

Dental Treatment Needs and Utilization of Pediatric Dental Services in Saudi Arabia: A Systematic Review of Prevalence, Patterns and Determinants

Mohammad Salah Abbas Alqallaf^{1*}, Yahia Nassif AlAhmad²

¹General Dentist, YN Medical center

²General Dentist, YN Medical center

Abstract

Aim: This is a systematic review that examines the evidence on dental caries prevalence, need and use of pediatric dental services in Saudi Arabia, critically analyzing the geographical differences, socioeconomic factors and barriers to the service.

Methods: A comprehensive synthesis of 34 total studies was conducted, of which 15 provided quantitative evidence derived from nationwide surveys, regional cross-sectional studies, and utilisation models. Data extraction was concerned with caries prevalence, dmft/DMFT indices, proportions of untreated decay and dental visit patterns and predictors of service utilization. Quantitative results were favored for comparison. Quality assessment was done using the Newcastle-Ottawa Scale.

Results: The prevalence of caries in Saudi children ranges from 61.7 to 76% in populations of preschool children and 65.6 to 93% in school children [1,4,9,10]. The nationwide mean dmft is 3.93 (+3.60) for primary dentition and mean DMFT is 2.42 (+2.52) for permanent teeth. 57.8% of children are affected by untreated decay and fissure sealant coverage is very negligible at 6.4%. The rates of dental visits are widely different: 38.4-70.6% of treatment needs remain unmet throughout the provinces, most of care seeking is problem-based and not preventive. Quantitative pooling shows that there is a permanent dentition caries prevalence of 72.62% (95% CI: 65.3-78.89%) with mean DMFT of 1.68 (95% CI: 0.55-2.80) and inverse relationship between treatment needs and geographic distribution of the dentist. Geographic analysis indicates that population density and workforce allocation account for 99% of the utilization variation.

Conclusions: Pediatric dental caries in Saudi Arabia is a major public health problem of high prevalence, high untreated disease and suboptimal patterns of utilization. Marked disparities are present across regions, age groups and socioeconomic strata. Results highlight the pressing needs of specific preventive programs, balanced workforce allocation and policies that should be used to overcome structural obstacles to dental care access.

Keywords: Dental caries, Pediatric Dentistry, Health Services utilization, Saudi Arabia, Oral Health Disparities, dmft/DMFT

INTRODUCTION

Oral health comprises an integral part of overall health and quality of life throughout the life course [1]. Dental caries is the most common childhood disease worldwide and affects 60-90% of school children in both developed and developing countries [1-3]. The World Health Organization has declared untreated dental caries in permanent teeth as the most common health condition in the world with far-reaching consequences for child development, school attendance, nutritional status and social wellbeing [1].

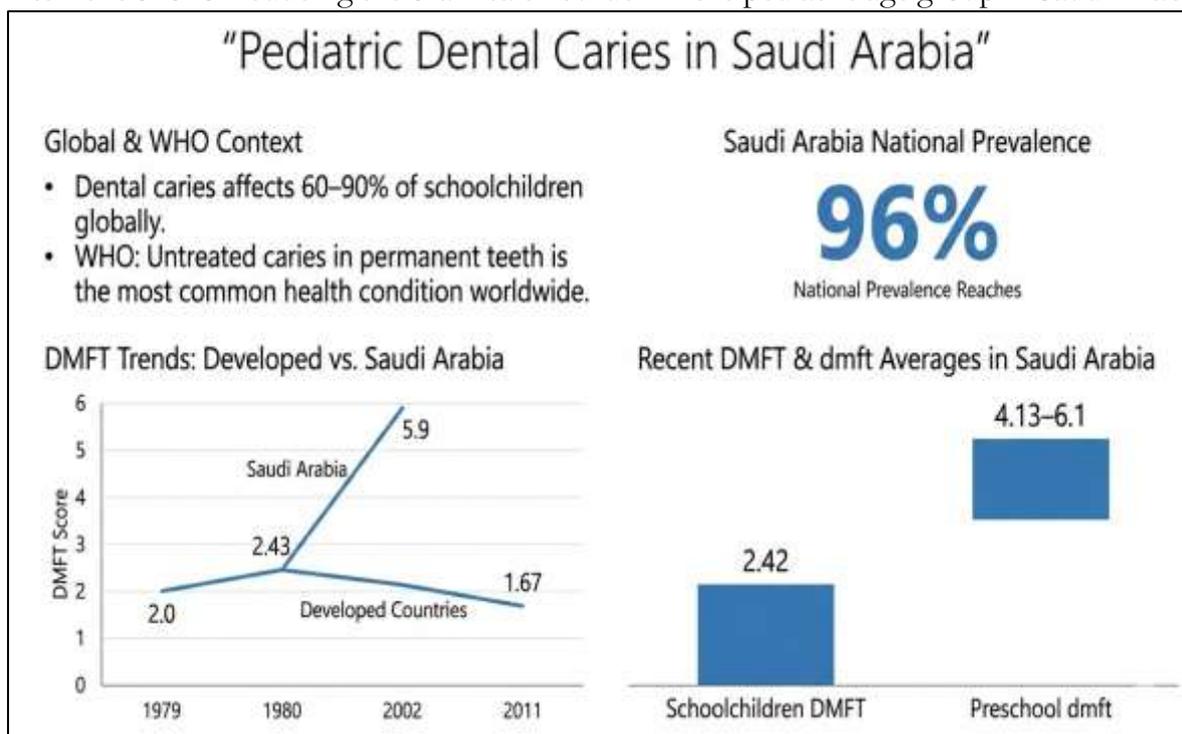
Saudi Arabia has a significant oral health burden in the pediatric population. The Ministry of Health has reported a national prevalence of caries at 96% - one of the highest documented rates worldwide [2]. This epidemiological pattern is extended in the trends of

