Original Paper

Distal and Proximal Influences on Self-Reported Oral Pain and Self-Rated Oral Health Status in Saudi Arabia: Retrospective Study Using a 2017 Nationwide Database

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Abstract

Background: Oral health significantly influences overall well-being, health care costs, and quality of life. In Saudi Arabia, the burden of oral diseases, such as dental caries and periodontal disease, has increased over recent decades, driven by various lifestyle changes.

Objective: To explore the associations between proximal (direct) and distal (indirect) influences that affect oral pain (OP) and self-rated oral health (SROH) status in the Kingdom of Saudi Arabia (KSA) using an adapted conceptual framework.

Methods: This retrospective cross-sectional study used data from a national health survey conducted in KSA in 2017. The sample included adults (N=29,274), adolescents (N=9910), and children (N=11,653). Sociodemographic data, health characteristics, and access to oral health services were considered distal influences, while frequency and type of dental visits, tooth brushing frequency, smoking, and consumption of sweets and soft drinks were considered proximal influences. Path analysis modeling was used to estimate the direct, indirect, and total effects of proximal and distal influences on OP and SROH status.

Results: The mean age of adult respondents was 42.2 years; adolescents, 20.4 years; and children, 10.58 years. Despite OP reports from 39% of children, 48.5% of adolescents, and 47.1% of adults, over 87% across all groups rated their oral health as good, very good, or excellent. A higher frequency of tooth brushing showed a strong inverse relationship with OP and a positive correlation with SROH (P<.001). Frequent dental visits were positively associated with OP and negatively with SROH (P<.001). Sweet consumption increased OP in adolescents (β=0.033, P=.007) and negatively affected SROH in children (β=–0.086, P<.001), adolescents (β=–0.079, P<.001), and adults (β=–0.068, P<.001). Soft drink consumption, however, was associated with lower OP in adolescents (β=–0.034, P=.005) and improved SROH in adolescents (β=0.063, P<.001) and adults (β=0.068, P<.001). Smoking increased OP in adults (β=0.030, P<.001). Distal influences like higher education were directly linked to better SROH (β=0.046, P=.003) and less OP (indirectly through tooth brushing, β=–0.004, P<.001). For children, high household income correlated with less OP (β=–0.030, P=.02), but indirectly increased OP through other pathways (β=0.024, P=.003). Lack of access was associated with negative oral health measures (P<.001).

Conclusions: Among the KSA population, OP and SROH were directly influenced by many proximal and distal influences that had direct, indirect, or combined influences on OP and SROH status.

(JMIR Public Health Surveill 2024;10:e53585) doi: 10.2196/53585

KEYWORDS

dental health surveys; nationwide database; public health dentistry; path analysis; oral health influences; oral pain; self-rated oral health; cross-sectional study; dental health; dentistry; oral health; self-reported; retrospective study; Saudi Arabia; proximal; distal; adult; children; youth; adolescent; teen; sociodemographic

Introduction

Oral health has a major impact on overall health, medical costs, and quality of life. Major oral conditions include dental caries, periodontal disease, and tooth loss. Between 1990 and 2017, the global burden of these conditions increased by 38% [1].

There are reports of an increase in the burden of oral diseases in the Kingdom of Saudi Arabia (KSA) over the last few decades [2]. This increase is likely due to transformations in lifestyle, such as changes in dietary habits, particularly an increase in consumption of sugary foods and tobacco products [3]. Thus, oral health conditions constitute one of the major public health concerns in KSA.

Self-reported oral health status has been used as an important subjective health indicator of oral health care needs and to evaluate the individual's quality of life [4]. Self-reported information is a cost-effective and time-saving method of data collection. Self-reported oral health can be affected by several factors, such as sociodemographic and socioeconomic factors, cultural values and beliefs, and existing oral health conditions [5].

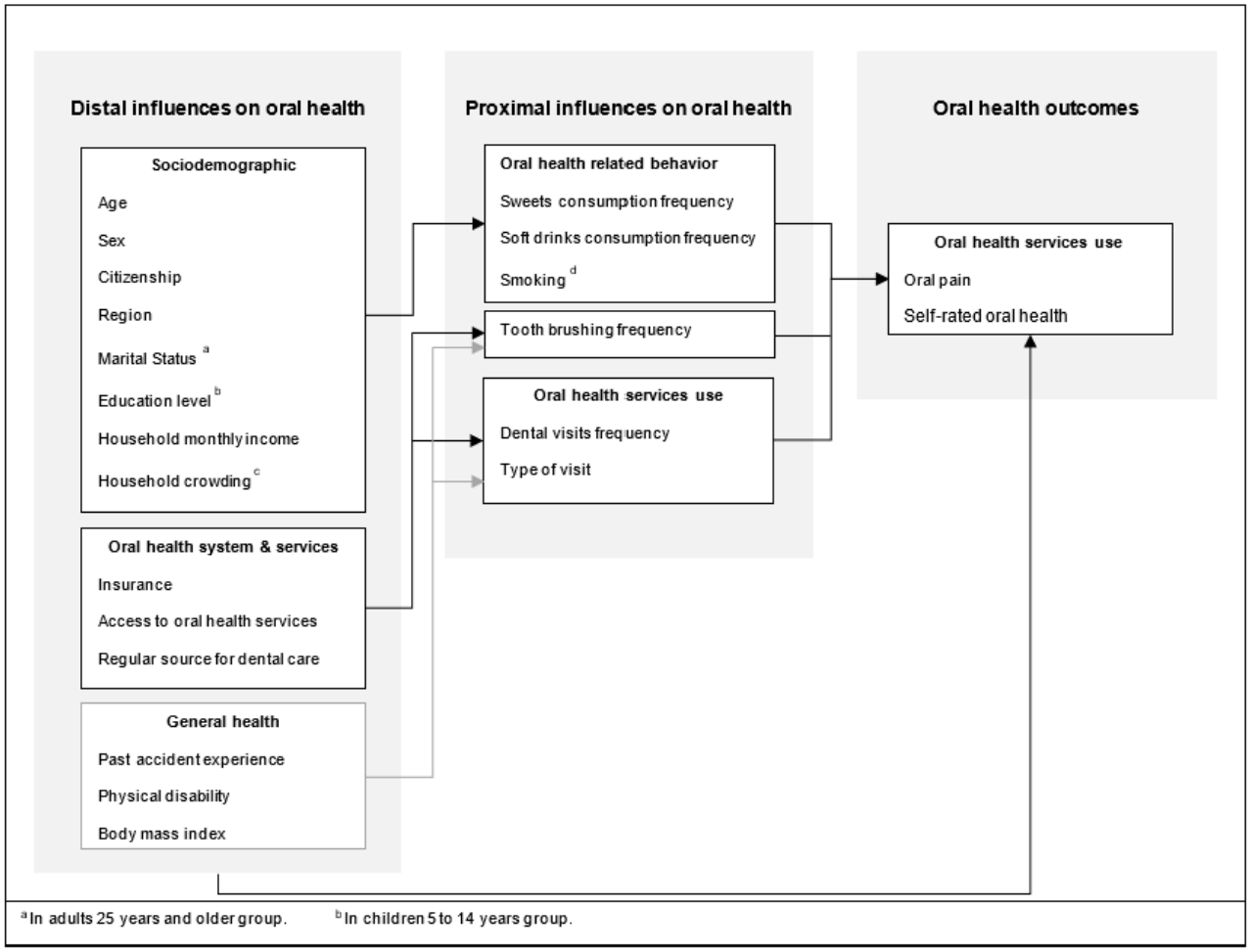
The Multidimensional Conceptual Model of Oral Health proposed by Gilbert et al [6] states that oral diseases and related tissue damage can result in oral pain (OP) and challenges in daily living that affect self-rated oral health (SROH) status. OP can cause difficulties in chewing and sleep disturbances [7]. In addition, it can affect school and work attendance, causing a loss of a significant number of study and working hours per year [8]. Because of these concerns, OP is frequently incorporated into national health surveys. A 1989 report from the United States reported that 14.5% of adults experienced OP during the past 6 months [9], while in the United Kingdom, 28% of adults were reported to experience difficulty from OP during the past year in 1998 [10].

SROH status serves as a valuable indicator of general oral health status [6]. It is considered a comprehensive index reflecting various dimensions of oral health, including functional, psychological, and social impacts on overall well-being [11]. It has been linked to clinical oral health status, such as dental caries, tooth mobility, and tooth loss [4]. Furthermore, SROH has been found to predict future oral health outcomes, as seen in longitudinal studies assessing maternal SROH and their children's caries experience in adulthood [12].

