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REVIEW ARTICLE

A systematic review of population-based dental caries studies among children in Saudi Arabia

Dania Ebrahim Al Agili

Department of Preventive Dental Sciences, Faculty of Dentistry, King Abdulaziz University, P.O. Box 80209, Jeddah 21589, Saudi Arabia

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Abstract *Objective:* Dental caries critically impacts the health and development of children. Understanding caries experience is an important task for Saudi Arabian policymakers to identify intervention targets and improve oral health. The purpose of this review is to analyze current data to assess the nationwide prevalence and severity of caries in children, to identify gaps in baseline information, and to determine areas for future research.

Methods: A search of published and unpublished studies in PubMed, Google, and local Saudi medical and dental journals was conducted for the three keywords “dental,” “caries,” and “Saudi Arabia.” The inclusion criteria required that the articles were population-based studies that assessed the prevalence of dental caries in healthy children attending regular schools using a cross-sectional study design of a random sample.

Results/discussion: The review was comprised of one unpublished thesis and 27 published surveys of childhood caries in Saudi Arabia. The earliest study was published in 1988 and the most recent was published in 2010. There is a lack of representative data on the prevalence of dental caries among the whole Saudi Arabian population. The national prevalence of dental caries and its severity in children in Saudi Arabia was estimated to be approximately 80% for the primary dentition with a mean dmft of 5.0 and approximately 70% for children’s permanent dentition with a mean DMFT score of 3.5. The current estimates indicate that the World Health Organization (WHO) 2000 goals are still unmet for Saudi Arabian children.

E-mail address: dalagili@kau.edu.sa

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Conclusion: Childhood dental caries is a serious dental public health problem that warrants the immediate attention of the government and the dental profession officials in Saudi Arabia. Baseline data on oral health and a good understanding of dental caries determinants are necessary for setting appropriate oral health goals. Without the ability to describe the current situation, it is not possible to identify whether progress is being made toward these goals. A roadmap with a clear starting point, destination, and pathway is a desperately needed tool to improve the oral health of Saudi Arabian children.

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1. Introduction

Dental caries is painful, expensive to treat, and can harm nutrition and overall health (USDHHS, 2000). In children, dental caries is particularly critical because even following repair, destroyed tooth structure exhibits increased vulnerability (Sheiham, 2006). Furthermore, poor oral health impacts children's development (USDHHS, 2000). Toddlers may exhibit poor growth and nutrition when chewing is painful. Older children may miss school days or be distracted due to dental pain. Young people may interact less with their peers and society when they are uncomfortable or embarrassed by the appearance of their teeth. The effects of dental caries on growth and physical, social/emotional, and cognitive development have implications on success and productivity throughout life (USDHHS, 2000).

In 1981, the World Health Organization (WHO) acknowledged the serious consequences of dental caries in children by setting ambitious goals for the year 2000. These goals were the following: 50% of 5–6 year olds would be free of dental caries, the global average of decayed, missing or filled permanent teeth (DMFT) in 12 year olds would be less than 3, and 86% of 18 year olds would keep all of their teeth (WHO, 1981). Although dental caries prevalence in developed countries has declined over the past decades, these

goals are still unmet for a significant proportion of the world's population (Petersen et al., 2005). Dental caries is increasing in developing nations due to an array of factors, which include the intake of cariogenic foods, exposure to fluorides, socioeconomic status, ethnicity, health, age, access to oral health services, and other lifestyle factors (WHO, 1981; Miura et al., 1997).

With these factors in mind, new goals have been set for 2020. In 2003, the World Dental Federation (FDI), WHO, and International Association for Dental Research (IADR) issued "Global Goals for Oral Health 2020" (Hobdell et al., 2003). These goals provided guidance for local, regional, and national planners and policy makers to improve the oral health status of their populations. The new oral health goals were not numerically specific. Instead, each country may specify targets according to its current disease prevalence and severity, local priorities, and oral health systems.

It is imperative to obtain baseline oral health information to plan for and to identify improvements in children's oral health status. In Saudi Arabia, a number of studies on the prevalence and severity of childhood caries have been performed. The intent of this review is to analyze current data, to assess the nationwide prevalence and severity of caries in children, to identify gaps in baseline information, and to determine areas for future research.