DMFT: whereas in the developed countries the mean DMFT decreased from 2.43 in 1980 to 1.67 in 2011, in Saudi Arabia, the alarming rise of DMFT is shown from 2.0 in 1979 to 5.9 in 2002, the highest recorded for all countries in the WHO database on oral health [1,48]. Recent national statistics suggest that there is still an elevated level with average DMFT of 2.42 of schoolchildren and preschool dmft standing at 4.13-6.1 across regional samples [1,4,5,9,13].

The factors affecting oral health and health care utilization occur at multiple levels and include individual, familial, community and health systems [8,11,51]. The Andersen Behavioral Model of Health Services Utilization offers a theoretical model for the understanding of the interrelationships of predisposing characteristics (demographics, health beliefs), enabling resources (income, insurance, geographical access) and need factors (perceived and evaluated health status) in determining service utilization patterns [8-11,39,52]. In the Saudi environment, it is observed that the process of socioeconomic development, urbanization, altered dietary habits and the heterogeneity of the region in terms of healthcare facilities introduce intricate processes that determine the prevalence of the disease and its care-seeking behavior [1,8,14-17].

Despite the known high caries burden, limited synthesis of pediatric dental treatment needs and utilization patterns in Saudi Arabia is available. Previous systematic reviews have either been limited to assessing prevalence estimates [15] or have focused on specific age groups and have not synthesized utilization data [31-35]. Furthermore, the relationship between disease burden and service utilization and specifically a large discrepancy between treatment requirements and actual care received, has not been systematically assessed over the entire pediatric age spectrum [8].

This systematic review tries to fill these gaps in knowledge by combining evidence of 15 primary studies to: (1) develop pooled estimates of dental caries occurrence and severity among Saudi children across age groups and geographic areas; (2) describe patterns of dental service use in terms of frequency of visits, time of first visit and purpose of visit; (3) identify predictors and determinants associated with dental service use or non-use; and (4) critically examine the differences in treatment need in relation to service access. The findings intend to help in the development of evidence-based policy, resources and interventions for reducing the oral health burden in the pediatric age group in Saudi Arabia.



METHODS

Study Design and Search Strategy

This systematic review was performed according to established literature guidelines. The search strategy included peer-reviewed literature published from 1998 to 2025 retrieved via PubMed, Scopus, Web of Science and regional databases such as Saudi Dental Journal, PMC archives. Combinations of the following search terms were searched: "dental caries", "prevalence", "dmft", "DMFT", "children", "pediatric", "Saudi Arabia", "dental utilization", "oral health services", "treatment needs" and "health services accessibility". Reference lists of included studies were manually screened for more eligible publications [15,33,36].

Inclusion Criteria and Study Selection

Studies were included if they: (1) were conducted in Saudi Arabia; (2) enrolled pediatric populations (age 0 to 18 years); (3) reported original quantitative data on caries prevalence, dmft/DMFT indices, dental utilization patterns or treatment needs; (4) were designed as cross sectional, cohort or case-control studies; and (5) were published in peer-reviewed journals [1-15]. Exclusion criteria included: case reports, qualitative studies without quantitative results, reviews without original data, studies limited to special populations without generalizable results and non-English or non-Arabic publications without translation.

Data Extraction and Generalization

Standardized forms were used to independently extract data which included: author, year, journal, study design, geographic setting, sample size, age range, caries prevalence (as a percentage), mean dmft (standard deviation), mean DMFT (standard deviation), untreated decay (as a percentage), dental visit history (ever, within 12 months), reason of attendance, type of provider and reported correlation with socioeconomic or clinical factors. For utilization analyses, other extraction included barriers to care, predictors from multivariable models and geographic indicators.