Distal and proximal influences play significant roles in shaping oral health outcomes such as OP and SROH. Proximal influences such as oral health-related behaviors and the use of oral health services directly impact oral health [13]. On the other hand, distal influences encompass broader determinants such as socioeconomic status and access to care determinants, which also have a substantial influence on oral health outcomes [14]. Understanding the interplay between distal and proximal influences is essential for addressing oral health status among populations and developing effective interventions to improve oral health outcomes across diverse populations.

The use of conceptual frameworks for understanding determinants in oral health research can serve as a coherent map to guide researchers when inquiring about oral health conditions. Conceptual frameworks can also help researchers to include multiple factors that may explain an outcome and aid in designing statistical analyses [15]. The objective of this study was to explore how proximal and distal influences on oral health are related to both OP experience and SROH status among KSA residents by using data from a national demographic and health survey (DHS) that was conducted in 2017 in KSA. A conceptual framework was developed (Figure 1) to guide the analysis.

Figure 1. Conceptual framework for distal and proximal influences on self-reported oral pain and oral health status in Saudi Arabia.



Methods

Data Source

The original data collection was approved by the institutional review board (IRB) of the Ministry of Health of the Kingdom of Saudi Arabia (Central IRB Log #: 2019-0131M). No additional IRB approval was needed for the secondary analysis, as it qualifies under Exemption 4 of US federal regulations [45 CFR 46.104(d)(4)] due to the use of existing, nonidentifiable data. The authors have permission to use the data, which was collected with participant consent. Data analysis was conducted at the Indiana University School of Dentistry, the Department of Biostatistics at the Indiana University School of Medicine, and the Richard M. Fairbanks School of Public Health, Indianapolis. The Human Research Protection Program from the Office of Research Compliance at Indiana University determined that this secondary analysis does not require further IRB review (Protocol #: 1808825963). Neither the study principal investigator nor key personnel had any financial conflict of interest concerning this research. The data were available at the office of the Directorate of Primary Health Care Centers (Ministry of Health, Headquarters, Riyadh, KSA). The Ministry of Health used a probability multistage stratified random sampling for the DHS. Details of the sampling procedure were published previously [16]. Briefly, house-to-house visits were conducted to interview the head of a family or an eligible representative and other specific family members between February 12, 2017, and May 23, 2017. Participants answered questions related to demographic, environmental, and health-related topics. The data were received in SPSS (IBM Corp) software format, and an analysis file was created, which comprised selected variables of interest. In total, 3 parallel analyses were performed based on the age of the respondent: children, 5-14 years; adolescents, 15-24 years; and adults, ≥25 years (details are given in [14]). The analysis was done at the Biostatistics Department, Indiana University School of Medicine, Indianapolis, Indiana, United States (IRB protocol number: 1808825963).

Development of the Model

Based on existing models, a multi-level conceptual framework was developed for oral health influences in KSA (Figure 1) on self-reported OP and SROH status among KSA residents. Constructs from the Multidimensional Conceptual Model of Oral Health proposed by Gilbert et al [6] and the World Health Organization Model for Oral Health Surveillance [17] were adapted by expanding the concept of proximal (direct) influences on oral health—such as diet and oral hygiene—to include distal (indirect) influences such as socioeconomic determinants.

Selection of Endogenous and Exogenous Variables

Model variables were selected after a careful review of the literature, identifying those that were both available in the survey

and previously reported to influence OP and SROH status. The model variables were classified as exogenous and endogenous. Exogenous variables are those that are not affected by other variables in the model (the distal or indirect influences), while endogenous variables are affected by other variables in the model, such as proximal influences and outcome variables. In total, 13 exogenous variables were included for the adult group, and 11 and 12 exogenous variables were included for the adolescent and children groups, respectively. In total, 8 endogenous variables were included for the adult group and 7 endogenous variables were included for the adolescent and children's groups, respectively. The variables are listed in (Table 1). Exogenous variables (distal influence variables) included the age [18] of participants as a continuous variable and gender [19] as a binary variable (males or females). Citizenship [20] status was coded as a binary variable: citizens and noncitizens. Geographic regions [2] were classified into the East, West, and Central versus the North and South. Marital status was dichotomized into currently married and not married (≥25 years only). Completed education level [21] was categorized as primary, intermediate, high school, intermediate diploma, and college or higher education. In total, 5 levels of household monthly income [22] were included: lower class income (3800 Riyals or less), marginal middle-class income (3801-7699 Riyals), basic middle-class income (7700-22,900 Riyals), upper middle-class income (22,901-38,200 Riyals), and upper-class income (>38,200 Riyals). Household crowding was calculated by dividing the number of family members by the number of sleeping rooms. The responses were then grouped into 4 levels: <1, 1-2, 2-3, and >3 persons per room. Past accident experience and physical disability were assessed as binary no or yes responses. BMI was dichotomized as normal (BMI=18.5-24.9) and abnormal (BMI <18.5 and >24.9). Health insurance was expressed as a binary variable of insured versus not insured. Access to oral health services [23] in the year prior to the survey was dichotomized into “no or I do not know and yes” responses. The source of dental care was dichotomized into a government versus private clinic.

Table 1. Weighted and non-weighted descriptive statistics for model variables by age group from the 2017 National Demographic and Health Survey conducted by the Ministry of Health of Saudi Arabia.

Variable	5-14 years			15-24 years			≥25 years		
	N	%	Wt.%	N	%	Wt.%	N	%	Wt.%
Sex									
Male	5813	49.9	50.9	4630	46.7	52.2	12,802	43.7	61.2
Female	5840	50.1	49.1	5280	53.3	47.8	16,472	56.3	38.8
Citizenship									
Citizen	10603	91.0	75.8	9064	91.5	79.6	26,225	89.6	53.2
Noncitizen	1050	9.0	24.2	846	8.5	20.4	3049	10.4	46.8
Region									
East, west, and central	8349	71.6	75.9	7032	71.0	75.2	21,634	73.9	79.3
North and south	3304	28.4	24.1	2878	29.0	24.8	7640	26.1	20.7
Marital status (≥25 years only)									
Married	__[a]	—	—	—	—	—	11,537	90.3	87.9
Not married	—	—	—	—	—	—	1243	9.7	12.1
Education (≥25 years only)									
Primary school education	—	—	—	—	—	—	3167	14.2	14.8
Intermediate school education	—	—	—	—	—	—	7465	33.4	38.9
High school education	—	—	—	—	—	—	6364	28.4	24.8
Intermediate Diploma	—	—	—	—	—	—	1282	5.7	5.0
College or higher education	—	—	—	—	—	—	4092	18.3	16.5
Monthly household income									
≤3800 Riyals	2134	37.8	40.4	1733	38.0	39.6	3599	21.6	25.3
3801–7699 Riyals	1258	22.3	21.9	1222	26.8	26.9	4190	25.1	29.7
7700–22,900 Riyals	2188	38.7	36.5	1552	34.0	32.3	8084	48.5	39.6
22,901–38,200 Riyals	40	0.7	0.6	32	0.7	0.7	694	4.2	4.8
>38,200 Riyals	29	0.5	0.5	24	0.5	0.6	109	0.7	0.6
Household crowding (5–14 years only)									
≤1 person/room	528	12.4	13.2	—	—	—	—	—	—
1-2 person/room	1967	46.1	45.5	—	—	—	—	—	—
2-3 person/room	1153	27.0	26.6	—	—	—	—	—	—
>3 person/room	622	14.6	14.6	—	—	—	—	—	—
Accident									
No	10,656	95.7	95.5	8826	93.4	93.0	26,168	94.8	94.4
Yes	483	4.3	4.5	624	6.6	7.0	1449	5.2	5.6
Disability									
No	11,000	98.7	98.7	9237	98.4	98.4	27,112	98.3	98.2
Yes	147	1.3	1.3	147	1.6	1.6	480	1.7	1.8
BMI (kg/m^2)									
Abnormal (<18.5 and >24.9)	5432	61.2	61.3	4940	60.4	61.6	14,643	59.6	63.2
Normal (18.5–24.9)	3439	38.8	38.7	3233	39.6	38.4	9925	40.4	36.8
Health insurance									
No	3477	78.4	70.7	2643	76.0	70.8	9396	73.7	59.9

