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ORIGINAL ARTICLE

The Saudi Arabian national demographic and health survey, 2017: Study design and oral health-related influences

Naif Abogazalah [a,b,*], Constantin Yiannoutsos [c], Esperanza-Angeles Martinez-Mier [b], Muhammad Tantawy [d], Juan Fernando Yepes [e]

[a] Department of Restorative Dental Sciences, King Khalid University College of Dentistry, Abha, Saudi Arabia
[b] Department of Cariology, Operative Dentistry and Dental Public Health, Indiana University School of Dentistry, Indianapolis, IN, USA
[c] Department of Biostatistics, Indiana University Richard M. Fairbanks School of Public Health, Indianapolis, IN, USA
[d] Health Center Affairs General Department, Ministry of Health, Riyadh, Saudi Arabia
[e] Department of Pediatric Dentistry, Indiana University School of Dentistry, Indianapolis, IN, USA

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Abstract *Objective:* To describe the study design, and the distal and proximal influences on oral health reported in the national demographic and health survey (DHS) of the Kingdom of Saudi Arabia (KSA) in 2017.

Methods: The 2017 KSA DHS used an innovative multistage stratified random-sampling technique to select the population sample by using primary health care centers' (PHCs) catchment areas as the primary sampling unit. Over 45,000 household heads plus a family member were interviewed. A conceptual framework for distal and proximal oral health influences specific to the KSA was adapted based on the oral health surveillance model. Cross-tabulation and Chi-square tests were performed with consideration for sample weights to provide estimates representative for the KSA population. Frequencies and weighted percentages for each variable reflecting each construct were reported.

Results: The total number of individuals included in the analysis was n = 55,511, ages ranging between 2 and > 65 years. Lack of dental care when needed was reported for 22.5 % of the population (males = 20.8 %/females = 24.7 %). Proportion of population from Central, West, East,

* Corresponding author at: Department of Cariology, Operative Dentistry and Dental Public Health, Indiana University School of Dentistry. 1121 West Michigan Street, Room DS 315, Indianapolis, IN 46202, USA.
E-mail address: nabogaza@iupui.edu (N. Abogazalah).

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South, and North regions who reported available dental care services when needed was 62.3 %, 58.0 %, 58.9 %, 62.3 %, and 60.1 %, respectively. PHCs were the most regular source for dental care (55.1 %). In total, 48.3 % visited the dentist at least once last year (males = 49.4 % /females = 46.8 %). Dental pain was the most common reason for last dental visit (69.0 %), while only 6.4 % reported visited the dentist for routine visit. Only 15.3 % reported brushing their teeth at least twice per day (males = 14.6 % /females = 16.4 %).

Conclusion: Two major oral health influences previously reported to have a significant negative influence on oral health, namely, limited routine dental check-up visits and inadequate oral hygiene, were present among KSA residents. Further inferential study is needed to investigate such influence on oral health status within the KSA population.

1. Introduction

Oral diseases are a major public health problem worldwide, causing pain and imposing economic burdens on individuals and countries' healthcare systems. Over the last few decades, developed countries have experienced a decrease in the incidence of dental caries and periodontal diseases, but their incidence has shown a sharp rise in middle- and low-income countries, driven mainly by social and economic changes (Kassebaum et al., 2017). Oral health can be influenced by exposure to various influences throughout a person's lifetime. These influences can be classified as proximal and distal (Petersen, 2005). Proximal influences can directly or relatively directly lead to adverse oral health outcomes, while distal influences shape the proximal influences and indirectly lead to adverse oral health outcomes (Fig. 1) (Petersen, 2005).

In the Kingdom of Saudi Arabia (KSA), data from many regional oral health surveys have demonstrated a high prevalence of oral diseases, especially dental caries, making them a national public health problem. A systematic review investigated the nationwide prevalence of dental caries in the KSA for studies conducted between 1988 and 2010 has showed that the prevalence of dental caries in the primary dentition of children younger than 6 years ranged between 62 % and 84 %, while in the permanent dentition, the prevalence varied between 58 % and 94 % (Al Agili, 2013). Poor oral hygiene practices and inadequate dental preventive visits were identified as the main proximal influences on oral health in the KSA (Almas et al., 2003; Morgano et al., 2010), while the main distal influences were disadvantaged sociodemographic conditions such as low parental income, low education, and lack of dental insurance (Al Hamdan and Fahmy, 2014; Alhabdan et al., 2018).

In dental public health research, it is important to identify the influences that may result in the development of oral diseases by using a multi-level risk assessment approach to plan effective health promotion programs (Watt et al., 2019). In 2017, the ministry of health (MOH) in the KSA conducted the largest and most comprehensive nationwide demographic and health survey (DHS). The DHS (2017 KSA DHS) provided data that should be instrumental to investigate the population's oral health risk factors in the KSA at the national level for the first time. The MOH used the catchment areas of primary healthcare centers (PHCs) as the primary sampling unit which, in terms of sampling methodology, was innovative.