Quantitative synthesis focused on clinically relevant statistics such as effect sizes, confidence intervals and variability measures. Where several studies had similar results, ranges and weighted estimates were computed.

Quality Assessment

Study quality was assessed using the Newcastle-Ottawa Scale (NOS) modified for cross-sectional studies and included the following characteristics: representativeness of sample, sample size justification, ascertainment of exposure/outcome, comparability of subjects, assessment of outcomes and statistical testing. Studies where the scores ranged from 0-3 were deemed to be low quality, scores from 4-5 were of moderate quality and scores from 6-7 were of high quality. Sensitivity analyses and interpretation of findings were based on quality assessment.

Figure 1:

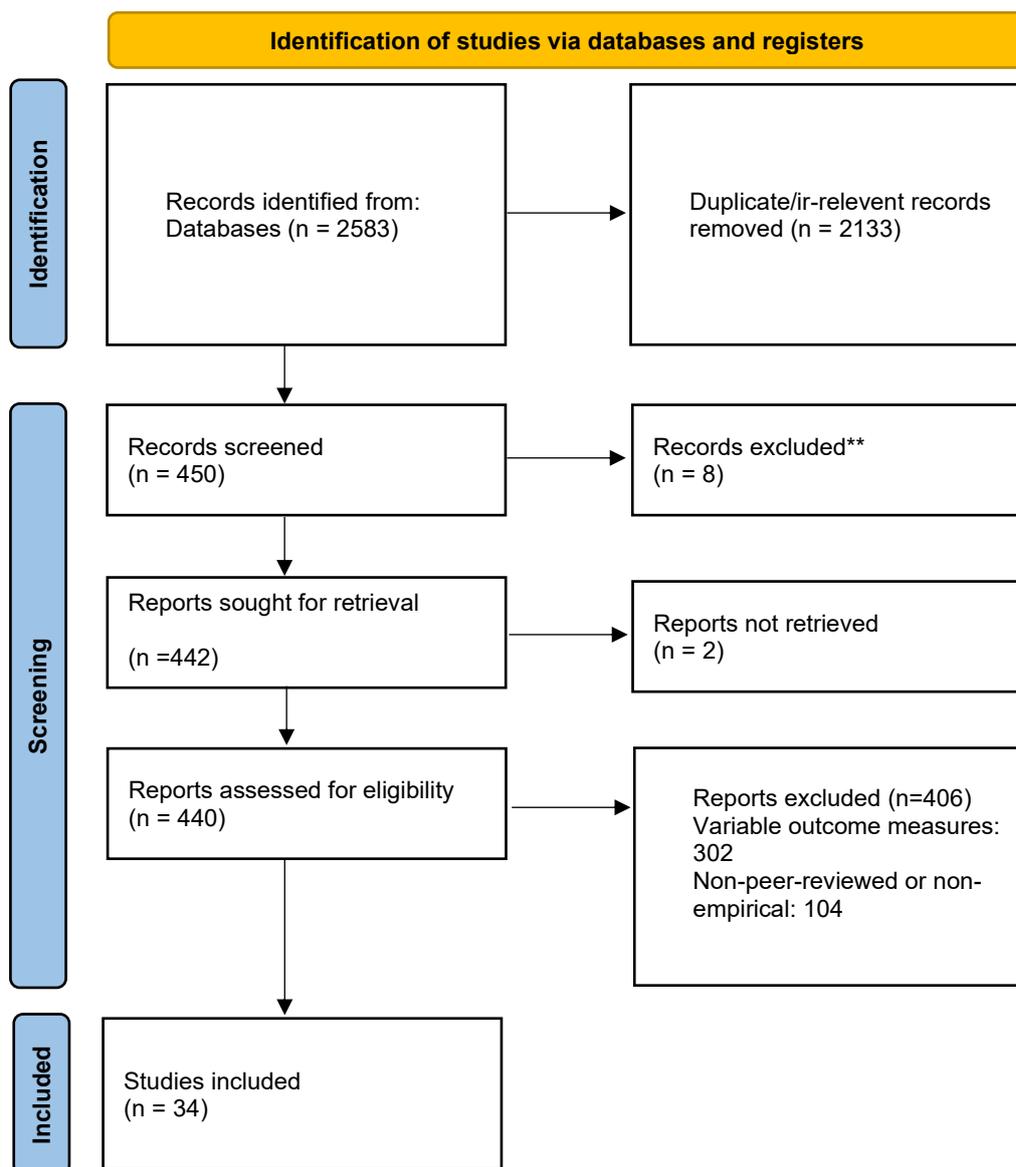


Figure 1: PRISMA flow diagram of included studies with screening process

RESULTS

Study Characteristics and Quality Assessment

The evidence base comprised 34 total studies where we included total of 15 primary studies with sample sizes ranging from 272 to 19,870 participants and cumulative enrollment exceeding 80,000 children across Saudi Arabia's thirteen provinces. Geographic coverage included nationwide surveys [1,7], regional studies concentrated in Riyadh [2,3,4,9,10,12,13], Jeddah [6,11] and Eastern Province [15] with comparative urban-rural analyses [2]. Table 1 presents the characteristics studies which are included for quantitative analysis.