Variable	5-14 years			15-24 years			≥25 years		
	N	%	Wt.%	N	%	Wt.%	N	%	Wt.%
Yes	957	21.6	29.3	836	24.0	29.2	3346	26.3	40.1
Access to health care									
Available/I don't know	8133	76.5	78.6	6725	74.9	76.5	18,666	70.5	76.5
Not available	2498	23.5	21.4	2251	25.1	23.5	7808	29.5	23.5
Source of care									
Government clinic	4146	81.5	76.3	4737	77.1	73.3	14,224	75.3	62.9
Private dental clinic or other clinic	941	18.5	23.7	1403	22.9	26.7	4663	24.7	37.1
Sweets consumption frequency									
I don't eat at all	813	7.3	7.5	1795	19.0	19.4	5467	19.7	20.5
Many times per month	4468	40.0	39.8	4217	44.7	44.4	12,379	44.6	44.9
Once per week	1441	12.9	13.7	1340	14.2	14.6	3924	14.2	14.0
Many times per week	2723	24.4	24.1	1451	15.4	15.1	4059	14.6	14.1
Once per day	1173	10.5	10.2	437	4.6	4.7	1344	4.8	4.5
Many times per day	550	4.9	4.6	188	2.0	1.8	556	2.0	2.0
Soft drinks consumption									
I don't drink at all	3476	31.3	31.5	3180	33.7	35.0	9297	33.5	37.1
Many times per month	3897	35.1	34.9	3341	35.4	34.5	9948	35.9	34.6
Once per week	1313	11.8	11.8	1184	12.5	12.3	3239	11.7	11.7
Many times per week	1794	16.1	16.3	1275	13.5	13.4	3795	13.7	12.4
Once per day	538	4.8	4.8	366	3.9	3.8	1070	3.9	3.2
Many times per day	91	0.8	0.7	100	1.1	1.0	389	1.4	1.1
Smoking (≥25 years only)									
No	—	—	—	—	—	—	25,937	91.5	93.0
Yes	—	—	—	—	—	—	2404	8.5	7.0
Tooth brushing frequency									
Never	1097	10.8	10.7	1026	11.7	11.1	3047	11.8	11.6
I clean my teeth somedays but not daily	3234	31.7	31.5	2185	24.9	24.9	6482	25.1	24.5
Once weekly	718	7.0	7.1	716	8.2	8.4	2139	8.3	9.0
Many times per week	1385	13.6	13.2	1023	11.7	11.6	2902	11.2	11.0
Once daily	2558	25.1	25.3	2321	26.5	27.1	6909	26.8	27.3
Twice or more daily	1201	11.8	12.3	1495	17.1	16.9	4341	16.8	16.5
Dental visits frequency									
Never visited a dentist or don’t know or don’t remember	1434	14.0	5.5	1219	13.7	13.4	6562	5.0	13.4
Not visited a dentist in the past year	4068	39.8	8.9	3223	36.2	35.7	9900	8.2	36.0
Once	2489	24.4	41.8	2096	23.6	23.9	6206	37.8	24.5
More than once	2227	21.8	23.2	2356	26.5	27.0	6606	23.7	26.1
Type of visit									
For a complaint	5395	91.6	91.0	5233	93.8	93.8	15,175	94.2	94.6
Routine examination and treatment	497	8.4	9.0	346	6.2	6.2	932	5.8	5.4
Oral pain									

Variable	5-14 years			15-24 years			≥25 years		
	N	%	Wt.%	N	%	Wt.%	N	%	Wt.%
Never felt	3825	37.8	39.8	2936	33.7	32.2	8779	34.0	32.5
Rarely	2145	21.2	21.2	1658	19.0	19.3	4971	19.3	20.4
Sometimes	2548	25.2	23.8	2275	26.1	26.9	6809	26.4	26.3
Many times	1603	15.8	15.2	1849	21.2	21.6	5260	20.4	20.8
Self-rated oral health status									
Bad	122	1.2	1.1	173	2.0	2.1	548	2.2	2.4
Acceptable	627	6.3	6.0	865	10.1	10.8	2372	9.4	10.5
Good	2756	27.7	27.6	2581	30.3	30.6	7624	30.2	32.8
Very good	3998	40.1	39.9	3278	38.4	38.3	9539	37.8	36.2
Excellent	2462	24.7	25.4	1635	19.2	18.2	5141	20.4	18.1

[a]Not applicable.

Endogenous variables (proximal influences and outcome variables) included the frequency of consuming sweets [24], individuals responded to the following question “How often do you eat sweets?” as “I don't eat at all, many times per month, once per week, many times per week, once per day, many times per day.” For soft drinks consumption frequency [25], “How often do you drink soft drinks?” responses were “I don't drink at all, many times per month, once per week, many times per week, once per day, many times per day.” For smoking status, [26] yes or no responses to the question “Do you smoke?” Frequency of tooth brushing [27,28] had 6 levels: “I have never cleaned my teeth, I clean my teeth some days but not daily, once weekly, many times per week, once daily, twice or more daily.” The frequency of dental visits was determined as from response to the question “How many times have you visited a dentist in the past year?” Valid answers include “never visited a dentist/I do not know or do not remember, did not visit the dentist in the past year, once, more than once.” For the type of visit, responses were dichotomized into visits for a complaint versus visits for routine examination and treatment [22]. For OP [6], the question was phrased as: “How many times during the past year have you felt pain in your teeth?” There were 4 levels of response: “never felt, rarely, sometimes, many times.” For SROH [6], participants were asked, “How would you describe the health of your teeth and gums?” Responses were “bad, acceptable, good, very good, excellent.”

Data Analyses

SPSS (IBM Corp) was used to perform descriptive analysis for the model variables (Table 1). R software (R Foundation for Statistical Computing) was used to perform the path analysis considering the sample weights. Missing values were not replaced or imputed in this analysis. The first step was to assess the multivariate normality of endogenous variables. Both skewness and kurtosis statistics confirmed that endogenous variables did not follow a multivariate normal distribution (P<.05). Owing to the presence of non-normal and missing data, full-information maximum likelihood estimation to perform path analysis available in the lavaan package (version 0.6.12) was used [29]. Robust standard errors (Huber-White) and scaled test statistics were calculated [30]. The software estimated the direct effect, as hypothesized in the model in (Figure 1), of each oral health influence, as well as the indirect effect for each exogenous variable on OP and SROH status through a path mediated by each proximal influence on oral health (Figure 1). For example, the effect of sex on OP was mediated by the frequency of tooth brushing. The total indirect effects on OP and SROH status reflected the effect of the path between each exogenous variable via all proximal influences on oral health. The total effects comprised the sum of the total indirect and direct effects of each distal influence on OP and SROH status.

A separate model was estimated for each age group—children 5–14 years, adolescents 15–24 years, and adults ≥25 years. Model fit was evaluated using the robust comparative fit index>0.9, robust Tucker-Lewis index>0.9, robust root mean-square-error of approximation <0.08, and robust standardized root-mean-square residual<0.08 [31].

Results

The conceptual model (Figure 1) states that OP and SROH status are directly influenced by distal and proximal influences on oral health. Furthermore, OP and SROH status are indirectly influenced by distal influences via all proximal influences except past accident experience, physical disability, and BMI, where they were indirectly influenced by OP and SROH status via only dental visit frequency, type of visit, and frequency of tooth brushing (Figure 1).

The final analysis included 29,274 adults ≥25 years of age (mean 42.2, SD 12.97), 9910 adolescents aged 15–24 (mean 20.4, SD 2.98) years, and 11,653 children aged 5 and 14 (mean 10.58, SD 2.84) years. Complete descriptive statistics are published elsewhere [16]. Table 1 presents a summary of the weighted and non-weighted estimates.

Despite 39% children, 48.5% adolescents, and 47.1% adults reporting OP in the past year, 92.9% children, 87.1% of adolescents, and 87.1% adults reported good, very good, or excellent SROH status, respectively.

The model goodness-of-fit measures showed an acceptable fit to the data, meeting the recommended values for the fit statistics (Table 2) [31].

Table 2. Model fit indices values.

