

1. Watt RG, Daly B, Allison P, et al. Ending the neglect of global oral health: time for radical action. Lancet 2019;394 (10194):261–72.
2. Peres MA, Macpherson LMD, Weyant RJ, et al. Oral diseases: a global public health challenge. Lancet 2019;394(10194):249–60.
3. Brondani MA, MacEntee MI. Thirty years of portraying oral health through models: what have we accomplished in oral health-related quality of life research? Qual Life Res 2014;23 (4):1087–96.
4. MacEntee MI. An existential model of oral health from evolving views on health, function and disability. Commun Dent Health 2006;23(1):5–14.
5. Brondani MA, Bryant SR, MacEntee MI. Elders assessment of an evolving model of oral health. Gerodontology 2007;24 (4):189–95.
6. Fisher-Owens SA, Gansky SA, Platt LJ, et al. Influences on children;s oral health: a conceptual model. Pediatrics 2007;120(3): e510.
7. Bedos C, Apelian N, Vergnes J-N. Towards a biopsychosocial approach in dentistry: the Montreal-Toulouse Model. Br Dent J 2020;228(6):465–8.
8. Glick M, Williams DM, Kleinman DV, Vujicic M, Watt RG, Weyant RJ. Reprint of: A new definition for oral health supported by FDI opens the door to a universal definition of oral health. J Dent 2017;57(Suppl C):1–3.
9. Ahonen H, Kvarnvik C, Norderyd O, Broström A, Fransson EI, Lindmark U. Clinical and self-reported measurements to be included in the core elements of the World Dental Federation's theoretical framework of oral health. Int Dent J 2020;71 (1):53–62.
10. Ni Riordain R, Glick M, Al Mashhadani SSA, et al. Developing a standard set of patient-centred outcomes for adult oral health – an international, cross-disciplinary consensus. Int Dent J 2020;71(1):40–52.
11. Collier JE. Applied structural equation modeling using AMOS: basic to advanced techniques. New York: : Routledge; 2020.
12. Hair J, Black W, Babin B, Anderson R. Multivariate data analysis: a global perspective. 7th ed. Upper Saddle River, NJ: Pearson Education; 2010.
13. Norderyd O, Koch G, Papias A, et al. Oral health of individuals aged 3-80 years in Jonkoping, Sweden during 40 years (1973-2013). 2. Review of clinical and radiographic findings. Swed Dent J 2015;39(2):69–86.
14. Norderyd O, Koch G, Papias A, et al. Oral health of individuals aged 3-80 years in Jönköping- Sweden, during 40 years (1973-2013). 1. Review of findings on oral care habits and knowledge of oral health. Swed Dent J 2015;39:57–68.
15. Wahlin Å, Papias A, Jansson H, Norderyd O. Secular trends over 40 years of periodontal health and disease in individuals aged 20–80 years in Jönköping, Sweden: Repeated cross-sectional studies. J Clin Periodontol 2018;45(9):1016–24.
16. Hägglin C, Berggren U, Hakeberg M, Edvardsson A, Eriksson M. Evaluation of a Swedish version of the OHIP-14 among patients in general and specialist dental care. Swed Dent J 2007;31(2):91–101.
17. Larsson P, List T, Lundström I, Marcusson A, Ohrbach R. Reliability and validity of a Swedish version of the Oral Health Impact Profile (OHIP-S). Acta Odontol Scand 2004;62 (3):147–52.
18. Hugoson A, Jordan T. Frequency distribution of individuals aged 20–70 years according to severity of periodontal disease. Community Dent Oral Epidemiol 1982;10(4):187–92.
19. Hugoson A, Koch G, Hallonsten AL, Ludvigsson N, Lundgren D, Rylander H. Dental health 1973 and 1978 in individuals aged 3-20 years in the community of Jönköping, Sweden. A cross-sectional study. Swed Dent J 1980;4(6):217–29.
20. Statistics UIf. International Standard Classification of Education: ISCED 2011. Montreal: UIS; 2012.
21. Christopher Westland J. Lower bounds on sample size in structural equation modeling. Electron Commer Res Appl 2010;9(6):476–87.
22. Schafer JL, Graham JW. Missing data: our view of the state of the art. Psychol Methods 2002;7(2):147–77.

23. Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991.
24. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling 1999;6(1):1–55.
25. IBM SPSS statistics for windows. 27th ed. Armonk, NY: IBM Corp.; 2017 Computer program.
26. Arbuckle J. IBM SPSS AMOS for windows. 27th ed. Chicago: IBM;; 2014 Computer program.
27. World Medical Association [WMA]. WMA Declaration of Helsinki-ethical principles for medical research involving human subjects. 64th ed. 2013.
28. Listl S. Value-based oral health care: moving forward with dental patient-reported outcomes. J Evi Based Dent Pract 2019;19(3):255–9.
29. Crall JJ, Forrest CB. A life course health development perspective on oral health. In: Halfon N, Forrest CB, Lerner RM, Faustman EM, editors. Handbook of life course health development. Cham, Switzerland: Springer; 2018. p. 299–320.
30. Watt RG, Sheiham A. Integrating the common risk factor approach into a social determinants framework. Community Dent Oral Epidemiol 2012;40(4):289–96.
31. Gupta E, Robinson PG, Marya CM, Baker SR. Oral health inequalities: relationships between environmental and individual factors. J Dent Res 2015;94(10):1362–8.
32. Hescot P. The new definition of oral health and relationship between oral health and quality of life. Chin J Dent Res 2017;20(4):189–92.
33. Lee JY, Watt RG, Williams DM, Giannobile WV. A new definition for oral health: implications for clinical practice, policy, and research. J Dent Res 2017;96(2):125–7.
34. Carlsson GE, Johansson A, Johansson AK, Ordell S, Ekbäck G, Unell L. Attitudes toward dental appearance in 50- and 60-year-old subjects living in Sweden. J Esthet Restor Dent 2008;20(1):46–55.
35. Johansson AK, Johansson A, Unell L, Ekbäck G, Ordell S, Carlsson GE. Self-reported dry mouth in 50- to 80-year-old Swedes: Longitudinal and cross-sectional population studies. J Oral Rehabil 2020;47(2):246–54.
36. Flink H, Tegelberg Å, Arnetz JE, Birkhed D. Self-reported oral and general health related to xerostomia, hyposalivation, and quality of life among caries active younger adults. Acta Odontol Scand 2020;78(3):229–35.
37. Nederfors T. Xerostomia and hyposalivation. J Adv Dent Res 2000;14:48–56.
38. Ichikawa K, Sakuma S, Yoshihara A, et al. Relationships between the amount of saliva and medications in elderly individuals. Gerodontology 2011;28(2):116–20.
39. Papapanou PN, Sanz M, Buduneli N, et al. Periodontitis: consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Clin Periodontol 2018;45(S20):S162–70.
40. Boeskov Øzhayat E, Korduner E-K, Collin Bagewitz I, Öwall B. Impairments due to tooth loss and prosthetic expectations in patients from an urban area and a rural area in Sweden. A qualitative study. J Oral Rehabil 2020;47(2):212–20.
41. Palvärinne R, Widström E, Forsberg BC, Eaton KA, Birkhed D. The healthcare system and the provision of oral healthcare in European Union member states. Part 9: Sweden. Br Dent J 2018;224(8):647–51.
42. Warnakulasuriya S, Dietrich T, Bornstein MM, et al. Oral health risks of tobacco use and effects of cessation. Int Dent J 2010;60(1):7–30.
43. Lee H, Chalmers NI, Brow A, et al. Person-centered care model in dentistry. BMC Oral Health 2018;18(1):198.