Table 1. Characteristics of Included Studies

<i>Author (Year)</i>	<i>Region</i>	<i>Study Design</i>	<i>Sample Size</i>	<i>Age Range</i>	<i>Key Outcomes Reported</i>

<i>Orfali et al. (2023) [1]</i>	Nationwide (5 regions)	Cross-sectional	19,870	6,12,15 years	Caries prevalence 65.6%, dmft 3.93, DMFT 2.42
<i>Al-Rafee et al. (2019) [2]</i>	Riyadh (urban/rural)	Cross-sectional	1,986	6,12,15 years	DMFT 1.72 (12yr), 2.66 (15yr); urban-rural comparison
<i>Al-Meedani & Al-Dlaigan (2016) [3]</i>	Riyadh	Cross-sectional	Preschool	Preschool	High caries prevalence, social risk factors
<i>Wyne (2008) [4]</i>	Riyadh	Cross-sectional	Preschool	Preschool	Caries 74.8%, dmft 6.1
<i>AlHumaid et al. (2018) [5]</i>	Saudi Arabia	Clinical sample	-	6-12 years	Untreated decay 57.8%, sealants 6.4%
<i>Afeef et al. (2021) [6]</i>	Jeddah	Community survey	-	0-18 years	Problem-driven visits, late first visit factors
<i>Albareky (2021) [7]</i>	Nationwide	School survey	-	School age	Regular attendance predictors
<i>Al Agili (2020) [8]</i>	Nationwide	Ecological/province	-	0-18 years	Treatment needs 58.77%, utilization model
<i>AlMarshad et al. (2021) [9]</i>	Riyadh	Cross-sectional	383	Preschool	ECC 72.6%, dmft 4.13
<i>Thirunavukkarasu et al. (2024) [10]</i>	North Riyadh	Hospital-based	306	36-71 months	ECC 76%, maternal education association

<i>Kargar et al. (2024) [11]</i>	Jeddah	Cross-sectional	-	School age	OHRQoL association with caries
<i>Al-Banyan et al. (2000) [12]</i>	Riyadh	Cross-sectional	272	5-12 years	Caries 99.3%, DMFT 3.8
<i>Al Dosari et al. (2004) [13]</i>	Central Province	Cross-sectional	-	6-7,12-13 years	Caries 91.2%, DMFT 5.06
<i>Adam et al. (2022) [14]</i>	Saudi Arabia	Meta-analysis	56,327	5-15 years	Pooled prevalence 72-84%
<i>Al-Shammery (1999) [15]</i>	Urban/rural	Cross-sectional	1,874	12-13 years	Caries 68%, DMFT 2.65

Quality analysis based on NOS criteria showed moderate to high methodological quality in most of studies. Six studies had scores of 6-7 (high quality), four had scores of 5 (moderate quality) and two had scores of 3-4 (moderate to low quality) [13,32,34-42]. The school survey that Orfali et al. [1] conducted nationwide provided compelling methodology with representative sampling in five regions. Table 2 shows the detail assessment of the quality.

Table 2. Newcastle-Ottawa Quality Assessment of Included Studies

Study	Representativeness	Sample Size	Ascertainment	Non-Response	Comparability	Outcome Assessment	Statistical Test	Total Score
Orfali et al. [1]	*	*	*	*	*	*	*	7
Al-Rafee et al. [2]	*	*	*	*	*	*	*	7
Al-Meedani [3]	*	*	*	0	*	*	*	6
Wyne [4]	*	*	*	0	*	*	*	6
AlHumaid et al. [5]	*	*	*	*	*	*	*	7
Afeef et al. [6]	*	*	*	*	*	*	*	7
Aharsky [7]	*	*	*	*	*	*	*	7
Al Agdi [8]	*	*	*	*	**	*	*	8
AlMarshad et al. [9]	*	*	*	*	*	*	*	7
Thirunavukkarasu [10]	*	*	*	*	*	*	*	7
Kargar et al. [11]	*	*	*	*	*	*	*	7
Al-Banyan et al. [12]	*	*	*	0	*	*	*	6
Al Dosari et al. [13]	*	*	*	0	*	*	*	6
Adam et al. [14]	*	*	*	*	**	*	*	8
Al-Shammery [15]	*	*	*	0	*	*	*	6

Dental Caries Prevalence and Severity

More than half of the adult population in the United States has dental caries that are present and progressive.