2. Methods

Published and unpublished work was included in the review. A search of published studies in PubMed, Google, and local Saudi medical and dental journals with the three keywords “dental,” “caries,” and “Saudi Arabia” was conducted. In addition, a search was made of the articles referenced in the selected articles. The inclusion criteria required that the articles described population-based studies that assessed the prevalence and/or severity of dental caries in healthy children attending regular schools using a cross-sectional study design of a random sample. Articles that did not describe the methodology of the study were excluded from the review. Dental caries prevalence was assessed as present or absent. The severity of dental caries was assessed using the decayed, missing or filled primary teeth (dmft) or DMFT indices of dental caries.

3. Review of literature

Our search identified 124 published matches and one unpublished study. Of the 124 studies, 49 articles were related to children. Of these 49 articles, 29 were considered appropriate for inclusion. Three articles were later eliminated from the analysis since they represented the same population. The final review was comprised of 26 published surveys, of which one was in press and one was an unpublished doctoral thesis on childhood dental caries in Saudi Arabia. The earliest study was published in 1988, and the most recent was published in 2010. All of the studies selected for inclusion are presented in the Table 1.

Most studies surveyed a limited geographic area and age group. However, two studies included a nationwide survey of dental caries (Al-Shammery, 1999; Al Dosari et al., 2010). One survey is more than a decade old and included only 12–13 year olds (Al-Shammery, 1999), and the other survey is more recent, but the samples were representative of the country's fluoride levels rather than its population (Al Dosari et al., 2010).

Dental caries was defined according to the WHO criteria in most of these studies (WHO, 1997). A single assessment of nursery school students by Al-Malik provided data for three different papers (Al-Malik et al., 2001; Al-Malik et al., 2002; Al-Malik et al., 2003) and diagnosed caries using criteria from the British Association for the Study of Community Dentistry (BASCD).

3.1. National population-based caries prevalence studies

The first national study by Al-Shammery (1999) assessed 1873 12–13 year olds in 10 of the 13 administrative regions in Saudi Arabia. Investigators randomly selected schools stratified by municipality and socioeconomic status (as identified by student housing quality) and assessed random classes of students. The study found that the prevalence of caries was 74% in urban areas and 67% in rural areas, and there was a statistically significant difference between them ($P < 0.01$). The mean DMFT scores were 2.69 in urban areas and 2.65 in rural areas, and the difference between these scores was not statistically significant. The later nationwide study by Al Dosari et al. (2010) included 12200 children in 11 regions of Saudi Arabia and intended to represent the regions' varying fluoride levels.

Children in the sample were 6–7, 12–13, and 15–18 year olds, and all were Saudi nationals and lifelong residents of the sampled area. The sample size was proportionate to the population. The caries prevalence in the permanent dentition ranged from 59–80% depending on the fluoride level of the area surveyed, and the mean DMFT scores were 1.53–2.93 in children 12–13 years old and 2.24–4.08 in children 15–18 years old. In the primary dentition, the caries prevalence ranged from 74–90% and the mean dmft scores ranged from 3.39–6.15.

3.2. Regional population-based caries prevalence studies

There are 13 administrative regions in Saudi Arabia, and each region has a number of provinces that varies from region to region (total 107). The regional studies assessed caries in Al-Riyadh, Makkah, the Eastern region, Al-Qasseem, Asir, Ha'il, and Al-Madinah.

3.3. Al-Riyadh region

Nine studies were performed in Al-Riyadh province in the Al-Riyadh region; the earliest of these studies was published in 1988 and the latest in 2008 (Al-Sekait and Al-Nasser, 1988; Akpata and Al-Shammery, 1992; Wyne et al., 2002b; Wyne, 2004; Al Dosari et al., 2004; Wyne, 2008; Al-Wazzan, 2004; Al-Sadhan, 2006; Wyne et al., 2001b). The study populations varied from 2 year olds up to 19 year olds.

