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Original Article

Prevalence and severity of dental caries in school children in Saudi Arabia: A nationwide cross-sectional study

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ABSTRACT

Aim: This nationwide study assessed the prevalence and severity of dental caries in 6-, 12-, and 15-year-old school children across Saudi Arabia. This study examined differences between genders and among regions regarding the mean values of decayed, missing, and filled teeth (dmft/DMFT), the care index (CI), and the significant caries index (SiC index).

Materials and methods: Data from 19,870 participants, 10,435 males and 9435 females, were collected using stratified multistage cluster random sampling. The survey team divided Saudi Arabia into five regions (northern, eastern, western, southern, and middle). To represent each respective region, a large city, two random towns (*peri*-urban), and four random rural areas were selected for surveying. Lastly, the sampling technique was applied by choosing random schools and random classes within the selected schools. Dental caries were assessed using the dmft/DMFT score, CI, and the top 30% and 10% of the sample dmft/DMFT scores (SiC30 and SiC10, respectively).

Results: The overall prevalence of caries was 65.6%, with 72.1 occurring in primary teeth and 61.7% in permanent teeth. The percentages of individuals with missing teeth and filled teeth were 9.0% and 20.5%, respectively. The mean dmft was 3.93 ± 3.60, while the mean DMFT was 2.42 ± 2.52; most of the DMFT components were significantly higher in females than males, while the dmft components were higher in males. The northern region had the highest and worst DMFT/dmft ratios of the five regions. The mean SiC30 and SiC10 values were significantly higher than the overall average DMFT/dmft values ($P < 0.001$).

Conclusion: Dental caries remain a public health challenge among school children in Saudi Arabia. The SiC and CI analysis indicated that caries management had a high overall efficacy, but that certain groups of the population may need targeted management in the future.

1. Introduction

Dental caries remain one of the most prevalent diseases worldwide (Robertson et al., 2019; Aqeeli et al., 2021). Water fluoridation, education, and improvements in global health care systems and services have contributed to the reduction of widespread caries (Robertson et al., 2019; Aqeeli et al., 2021); however, caries remain problematic (Robertson et al., 2019; Aqeeli et al., 2021). In Saudi Arabia, dental caries are prevalent across all age groups, posing a significant public health challenge in the health care sector (Al Ayyan et al., 2018; Bahannan et al., 2018; Aqeeli et al., 2021).

The current nationwide status of caries in Saudi Arabia is unclear. Previous nationwide studies have noted that the incidence of dental caries increased by 10% in the beginning of 21st century (Al-Shammery, 1999; Al Dosari et al., 2004). Most studies on this topic refer to a systematic review conducted a decade ago by Al Agili et al. (2013) in which the estimated prevalence of caries in children was 80% (mean dmft of 5.0) for primary dentition, and 70% (mean DMFT of 3.5) for permanent dentition. There have been several other studies on the topic, but they have mostly covered specific localities such as a cities or universities, giving most of their samples selection bias and limiting any extrapolation to the national population. Despite this, the majority of these

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studies have compared their results to those of Al Agili et al. (2013) and found them to be consistent, indicating that little has changed over the last 10 years. Therefore, the objectives of this nationwide study were to assess the prevalence and severity of dental caries in primary and permanent teeth among three age groups of school children (6-, 12-, and 15-year-olds) across the country, which has never been done before. Furthermore, this study calculated the care index (CI) and significant caries index (SiC index) of the total study population and explored differences among genders and regions.

2. Material and methods

2.1. Study design and sample selection

This cross-sectional study used the stratified multilevel cluster random sampling technique. Firstly, the national list of schools and students was obtained. Then, the survey team divided Saudi Arabia into five regions (northern, eastern, western, southern, and middle). To represent the regions, within each region a large city, two random towns (*peri*-urban), and four random rural areas were selected. Lastly, the sampling technique was applied by choosing random schools and then random classes from those schools. The pool of schools included both government and private schools. The randomized selection process resulted in a near 1:1 selection ratio between genders and representative samples of all socioeconomic levels.