The primary objective of this study was to describe the proximal and distal influences on oral health according to gender, age group, and region differences at a national level in the KSA by utilizing data from the 2017 KSA DHS. We adapted a conceptual framework for oral health influences in the KSA

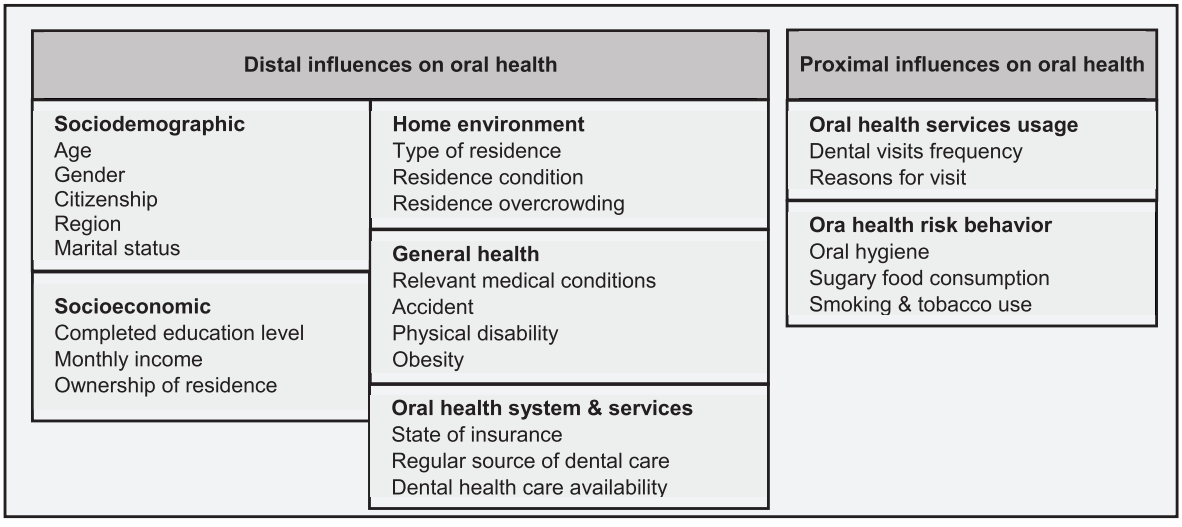

Fig. 1 Adapted framework for distal and proximal influences on oral health.

(Fig. 1) from the World Health Organization (WHO's) model for Oral Health Surveillance (Petersen, 2005). The secondary objective was to describe the study design of the 2017 KSA DHS.

2. Materials and methods

2.1. Survey design

The present study used a cross-sectional design for the 2017 DHS KSA covering all regions of the KSA by using multistage stratified random sampling. The target population included all non-institutionalized residents of the KSA. House-to-house visits were conducted to interview the head of the household or an eligible representative plus a randomly selected family member. The proposed sample size was a target number of 50,000 households, which constitutes approximately (1 %) of the nationwide household size (Abdul Salam, 2013). A family member representing each age group was selected within each household.

2.2. Sample strategy and distribution

The MOH delivers health services through twenty regional directorates of health (thirteen administrative regions in addition to seven major governorates). The regional directorates of health run 2282 PHC centers nationwide. Each PHC center has a well-defined geographic area called the catchment area. Based on the population sizes within each PHC catchment areas, they were classified into eight strata representing different population densities and reflecting the socio-demographic nature of the people living in the geographic locations in the KSA (Table S1).

In each stratum, a sample of 25 % (total number of PHC = 571) of the PHC centers within the KSA were randomly selected by selecting the 4th PHC from a list where PHC catchment areas were ordered by population density from least to highest populous PHC catchment area. The list was available from the MOH registries.

Fifty-thousand households were distributed across the eight strata in proportion to the population size of each stratum (Table S1). The number of households per stratum was calculated based on the following formula:

$$Numberofhouseholdsassignedperstratum = \frac{50,000households \times proportionofpopulationsizeperstratum}{100}$$

The proportion of population size per stratum was calculated as follows:

$$Proportionofpopulationsizeperstratum = \frac{Populationsizeperstratum}{totalpopulationsize} \times 100$$

The number of households assigned to each stratum was then distributed to the selected 25% PHC centers. Within each household, one family member representing each age group was randomly selected. The third youngest person in each age group was selected. If two persons were available, the second one was selected. If only one person was available, he/she was selected.

The population size per stratum was derived from MOH registries in 2016. The total population size of the KSA was calculated according to the KSA 2010 national census data (Statistics, 2010).

2.3. Overview of the survey

Training was conducted centrally at MOH headquarters (Riyadh, KSA) for regional field supervisors and trainers, who, in turn, conducted peripheral training workshops and meetings for the field investigators in their respective regions. In each PHC catchment area, a field investigation team was assigned to cover their area using a cartography map. Consent by the head of the household for the team to enter homes and verbally accept the survey questionnaire was considered as willingness to participate in the survey. The house-to house visits were taken place between February 12, 2017, to May 23, 2017.