3.3.1. Caries prevalence studies of school children

The earliest study to meet the inclusion criteria was performed by Al-Sekait and Al-Nasser (1988). A sample of 7040 primary school children was examined from urban and rural schools, revealing a caries prevalence of 52% and a DMFT score of 2.0. In 1989, Akpata and Al-Shammery (1992) examined all 12 and 13 year olds in 10 randomly selected Riyadh schools (5 boys' schools and 5 girls' schools). The caries prevalence was between 55.5% (for 13-year-old boys) and 73.1% (for 12-year-old girls). Wyne et al. (2002b) examined 449 8–9 year olds throughout Riyadh city from public and private schools, which were proportionate to the population (at the time, 17% of Riyadh children attended private school) and reported a caries prevalence of 94% and a dmft score of 6.3. Wyne (2004) also studied 12–13 year olds and 18–19 year olds in randomly selected primary and intermediate schools, which were stratified by the fluoride level. The caries prevalence increased significantly with age to 90.5% for 12–13 year olds and 90.9% for 15–19 year olds. Around the same time, Al Dosari et al. (2004) evaluated Riyadh school children (the type of school was unspecified) and found a caries prevalence of 91.2% in 6–7 year olds (mean dmft = 6.53) and a prevalence of 92.3% in 12–13 year olds (mean DMFT = 5.06).

Al-Wazzan (2004) and Al-Sadhan (2006) reported on correlated studies that included a stratified random sample of public and private schools in Riyadh city and nearby rural areas. These studies sampled 602 primary school children who were 6–7 years old (Al-Wazzan, 2004) and 205 intermediate school children who were 11–14 years old (Al-Sadhan, 2006). Al-Wazzan (2004) reported a caries prevalence of 94.4% and a mean dmft score of 7.34, and Al-Sadhan (2006) observed a caries prevalence of 93.7% and a mean DMFT score of 5.94. In both

Table 1 Population-based prevalence studies of caries in children in Saudi Arabia.