2.2. Ethical consideration

The study received approval from the Ethical Research Committee, Faculty of Dentistry at King Abdulaziz University (# 059–02-23), and followed guidelines recognized by the Declaration of Helsinki.

2.3. Study population

The target population was school age children attending elementary and intermediate schools in Saudi Arabia. The age index was selected in guidance with the WHO approach: 6-, 12-, and 15-year-olds. The subjects in the first age group were between their 6th and 7th birthdays on the day of examination. The same applied to the other two age groups for their respective ages. All children of any gender within these age groups in selected schools and classes were included. Children must have been attending school at the time of the examination to be included. Children with mental or psychological conditions who were unable to interpret the questionnaire and those whose parents failed to consent were excluded.

2.4. Data collection and variables

The survey was planned by the Department of Dental Public Heath, Faculty of Dentistry, King Abdulaziz University. Calibration and training, which consisted of three two-hour sessions, were conducted for each city in each region separately. The first session was a lecture which covered a discussion of cases and online cases. Then two sessions covered clinical examinations of five randomly selected age groups of children to ensure reliability, clarity of survey, and the feasibility of patient examinations. Intra and inter-examiner reliability was assessed by re-examining the same patients after one week. Instructors of survey conduction followed the guidelines established by the WHO.

Oral examinations were conducted based on the World Health Organization Oral Health Survey Methods (World Health Organization, 2013; 2021). Students were screened in their classroom while seated on a chair and under artificial light. Severity of caries was evaluated according to the dmft (primary teeth) and DMFT (permanent teeth). The prevalence of caries was calculated as the percentage of children with caries lesions on teeth (d/D > 0). Then, the significant caries index (SiC) and care index (CI) were calculated. SiC of the study samples was calculated for the highest 30% and 10% of the dmft/DMFT scores, referred to as SiC30 and SiC10, respectively. CI was calculated as ft / dmft × 100% or DT / DMFT × 100.

2.5. Sample size calculation

One percent of the three index-age populations (6, 12, and 15) was selected to represent of the total population to be surveyed as follows: Age group population was taken as the estimate from 2020 published on the website of the General Authority of Statistics. Then, the populations of the five regions of the kingdom were taken from the General Directorate of Statistics of the MOH. Using these population data, the weights of each region were calculated. To ensure an acceptable degree of variability, the sampling was distributed among the 5 main regions of the Kingdom according to their respective weights. Then, random sampling was used to select the participating schools and classes for both genders in each region. Based on that, the total required sample size was set at 19870, with 10,435 males and 9435 females.

2.6. Statistical analysis

Descriptive statistics (mean ± standard deviation or frequency and percentage) were used to calculate the prevalence and severity of caries. The dmft/DMFT values were analyzed and used to compare between groups using the Mann-Whitney U and Kruskal-Wallis tests with significance levels set at alpha level 0.05. All statistical tests were conducted using the IBM SPSS software (version 23.0, IBM SPSS Inc., NY, USA).

3. Results

3.1. Overall results and stratified by gender

Of the children examined, 65.6% had obvious caries, 9.0% had missing teeth, and 20.5% had filled teeth (Table 1). The percentages of

Table 1
Prevalence of caries, missing and filled teeth among study sample and stratified by gender.