The questionnaire included different sociodemographic, environment- and health-related questions. The family head questionnaire covered topics relevant to the household. Other family members' questionnaires covered health specific topics relevant to their age group. Anthropometric measurements, namely, weight and height were obtained. Oral health questionnaire was derived from the World Health Organization oral health assessment tool (Organization 2013). A pilot survey was conducted prior to the main survey in eight governates to assess feasibility. Further details about the sample distribution, survey implementation, survey design and tools, and sampling weights are available at the office of Directorate of Primary Health Care Centers (MOH headquarters, Riyadh, KSA).

2.4. Model adaptation

The conceptual framework (Fig. 1) was adapted based on both the WHO's model for Oral Health Surveillance (Petersen, 2005) and the available variables reported in the 2017 KSA DHS. The constructs and variables included in the framework were detailed in Table S2.

2.5. Data processing and statistical analysis

A data management plan was prepared by the MOH in collaboration with the Biostatistics Department, Indiana University School of Medicine, Indianapolis, Indiana, USA (IRB number: 1808825963). Three main datasets were received: household head dataset (N = 45,287); adult family member dataset (N = 40,955); and pediatric and adolescent family member datasets (N = 15,585). Each family was assigned a number to track family members to their respective household heads. The household head, adult family member, and pediatric and adolescent family member datasets were merged to track measures to the household head. Among the 45,287 household heads, 20,294 had a valid family number that allowed merging. After merging, data for 55,511 participants were available for analysis.

Cross-tabulation was performed to describe the distal and proximal influences on oral health. SPSS (IBM Corp. Armonk, NY, USA) software was used to perform the analysis. Variable selection was guided by the multi-level conceptual framework (Fig. 1). Chi-squared tests were performed to compare

sex-related, age-group, and geographic region differences in proximal and distal influences. Analysis was performed with consideration for sample weights to provide estimates representative for KSA residents. Data analysis was performed by (NA) at the Cariology, Operative Dentistry, and Dental Public Health Department, Indiana University School of Dentistry, in collaboration with the Biostatistics Department, Indiana University School of Medicine, Indianapolis, Indiana, USA.

3. Results

Participants aged 25 to 44 years constituted the largest age group (40.7 %). There were more female respondents than males, but the weighted estimates indicated that the male population was larger than the female population. Almost one-third of KSA residents were non-Saudi citizens. Almost 90 % of the household heads were currently married. Results for proximal and distal influences on oral health for total population are illustrated in Tables 1 and 2. Table 3illustrates major distal and proximal influences on oral health by gender.

More female participants (23.5 %) had college or higher degrees than males (6.3 %). A middle household income of 7,700 to 22,900 SAR was the most frequently reported (38.3 % of the sample population). Over half of the population owned their homes. Most respondents lived in flats (55.3 %) or houses (41.4 %), which were either new (34.5 %) or in a good condition (57.2 %), while < 10 % lived in old decaying housing. Approximately 80 % of the respondents shared a bedroom with another family member.

Approximately 36 % of the household heads and their family members reported that they were covered by health insurance. Also, around 22 % of the respondents reported a lack of dental services when needed, with females reporting less availability than males. Elderly (65 + years) and older adults (55–64 years) reported more lack of dental care when needed (around 27 %) than the rest of adult age groups (10.7 % for 2–4 years old children and between 21.1 % − 23.5 % for 5–54 years). Table 4 shows the major distal and proximal influences on oral health based on age groups.

PHCs were reported as the most regular source of dental care, followed by private clinics, which were used by approximately-one-third of the population. However, Central region reported the lowest usage of PHCs (37.1 %) and the highest for private clinic (40.7 %), while the North region was the highest user of PHC (80.8 %) and lowest in private clinics (10.7 %). Table 5 illustrates major distal and proximal influences based on geographic region differences.

4. Discussion

Traditionally, national-level surveys use a multistage cluster sampling design to select their sample. The first stage of this process involves identifying the primary sampling unit by selecting naturally occurring clusters or areas, which are usually census enumeration areas, followed by random household selection (USAID, 2020). Cluster-sampling designs have limitations, however, the most important of which has to do with less precise estimates of the population parameters due to an increase in sampling error among the clusters (Dixon et al., 2016). To overcome this limitation, the 2017 KSA DHS applied a stratified random sampling design. This was possible

Table 1 Distal influences on oral health for total population.