Index	Values for the model of each age group					
	Non-weighted			Weighted		
	5-14 years	15-24 years	25+ years	5-14 years	15-24 years	25+ years
Robust comparative fit index (RCFI)	0.964	0.927	0.920	0.966	0.971	0.958
Robust Tucker–Lewis index (RTLI)	0.889	0.813	0.806	0.908	0.919	0.884
Robust root-mean-square error of approximation (RRMSEA)	0.029	0.036	0.035	0.027	0.024	0.028
Robust standardized root-mean-square residual (RSRMR)	0.020	0.027	0.029	0.031	0.020	0.028

Proximal Influences on Oral Health Effects

A higher tooth brushing frequency was strongly associated with less OP and positive SROH status in all groups. In contrast, a higher number of dental visits was associated with more OP and less favorable SROH status in all age groups. Routine examination and treatment were linked to less OP in all age groups and better SROH status in the adult and adolescent groups. Consumption of sweets was linked to greater OP in adolescents (β=0.033, *P*=.007) and negative SROH status in children (β=–0.086, *P*<.001), adolescents (β=–0.079, *P*<.001), and adults (β=–0.068, *P*<.001). Soft drinks were linked to lower OP in the adolescent group (β=–0.034, *P*=.005). Higher consumption of soft drinks was associated positively with SROH status (β=0.063, *P*<.001) in the adolescent and adult groups (β=0.068, *P*<.001). Smoking was associated with more OP (β=0.030, *P*<.001) in the adult group (Table 3).

Table 3. Direct effects of the distal and proximal influences on oral pain and self-rated oral health status based on conceptual framework (Figure 1). Data from the 2017 National Demographic and Health Survey conducted by the Ministry of Health of Saudi Arabia.

Pathway	5-14 years					15-24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Oral pain															
Age	0.009	0.011	.426	–0.013	0.030	0.006	0.010	.54	–0.014	0.026	–0.010	0.010	.33	–0.029	0.010
Sex	0.017	0.009	.06	–0.001	0.035	0.003	0.011	.76	–0.018	0.024	0.008	0.011	.43	–0.012	0.029
Citizenship	–0.081	0.014	*<.001*[d]	–0.109	–0.053	–0.004	0.016	.81	–0.035	0.027	–0.015	0.013	.23	–0.040	0.010
Region	–0.006	0.009	.465	–0.024	0.011	–0.018	0.010	.07	–0.038	0.002	–0.046	0.013	*<.001*	–0.071	–0.021
Marital status (≥25 years only)	—[e]	—	—	—	—	—	—	—	—	—	0.022	0.015	.13	–0.006	0.051
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	–0.006	0.014	.67	–0.033	0.021
Monthly household income	–0.030	0.013	*.02*	–0.055	–0.004	0.010	0.015	.49	–0.019	0.039	–0.021	0.015	.16	–0.050	0.008
Household crowding (5-14 years only)	0.002	0.016	.89	–0.029	0.033	—	—	—	—	—	—	—	—	—	—
Health insurance	–0.036	0.017	*.033*	–0.068	–0.003	0.051	0.018	*.004*	0.016	0.085	0.042	0.015	*<.001*	0.012	0.072
Access to health care	0.195	0.010	*<.001*	0.175	0.215	0.009	0.010	.34	–0.010	0.029	0.015	0.010	.11	–0.003	0.034
Source of care	0.053	0.016	*.001*	0.022	0.083	0.012	0.014	.41	–0.016	0.040	–0.001	0.016	.94	–0.032	0.030
Accident	0.051	0.010	*<.001*	0.032	0.070	0.028	0.009	*.002*	0.010	0.046	0.007	0.013	.60	–0.019	0.032
Disability	0.012	0.009	.16	–0.005	0.030	0.008	0.009	.38	–0.009	0.025	0.027	0.008	*.001*	0.011	0.042
BMI (kg/m^2)	0.015	0.011	.18	–0.007	0.038	–0.033	0.011	*.003*	–0.055	–0.011	–0.013	0.011	.27	–0.035	0.010
Sweets consumption frequency	0.007	0.010	.52	–0.014	0.027	0.033	0.012	*.007*	0.009	0.057	0.019	0.012	.10	–0.004	0.041
Soft drinks consumption	0.021	0.011	.058	–0.001	0.043	–0.034	0.012	*.005*	–0.058	–0.01	–0.023	0.012	.06	–0.047	0.001
Smoking (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.045	0.012	*<.001*	0.021	0.069
Tooth brushing frequency	–0.038	0.010	*<.001*	–0.057	–0.018	–0.098	0.01	*<.001*	–0.118	–0.078	–0.079	0.011	*<.001*	–0.101	–0.058

Pathway	5-14 years					15-24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Dental visits frequency	0.510	0.012	*<.001*	0.486	0.534	0.614	0.01	*<.001*	0.594	0.633	0.577	0.012	*<.001*	0.554	0.600
Type of visit	–0.064	0.014	*<.001*	–0.090	–0.037	–0.063	0.015	*<.001*	–0.092	–0.034	–0.088	0.016	*<.001*	–0.120	–0.056
Self-rated oral health status															
Age	–0.044	0.013	*.001*	–0.069	–0.018	–0.033	0.013	*.008*	–0.058	–0.009	0.013	0.011	.22	–0.008	0.035
Sex	–0.030	0.011	*.009*	–0.052	–0.007	0.023	0.013	.09	–0.003	0.048	–0.020	0.012	.11	–0.045	0.004
Citizenship	0.067	0.018	*<.001*	0.032	0.102	0.013	0.020	.53	–0.026	0.051	–0.050	0.015	*.001*	–0.080	–0.020
Region	–0.080	0.012	*<.001*	–0.103	–0.057	–0.014	0.013	.26	–0.039	0.011	–0.008	0.014	.55	–0.035	0.019
Marital status (≥25 years only)	—	—	—	—	—	—	—	—	—	—	–0.009	0.019	.62	–0.046	0.027
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.046	0.015	*.003*	0.016	0.077
Monthly household income	0.073	0.016	*<.001*	0.042	0.104	0.018	0.018	.31	–0.017	0.053	–0.028	0.018	.11	–0.063	0.006
Household crowding (5-14 years only)	–0.045	0.020	*.02*	–0.084	–0.006	—	—	—	—	—	—	—	—	—	—
Health insurance	–0.014	0.020	.49	–0.053	0.025	–0.160	0.021	*<.001*	–0.201	–0.119	–0.135	0.018	*<.001*	–0.171	–0.099
Access to health care	–0.096	0.013	*<.001*	–0.122	–0.071	0.045	0.013	*.001*	0.019	0.070	0.016	0.011	.14	–0.005	0.038
Source of care	–0.136	0.018	*<.001*	–0.172	–0.100	–0.001	0.017	.96	–0.035	0.033	0.019	0.018	.29	–0.017	0.055
Accident	–0.033	0.012	*.007*	–0.057	–0.009	–0.011	0.014	.44	–0.038	0.016	–0.043	0.011	*<.001*	–0.065	–0.022
Disability	–0.016	0.010	.12	–0.036	0.004	–0.078	0.018	*<.001*	–0.112	–0.044	–0.049	0.018	*.006*	–0.085	–0.014
BMI	0.051	0.013	*<.001*	0.025	0.077	0.093	0.013	*<.001*	0.067	0.118	0.067	0.013	*<.001*	0.042	0.093
Sweets consumption frequency	–0.086	0.013	*<.001*	–0.112	–0.061	–0.079	0.015	*<.001*	–0.109	–0.05	–0.065	0.014	*<.001*	–0.092	–0.039
Soft drinks consumption	0.022	0.013	.10	–0.004	0.048	0.063	0.015	*<.001*	0.035	0.092	0.068	0.014	*<.001*	0.040	0.096
Smoking (≥25 years only)	—	—	—	—	—	—	—	—	—	—	–0.012	0.015	.40	–0.042	0.017

Pathway	5-14 years					15-24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Tooth brushing frequency	0.129	0.013	*<.001*	0.104	0.154	0.162	0.014	*<.001*	0.135	0.189	0.158	0.014	*<.001*	0.131	0.186
Dental visits frequency	–0.130	0.014	*<.001*	–0.157	–0.104	–0.143	0.014	*<.001*	–0.17	–0.116	–0.132	0.015	*<.001*	–0.161	–0.104
Type of visit	0.021	0.015	.18	–0.010	0.051	0.046	0.015	*.002*	0.017	0.075	0.047	0.015	*.001*	0.018	0.075

[a]β: standardized regression weights.

[b]Significant pathways in italic font.

[c]Not applicable.

Distal Influences on Oral Health Effects

Tables 3-5 illustrate the direct, total indirect, and total effects, respectively, of oral health influences on OP and SROH status. Tables S1, S2, and S3 in Multimedia Appendix 1 show the direct effects of the distal influences on the proximal influences and the indirect effects of each distal influence on both OP and SROH status via each proximal influence.