Variables	General	Males	Females	P value
	N = 19870	N = 10435	N = 9435	
Decay teeth				
Overall	13041 (65.6)	6842 (65.6)	6200 (65.7)	0.830
6 year (primary teeth)	5382(72.1)	2986 (72.8)	2396 (71.4)	0.177
12 and 15 (permanent teeth)	7659(61.7)	3856 (60.9)	3804 (62.6)	0.049*
12 years only	4003(57.9)	1960 (56.4)	2043 (59.4)	0.011*
15 years only	3656(66.5)	1895 (66.4)	1761 (66.7)	0.747
Missing teeth				
Overall	1796(9.0)	1055 (10.1)	741(7.9)	< 0.001*
6 year (primary teeth)	1123(15.1)	744(18.1)	379(11.3)	< 0.001*
12 and 15 (permanent teeth)	673(5.4)	311(4.9)	362(6.0)	0.011*
12 years only	319(4.6)	152(4.4)	167(4.9)	0.335
15 years only	354(6.4)	159(5.6)	195(7.4)	0.007*
Filled teeth				
Overall	4083(20.5)	1937 (18.6)	2146 (22.7)	< 0.001*
6 year (primary teeth)	1378(18.5)	734(17.9)	644(19.2)	0.154
12 and 15 (permanent teeth)	2705(21.8)	1203 (19.0)	1502 (24.7)	< 0.011*
12 years only	1127(16.3)	501(14.4)	626(18.2)	< 0.001*
15 years only	1578(28.7)	702(24.6)	876(33.2)	< 0.001*

* P value < 0.05.

children with caries and missing teeth were the highest among 6-year-old children (72.1% and 15.1%, respectively), followed by 15-year-olds (66.5% and 6.4%, respectively) and 12-year-olds (57.9% and 4.6%, respectively). Females had higher prevalence of decay, missing teeth, and filled teeth in both 12- and 15-year-olds in both primary and permanent teeth compared with males, with significant differences ($P < 0.05$) in almost all categories. However, 6-year-old males had higher prevalence of decay and missing teeth than females (Table 1). Fig. 1 shows that males had higher prevalence of decay and missing teeth, but fewer filled teeth in both primary and permanent teeth compared to females.

The DMFT score of both 12- and 15-year-olds was 2.42 ± 2.52 (permanent teeth), at 1.93 ± 2.08 among 12-year-olds and 3.03 ± 2.86 among 15-year-olds (Table 2). Overall, females had higher scores than males in all DMFT components across all age categories ($P < 0.05$). However, the difference was not statistically significant in the missing teeth of 12-year-olds and the decay teeth of 15-year-olds. Males also had a lower CI than females across all age categories.

Table 3 shows that the dmft score was 3.93 ± 3.60 in 6-year-olds (primary teeth). The dt, mt, and filled teeth scores were 3.21 ± 3.30, 0.30 ± 0.91, and 0.41 ± 1.12, respectively. Overall, males had higher scores than females in all dmft components except for df. Females had higher df scores, but the difference was not statistically significant ($P = 0.126$). Males also had lower CI values compared with females (Table 3). Overall, the DMFT components were higher in females than males, while the dmft components were higher in males (Fig. 2).

3.2. Results stratified by region

The percentage of children with obvious caries was highest in the northern region in all age categories (84.0%), followed by the southern region (75.2%) (Table 4). At the same time, the northern region had the lowest number of filled teeth compared to other regions in all age categories ($P < 0.001$). The middle region had the highest number of missing teeth (10.2%), while the eastern region had the lowest (8.0%; $P < 0.001$) (Table 4). Moreover, the northern region almost always had higher prevalence of decay and missing teeth and fewer filled teeth in both primary and permanent teeth compared with other regions (Supplemental Fig. 1).

The northern region had the highest DMFT scores, DT, and MT among 12-, 15-, and 12/15-year-olds (permanent teeth) and the majority of the differences were statistically significant ($P < 0.001$). The western region had the lowest DMFT scores and DT and the eastern region had the lowest MT and the highest FT in all age categories. The northern region also had the lowest care index of all the regions in all age categories (Supplemental table 1).

The northern region had the highest dmft scores among 6-year-olds (5.67 ± 4.07; primary teeth) (Supplemental table 2). The northern region also had the highest dt and lowest ft scores, 5.24 ± 3.92 and 0.14 ± 0.60, respectively. The eastern region scored the lowest in the dmft and dt components (3.62 ± 3.39 and 2.99 ± 3.14, respectively). The middle region scored the highest in the FT component (0.51 ± 1.27), while the western region scored the highest in the mt component. All these differences were statistically significant at $P < 0.001$. The northern region also had the lowest care index of all the regions (Supplemental table 2). Overall, the DMFT and dmft components were the highest and the filled component was the lowest in the northern region compared with the other regions (Supplemental Fig. 2).