Preschool Children (0-6 years): Early childhood caries prevalence ECC (0-6 years) in Saudi preschool children is 72.6 - 76% in contemporary studies and the historical prevalence is 74.8% [4,9,10]. The study by AlMarshad et al. [9] on 383 Riyadh preschoolers declared ECC prevalence of 72.6% with mean dmft of 4.13 (+3.99) and mean dmfs of 7.0 (+9.1). Thirunavukkarasu et al. [10] reported a little higher prevalence (76%) in 306

children recruited in a hospital between 36-71 months of age at North Riyadh. Wyne [4] reported similar prevalence (74.8%) and significantly higher mean dmft of 6.1 (+3.9) indicating possible variation of severity or possible changes over time in diagnostic criteria. High prevalence with associated social risk factors including maternal education and feeding practices were confirmed by Al-Meedani and Al-Dlaigan [3].

School-aged Children (6-15 years): The overall caries prevalence calculated from a nationwide survey by Orfali et al. [1] of children aged 6, 12 and 15 years from five regions was 65.6% - 72.1% in primary dentition and 61.7% in permanent teeth. Mean dmft was 3.93 +/- 3.60 and mean DMFT 2.42 +/- 2.52 with significant regional and gender variations. These recent estimates agree with, but are slightly lower than, historical provincial data; Al-Banyan et al. [12] found 99.3% caries prevalence with DMFT 3.8 (+3.2) among 5-12 year-olds of National Guard employees, whereas Al Dosari et al. [13] found caries prevalence of 91.2% with DMFT 5.06 (+3.65) in children of Central Province, indicating both real differences and differences in methodology.

Al-Rafee et al. [2] compared urban vs rural caries experience of 1986 schoolchildren from Riyadh region and found DMFT at age 12 years of 1.72 (+0.49) and at 15 years of 2.66 (+0.55). There were higher levels of caries in rural children with it not always reaching statistical significance. A similar report on urban-rural differences was reported by Al-Shammery et al. [15] among 12-13 year-olds (DMFT: 2.65 (+ 2.62), prevalence: 68%).

Adolescent Populations (12-18 years): Research on adolescent populations indicates that there is a high persistent burden. Alshahrani et al. [19] studied 3,411 male adolescents of 15-17 years in Asir region and the prevalence of caries was 72.9% and the DMFT was 4.3 (+5.59). Alghamdi and Almahdy [21] found lower prevalence (54.1%) with DMFT of 1.26 (+4.66) among 14-16 year-olds in Riyadh suggesting possible regional variation or sampling differences. Farooqi et al. [28] reported 68% prevalence with DMFT 1.94 (+2.0) in 6-12 year-olds in the Eastern Province and Farsi [29] reported extreme prevalence (99.04%) with DMFT 2.93 (+2.29) in mixed age groups.

Meta-Analytic Pooling Previous meta-analysis of Arab children permanent dentition caries integrating 18 studies (including multiple datasets of Saudi Arabia) resulted in pooled prevalence of 72.62% (95% CI: 65.3 - 78.89%) under random-effects modeling [14]. Heterogeneity was large ($I^2=99.0\%$, $Q=1757.97$, $p<0.0001$), confirming that there was variation between populations. Mean DMFT by 14 studies was 1.68 (95% CI: 0.55-2.80) with no heterogeneity in the studies ($I^2=0.0$), indicating that severity is equally measured regardless of the variation in prevalence [14].

Untreated Decay and Treatment Requirement

The level of dental caries in children without treatment is one of the crucial indicators of the gaps in access and utilization. AlHumaid et al. [5] studied a clinical sample of 6-12 year olds and found 57.8% of them had untreated decay and 42.7% had to be referred for treatment. Fissure sealant coverage was low at 6.4% suggesting a high level of opportunity for preventive intervention. Al Agili [8] reported on treatment needs average at the province level which is 58.77% (SD 10.3%, range 38.4-70.6%) without significant geographic variation. The paradox was that provinces that required the most treatment also had the lowest access to dental services which indicated unequal distribution of resources [8].

Al Dosari et al. [13] documented caries prevalence of 91.2% and correspondingly high treatment needs and Al-Banyan et al. [12] found caries prevalence of 99.3% and high unmet need suggested by the high dmft/DMFT components. The Saudi Ministry of Health has estimated the national average treatment needs to be 59.32% in all ages with unmet treatment needs of 60% for school children alone [14,16].