Variable	N[a]	wN[b]	w%[c]
Sociodemographic			
Age groups			
2–4	4674	2963	5.4
5–14	11,653	9365	16.9
15–24	9910	8435	15.3
25–34	11,072	10,893	19.7
35–44	8495	11,586	21.0
45–54	5066	6921	12.5
55–64	2834	3248	5.9
65 +	1807	1843	3.3
Gender			
Male	25,619	31,848	57.6
Female	29,892	23,406	42.4
Citizenship			
Citizen	50,155	34,555	62.5
Non-citizen	5356	20,699	37.5
Region			
North	11,447	4002	7.2
South	17,836	8193	14.8
East	11,041	8441	15.3
West	10,222	18,166	32.9
Central	4965	16,452	29.8
Marital status			
Married	20,785	17,546	89.1
Not-married	2036	2140	10.9
Socioeconomic			
Completed education level			
Primary school	7633	7446	19.7
Intermediate school	13,648	15,107	39.9
High school	9604	8710	23.0
Intermediate Diploma	1508	1427	3.8
College or higher education	5505	5182	13.7
Monthly household income			
(> 38,200 Riyals)	172	166	0.6
(22,901–38,200 Riyals)	776	991	3.4
(7,700–22,900 Riyals)	12,871	11,130	38.3
(3,801–7,699 Riyals)	7254	8124	28.0
(3,800 Riyals or less)	8086	8622	29.7
Ownership of residence			
Own	14,724	11,160	57.6
Rent	7606	8024	41.4
Other	295	198	1.0
Home Environment			
Type of residence			
Flat	12,169	10,711	55.3
House	10,204	8419	43.4
Other	280	251	1.3
Residence condition			
New	8518	6754	34.5
Old in good condition	12,566	11,216	57.2
Old decaying	1652	1627	8.3
Residence overcrowding			
≤1 person per room	4046	3960	21.1
1–2 person per room	9972	8190	43.7
> 2 person per room	7815	6579	35.1
General Health			
History of medical conditions			
History of hypertension	2859	2859	26.5
History of diabetes	786	786	7.3
Other diseases	7130	7130	66.2
Past accident experience			
Yes	2687	2850	5.5
No	50,014	49,360	94.5

(*continued on next page*)

Table 1 (*continued*)

Variable	N[a]	wN[b]	w%[c]
Type of accident			
Car accident	1530	1742	62.9
Electric accident	76	65	2.3
Fall	688	695	25.1
Hot liquid burn	135	137	4.9
Other	156	131	4.7
History of physical disability			
Yes	823	867	1.7
No	51,772	51,471	98.3
Type of disability			
Movement disability	259	287	37.2
Vision disturbance	290	302	39.0
Hearing disturbance	61	96	12.5
Speech disturbance	45	31	3.9
Other	62	57	7.4
Body mass index			
Underweight = <18.5	7426	5624	12.7
Normal weight = 18.5–24.9	17,161	16,189	36.5
Overweight = 25–29.9	12,728	13,706	30.9
Obesity = 30 or greater	7561	8863	20.0
Oral health system & services			
State of insurance			
Yes	5635	7108	36.3
No	17,080	12,489	63.7
Family state of insurance			
Yes	5277	6648	36.5
No	15,391	11,580	63.5
Regular source of dental care			
PHC	19,977	16,813	55.1
Governmental hospital	3225	3468	11.4
Private clinic	6260	9036	29.6
Other	779	1209	4.0
Dental care availability when needed			
Not available	13,028	11,178	22.5
Available	29,105	29,974	60.2
Do not remember	8036	8598	17.3

[a] Non-weighted frequency. [b] Weighted frequency. [c] Weighted percent. Data were not complete for some variables (missing data from participants).

Table 2 Proximal influences on oral health for total population.

Variable	Total		
	N[a]	wN[b]	w%[c]
Oral health service usage			
Dental visit frequency last year			
Once	11,459	11,651	23.8
More than once	11,570	11,991	24.5
Did not visit a dentist in the past year	19,014	18,351	37.5
Never visited a dentist	4661	4306	8.8
I do not know or do not remember	2507	2675	5.5
Reasons for last dental visit			
Pain or problem in your teeth or gums or mouth	19,762	20,478	69.0
For treatment and follow up	3819	4139	13.9
Routine examination and treatment	156	1911	6.4
I don't know	2029	2689	9.1
Other	2741	461	1.6
Dental health risk behavior			
Tooth brushing frequency			
I have never cleaned my teeth	5845	5656	11.7
I clean my teeth some days but not daily	13,248	12,719	26.3
Once weekly	3985	4190	8.7
Many times per week	5679	5518	11.4
Once daily	12,477	12,838	26.6
Twice or more daily	7217	7417	15.3
Frequency of eating sweets			
I don't eat at all	8460	9162	17.5
Many times per month	29,922	30,123	57.5
Many times per week	9148	8540	16.3
Once or more per day	5225	4584	8.7
Frequency of drinking soft drinks			
I don't drink at all	18,800	19,575	37.3
Many times per month	24,075	23,787	45.4
Many times per week	7109	6744	12.9
Once or more per day	2650	2332	4.4
Smoking status			
Yes	3321	3014	6.4
No	41,948	44,206	93.6
Secondhand smoker status			
Yes	4684	4780	18.3
No	20,338	21,323	81.7

[a] Non-weighted frequency. [b] Weighted frequency. [c] Weighted percent. Data were not complete for some variables (missing data from participants).

because of the universal coverage of all inhabited regions by PHCs. The stratified random sampling design provided more precise estimates of population characteristics because of the reduced sampling error in comparison with a multistage cluster design (Dixon et al., 2016).