Table 4. Total indirect effects for the distal influences on oral pain and self-rated oral health status based on conceptual framework (Figure 1). Data from the 2017 National Demographic and Health Survey conducted by the Ministry of Health of Saudi Arabia.

Pathway	5–14 years					15–24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Oral pain															
Age	0.062	0.007	*<.001*[b]	0.048	0.077	0.015	0.008	.06	–0.001	0.030	–0.002	0.007	.83	–0.016	0.013
Sex	0.000	0.006	.97	–0.011	0.011	–0.003	0.009	.73	–0.020	0.014	–0.016	0.008	*.04*	–0.032	–0.001
Citizenship	–0.004	0.009	.66	–0.022	0.014	0.026	0.014	.06	–0.001	0.053	0.023	0.009	*.02*	0.004	0.041
Region	0.027	0.006	*<.001*	0.016	0.037	–0.014	0.009	.11	–0.032	0.003	0.000	0.009	.96	–0.017	0.018
Marital status (≥25 years only)	—[c]	—	—	—	—	—	—	—	—	—	0.003	0.014	.86	–0.025	0.030
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.010	0.011	.37	–0.012	0.031
Monthly household monthly income	0.024	0.008	*.003*	0.008	0.040	–0.006	0.012	.60	–0.029	0.017	0.010	0.012	.43	–0.014	0.033
Household crowding (5-14 years only)	–0.010	0.009	.30	–0.028	0.009	—	—	—	—	—	—	—	—	—	—
Health insurance	–0.023	0.010	*.03*	–0.043	–0.003	–0.024	0.017	.17	–0.058	0.010	–0.019	0.013	.13	–0.043	0.006
Access to health care	0.215	0.007	*<.001*	0.202	0.227	–0.012	0.009	.17	–0.028	0.005	–0.010	0.007	.15	–0.023	0.003
Source of care	–0.014	0.010	.17	–0.033	0.006	–0.016	0.012	.20	–0.039	0.008	–0.018	0.012	.14	–0.041	0.006
Accident	0.038	0.006	*<.001*	0.026	0.050	0.014	0.009	.10	–0.003	0.031	–0.016	0.009	.06	–0.033	0.001
Disability	0.007	0.006	.21	–0.004	0.019	–0.004	0.009	.66	–0.023	0.014	0.004	0.010	.68	–0.016	0.024
BMI (kg/m^2)	0.015	0.007	*.03*	0.001	0.028	–0.014	0.009	.12	–0.032	0.004	–0.020	0.008	*.02*	–0.036	–0.004
Self-rated oral health status															
Age	0.000	0.005	.97	–0.009	0.009	–0.006	0.003	.07	–0.012	0.000	0.001	0.003	.62	–0.004	0.006
Sex	0.006	0.003	*.04*	0.000	0.011	0.001	0.003	.78	–0.005	0.007	0.006	0.003	*.03*	0.001	0.012
Citizenship	0.005	0.004	.20	–0.002	0.012	–0.004	0.005	.42	–0.014	0.006	–0.005	0.004	.20	–0.012	0.002
Region	–0.019	0.003	*<.001*	–0.024	–0.014	0.003	0.004	.36	–0.004	0.011	–0.003	0.005	.53	–0.013	0.006

Pathway	5–14 years					15–24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Marital status (≥25 years only)	—	—	—	—	—	—	—	—	—	—	–0.003	0.005	.58	–0.013	0.007
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.004	0.004	.30	–0.004	0.012
Monthly household income	–0.003	0.003	.42	–0.010	0.004	0.000	0.005	.98	–0.009	0.009	0.000	0.005	.97	–0.009	0.009
Household crowding (5-14 years only)	0.003	0.004	.50	–0.005	0.010	—	—	—	—	—	—	—	—	—	—
Health insurance	0.003	0.004	.53	–0.006	0.011	0.007	0.007	.28	–0.006	0.021	–0.012	0.006	*.04*	–0.023	0.000
Access to health care	–0.068	0.006	*<.001*	–0.080	–0.056	0.005	0.003	.14	–0.002	0.012	0.009	0.003	*.002*	0.003	0.014
Source of care	0.012	0.005	*.009*	0.003	0.021	0.006	0.005	.18	–0.003	0.015	0.010	0.004	*.03*	0.001	0.018
Accident	–0.007	0.002	*.003*	–0.012	–0.003	–0.003	0.003	.36	–0.010	0.004	0.008	0.003	*.01*	0.002	0.014
Disability	–0.001	0.002	.77	–0.005	0.004	0.001	0.003	.74	–0.005	0.008	0.000	0.003	.96	–0.006	0.006
BMI	–0.004	0.003	.10	–0.010	0.001	0.006	0.003	.09	–0.001	0.013	0.004	0.003	.19	–0.002	0.010

[a]β: standardized regression weights.

[b]Significant pathways in italic font.

[c]Not applicable.

Table 5. Total effects for the distal influences on oral pain and self-rated oral health status based on conceptual framework (Figure 1). Data from the 2017 National Demographic and Health Survey conducted by the Ministry of Health of Saudi Arabia.

Pathway	5–14 years					15–24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Oral pain															
Age	0.071	0.012	*<.001*[b]	0.047	0.095	0.021	0.013	.10	–0.004	0.046	–0.011	0.011	.31	–0.033	0.010
Sex	0.017	0.011	.11	–0.004	0.038	0.000	0.013	.98	–0.026	0.026	–0.008	0.012	.52	–0.032	0.016
Citizenship	–0.085	0.017	*<.001*	–0.119	–0.052	0.022	0.021	.27	–0.018	0.063	0.008	0.015	.61	–0.022	0.037
Region	0.020	0.011	.06	–0.001	0.041	–0.033	0.013	*.01*	–0.058	–0.008	–0.045	0.013	*<.001*	–0.070	–0.021
Marital status (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.025	0.021	.23	–0.015	0.065
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.004	0.017	.82	–0.029	0.036
Monthly household income	–0.006	0.016	.72	–0.037	0.025	0.004	0.019	.83	–0.032	0.040	–0.011	0.018	.52	–0.046	0.023
Household crowding (5-14 years only)	–0.008	0.018	.68	–0.043	0.028	—	—	—	—	—	—	—	—	—	—
Health insurance	–0.058	0.020	*.003*	–0.097	–0.020	0.027	0.024	.26	–0.020	0.073	0.023	0.018	.20	–0.013	0.059
Access to health care	0.410	0.010	*<.001*	0.390	0.430	–0.002	0.013	.86	–0.028	0.023	0.006	0.011	.61	–0.016	0.028
Source of care	0.039	0.018	*.03*	0.003	0.074	–0.004	0.018	.83	–0.039	0.032	–0.019	0.018	.30	–0.055	0.017
Accident	0.089	0.012	*<.001*	0.067	0.112	0.042	0.013	*.001*	0.017	0.067	–0.009	0.014	.51	–0.037	0.018
Disability	0.020	0.011	.07	–0.002	0.042	0.004	0.012	.77	–0.021	0.028	0.031	0.013	*.02*	0.005	0.057
BMI	0.030	0.013	*.02*	0.004	0.056	–0.047	0.014	*.001*	–0.074	–0.020	–0.032	0.014	*.02*	–0.059	–0.006
Self-rated oral health status															
Age	–0.044	0.013	*.001*	–0.069	–0.018	–0.039	0.013	*.002*	–0.063	–0.014	0.015	0.011	.19	–0.007	0.037
Sex	–0.024	0.012	*.04*	–0.047	–0.002	0.023	0.013	.08	–0.003	0.050	–0.014	0.013	.29	–0.039	0.011
Citizenship	0.072	0.018	*<.001*	0.037	0.107	0.008	0.020	.67	–0.030	0.047	–0.055	0.016	*<.001*	–0.085	–0.024
Region	–0.099	0.012	*<.001*	–0.121	–0.076	–0.011	0.013	.39	–0.036	0.014	–0.011	0.013	.40	–0.037	0.015

Pathway	5–14 years					15–24 years					≥25 years				
	β[a]	SE	*P* value	95% CI		β	SE	*P* value	95% CI		β	SE	*P* value	95% CI	
Marital status (25+ only)	—	—	—	—	—	—	—	—	—	—	–0.012	0.019	.53	–0.050	0.026
Education (≥25 years only)	—	—	—	—	—	—	—	—	—	—	0.050	0.016	*.002*	0.019	0.082
Monthly household income	0.070	0.016	*<.001*	0.038	0.101	0.018	0.018	.31	–0.017	0.054	–0.028	0.019	.14	–0.064	0.009
Household crowding (5-14 years only)	–0.043	0.020	*.03*	–0.081	–0.005	—	—	—	—	—	—	—	—	—	—
Health insurance	–0.011	0.020	.58	–0.050	0.028	–0.152	0.022	*<.001*	–0.195	–0.109	–0.146	0.018	*<.001*	–0.182	–0.110
Access to health care	–0.164	0.011	*<.001*	–0.187	–0.142	0.050	0.013	*<.001*	0.024	0.075	0.025	0.011	*.03*	0.003	0.047
Source of care	–0.124	0.018	*<.001*	–0.160	–0.088	0.005	0.018	.77	–0.029	0.040	0.029	0.019	.12	–0.007	0.065
Accident	–0.040	0.012	*.001*	–0.064	–0.016	–0.014	0.013	.29	–0.039	0.012	–0.036	0.012	*.002*	–0.059	–0.013
Disability	–0.017	0.011	.14	–0.039	0.005	–0.077	0.016	*<.001*	–0.109	–0.045	–0.050	0.018	*.005*	–0.085	–0.015
BMI	0.047	0.013	*<.001*	0.021	0.073	0.099	0.013	*<.001*	0.072	0.125	0.071	0.014	*<.001*	0.045	0.098

[a]β: standardized regression weights.