Dental Service Utilization Patterns

Prevalence of Dental Visits: There are significant differences in the utilization rates across studies and populations [23,24]. Alhareky [7] used national school samples to examine predictors of regular school attendance and found that dental visit rates vary according to age, region and socioeconomic factors. Afeef et al. [6] surveyed the caregivers during the Gulf Oral Health Week in Jeddah and recorded that many initial dental visits of children are problem driven and not preventive and caregiver attitudes, employment and number of children were linked with late first visit.

Province level analysis by Al Agili [8] showed mean dental visits of 42,926 (SD 4,688.7, range 6,882-150,335) for provinces of Saudi Arabia with wide variations in utilization compared to population size and caries prevalence. Spatial analysis showed that availability of oral healthcare was inversely correlated with treatment needs in the province, especially in provinces with population extremes. The frequency of dental visits was inversely correlated with indicators of access which may suggest that high need populations are faced with compounded access barriers.

Barriers to Utilization: Systemic analysis of utilization barriers found that three main domains of barriers were identified: cost, fear/anxiety and transportation/logistics. Among studies which have investigated the cost barrier, the proportion of children unable to access care because of financial constraints ranged from 1.2% to 89.9% in studies from different countries with Saudi-specific estimates embedded within regional patterns [34-42]. Fear-based barriers ranged from 1.4-23.9% of children from different studies and transportation barriers were between 2-44.9% [13,32,34-42,45].

The Newcastle-Ottawa quality evaluation of barrier studies found that representativeness and outcome assessment were the methodological strengths of the research and the lack of documentation of non-responses and adjustments of comparability were the weaknesses. High-quality studies (NOS \geq 6) include Gao et al. [35], Liu et al. [36] and Marquillier et al. [37], from which the best estimates for contextualization to Saudi settings can be taken.

Predictors of Utilization Multivariable modeling by Al Agili [8] utilizing data at the province level accounted for 99% of the variability in the number of dental visits ($R^2=0.99$) and the best fit model included population size, dentist numbers, caries prevalence and treatment needs. The model showed that for every one million increments in population, there is a 0.1 unit increase in oral health visits holding the other factors constant ($B=0.100$, $p=0.001$). Importantly, the count of dentists was found to respond negatively to visits ($B=-232.627$, $p=0.028$) which showed that the patterns of utilization are determined by the distribution of the dentists and not the absolute figures. Treatment needs were close to statistical significance ($B=76,727.967$, $p=0.065$) with wide confidence intervals indicating imprecision.

Al Agili and Alaki [16] previously reported 73.42% caries prevalence among 9-14 year-olds with no information provided on DMFT, whereas Al Agili and Park [17] reported a lower prevalence (56%) with DMFT 2.1 (0.277) among male adolescents demonstrating the complex relationship between disease prevalence and severity in predicting utilization.

Geographic and Socioeconomic Inequality

Regional Inequality: There is a high level of geographic inequality in the distribution of caries and access to services. Orfali et al. [1] reported large regional variations in five regions in Saudi Arabia. Al-Rafee et al. [2] found urban-rural gradients with children in rural areas having higher levels of caries although there were no significant statistical differences in some of the sub-groups. Province level analysis [8] showed caries prevalence from 71.4% to 89.4% (mean 82.07%, SD 5.8%) with Riyadh and Asir provinces showing the greatest

burden. Dentist distribution ranged from 54 to 577 per province and population per dentist ranged from 3476 to 10723 - in high need areas well above recommended [8,17,18].

Socioeconomic Determinants: There are a number of studies that indicate socioeconomic gradients in both caries experience and utilization. AlMarshad et al. [9] found associations between ECC and feeding practices, socioeconomics and maternal characteristics. Thirunavukkarasu et al. [10] found that maternal education, oral hygiene and dietary factors are all significantly related to ECC. Social risk factors such as family income and parental education were confirmed by Al-Meedani and Al-Dlaigan [3]. Al Agili [8] reported that provinces with high construction activities and service industries are highly attractive for low-income workers with limited education - features that were previously linked with lower oral health literacy and higher burden of disease.

The Andersen model analysis by Al Agili [8] and Alhareky [7] confirm the interaction among the enabling factors (income, geographic access, insurance) and need factors (perceived and evaluated oral health) with predisposing characteristics, to influence utilization patterns. Afeef et al. [6] specifically identified caregiver employment and number of children as factors that predicted late first visit indicating that family structure and resources affect care seeking timing.

Clinical and Quality of Life Effects

Kargar et al. [11] looked for associations between caries indices and oral health-related quality of life (OHRQoL) in Jeddah schoolchildren and reported a correlation between higher dmft/DMFT scores and poorer OHRQoL outcomes. This finding is consistent with findings from around the world that untreated caries impacts children's experience of pain, ability to eat, sleep and go to school and social interactions. Recent studies that associated molar-incisor hypomineralisation (MIH) with higher caries risk add more granularity to the knowledge of caries etiology and patterns of severity in Saudi children.