3.3. Significant index caries (SiC)

The mean values of SiC30 and SiC10 for primary teeth (8.4 ± 2.68 and 11.2 ± 2.88, respectively) and for permanent teeth (5.42 ± 2.16 and 7.85 ± 2.19, respectively) were significantly higher than the overall average dmft/DMFT values (Fig. 2). There were no significant differences in SiC30 or SiC10 between females and males. We observed the same pattern when evaluating all regions, but the northern region had the highest SiC30 and SiC10 of all the regions (Supplemental Fig. 2) ($P < 0.001$).

4. Discussion

At the time of this study, the prevalence of dental caries among the study population was still high. However, it was much lower compared to the previous nationwide study (Al Agili et al, 2013). This showed that caries remain a serious problem and the most important oral health disease among school aged children in Saudi Arabia compared with other countries such as UK. The overall caries prevalence was about 23.4% to 29.0.3% among 5-year-old children in the studies conducted by public health England (England P.H., 2020; 2022). However, while this remains a serious problem, economic development, improved health care services provided, and increased number of dentists/clinics have helped to improve the situation. The prevalence observed here was similar to what has been observed in adjacent countries in the middle

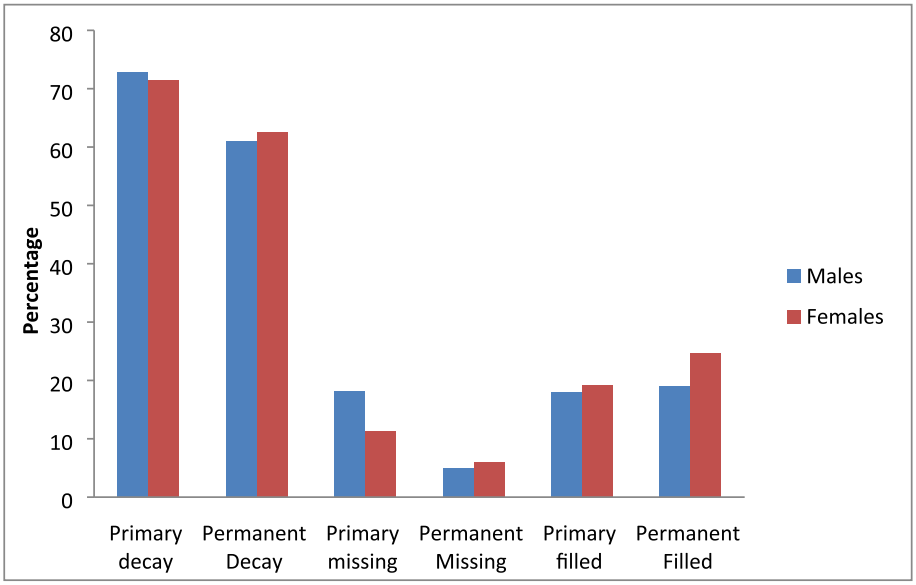

Fig. 1. Prevalence of caries, missing and filled teeth among study sample and stratified by gender.

Table 2
Mean and median of DMFT score and component of permanent teeth among 12 and 15 years old and stratified by gender.