Our results indicate that people aged between 25 and 44 years constitute over 50 % of the population. As this age group grows older, the proportion of people aged over 65 years is estimated to double by 2030 and triple by 2040 (United Nations, December 2019). As people age, the cost and demand for dental treatment is expected to increase due to the cumulative effect of constant exposure to risk factors of oral diseases and the biological changes occurring as a result of aging, such as the ability to perform oral hygiene practices (López et al., 2017). To ensure oral health welfare of the growing aging population, oral public healthcare officials need to prepare for these challenges.

The KSA residents are offered several channels to obtain free-of-cost oral healthcare services, yet 22.5 % reported they were unable to obtain oral health services when needed. A study conducted on the elderly population in Riyadh reported that lack of perceived need, no insurance, cost, and transportation were the main barriers to obtaining dental services (Hamasha et al., 2019). Furthermore, our results showed that a few participants reported visiting the dentist for routine checkups (6.4 %), while the majority (82.9 %) reported that the main reason was pain or dental treatment. This finding agrees with a previous national level study that reported similarly low numbers of Saudis who visited the dentist for a routine checkup (El Bcheraoui et al., 2016). Oral health access and use is a complex phenomenon that requires a conceptualized understanding of the links between the oral healthcare services systems and the population. Identifying factors such as predisposing, enabling, and need conditions at a conceptual and individual level is crucial to understanding access and use of oral health services (Andersen 2008). Future investigation is

Table 3 Major distal and proximal influences on oral health by gender.

Variable	Males			Females			*p*
	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	
Distal influences							
Oral health system & services							
State of insurance							
Yes	2433	4242	40.5	3202	2866	31.4	< 0.001
No	6997	6220	59.5	10,083	6269	68.6	
Family state of insurance							
Yes	2241	3936	39.4	3036	2712	32.9	< 0.001
No	6680	6054	60.6	8711	5526	67.1	
Regular source of dental care							
PHC	9529	9486	51.5	10,448	7327	60.5	< 0.001
Governmental hospital	1378	2097	11.4	1847	1371	11.3	
Private clinic	2796	5878	31.9	3464	3158	26.1	
Other	427	956	5.2	352	253	2.1	
Dental care availability when needed							
Not available	5732	5979	20.8	7296	5199	24.7	< 0.001
Available	13,442	17,369	60.5	15,663	12,605	59.9	
Do not remember	3918	5365	18.7	4118	3233	15.4	
Proximal influences							
Oral health service usage							
Dental visit frequency last year							
Once	5360	6900	24.3	6099	4751	23.1	< 0.001
More than once	5325	7113	25.1	6245	4878	23.7	
Did not visit a dentist in the past year	8758	10,361	36.5	10,256	7990	38.8	
Never visited a dentist	2255	2499	8.8	2406	1807	8.8	
I do not know or do not remember	1105	1518	5.3	1402	1157	5.6	
Reasons for last dental visit							
Pain or problem in your teeth or gums or mouth	9264	12,150	69.0	10,654	8328	69.0	0.007
For treatment and follow up	1808	2538	14.4	2011	1601	13.3	
Routine examination and treatment	950	1107	6.3	1079	804	6.7	
I don't know	1273	1552	8.8	1468	1137	9.4	
Other	220	256	1.5	240	205	1.7	
Dental health risk behavior							
Tooth brushing frequency							
I have never cleaned my teeth	2869	3473	12.3	2976	2183	10.8	< 0.001
I clean my teeth some days but not daily	6364	7461	26.5	6884	5258	26.0	
Once weekly	1898	2544	9.0	2087	1646	8.1	
Many times per week	2645	3209	11.4	3034	2309	11.4	
Once daily	5550	7337	26.1	6927	5501	27.2	
Twice or more daily	3168	4108	14.6	4049	3309	16.4	
Frequency of eating sweets							
I don't eat at all	3812	5294	17.5	4648	3868	17.5	< 0.001
Many times per month	14,041	17,718	58.6	15,881	12,405	56.0	
Many times per week	4177	4792	15.8	4971	3748	16.9	
Once or more per day	2401	2440	8.1	2824	2144	9.7	
Frequency of drinking soft drinks							
I don't drink at all	8400	11,012	36.3	10,400	8563	38.8	< 0.001
Many times per month	11,357	14,117	46.5	12,718	9670	43.8	
Many times per week	3392	3931	13.0	3717	2813	12.7	
Once or more per day	1256	1289	4.2	1394	1043	4.7	
Smoking status							
Yes	1494	1748	6.3	3321	1266	6.5	0.286
No	19,263	26,075	93.7	41,948	18,131	93.5	
Secondhand smoker status							
Yes	2243	3000	19.3	2441	1780	16.8	< 0.001
No	9372	12,539	80.7	10,966	8784	83.2	

Data were not complete for some variables (missing data from participants).
[a] Non-weighted frequency. [b] Weighted frequency. [c] Weighted percent.

Table 4 Major distal and proximal influences on oral health by age group.