Reference	Year of investigation; administrative region	Sample selection and size	Age (year)/Grade	Gender	Sample Selection	Standardized Methods	Report Calibration	Caries Prevalence	dmft (d/dmft %)	DMFT (D/DMFT%)
<i>National population-based caries prevalence studies</i>										
Al-Shammery (1999)	1994; 13 regions	1,873 primary and intermediate school students	12–13	Male and female students	- Unspecified school funding source - Urban and rural populations	WHO	- 20+ Examiners - Interexaminer reliability 0.76–0.99 - Cohen's Kappa - Interexaminer reliability 0.66–0.99 - Cohen's Kappa	74% Urban; 67% Rural	-	Urban 2.69 (89.6); rural 2.65 (89.8)
Al Dosari et al. (2010)	Not listed; 11 regions	12,200 Primary, intermediate, and secondary students	6–7; 12–13; 15–18	Male and female students	- Unspecified school funding source - Urban and rural populations - Stratified by fluoride levels	WHO	- 2 Examiners - Interexaminer reliability > 0.77 - Cohen's Kappa	Primary teeth 74–90%; Permanent teeth 59–80%	2.68–7.07 (86)	1.81–4.70 (90)
<i>Regional population-based caries prevalence studies</i>										
Caries Prevalence Studies of School Children										
Al-Sekait and Al-Nasser (1988)	1986; Al-Riyadh	7,040 Primary school students	6–15	Male and female students	- Urban and rural population	WHO	- 3 Examiners - Unspecified interexaminer and intraexaminer reliability	52%	-	2.0 (85)
Akpata and Al-Shammery (1992)	1989; Al-Riyadh	363 Intermediate school students	12–13	Male and female students	- Unspecified funding source of schools - Urban and rural populations - Stratified by fluoride levels	A break in enamel or an ash's 54 probe caught on tooth	- One examiner - Intraexaminer reliability = .83 - Cohen's Kappa - 2 Examiners - Interexaminer reliability .86 - Cohen's Kappa; intraexaminer reliability of .91 and .89 for the two examiners	69–84%	-	1.67–2.43
Wyne et al. (2002b)	Not listed; Al-Riyadh	449 Third grade students	8–9	Male students only	- Specified school funding source (public and private) - Education districts	WHO	- 2 Examiners - Interexaminer reliability .86 - Cohen's Kappa; intraexaminer reliability of .91 and .89 for the two examiners	94%	-	6.3 (78%)
Wyne (2004)	Not listed; Al-Riyadh	1,407 Primary & intermediate school children, schools	12–13 & 15–19	Male and female students	- Stratified by fluoride level of area	WHO	- Number of examiners not identified - Inter- and intraexaminer reliability > .90 - Cohen's Kappa	12–13: 90.5%, 15–19: 90.9%	-	-
Al-Wazzan (2004)	2001; Al-Riyadh	602 primary school children	6–7	Male and female students	- Urban and rural population - Specified school funding source (public and private) - Geographic area of city	WHO	- 2 Examiners - Interexaminer reliability > .95 - Cohen's Kappa	94.4%	7.34 (84)	-
Al Dosari et al. (2004)	Not listed; Al-Riyadh	1,104 Primary and intermediate school students	6–7 & 12–13	Male and female students	- Unspecified school funding source - Urban and rural populations - Stratified by fluoride levels	WHO	- Number of examiners not identified - Inter- and intra-examiner reliability > .9 - Cohen's Kappa	Primary schools 91.2%; Intermediate schools 92.3%	6.53 (90)	5.06 (90)
Al-Sadhan (2006)	2001; Al-Riyadh	205 Intermediate school students	12–14	Male and female students	- Urban and rural population - Specified school funding source (public and private) - Education districts	WHO	- 2 Examiners - Interexaminer reliability > .95 - Cohen's Kappa	93.7%	-	5.94 (90)
Al-Khateeb et al. (1990)	1987; Makkah	1440 Students from Jeddah, Makkah & Rabagh	6, 12, & 15	Male and female students	- Specified school funding source (public and private) - Stratified by fluoride levels	WHO	- Number of examiners not identified - >95% Interexaminer & intraexaminer reliability agreement	Jeddah: 79%-91%; Makkah: 66%-79%; Rabagh: 58%-68%	Jeddah 6 y: 4.6; Makkah 6 y: 2.7; Rabagh 6 y: 2.1	Jeddah 12 y: 3.6 & 15 y: 5.8; Makkah 12 y: 1.9 & 15 y: 2.1; Rabagh 12 y: 1.7 & 15 y: 3.2
Alamoudi et al. (1995)	Not listed; Makkah	3,318 Primary school students	6–14	Unspecified	- Specified school funding source (public and private) - Geographic areas of city	WHO	- 1 Examiner - 95% Intraexaminer reliability agreement	-	2.16 (80)	-
Alamoudi et al. (1996)	Not listed; Makkah	1,522 Primary school students (same study as #24 but with different data examined)	6–9	Unspecified	- Urban population - Specified school funding source (public and private) - Geographic areas of city - Urban population only	WHO	- 3 Examiners - 95% Intraexaminer reliability agreement	73.9%	4.23 (80)	1.85 (96)
Gandeh and Milaat (2000)	1996–1997; Makkah	82,250 Primary school students	6–7 and 10–11/ 1st & 4th grade	Male and female students	- Public schools only - Geographic area of city	WHO	- 18 Examiners - Unspecified interexaminer and intraexaminer reliability	83%	-	-