Variables	General	Males	Females	P value
	N = 12409	N = 6332	N = 6077	
12 and 15 years				
DMFT				< 0.001*
Mean ± SD (Min – Max)	2.42 ± 2.52 (0–22)	2.29 ± 2.45 (0–19)	2.55 ± 2.57 (0–22)	
Median (IQR)	2(0–4)	2(0–4)	2(0–4)	
DT				0.028*
Mean ± SD (Min – Max)	1.90 ± 2.24 (0–19)	1.86 ± 2.22 (0–19)	1.94 ± 2.26 (0–18)	
Median (IQR)	1(0–3)	1(0–3)	1(0–3)	
MT				0.010*
Mean ± SD (Min – Max)	0.08 ± 0.38 (0–9)	0.07 ± 0.33 (0–6)	0.09 ± 0.42 (0–9)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
FT				< 0.001*
Mean ± SD (Min – Max)	0.44 ± 1.05 (0–12)	0.36 ± 0.91 (0–9)	0.53 ± 1.16 (0–12)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
Care Index CI (%)	18.2	15.7	20.8	NA
12 years				
DMFT				< 0.001*
Mean ± SD (Min – Max)	1.93 ± 2.08 (0–15)	1.82 ± 2.06 (0–15)	2.04 ± 2.09 (0–13)	
Median (IQR)	2(0–3)	1(0–3)	2(0–3)	
DT				0.006*
Mean ± SD (Min – Max)	1.58 ± 1.87 (0–15)	1.52 ± 1.86 (0–15)	1.63 ± 1.88 (0–12)	
Median (IQR)	1(0–3)	1(0–2)	1(0–3)	
MT				0.308
Mean ± SD (Min – Max)	0.07 ± 0.36 (0–6)	0.06 ± 0.30 (0–6)	0.08 ± 0.41 (0–6)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
FT				< 0.001*
Mean ± SD (Min – Max)	0.29 ± 0.79 (0–8)	0.24 ± 0.71 (0–7)	0.33 ± 0.86 (0–8)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
Care Index CI (%)	15	13.2	16.2	NA
15 years				
DMFT				< 0.001*
Mean ± SD (Min – Max)	3.03 ± 2.86 (0–22)	2.85 ± 2.76 (0–19)	3.22 ± 2.96 (0–22)	
Median (IQR)	3(1–4)	2(0–4)	3(1–5)	
DT				0.475
Mean ± SD (Min – Max)	2.30 ± 2.57 (0–19)	2.26 ± 2.54 (0–19)	2.34 ± 2.63 (0–18)	
Median (IQR)	2(0–4)	2(0–4)	2(0–4)	
MT				0.007*
Mean ± SD (Min – Max)	0.09 ± 0.40 (0–9)	0.08 ± 0.37 (0–4)	0.10 ± 0.44 (0–9)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
FT				< 0.001*
Mean ± SD (Min – Max)	0.64 ± 1.28 (0–12)	0.51 ± 1.10 (0–9)	0.78 ± 1.43 (0–12)	
Median (IQR)	0(0–1)	0(0–0)	0(0–1)	
Care Index CI (%)	21.1	17.9	24.2	NA

* P value < 0.05, NA: Not applicable.

Table 3
Mean and median of dmft score and component of primary teeth among 6 years old and stratified by gender.

Variables	General	Males	Females	P value
	N = 7461	N = 4103	N = 3358	
dmft				0.027*
Mean ± SD(Min – Max)	3.93 ± 3.60 (0–20)	4.04 ± 3.75 (0–20)	3.80 ± 3.41 (0–19)	
Median (IQR)	3(1–6)	3(1–6)	3(1–6)	
dt				0.237
Mean ± SD(Min – Max)	3.21 ± 3.30 (0–20)	3.26 ± 3.39 (0–20)	3.17 ± 3.20 (0–19)	
Median (IQR)	2(0–5)	2(0–5)	2(0–5)	
mt				< 0.001*
Mean ± SD(Min – Max)	0.30 ± 0.91 (0–11)	0.38 ± 1.04 (0–11)	0.21 ± 0.71 (0–9)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
ft				0.126
Mean ± SD(Min – Max)	0.41 ± 1.12 (0–9)	0.40 ± 1.12 (0–9)	0.43 ± 1.12 (0–9)	
Median (IQR)	0(0–0)	0(0–0)	0(0–0)	
Care Index CI (%)	10.4	9.9	11.3	NA

* P value < 0.05, NA: Not applicable.

east (Gökalp et al., 2010; Ramazani and Rezaei, 2017); however, it was about six times higher than in western countries (Fleming and Afful, 2018; Masood et al., 2019).