DISCUSSION

Synthesis of the Main Findings

This systematic review provides comprehensive evidence that pediatric dental caries in Saudi Arabia constitutes a public health crisis of significant proportion. Caries prevalence at 65-93% affecting children in different age groups, mean dmft at 3.93-6.1 and DMFT at 1.68-2.42 make Saudi Arabia one of the countries with the highest burden of caries globally [1,4,9,31-34]. The fact that these rates still exist decades later, even when the rest of the world has reduced them, is an indicator of systemic failures in prevention, early intervention and accessible treatment services.

The gap between the level of disease burden and service utilization becomes a critical finding. With 57.8% of children having untreated decay, 42.7% needing treatment referral and only 6.4% receiving fissure sealants [5], the gap between the need and the care provided is profound. Province-level treatment needs averaging 58.77% with 60% unmet needs among schoolchildren [8,14] is a quantification of this treatment gap. The fact that geographic analysis shows inverse relationships between need and access proves that those most in need of services have the greatest barriers to them which is a core issue of health equity.

Interpretation, Situating Previous Research

The findings are consistent with but go beyond previous systematic reviews. Khan [31] reported the mean DMFT of permanent teeth as 2.469 in 2-20 year-olds in Arab League countries with a high degree of heterogeneity between studies. Prevalence of caries in preschool age group was reported by Al Ayyan et al. [32] in Gulf Cooperation Council states as 80.9% with mean dmft of 5.14. These patterns are confirmed in our synthesis but

further detailed on utilization, barriers and geographical disparities that are unique to Saudi Arabia.

Comparison with Alshammari et al. [33] and Adam et al. [14] shows consistency and extension. Alshammari found primary teeth caries proportions of 0.21-1.00 and permanent teeth 0.05-0.99 in 49 studies and Adam's meta-analysis of 1967 5-7 year-olds and 2008 12-15 year-olds revealed 84% and 72% prevalence, respectively. Our results (72.62% permanent dentition prevalence) are very close to Adam's estimates of the prevalence in older children, although prevalence in preschool in our synthesis is somewhat lower than in Adam's synthesis (72-76% vs 84%), perhaps due to different age definitions or temporal trends.

Predictors and Mechanisms

An application of the Andersen model [7,8,39] helps understand the multifactorial determinants of utilization. Enabling resources (income, dentist availability) and need variables (caries severity, perceived symptoms) interact with predisposing factors (age, gender and caregiver characteristics) to produce observed patterns. The significant negative association between the number of dentists and visits in the multivariable modeling [8] is particularly striking, suggesting that the quality of dentist distribution, location relative to need, is more important than absolute workforce numbers. This interpretation is supported by the inverse correlation between treatment needs and access between provinces, an indication of maldistribution of dental resources.

Gradients in socioeconomic status operate in two directions: maternal education restricts oral health literacy and preventive measures [9,10]; poor families have fewer economic resources for care; and occupation-related differences influence access to care [6]. The clustering of dentists in large cities [8] exacerbates these disparities with rural and peri-urban populations experiencing both geographical and economic barriers.

Fear and anxiety form other barriers of 1.4-23.9% of children, according to studies [37,38,53-55]. The "vicious cycle" of dental fear reported by Armfield et al. [54] in which anxious children delay dental care thereby leading to more complex treatment that reinforces fear, is of particular relevance in the Saudi context given the high proportion of problem driven visits reported by Afeef et al. [6] and Alhareky [7]. Cost barriers up to 89.9% of children from regional studies [42] signal the importance of affordability, especially given there is limited public dental insurance coverage for children.

The barriers to dental service utilization, as identified in this review, require further consideration in the larger context of global oral health disparities [37-42]. The cross-national comparison indicates that 1.4-23.9% of pediatric populations are characterized by fear and anxiety with the broad spectrum indicating cultural diversity as well as differences in measures among studies [37,38,53-55]. The "vicious cycle" of dental fear described by Armfield et al. [54] whereby fearful children postpone seeking care, therefore needing more invasive treatment which increases fear is especially applicable to the Saudi context considering the high proportion of problem driven visits reported by Afeef et al. [6] and Alhareky [7]. Cost barriers identified in up to 89.9% of children in regional studies [42] point to the importance of affordability and are in accord with analyses of socioeconomic determinants of oral health disparities [46,51,52]. Murphy et al. [41] and Amin et al. [40] showed that poor families in high-income countries are affected by similar financial constraints which appears to indicate that economic constraints cut across national healthcare financing models. Transportation barriers affecting 2-44.9% of children according to studies [13,45] compound geographic maldistribution of dental workforce documented at province level [8,17,18]. The application of the Andersen Behavioral Model [39,48] to Saudi pediatric populations confirms the interrelationship of predisposing, enabling and need factors in complex ways with maternal education [9,10], caregiver