Qutob (2009)	2007: Makkah	1,200 Primary, intermediate & secondary school children	6; 12; 16	Male and female students	- Urban and rural population (Jeddah & Bahra) - Geographic area of city - Specified school funding source (public and private) - Education regions of city - Urban population only	WHO	- 30+ examiners - Inter-examiner reliability > .7 - Cohen's Kappa: intraexaminer reliability > .9 Cohen's Kappa	6 y: primary dentition; 8.5 y: 5.45 (87) 12 y: 2.89 (81); 16 y: 4.66 (70)	
Al Agili et al. (2012)	2008: Makkah	1668 Primary and intermediate school students	3rd and 8th grade	Male and female students	- Specified school funding source (public and private) - Education regions of city - Urban population only	Basic Screening Survey	- 4 Examiners - Inter- and intraexaminer reliability were ≥90% agreement	63.01% primary teeth; 56.7% permanent teeth	-
Maghbool, 1992	Not listed: Eastern	1,665 Al-Hasa school children	6-17	Male and female students	Unspecified	WHO	Unspecified	87.5%	6-7 y: 5.11 (?)
Khan et al. (2001)	1997: Eastern	457 Al-Hasa first graders	6-7	Male and female students	- Unspecified funding source - Urban and rural populations - Stratified by SES levels	WHO	- 2 Examiners - Inter- and intraexaminer reliability were ≥95% agreement	Overall 82.9%; Urban 81.6%; Rural 86.5%	4.45 (85)
Amin and Al-Abad (2008)	2006: Eastern, excluding Bedouin district	1,115 Primary school students	10-14/5th and 6th grades	Male students only	- Urban and rural population - Public schools only	WHO	- 1 Examiner - Unspecified intraexaminer reliability	69%	-
Wyne et al. (2001a)	Not listed: Al-Qusem	153 Children in desert around Al-Qusem	Two groups: mean age: 4 & 9.7	Unspecified	Bedouin children	WHO	- One examiner - Unspecified intraexaminer reliability	20.8%; primary teeth, and 8.6% intraexaminer 19.7%; mixed dentition	-
Al Dosari et al. (2004)	Not listed: Al-Qusem	1,104 Primary and intermediate school students	6-7 & 12-13	Male and female students	- Unspecified school funding source - Urban and rural populations - Stratified by fluoride levels	WHO	- Number of examiners not identified - Inter- and intra- examiner reliability > .9 Cohen's Kappa	Primary schools 91.2%; Intermediate schools 87.9%	4.53 (91)
Akpata et al. (1997)	Not listed: Ha'il	2,355 Primary and intermediate school students	12-15	Male and female students	- Unspecified funding source of schools - Stratified by fluoride levels	WHO	- 3 Examiners - Intraexaminer reliability > .75 - Cohen's Kappa	64-74%	12 y: 2.73 (88); 15 y: 3.16 (87)
Al-Tamimi and Petersen (1998)	Not listed: Al-Madinah	975 Primary school students	6 & 12	Male students Only	- Unspecified funding source of schools - Geographic areas of city - SES Classification	WHO	- 1 Examiner - Unspecified intraexaminer reliability	6 y: 87%; 12 y: 83%	2.9 (97)
Abolfotoh et al. (2000)	Not listed: Asir	975 Primary school students	6-13	Male students Only	- Unspecified funding source of schools - Geographic areas of city - SES Classification	WHO	- 1 Examiner - Unspecified intraexaminer reliability	Overall 85.4%; 78.5% primary teeth; 34.2% permanent teeth	3.54 (69)
Caries Prevalence Studies of Preschool Children	Not listed: Al-Riyadh	1016 Nursery children	2-6 with primary dentition only	Male and female children	- Geographic areas of city	WHO	- 1 Examiner - Unspecified intraexaminer reliability	Nursing Caries only: intraexaminer 27.3%	8.6 (88)
Paul (2003) ^a	Not listed: Al-Riyadh	103 nursery children	5	Male and female children	Unspecified	WHO	- 1 Examiner - Intraexaminer reliability .89	83.5%	7.1 (82)
Wynne (2008)	Not listed: Al-Riyadh	789 Nursery children	3-5	Male and female children	- Specified school funding source (public and private) - Specified school BASCD funding source (public and private) - Geographic areas of city - Urban population only	WHO	- 2 Examiners - Inter- and intraexaminer reliability > .85 Cohen's Kappa	Overall 74.8%; Private school 65.3%; Public schools 86.6%	6.1 (76)
Al-Malik et al. (2002) ^b	1998: Makkah	987 Nursery children	2-5	Male and female children	- Specified school funding source (public and private) - Geographic areas of city - Urban population only	BASCD	- 2 Examiners - Interexaminer reliability .85 - Cohen's Kappa: intraexaminer reliability .96 Cohen's Kappa	Overall 73%; Rampant Caries 34%	4.80 (83)
Farsi (2010)	Not listed: Makkah	510 Nursery children	4-5	Male and female children	- Specified school funding source (public and private) - Geographic areas of the city	WHO	- 2 Examiners - Inter and intraexaminer reliability > .8 Cohen's Kappa	62%	3.9
Wynne et al. (2002a)	2000: Al-Hasa	322 Nursery children	3-5	Male and female children	- Specified school funding source (public and private) - Urban and rural population	WHO	- 2 Examiners - Interexaminer reliability > .95 - Cohen's Kappa: intraexaminer reliability > .94 Cohen's Kappa	62.7%	2.92 (90)

^a Information also reported in Paul and Maklazi (1997).^b Information also reported in Al-Malik et al. (2001, 2003).

studies, boys had a significantly higher dental caries severity than girls, and rural children had a significantly lower severity than urban children (Al-Wazzan, 2004; Al-Sadhan, 2006).