Variable	2–4		5–14		15–24		25–34		35–44		45–54		55–64		65+		*p*
	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	
Distal influences																	
Oral health system & services																	
State of insurance																	
Yes	NA	NA	NA	NA	NA	NA	1616	41.0	1681	42.5	954	40.4	471	36.0	233	28.9	< 0.001
No	NA	NA	NA	NA	NA	NA	2321	59.0	2276	57.5	1408	59.6	839	64.0	573	71.1	
Family state of insurance																	
Yes	366	34.6	924	31.0	732	29.1	1506	40.6	1548	41.6	909	41.3	436	34.4	227	29.1	< 0.001
No	691	65.4	2055	69.0	1781	70.9	2204	59.4	2169	58.4	1294	58.7	832	65.6	553	70.9	
Regular source of dental care																	
PHC	55	58.5	2618	66.0	3277	63.4	3640	52.4	3483	48.6	2059	49.4	958	50.7	722	64.5	< 0.001
Governmental hospital	6	6.4	408	10.3	515	10.0	829	11.9	809	11.3	579	13.9	193	10.2	130	11.6	
Private clinic	30	31.9	872	22.0	1249	24.2	2159	31.1	2456	34.2	1376	33.0	681	36.0	213	19.0	
Other	3	3.2	67	1.7	130	2.5	319	4.6	424	5.9	152	3.6	59	3.1	55	4.9	
Dental care availability when needed																	
Not available	277	10.7	1819	21.4	1805	23.5	2253	22.9	2409	23.2	1399	22.1	783	27.3	432	27.2	< 0.001
Available	1965	76.0	5243	61.8	4660	60.7	5867	59.6	6109	58.8	3841	60.7	1499	52.4	790	49.7	
Do not remember	343	13.3	1427	16.8	1206	15.7	1722	17.5	1865	18.0	1086	17.2	581	20.3	368	23.1	
Proximal influences																	
Oral health service usage																	
Dental visit frequency last year																	
Once	417	16.9	1884	23.2	1813	23.9	2306	23.7	2526	24.5	1616	26.1	681	23.4	406	24.7	< 0.001
More than once	235	9.5	1666	20.5	2052	27.0	2518	25.9	2835	27.5	1519	24.5	755	26.0	410	24.9	
Did not visit a dentist in the past year	1147	46.5	3396	41.8	2714	35.7	3648	37.5	3538	34.3	2249	36.3	1054	36.3	607	36.9	
Never visited a dentist	583	23.6	724	8.9	581	7.6	688	7.1	838	8.1	499	8.1	262	9.0	132	8.0	
I do not know or do not remember	87	3.5	447	5.5	438	5.8	556	5.7	590	5.7	315	5.1	154	5.3	89	5.4	
Reasons for last dental visit																	
Pain or problem in your teeth or gums or mouth	472	56.2	2933	64.7	3340	69.1	4272	70.6	4790	72.0	2725	69.9	1243	67.2	703	68.8	< 0.001
For treatment and follow up	102	12.1	681	15.0	641	13.3	832	13.7	901	13.5	532	13.7	295	15.9	155	15.2	
Routine examination and treatment	151	18.0	409	9.0	302	6.2	352	5.8	282	4.2	241	6.2	113	6.1	63	6.2	
I don't know	107	12.7	430	9.5	460	9.5	495	8.2	589	8.9	350	9.0	174	9.4	84	8.2	
Other	8	1.0	80	1.8	93	1.9	102	1.7	89	1.3	48	1.2	25	1.4	17	1.7	
Dental health risk behavior																	
Tooth brushing frequency																	
I have never cleaned my teeth	413	17.8	866	10.7	830	11.1	1054	11.0	1235	12.0	744	12.2	343	12.2	171	10.5	< 0.001
I clean my teeth some days but not daily	837	36.0	2544	31.5	1861	24.9	2358	24.5	2395	23.2	1630	26.8	703	24.9	390	24.0	
Once weekly	249	10.7	572	7.1	626	8.4	915	9.5	915	8.9	494	8.1	295	10.5	124	7.6	
Many times per week	241	10.4	1067	13.2	862	11.6	1040	10.8	1131	11.0	699	11.5	327	11.6	150	9.2	
Once daily	460	19.8	2045	25.3	2022	27.1	2637	27.4	2958	28.7	1512	24.8	703	24.9	501	30.9	
Twice or more daily	124	5.3	995	12.3	1260	16.9	1605	16.7	1686	16.3	1010	16.6	448	15.9	287	17.7	
Frequency of eating sweets																	
I don't eat at all	237	8.5	675	7.5	1556	19.4	2108	20.4	2338	21.4	1402	21.5	533	17.4	313	17.9	< 0.001
Many times per month	1370	48.9	4807	53.6	4742	59.0	6017	58.4	6380	58.3	3724	57.0	2018	65.8	1066	60.8	
Many times per week	578	20.6	2165	24.1	1215	15.1	1498	14.5	1454	13.3	1012	15.5	356	11.6	263	15.0	

Table 4 (*continued*)