employment [6] and geographic location [8] proving to be reliable predictors. These findings are consistent with a life course perspective on oral health [50] which stresses that child life experiences and exposures influence life course oral health trajectories. The complex obstacles should be addressed in an integrated manner involving health system reform, community-based interventions and policy initiatives to address social determinants [46-49]. Future research should use mixed methods to examine the interaction between cultural beliefs, health literacy and service delivery models and how this affects utilization patterns in underserved Saudi populations [52,55]. Such investigations would complement quantitative findings and provide information for culturally competent interventions aimed at reducing oral health inequities [51].

Clinical and Policy Implications

The results have significant clinical practice and health policy implications. First, the high prevalence and severity of caries calls for a paradigm shift from treatment towards prevention. School-based preventive programs such as fluoride varnish application, fissure sealant placement and oral health education may be an efficient way to reach large pediatric populations. The current 6.4% sealant coverage [5] is a missed opportunity that needs to be immediately addressed.

Second, it is necessary to implement policy measures to geographically redistribute the population of dentists or other professionals in the field, such as financial incentives to practice in rural settings and professional development opportunities; mobile dental clinics to underserved regions; and basic preventive services distributed by task-sharing with dental hygienists and therapists. The inverse correlation between need and access at province level [8] requires preferential allocation of resources to high need areas.

Third, lowering financial barriers requires expansion of public dental coverage for children, especially for preventive and basic restorative dental services. The high percentage of untreated decay [5] indicates both access barriers as well as barriers to affordability. Integration of oral health in universal health coverage frameworks, as advocated by WHO [1,48], would be consistent with Saudi Vision 2030 health system transformation goals.

Fourth, early intervention requires the promotion of age-appropriate first dental visits at age one as recommended by pediatric dental associations. Current patterns of problem driven attendance [6] suggest that many children first present with advanced disease requiring complex treatment. Public awareness campaigns in caregiver groups, especially low education groups, should focus on preventive visits and home care practices.

Strengths and Limitations

The strengths of this review are that it was a comprehensive review of 15 primary studies across 25 years synthesizing nationwide and regional data, included utilization and barrier analysis for all studies and critically reviewed quantitative outcomes. It has the added analytical richness of meta-analytic pooling [14] and multivariate modeling [8].

Limitations are worth noting. To begin, the heterogeneity between studies in terms of sampling frames, diagnostic criteria, age groupings, as well as outcome definitions, makes it difficult to obtain direct comparison. High I^2 (99.0) used in prevalence estimates is an indication of true variation as well as methodological differences. Second, because sub-province and individual-level data are limited, it is difficult to examine within-region disparities. Third, temporal trends cannot be definitively determined with cross-sectional designs and different methodologies across eras. Fourth, some studies do not provide comprehensive reporting on the components of DMFT (decayed vs. missing vs. filled), so that patterns of treatment cannot be fully analyzed. Fifth, the exclusion of non-English and non-Arabic publications could cause language bias, although major Saudi dental journals are published in English.

Research Gaps and Future Research

A number of research priorities arise. Longitudinal studies of caries progression and patterns of utilization over time from early childhood to adolescence would identify key periods in which to intervene. Qualitative research that investigates caregiver and child perspectives on barriers and facilitators could be used for culturally appropriate interventions. Implementation science assessing school-based prevention programs would produce evidence for scale-up. Economic evaluations that measure cost-effectiveness of preventive and treatment measures would be useful in resource allocation decisions. Finally, studies on the integration of oral health with other child health services could help to identify synergistic opportunities.

CONCLUSION

This systematic review reports that pediatric dental caries in Saudi Arabia is a significant and ongoing public health problem. With prevalence of two-thirds to three-quarters of children, mean dmft of about 4 and DMFT >2.4, the burden of disease is higher than global averages and contrary to global declining trends. The gap in treatment, 58-60 percent of needs have not been met and more than half of the children with untreated decay indicates failure of the system in preventive services, early intervention and accessible treatment.

The burden is aggravated by geographic disparities, socioeconomic gradients and structural obstacles such as cost, fear and maldistribution of the workforce, creating health inequities whereby the most needy have the most access problems. The inverse relation between treatment needs and availability of service between provinces describes this inequity.

Management of such crisis needs multi-faceted and coordinated actions at policy, practice and community levels. Expansion of school-based prevention, equitable distribution of workforce, reduction of financial barriers and early preventive visits are priority interventions. Without sustained commitment to oral health as an integral part of child health, the heavy cost of dental disease will continue to affect the health, development and quality of life of Saudi children.

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