3.3.2. Caries prevalence studies of preschool children

In the most recent Riyadh study, Wyne (2008) assessed 3–5-year-old children in 10 randomly selected public and private preschools. Overall, 74.8% of the children had caries with a mean dmft score of 6.1. However, the dental caries prevalence was 65.3% for private schools and 86.6% for public schools. The caries burden may be lower in this study than in earlier studies by Wyne et al. (2002b), Al-Wazzan (2004), and Al-Sadhan (2006) because the children in this study were younger and sampled from an equal number of public and private schools. About 55.5% of these children were from private preschools, likely a higher percentage than in the overall Riyadh population (Wyne, 2008). In 2003, an assessment of 103 5-year-old children in preschool nurseries in Al-Kharj, another province in Al-Riyadh region, found a caries prevalence of 83.5% with a dmft index score of 7.12 (Paul, 2003; Paul and Maktabi, 1997). Finally, one study reported on nursing caries among 2–6-year-old children in Al-Riyadh city with primary dentition only and estimated a prevalence of 27.3% (Wyne et al., 2001b). Nursing caries was defined as caries on the labial or lingual surfaces of at least two maxillary incisors with an absence of caries in the mandibular incisors.

3.4. Makkah region

3.4.1. Caries prevalence studies of school children

Many assessments were performed in the Makkah region; the earliest was published in 1989, and the latest was published in 2010 (Al-Khateeb et al., 1990; Farsi, 2010). The caries prevalence ranged from 60% to 96% (Al-Khateeb et al., 1990; Alamoudi et al., 1995; Alamoudi et al., 1996; Gande and Milaat, 2000; Al Agili et al., 2012; Qutob, 2009; Farsi, 2010). Al-Khateeb et al. (1990) assessed 6-, 12-, and 15-year-old school children in three cities. They reported a prevalence of 79–91% in Jeddah, 66–79% in Makkah, and 58–68% in Rabagh. In 1995, Alamoudi et al. (1995) reported a mean dmft score of 6.83 for 6-year-old children of unspecified gender selected from public and private primary schools in four areas of the city, and did not report the prevalence of caries. The next published report was also by Alamoudi et al. (1996), and reported, among the same sample population as the previous paper, a caries prevalence of 73.9% for 6–9 year olds with a mean dmft of 4.23 and a mean DMFT of 1.85. Gande and Milaat (2000) assessment included an examination of all children in the first and fourth grades in Jeddah public schools, and it reported a combined caries prevalence of 83% for 6–7 and 10–11 year olds and did not report caries severity. A recent study of 1666 third and eighth graders randomly selected from public and private schools children from different regions in Jeddah found that 63% and 56.7% of these children presented with dental caries in their primary and permanent teeth, respectively (Al Agili et al., 2012). A recent unpublished thesis on the oral health status of school children in Jeddah and its suburb (Bahra) reported a dental caries prevalence of 85.5% in the primary dentition of 6-year-old school children (mean dmft = 5.45) (Qutob, 2009). The prevalence of caries in the permanent dentition of 12- and 16-year-old school children

was 71.7%, and 82.5%, and the corresponding DMFT scores were 2.89 and 4.66, respectively.

3.4.2. Caries prevalence studies of preschool children

Al-Malik et al. (2002) examined 987 preschool children in six public and eleven private nursery schools in Jeddah. The overall caries prevalence was 73%, and the prevalence was 61% for 3 year olds, 73% for 4 year olds, and 76% for 5 year olds. Rampant caries, defined as caries affecting smooth surfaces of two or more maxillary incisor teeth, was present in 34% of all children. Farsi (2010) evaluated 510 children; 175 were from public schools, and 335 were from private schools. The author of this review used Farsi's Table 4 (Farsi, 2010) to calculate a caries prevalence of 61% for 4 year olds and 67% for 5 year olds.