Variable	2–4		5–14		15–24		25–34		35–44		45–54		55–64		65+		*p*
	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	wN [a]	w%[b]	
Once or more per day	616	22.0	1325	14.8	523	6.5	686	6.7	766	7.0	398	6.1	159	5.2	110	6.3	
Frequency of drinking soft drinks																	
I don't drink at all	1791	65.4	2807	31.5	2819	35.0	3812	36.8	4143	37.7	2548	38.9	1063	34.3	592	33.8	< 0.001
Many times per month	725	26.5	4165	46.7	3765	46.8	4855	46.9	5013	45.6	2908	44.4	1540	49.7	817	46.6	
Many times per week	164	6.0	1457	16.3	1080	13.4	1215	11.7	1377	12.5	817	12.5	379	12.2	255	14.5	
Once or more per day	57	2.1	492	5.5	381	4.7	463	4.5	457	4.2	271	4.1	119	3.8	90	5.1	
Smoking status																	
Yes	NA	NA	NA	NA	NA	NA	810	7.7	729	6.5	452	6.9	196	6.2	144	8.1	< 0.001
No	NA	NA	NA	NA	NA	NA	9695	92.3	10,448	93.5	6097	93.1	2958	93.8	1637	91.9	
Secondhand smoker status																	
Yes	NA	NA	NA	NA	NA	NA	1228	20.7	1136	18.4	749	20.6	276	16.0	178	18.9	< 0.001
No	NA	NA	NA	NA	NA	NA	4691	79.3	5046	81.6	2886	79.4	1444	84.0	763	81.1	

Data were not complete for some variables (missing data from participants). NA = Non applicable.
[a] Weighted frequency (non-weighted frequency is not shown because of the space limitation. Non-weighted frequency is available in table S5).
[b] Weighted percent.

Table 5 Major distal and proximal influences on oral health by geographic region.

Variable	North			South			East			West			Central			*p*
	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	
Distal influences																
Oral health system & services																
State of insurance																
Yes	68	44	3.9	479	298	27.0	995	776	24.3	896	899	11.6	3197	5091	79.0	< 0.001
No	1593	1081	96.1	1322	804	73.0	4123	2422	75.7	8889	6826	88.4	1153	1355	21.0	
Family state of insurance																
Yes	57	37	3.7	472	285	27.4	932	724	27.6	736	710	9.7	3080	4891	78.4	< 0.001
No	1490	955	96.3	1225	755	72.6	3166	1903	72.4	8479	6616	90.3	1031	1351	21.6	
Regular source of dental care																
PHC	2540	2101	80.8	4331	3650	75.3	4446	2934	62.7	5753	4630	51.5	2907	3499	37.1	< 0.001
Governmental hospital	296	201	7.7	515	383	7.9	707	485	10.4	756	1216	13.5	951	1184	12.6	
Private clinic	339	278	10.7	893	699	14.4	1215	1172	25.1	1727	3053	34.0	2086	3835	40.7	
Other	32	19	0.7	168	116	2.4	147	85	1.8	88	86	1.0	344	903	9.6	
Dental care availability when needed																
Not available	1495	1059	28.6	2339	1756	23.6	2686	1751	22.6	4293	3739	23.9	2215	2873	18.9	< 0.001
Available	2670	2222	60.1	5780	4630	62.3	5641	4575	58.9	8868	9078	58.0	6146	9468	62.3	
Do not remember	438	416	11.3	1334	1046	14.1	1949	1435	18.5	2334	2845	18.2	1981	2856	18.8	
Proximal influences																
Oral health service usage																
Dental visit frequency last year																
Once	1185	1031	29.7	1999	1591	21.4	2374	1724	22.9	3600	3956	24.6	2301	3348	23.1	< 0.001
More than once	790	684	19.7	2259	1839	24.8	2449	2009	26.7	3798	4277	26.6	2274	3181	22.0	
Did not visit a dentist in the past year	1780	1323	38.1	3569	2905	39.1	3801	2739	36.5	6138	6221	38.7	3726	5164	35.7	
Never visited a dentist	483	344	9.9	906	687	9.3	675	529	7.0	1602	1282	8.0	995	1464	10.1	
I do not know or do not remember	142	88	2.5	548	403	5.4	513	512	6.8	452	357	2.2	852	1316	9.1	
Reasons for last dental visit																

(*continued on next page*)

Table 5 (*continued*)