[b]Significant pathways in italic font.

[c]Not applicable.

Age and Sex

There was a negative direct effect between age and SROH (Table 3) in both the children (β=–0.044, *P*=.001) and adolescent (β=–0.033, *P*=.008) groups. An indirect positive effect (β=0.062, *P*<.001) was found between age and OP in the children group (Table 4). Total effect (Table 5) of age was detected in the children group for both OP (positive relation) and SROH status (negative relation).

Among female children, a negative direct effect (β=–0.030, *P*=.009) was found with SROH (Table 3). Total indirect effect showed a negative association between female adults and OP (β=–0.016, *P*=.04; Table 4). This total indirect effect was mediated by dental visits and tooth brushing frequency, as a positive direct link was found between female sex and tooth brushing frequency in both the child (β=0.073, *P*<.001) and adult groups (β=0.026, *P*=.04; Tables S1 and S3 in Multimedia Appendix 1). Also, the total indirect effect revealed a positive association between female children (β=0.006, *P*=.04) and adults (β=0.006, *P*=.03) with SROH (Table 4). However, total effect showed a negative association between female children and SROH (β=–0.024, *P*=.04; Table 5).

Citizenship, Regions, and Education Levels

Among non-Saudi citizens, the direct (β=–0.081, *P*<.001) and total (β=–0.085, *P*<.001) effects showed a negative association with OP in the children's age group but a positive association in the adult group (β=0.023, *P*=.02) through the total indirect effect.

Adolescents and adults from the north and south regions were linked to less OP than those from the east, west, and central regions through the total (β=–0.033, *P*=.01 and β=–0.045, *P*<.001) effects pathways (Table 5). However, OP was positively

linked to children from the southern and northern regions through the total indirect pathway (β=0.027, *P*<.001).

Higher education level was associated with positive SROH status directly (β=0.046, *P*=.003) and through the total direct effect pathway (β=0.050, *P*=.002). Furthermore, higher education was linked with greater tooth brushing frequency and less OP indirectly via tooth brushing frequency (β=–0.004, *P*<.001) and positive SROH status (β=0.008, *P*<.001) (Table S3 in Multimedia Appendix 1).

Monthly Household Income and Insurance

In the children group, higher household income was associated with less OP through the direct pathway (β=–0.030, *P*=.02), but higher income was positively associated with greater OP through the total indirect pathway (β=0.024, *P*=.003). In addition, higher income was associated with less OP (β=–0.002, *P*=.03) and a positive SROH status (β=0.006, *P*=.007) when mediated by tooth brushing frequency (Table S1 in Multimedia Appendix 1).

In the children group, having health insurance was associated with less OP through direct (β=–0.36, *P*=.03), total indirect (β=–0.023, *P*=.03), and total effect pathways (β=–0.058, *P*=.003). On the other hand, insurance was associated positively with OP through the direct pathway in both adolescents (β=0.051, *P*=.004) and adults (β=0.042, *P*<.001). Moreover, in adults, insurance was linked to less OP indirectly via dental visit frequency (β=–0.028, *P*=.01).

Access to Oral Health Services

In the children group, lack of access to oral health care was linked to more OP and negative SROH status through direct, total indirect, and total effects (Tables 2-4).

Private clinic visits as the regular source of dental care were associated with more OP and worse SROH status in the children group through the direct (for OP: β=0.053, *P*=.001 and for SROH status: β=–0.136, *P*<.001, respectively) and through total effect pathways (for OP: β=0.039, *P*=.03; for SROH status: β=–0.124, *P*<.001). However, private clinic visits as the regular source of dental care were associated with better SROH status through a total indirect effect (β=0.012, *P*=.009). Private clinic as the regular source of dental care was associated with less OP and better SROH status in the children group through the indirect effect via tooth brushing frequency (for OP: β=–0.005, *P*=.003; for SROH status: β=0.017, *P*<.001).

Past Accident Experience and Physical Disability

In the adult group, past accident experience was negatively associated with SROH status through the direct (β=–0.043, *P*<.001) and total effects pathways (β=–0.036, *P*=.002) and positively associated with SROH status through the total indirect pathway (β=0.008, *P*=.01).

Physical disability was linked to OP and negative SROH status in the child group through the total-effects pathway (Table 4). In the adult group, physical disability was associated with greater OP and worse SROH status through the direct and total effect pathways (Tables 2 and 4).

BMI

Normal BMI was linked to better SROH status through the direct pathway (β=0.051, *P*<.001) and through the total effect pathway (β=0.047, *P*<.001). In the adolescent group, normal BMI was linked to less OP and better SROH status through the direct and total effects pathways (Tables 2 and 4). In the adult group, normal BMI was linked to less OP through the total indirect and total effect pathways (Tables 3 and 4).

Discussion

Principal Findings

The findings of this study partially support the adapted conceptual framework for distal and proximal influences on self-reported OP and SROH status in Saudi Arabian residents (Figure 1). All proximal influences were associated with OP, except sweets and soft drink consumption in the children and adult groups. Unexpectedly, the consumption of soft drinks was associated with less OP in the adolescent group, although OP was positively associated with greater consumption of sweets. Moreover, all proximal influences were associated with SROH status except soft drink consumption and type of dental visit in the children's age group and smoking in the adult group. In addition, greater consumption of sweets and a higher number of dental visits were negatively associated with SROH status in the adolescent and children groups, but soft drink consumption was positively linked to SROH status in the adolescent and adult groups. Regarding distal influences, the majority of them showed an association with both OP and SROH status through the direct, indirect, and total effect pathways.

This study indicated that the prevalence of OP in Saudi Arabia is high. Data from 20 different countries in a meta-analysis illustrated that OP prevalence in children and adolescents was 36.2% [32]. This is almost half of the prevalence found in this study in similar age groups (60.2% for children and 67.8% for adolescents in KSA). Furthermore, the findings from this study differed from National Health and Nutrition Examination Survey (NHANES) 2015-2018 data [33] on adult US residents where OP was associated with education and income level, while in KSA it was not.

The findings from this study indicated that dental visit frequency was positively associated with OP and negatively associated with SROH status, while routine visits were associated with less pain and better SROH status in all age groups. It would be expected that a higher frequency of dental visits would be associated with better oral health; however, it appears that Saudi residents visit the dentist mainly when they have a complaint, such as OP, and do not normally visit the dentist for a routine check-up. A similar trend has been previously reported in national [34] and some subnational studies in Saudi Arabia [35-37]. The lack of interest in routine oral examinations and treatment visits (9.0% of children, 6.2% of adolescents, and 5.4% of adults reported routine dental visits) can be explained by the habitually optimistic view of the Saudi population about their oral health, as 92.9% of children, 87.1% of adolescents, and adults self-rated their oral health as good to excellent despite roughly two-thirds of them having reportedly experienced OP during the previous 6 months. Infrequent routine visits and

optimistic SROH status combined with less frequent tooth brushing is a critical finding of this study because the conclusion of these combined observations is that Saudi residents do not recognize risk factors that can adversely affect their oral health. This could be due to the cultures and beliefs in KSA, which are reinforced by the family and community [38]. Oral health officials and policy makers should consider raising public awareness about the importance of oral hygiene and routine dental clinic visits to improve oral health in the general population.