According to the World Health Organization classifications, the mean DMFT and dmft obtained in the current investigation could be considered low to moderate (World Health Organization, 2013). This could be due to the lower prevalence of carries in permanent teeth (Lynch, 2013). However, the mean DMFT and dmft of the top one-third of the sample (SiC30) could be considered very high based on the WHO DMFT classification rubric, which indicated that additional attention and intervention from health care systems/providers is required. The CI showed that the efficacy of caries management was higher in females than males when managed using restorations. Overall, the efficacy of caries management was high compared with previous studies, which meant there has been high effort dedicated to caries management in Saudi Arabia (Robertson et al., 2019).

Nowadays, it is highly recommended that indexes integrating DMFT be used to understand the distribution of caries, such as the SiC index, and to measure the efficacy of treating dental caries, such as the care index. These indexes showed that caries in Saudi Arabia were not normally distributed and that younger groups of children need increased attention due to the severity of dental caries. However, the efficacy of treating dental caries was high, which indicated that this small group had difficulty in accessing dental services. This illustrated the urgent need of targeted personalized dental programs focusing on prevention and treatment, rather than oral health education alone; education is often the only dental care provided in these areas and may not be effective, indicating that total reform is needed (Baghdadi, 2011; Watt et al., 2001).

When we look at gender, the results and percentages were similar between males and females, although there were slight statistically significant differences, but this may have been due to the large sample size and may not be considered clinically significant. Bahannan et al. (2018) and Aqeeli et al. (2021) reported that male children had higher caries experience than females, while Farooqi et al. (2015) found no differences between genders. Overall, studies have reported that female school children exhibit better brushing and flossing behaviors (Farsi et al., 2004).

There are other factors which may contribute to the distribution of caries in Saudi Arabia. One such factor is high sugar diets (Afeef et al., 2021). Moreover, the regularity of dental visits for routine check-ups may vary among regions (AlHumaid et al., 2018; Afeef et al., 2021). In fact, one in four children have never visited a dentist in Jeddah city, which is the second largest city in Saudi Arabia (Al Agili and Farsi, 2020). Furthermore, fluoride concentration in drinking water supply in Saudi Arabia is suboptimal, making it another potential contributing factor (Bakhurji and Alqahtani, 2018).

This study has several notable strengths. It is the first study of it is kind in Saudi Arabia in that it used multistage stratified cluster sampling instead of convenience sampling. This ensured that the sample is representative of the target population and reduced selection bias.

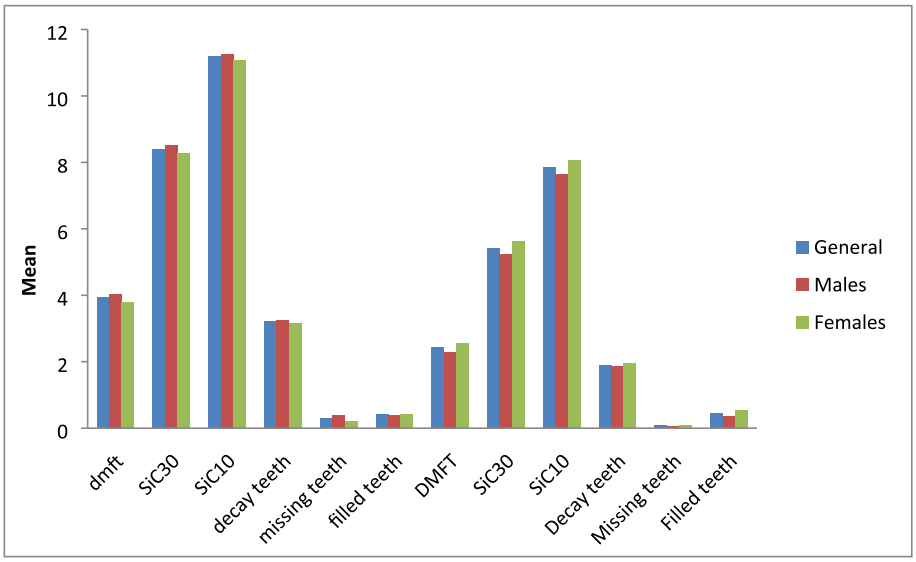

Fig. 2. Mean of DMFT score and component of permanent teeth among 12 and 15 years old and stratified by gender.