Variable	North			South			East			West			Central			*p*
	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	N[a]	wN[b]	w%[c]	
Pain or problem in your teeth or gums or mouth	1715	1521	74.5	3734	3048	69.5	4214	3315	66.4	6460	6962	72.0	3795	5632	65.5	< 0.001
For treatment and follow up	293	248	12.2	698	569	13.0	784	731	14.7	1167	1428	14.8	877	1163	13.5	
Routine examination and treatment	142	120	5.9	331	301	6.9	473	319	6.4	641	591	6.1	442	580	6.7	
I don't know	217	142	7.0	622	403	9.2	668	573	11.5	540	536	5.5	694	1035	12.0	
Other	11	10	0.5	80	62	1.4	80	51	1.0	168	151	1.6	121	189	2.2	
Dental health risk behavior																
Tooth brushing frequency																
I have never cleaned my teeth	664	486	13.8	1226	1004	13.7	1151	947	12.7	1696	1488	9.4	1108	1731	12.2	< 0.001
I clean my teeth some days but not daily	1314	1193	34.0	2734	2004	27.4	3009	2292	30.6	3566	3674	23.3	2625	3556	25.0	
Once weekly	426	349	9.9	751	624	8.5	734	582	7.8	1309	1586	10.1	765	1050	7.4	< 0.001
Many times per week	520	386	11.0	1297	1038	14.2	1216	924	12.3	1570	1472	9.3	1076	1698	11.9	
Once daily	1059	841	23.9	2035	1711	23.4	2609	1942	26.0	4331	4823	30.6	2443	3520	24.7	
Twice or more daily	364	258	7.3	1161	946	12.9	1025	796	10.6	2781	2734	17.3	1886	2683	18.8	
Frequency of eating sweets																
I don't eat at all	871	635	17.3	1837	1500	19.5	1634	1150	14.2	1795	1849	10.7	2323	4028	25.6	< 0.001
Many times per month	2841	2360	64.2	5380	4447	57.7	6052	4765	59.0	9940	10,376	60.2	5709	8174	52.0	
Many times per week	509	379	10.3	1673	1185	15.4	1785	1369	16.9	3430	3423	19.9	1751	2184	13.9	
Once or more per day	399	300	8.2	866	579	7.5	1073	798	9.9	1743	1583	9.2	1144	1325	8.4	
Frequency of drinking soft drinks																
I don't drink at all	1289	977	26.2	3261	2593	33.6	3180	2198	27.1	5942	5640	32.8	5128	8167	52.1	< 0.001
Many times per month	2500	2131	57.1	4225	3414	44.2	5187	4116	50.7	8027	8628	50.2	4136	5498	35.0	
Many times per week	605	437	11.7	1738	1335	17.3	1524	1261	15.5	2085	2232	13.0	1157	1478	9.4	
Once or more per day	233	184	4.9	528	385	5.0	661	540	6.7	777	680	4.0	451	544	3.5	
Smoking status																
Yes	845	657	18.7	1334	1076	15.5	718	712	9.8	225	187	1.2	199	382	2.7	< 0.001
No	3399	2857	81.3	6904	5849	84.5	8408	6541	90.2	14,197	15,416	98.8	9040	13,542	97.3	
Secondhand smoker status																
Yes	882	695	37.4	1312	1125	29.1	1050	987	24.0	983	1098	12.8	457	874	11.4	< 0.001
No	1501	1164	62.6	3249	2745	70.9	4128	3122	76.0	6747	7491	87.2	4713	6801	88.6	

[a] Non-weighted frequency. [b] Weighted frequency. [c] Weighted percent. Data were not complete for some variables (missing data from participants).

needed to understand oral healthcare access and its use in the KSA.

This study indicated that the Central region population had the highest insurance coverage and the highest utilization of dental private clinics as the regular source of dental care. This can be due to the KSA's government efforts to transform the health care system. In 2003 the Cooperative Health Insurance Act was enacted, and the Council of Cooperative Health Insurance was established. The council recommended compulsory employment-based health insurance. First stage was implemented in 2006 by compels private sectors employers to provide health insurance to their employees. The second phase, which involves public sector employees, and third phase, which covers all other groups, are expected to be applied (Almalki et al., 2011). Studies evaluating oral health care access and use in the KSA are required to evaluate the effectiveness of such reforms on oral health wellbeing among the KSA's population.

Our study has some important limitations due to the inherent response biases associated with self-reported surveys, such as recall or social desirability biases. The answers to many questions, such as those evaluating the reasons for and frequency of dental visits, were largely dependent on the respondents' ability to recall past experiences. Moreover, social desirability bias may have influenced the responses to the smoking-related questions, since only 6.4 % of the respondents reported that they were currently smoking, in comparison with 12.2 % in a previous study that was conducted in 2012 (Moradi-Lakeh et al., 2015). This wide discrepancy in reporting smoking status should be addressed when designing future

studies. Another limitation of this survey is the lack of data for clinical oral health outcomes such as previous caries experience. It would be valuable to include data for such measures in future national health surveys.

5. Conclusions

The 2017 KSA DHS provided a comprehensive information about oral health influences in Saudi Arabia for the first time at a substantial national scale due the DHS's large sample size, broad geographic distribution, wide age range, and the extensive social and health information included in the survey. Among the investigated oral health influences, two that were previously reported to have a significant negative influence on oral health were identified for the population in the KSA: infrequent routine dental examination visits and inadequate oral hygiene. Future studies should investigate if they also negatively influence oral health within the conditions and environment of the KSA population.

Ethical statement

The original collection of the data for this study was approved by the Institutional Review Board of the Ministry of Health of the Kingdom of Saudi Arabia (Central IRB Log #: 2019–0131 M). No new data was collected to complete our study analysis. The Human Research Protection Program (HRPP) from the Office of Research Compliance at Indiana University, determined that this project does not require IRB review (Protocol #: 1808825963).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2022.12.001.

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