This study had several important limitations. Its cross-sectional nature, like all similar DHS studies, limits the ability to investigate distal and proximal influences on OP and SROH status over time, hindering the assessment of causal relationships between the predictive factors considered and the study outcome. On the other hand, this study is the first to assess the association between a number of predictive factors and oral health outcomes using a conceptual framework to guide the analysis. To our knowledge, no longitudinal study has measured changes in oral health status in Saudi Arabia, which is needed to determine oral health risk factors specific to this country's population.

Another major limitation in this study is the subjectivity of a self-reported survey over objective clinical evaluation, which may introduce response bias such as recall bias [39] in the responses (such as dental visit frequency in the past year) or social desirability bias [40] (such as not revealing smoking status). Such biases may have influenced the response to the question related to the consumption of soft drinks, particularly in the adolescent group. Adolescents who consume more soft drinks might underreport their OP due to a perception that admitting to pain could lead to restrictions on their soft drink consumption by parents or guardians [41], which in turn may have resulted in the apparent association of increased soft drink consumption with lower OP and better SROH status, which goes against clear evidence of an association between higher soft drink consumption and negative oral health outcomes in a number of cross-sectional and longitudinal studies [42]. Furthermore, self-reported OP and SROH status may not reflect exact oral health clinical status because they express a person's perception of their OP and oral health, which can be influenced by psychosocial and cultural factors. For example, NHANES 2003-2004 data from the United States showed that Latinos reported better SROH status than White individuals, while Latino individuals had more oral disease and lower access to and use of dental care [43]. Although using SROH indicators over a clinical measurement may have introduced some reporting bias, it is still a convenient, cost-effective, and expedited method to assess oral health status at a national level with a large sample and has shown a positive association with clinical oral health status [20]. Self-reported oral health measures have been used in many countries and national surveys, such as NHANES [33,43].

Despite these limitations, this study has a number of strengths, including the use of data from the 2017 KSA DHS, which applied a random sampling design with a large sample size, over a wide geographic distribution, and broad age range, which ensured the representative nature of the findings to the entire KSA, a heterogeneous country characterized by areas of very high income within a developing country. The second advantage is the use of the conceptual framework to guide the analysis, which enabled the use of path analysis. This is a preferred approach to delineate complex relationships, including both the direct and indirect effects of numerous predictive factors, over traditional multiple regression methods. This enabled testing the direct and indirect effects of different oral health influences on SROH status and OP. In this regard, the conceptual framework in this study is a significant contribution to the understanding of oral health influences in Saudi Arabia. However, the inclusion of other important oral health influences, such as coping skills and social support constructs, could have increased the explanatory power of the study [44].

Conclusions

Although OP is prevalent among Saudi residents, they still have a positive view of their oral health. Frequent tooth brushing, routine dental visits, and reduced sweet consumption are associated with less OP and better SROH. However, more frequent dental visits seem to address complaints rather than preventive care. Future research should investigate why residents have a positive perception of oral health despite high levels of OP and negative outcomes.

Acknowledgments

The authors would like to thank the Health Center Affairs General Department at the Ministry of Health in the Kingdom of Saudi Arabia for providing data. We would also like to thank Beverly Musick, Steve Brown, and Katie Lane, Department of Biostatistics. R.M. Fairbanks School of Public Health for their work on primary data processing. This study was conducted in Indiana University School of Dentistry as partial fulfillment for requirements for PhD degree in Dental Sciences. This study was supported by the Indiana University School of Dentistry, Department of Cariology, Operative Dentistry and Dental Public Health.

Data Availability

The datasets generated during and/or analyzed during this study are not publicly available due to Indiana's University agreement with the Ministry of Health of Saudi Arabia, but can be available from the office of the Directorate of Primary Health Care Centers (Ministry of Health Headquarters, Riyadh, Kingdom of Saudi Arabia).

Conflicts of Interest

The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Multimedia Appendix 1

Additional material.
[DOCX File , 126 KB-Multimedia Appendix 1]

References

1. GBD 2017 Oral Disorders Collaborators, Bernabe E, Marcenes W, Hernandez C, Bailey J, Abreu L, et al. Global, regional, and national levels and trends in burden of oral conditions from 1990 to 2017: a systematic analysis for the global burden of disease 2017 study. J Dent Res. 2020;99(4):362-373. [FREE Full text] [doi: 10.1177/0022034520908533] [Medline: 32122215]
2. Al Agili DE. A systematic review of population-based dental caries studies among children in Saudi Arabia. Saudi Dent J. 2013;25(1):3-11. [FREE Full text] [doi: 10.1016/j.sdentj.2012.10.002] [Medline: 23960549]
3. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. Bull World Health Organ. 2005;83(9):661-669. [FREE Full text] [Medline: 16211157]
4. Wu B, Plassman BL, Liang J, Remle RC, Bai L, Crout RJ. Differences in self-reported oral health among community-dwelling black, Hispanic, and white elders. J Aging Health. 2011;23(2):267-288. [FREE Full text] [doi: 10.1177/0898264310382135] [Medline: 20858912]
5. Joaquim AMC, Wyatt CCL, Aleksejūnienė J, Greghi SLA, Pegoraro LF, Kiyak HA. A comparison of the dental health of Brazilian and Canadian independently living elderly. Gerodontology. 2010;27(4):258-265. [doi: 10.1111/j.1741-2358.2009.00340.x] [Medline: 20545778]
6. Gilbert GH, Duncan RP, Heft MW, Dolan TA, Vogel WB. Multidimensionality of oral health in dentate adults. Med Care. 1998;36(7):988-1001. [doi: 10.1097/00005650-199807000-00006] [Medline: 9674617]
7. Locker D, Grushka M. The impact of dental and facial pain. J Dent Res. 1987;66(9):1414-1417. [doi: 10.1177/00220345870660090101] [Medline: 3476612]
8. Shepherd MA, Nadanovsky P, Sheiham A. The prevalence and impact of dental pain in 8-year-old school children in Harrow, England. Br Dent J. 1999;187(1):38-41. [doi: 10.1038/sj.bdj.4800197] [Medline: 10452189]
9. Vargas CM, Macek MD, Marcus SE. Sociodemographic correlates of tooth pain among adults: United States, 1989. Pain. 2000;85(1-2):87-92. [doi: 10.1016/s0304-3959(99)00250-x] [Medline: 10692606]
10. Pau A, Croucher RE, Marcenes W. Demographic and socio-economic correlates of dental pain among adults in the United Kingdom, 1998. Br Dent J. 2007;202(9):E21; discussion 548-E21; discussion 549. [doi: 10.1038/bdj.2007.171] [Medline: 17322865]
11. Ohara Y, Hirano H, Watanabe Y, Obuchi S, Yoshida H, Fujiwara Y, et al. Factors associated with self-rated oral health among community-dwelling older Japanese: a cross-sectional study. Geriatr Gerontol Int. 2015;15(6):755-761. [doi: 10.1111/ggi.12345] [Medline: 25244626]
12. Shearer DM, Thomson WM, Broadbent JM, Poulton R. Maternal oral health predicts their children's caries experience in adulthood. J Dent Res. 2011;90(5):672-677. [FREE Full text] [doi: 10.1177/0022034510393349] [Medline: 21248361]
13. Perera I, Ekanayake L. Influence of oral health-related behaviours on income inequalities in oral health among adolescents. Community Dent Oral Epidemiol. 2011;39(4):345-351. [doi: 10.1111/j.1600-0528.2010.00606.x] [Medline: 21241348]
14. Silva JVD, Oliveira AGRDC. Individual and contextual factors associated to the self-perception of oral health in Brazilian adults. Rev Saude Publica. 2018;52:29. [FREE Full text] [doi: 10.11606/S1518-8787.2018052000361] [Medline: 29641654]
15. 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):1087-1096. [doi: 10.1007/s11136-013-0541-3] [Medline: 24097081]
16. Abogazalah N, Yiannoutsos C, Martinez-Mier EA, Tantawy M, Yepes JF. The Saudi Arabian National Demographic and Health Survey, 2017: study design and oral health-related influences. Saudi Dent J. 2023;35(1):80-89. [FREE Full text] [doi: 10.1016/j.sdentj.2022.12.001] [Medline: 36817022]
17. World Health Organization. Oral Health Surveys: Basic Methods. Geneva. World Health Organization; 2013.
18. Steele JG, Sanders AE, Slade GD, Allen PF, Lahti S, Nuttall N, et al. How do age and tooth loss affect oral health impacts and quality of life? A study comparing two national samples. Community Dent Oral Epidemiol. 2004;32(2):107-114. [doi: 10.1111/j.0301-5661.2004.00131.x] [Medline: 15061859]
19. MacEntee MI, Stolar E, Glick N. Influence of age and gender on oral health and related behaviour in an independent elderly population. Community Dent Oral Epidemiol. 1993;21(4):234-239. [doi: 10.1111/j.1600-0528.1993.tb00763.x] [Medline: 8370262]
20. Liu Y. Differentiation of self-rated oral health between American non-citizens and citizens. Int Dent J. 2016;66(6):350-355. [FREE Full text] [doi: 10.1111/idj.12248] [Medline: 27424563]
21. Vargas CM, Crall JJ, Schneider DA. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988-1994. J Am Dent Assoc. 1998;129(9):1229-1238. [doi: 10.14219/jada.archive.1998.0420] [Medline: 9766104]
22. Litt MD, Reisine S, Tinanoff N. Multidimensional causal model of dental caries development in low-income preschool children. Public Health Rep. 1995;110(5):607-617. [FREE Full text] [Medline: 7480616]