Table 4
Prevalence of caries, missing and filled teeth among study sample and stratified by regions.

Variables	Northern	Southern	Eastern	Western	Middle	P value
	N = 1217	N = 2576	N = 4471	N = 6001	N = 5605	
Decay teeth						
Overall	1022(84.0)	1937(75.2)	2749(61.5)	3558(59.3)	3775(67.4)	< 0.001*
6 year (primary teeth)	371(86.5)	747(77.2)	1162(70.2)	1446(67.5)	1656(73.0)	< 0.001*
12 and 15 (permanent teeth)	651(82.6)	1190(74.0)	1587(56.4)	2112(54.7)	2119(63.5)	< 0.001*
12 years only	323(76.4)	593(70.8)	800(54.0)	1098(49.7)	1189(60.6)	< 0.001*
15 years only	328(89.9)	597(77.4)	787(59.0)	1014(61.5)	930(67.6)	< 0.001*
Missing teeth						
Overall	119(9.8)	206(8.0)	349(7.8)	550(9.2)	572(10.2)	< 0.001*
6 year (primary teeth)	53(12.4)	110(11.4)	217(13.1)	345(16.1)	398(17.6)	< 0.001*
12 and 15 (permanent teeth)	66(8.4)	96(6.0)	132(4.7)	205(5.3)	174(5.2)	0.001*
12 years only	30(7.1)	45(5.4)	57(3.8)	100(4.5)	87(4.4)	0.058
15 years only	36(9.9)	51(6.6)	75(5.6)	105(6.4)	87(6.3)	0.070
Filled teeth						
Overall	123(10.1)	655(25.4)	911(20.4)	1064(17.7)	1330(23.7)	< 0.001*
6 year (primary teeth)	31(7.2)	213(22.0)	288(17.4)	363(16.9)	483(21.3)	< 0.001*
12 and 15 (permanent teeth)	92(11.7)	442(27.5)	623(22.1)	701(18.2)	847(25.4)	< 0.001*
12 years only	38(9.0)	176(21.0)	216(14.6)	297(13.5)	400(20.4)	< 0.001*
15 years only	54(14.8)	266(34.5)	407(30.5)	404(24.5)	447(32.5)	< 0.001*

* P value < 0.05.

Moreover, before undertaking the field study, several training and pilot clinical examinations of patients were conducted to calibrate the examiners and reduce detection/measurement bias. In addition, we followed the World Health Organization criteria in terms of age groups, examination procedures, and indexes, which makes this study more comparable with studies globally. However, although the cross-sectional study design is the most suitable for estimating the prevalence of caries over a short period of time, it is unable to establish a temporal relationship between dental myths and beliefs and oral health status. Moreover, it is highly recommended that future studies investigate the potential factors that contribute to the prevalence of caries, such as nationality, number of dentist visits, access to health care, oral hygiene practices, diet, and socioeconomic status. All these factors have been shown to contribute to some extent in previous studies (Alayadi et al., 2019; Tchicaya and Lorentz, 2014).

5. Conclusion

Dental caries persist as a dental public health challenge among school children in Saudi Arabia. However, a significant effort to reduce the prevalence of caries to date has alleviated the problem somewhat. The care index and SiC index showed that the efficacy of treatment of dental caries was high. However, there are certain groups that may need to be targeted with increased attention and treatment in the future.

CRediT authorship contribution statement

Saud M. Orfali: Supervision, Writing – review & editing. **Ali S. Alrumikhan:** Supervision, Writing – review & editing. **Nader A. Assal:** Supervision, Writing – review & editing. **Adel M. Alrusayes:** Supervision, Writing – review & editing. **Zuhair S. Natto:** Investigation, Writing – original draft, Writing – review & editing.

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.2023.09.008.

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