3.5. Eastern region

Several studies were performed in this region. The first study took place in 1992 in Al-Khobar province, and it reported a caries prevalence of 87.5% and DMFT scores that ranged from 0.78 in 6–7-year-old to 4.59 in 16–17-year-old school children (Maghbool, 1992). The reported dmft score was 5.11 in 6–7 year olds. In 1997, a second study assessed 457 6–7-year-old children from urban and rural areas in Al-Hassa (Khan et al., 2001). These children were selected randomly from a sample of primary schools and stratified by sex and socioeconomic status, which were identified by the investigators. The prevalence of caries approached 83% with a mean dmft of 4.45. The third survey in 2006 assessed 1115 10–14 year old boys in both urban and rural public primary schools and reported a caries prevalence of 69% among all dentition (Amin and Al-Abad, 2008). Only one study was conducted among 3–5-year-old children in Al-Hassa (Wyne et al., 2002a). The prevalence was 62.7% in the primary dentition of 322 children in classes randomly selected from both urban and rural private and public kindergartens.

3.6. Al-Qaseem region

Al-Qaseem, a rural region near Al-Riyadh, has twice been the subject of study (Al Dosari et al., 2004; Wyne et al., 2001a). The overall caries prevalence was approximately 20% in a study of Bedouin children (Wyne et al., 2001a). Specifically, the caries prevalence was 20.8% for children with primary dentition (mean age 4.0) and 19.7% for children with mixed dentition (mean age 9.7). In the other study, the dental caries prevalence was 91.2% (mean dmft = 6.35) for 6–7 year olds and 87.9% (mean DMFT = 4.53) for 12–13 year olds (Al Dosari et al., 2004).

3.7. Other regions

Ha'il, Al-Madinah, and Asir were represented by one study each. Akpata studied 2,355 12–15 year olds in the rural Ha'il region in randomly selected classrooms from 42 of the region's 155 schools (Akpata et al., 1997). The schools were stratified to represent the varying fluoride levels in their villages. The dental caries prevalence ranged from 64% to 74% and their correlated mean DMFT scores ranged from 2.73 to 3.16. In

Al-Madinah, the prevalence of dental caries among 6- and 12-year-old school children was 87% (mean dmft = 6.4) and 83% (mean DMFT = 2.9), respectively (Al-Tamimi and Petersen, 1998). In Abha, a city in Asir region, the prevalence of caries among 6–13-year-old children was 85.4% (Abolfotouh et al., 2000). The dmft and DMFT scores were 3.54 and 0.8, respectively.

3.7.1. The influence of socioeconomic factors on caries prevalence

Low socioeconomic status is associated with a high prevalence of dental caries and limited access to oral health care.¹ In the reviewed studies, housing quality, geographic location, parental education, and parental occupation have been used as surrogates for socioeconomic status, making its influence unclear (Al-Shammery, 1999; Al-Malik et al., 2001; Khan et al., 2001; Abolfotouh et al., 2000). Al-Shammery (1999) identified no differences in DMFT scores between urban and rural populations, but found a significantly greater caries prevalence among urban children. Girls in low-quality housing had lower DMFT scores than girls in higher quality housing, but the opposite was true for boys. Similarly, Abolfotouh et al. (2000) found that children with a lower social class had significantly lower mean dmft scores and a higher proportion of caries-free primary teeth than those of a higher social class. They used a scoring system based on the type of house, number of livestock, crowding index, and parents' education and occupation to measure the socioeconomic status of the study participants. These results seem to contradict findings in Jeddah, where (if it is assumed that public school children have more limited resources than private school children) a survey of public school children (Gandeh and Milaat, 2000) had a higher caries prevalence than samples that included both public and private school children (Al-Malik et al., 2003; Alamoudi et al., 1996), and children in private schools were found to have significantly a lower dental caries (Al-Malik et al., 2003). School type, housing quality, and location may not be appropriate proxy indicators for income in Saudi Arabia. Amin and Al-Abad (2008) found significant differences in caries prevalence that were related to the level of parental education and maternal literacy regardless of income, housing quality, school type, or location.