23. Lave JR, Keane CR, Lin CJ, Ricci EM. The impact of dental benefits on the utilization of dental services by low-income children in western Pennsylvania. Pediatr Dent. 2002;24(3):234-240. [Medline: 12064498]
24. Gustafsson BE, Quensel CE, Lanke LS, Lundqvist C, Grahnen H, Bonow BE, et al. The Vipeholm dental caries study; the effect of different levels of carbohydrate intake on caries activity in 436 individuals observed for five years. Acta Odontol Scand. 1954;11(3-4):232-264. [doi: 10.3109/00016355308993925] [Medline: 13196991]
25. Al-Zahrani A, Al-Qahtani M, Al-Barti M, Bakhurji EA. Dietary determinants of dental caries prevalence and experience in Saudi schoolchildren: frequency versus quantity. ScientificWorldJournal. 2022;2022:5447723. [FREE Full text] [doi: 10.1155/2022/5447723] [Medline: 35027880]
26. Bergström J, Eliasson S, Dock J. A 10-year prospective study of tobacco smoking and periodontal health. J Periodontol. 2000;71(8):1338-1347. [doi: 10.1902/jop.2000.71.8.1338] [Medline: 10972650]
27. Farooqi FA, Khabeer A, Moheet IA, Khan SQ, Farooq I, ArRejaie AS. Prevalence of dental caries in primary and permanent teeth and its relation with tooth brushing habits among schoolchildren in eastern Saudi Arabia . Saudi Med J. 2015;36(6):737-742. [FREE Full text] [doi: 10.15537/smj.2015.6.10888] [Medline: 25987118]
28. Haugejorden O, Nord A, Klock KS. Direct evidence concerning the 'major role' of fluoride dentifrices in the caries decline. A 6-year analytical cohort study. Acta Odontol Scand. 1997;55(3):173-180. [doi: 10.3109/00016359709115412] [Medline: 9226428]
29. Rosseel Y. lavaan: an R package for structural equation modeling. J Stat Soft. 2012;48(2):1-36. [doi: 10.18637/jss.v048.i02]
30. Arminger G, Schoenberg RJ. Pseudo maximum likelihood estimation and a test for misspecification in mean and covariance structure models. Psychometrika. 1989;54(3):409-425. [doi: 10.1007/bf02294626]
31. Savalei V. On the computation of the RMSEA and CFI from the mean-and-variance corrected test statistic with nonnormal data in SEM. Multivariate Behav Res. 2018;53(3):419-429. [doi: 10.1080/00273171.2018.1455142] [Medline: 29624085]
32. Santos PS, Barasuol JC, Moccelini BS, Magno MB, Bolan M, Martins-Junior PA, et al. Prevalence of toothache and associated factors in children and adolescents: a systematic review and meta-analysis. Clin Oral Investig. 2022;26(2):1105-1119. [doi: 10.1007/s00784-021-04255-2] [Medline: 34791550]
33. Aldosari M, Mendes SDR, Aldosari A, Aldosari A, de Abreu MHNG. Factors associated with oral pain and oral health-related productivity loss in the USA, National Health and Nutrition Examination Surveys (NHANES), 2015-2018. PLoS One. 2021;16(10):e0258268. [FREE Full text] [doi: 10.1371/journal.pone.0258268] [Medline: 34634083]
34. El Bcheraoui C, Tuffaha M, Daoud F, Kravitz H, AlMazroa MA, Al Saeedi M, et al. Use of dental clinics and oral hygiene practices in the Kingdom of Saudi Arabia, 2013. Int Dent J. 2016;66(2):99-104. [FREE Full text] [doi: 10.1111/idj.12210] [Medline: 26749526]
35. Alsubaie ASR. Oral health-related behaviors and dental pain among children in Saudi Arabia. J Int Oral Health. 2019;11(1):1. [doi: 10.4103/jioh.jioh_253_18]
36. Almutlaqah MA, Baseer MA, Ingle NA, Assery MK, Al Khadhari MA. Factors affecting access to oral health care among adults in abha city, Saudi Arabia. J Int Soc Prev Community Dent. 2018;8(5):431-438. [FREE Full text] [doi: 10.4103/jispcd.JISPCD_205_18] [Medline: 30430071]
37. Gowdar IM, Alqahtani AM, Asiri AM, Aldossary SF, Alkhurayef IA, Alheneshi DI. Oral health myths among general population at riyadh region, Saudi Arabia. J Pharm Bioallied Sci. 2021;13(Suppl 1):S241-S245. [FREE Full text] [doi: 10.4103/jpbs.JPBS_700_20] [Medline: 34447085]
38. Butani Y, Weintraub JA, Barker JC. Oral health-related cultural beliefs for four racial/ethnic groups: assessment of the literature. BMC Oral Health. 2008;8(1):26. [FREE Full text] [doi: 10.1186/1472-6831-8-26] [Medline: 18793438]
39. Peer E, Gamliel E. Too reliable to be true? Response bias as a potential source of inflation in paper-and-pencil questionnaire reliability. Pract Assess Res Eval. 2011;16(1):9.
40. Fisher RJ, Katz JE. Social-desirability bias and the validity of self-reported values. Psychol Mark. 2000;17(2):105-120. [doi: 10.1002/(sici)1520-6793(200002)17:2<105::aid-mar3>3.0.co;2-9]
41. Brener ND, Billy JOG, Grady WR. Assessment of factors affecting the validity of self-reported health-risk behavior among adolescents: evidence from the scientific literature. J Adolesc Health. 2003;33(6):436-457. [doi: 10.1016/s1054-139x(03)00052-1] [Medline: 14642706]
42. Tahmassebi JF, Duggal MS, Malik-Kotru G, Curzon MEJ. Soft drinks and dental health: a review of the current literature. J Dent. 2006;34(1):2-11. [doi: 10.1016/j.jdent.2004.11.006] [Medline: 16157439]
43. Maida CA, Marcus M, Spolsky VW, Wang Y, Liu H. Socio-behavioral predictors of self-reported oral health-related quality of life. Qual Life Res. 2013;22(3):559-566. [FREE Full text] [doi: 10.1007/s11136-012-0173-z] [Medline: 22528238]
44. Fisher-Owens SA, Gansky SA, Platt LJ, Weintraub JA, Soobader MJ, Bramlett MD, et al. Influences on children's oral health: a conceptual model. Pediatrics. 2007;120(3):e510-e520. [doi: 10.1542/peds.2006-3084] [Medline: 17766495]

Abbreviations

DHS: demographic and health survey
IRB: institutional review board
KSA: Kingdom of Saudi Arabia

NHANES: National Health and Nutrition Examination Survey
OP: oral pain
SROH: self-rated oral health

Edited by A Mavragani; submitted 12.10.23; peer-reviewed by RP Shaik, K Al-Khalifa; comments to author 12.06.24; revised version received 06.09.24; accepted 25.09.24; published 20.12.24

Please cite as:
Abogazalah N, Yiannoutsos C, Soto-Rojas AE, Bindayeld N, Yepes JF, Martinez Mier EA
Distal and Proximal Influences on Self-Reported Oral Pain and Self-Rated Oral Health Status in Saudi Arabia: Retrospective Study Using a 2017 Nationwide Database
JMIR Public Health Surveill 2024;10:e53585
URL: https://publichealth.jmir.org/2024/1/e53585
doi: 10.2196/53585
PMID: 39706582