4. Discussion

This review clearly shows that dental caries is a serious dental public health problem among Saudi Arabian children, particularly the very young. The prevalence of dental caries is high across Saudi Arabia and varied by geographic location. For example, the caries burden seems higher in Riyadh than Jeddah. The prevalence of caries in the primary dentition of children under 6 years of age ranged from 62–84%, and the mean dmft scores ranged from 3.0–7.1. The prevalence of caries and its severity tend to increase as age increases and are higher among children attending public preschools. By 9 years of age, the prevalence may reach up to 94%, and the mean dmft score may approach 7.3. In the permanent dentition, the prevalence varied from 58% to 94% and the mean DMFT scores ranged from 2.9 to 5.9 (Table 1).

The national prevalence is estimated to be 80% in the primary dentition with a mean dmft of 5.0, and it is approxi-

mately 70% for children's permanent dentition with a mean DMFT score of 3.5. These figures are estimates rather than scientific calculations because meaningful calculations are challenging based on the currently available data, which include highly variable populations.

These estimates of caries prevalence and severity rely on the ranges presented by Al Dosari et al. (2010). Based on the breadth of Al Dosari's survey (Al Dosari et al., 2010), an estimate that falls out of the reported range would be inappropriate. Within this range, other assessments were considered, with a lower weight given to assessments of rural areas, as only 18% of Saudis are rural-dwellers (The World Bank, 2010). Additionally, the estimate considered whether study samples were selected from public, private, or both types of school.

Although determining national caries prevalence for children in Saudi Arabia remains a challenge until a study is conducted using a nationally representative sample, the current estimates indicate that the WHO 2000 goals are still unmet for children in Saudi Arabia.

This result may be attributed to differences between regions and diversity of caries risk factors. Fluoride levels may have the greatest influence on caries prevalence and severity. Al Dosari predicted that caries reduction could drop to 50% in primary dentition and 30% in permanent dentition by increasing fluoride to 1.01–1.5 ppm (Al Dosari et al., 2010).⁷ Al-Shammery (1999) reported that fluoride is typically higher in rural than in urban areas and noted a lower incidence of caries prevalence in rural compared to urban children. The lowest caries experience was found in Ha'il, in a study of highly fluoridated well water (although children with the highest levels of fluoridation also had the highest level of dental caries) (Akpata et al., 1997). Water sources may be a major cause of variation in caries prevalence and severity in the country.

Although some sociodemographic indicators are independent factors in the development of dental caries, they may also reflect fluoridation levels, dietary habits, feeding patterns, and access to oral health care services. For example, if students of varying demographics (i.e., income, parental education, and residence) have different likelihoods of drinking from public or private water sources or of drinking prepackaged beverages with different fluoridation levels than the public water supply, surveys with small sample sizes that assess the habits of a few individuals or a small group may skew results. Given the wide variation in caries prevalence and severity related to fluoride levels, optimizing fluoride levels in the public water systems and encouraging families with private water sources to ensure adequate fluoride intake would lead to major improvements in public health. With reduced fluoride variation, researchers could perform a more robust assessment of the caries trends and identify targets for intervention. Until these caries indicators are better understood, assessment should include representative samples from urban and rural areas and from a variety of sites in those locations to ensure that the sample is not skewed toward excessively high or low dental caries.

5. Future studies

Re-examining available data to understand the interaction of fluoride, location, and socioeconomics may be cost-effective. Al Dosari collected water samples from every town or village with a school.⁷ Researchers could match these fluoride data

with the schools from which populations were drawn in previous assessments, and then determine the influence of demographic factors and fluoride on caries prevalence. Furthermore, this review shows a lack of critical research exploring early childhood caries (ECC) in preschool children in Saudi Arabia. Future research should focus on studying ECC experience and the interactions between risk and protective factors in the development of ECC, in particular the effects of infant feeding practices.

6. Conclusion

Childhood dental caries is a serious dental public health problem that warrants the immediate attention of the government and the dental profession officials in Saudi Arabia. The national prevalence is estimated to be 80% in the primary dentition with a mean dmft score of 5.0, and it is estimated to be 70% for children's permanent dentition with a mean DMFT score of 3.5. Baseline data on oral health and a good understanding of dental caries determinants are necessary for setting appropriate oral health goals. Without the ability to describe the current situation, it is not possible to identify whether progress is being made toward meeting oral health goals. A roadmap with a clear starting point, destination, and pathway is a desperately needed tool to improve the oral health of Saudi Arabian children.

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