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Oral health of Hong Kong children: a historical and epidemiological perspective

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ABSTRACT

Objective: To provide a historical and epidemiological overview of the oral health of Hong Kong children.

Methods: Literature published before 2014 related to the oral health of Hong Kong children, supplemented with information accessed from government-archived oral health reports, was sourced using electronic databases and hand searches. Dental caries experience, periodontal health, enamel defects, and malocclusion of Hong Kong children were reviewed.

Results: A decline in the prevalence and extent of dental caries was observed among Hong Kong schoolchildren and adolescents after the 1960s. Among preschool children, however, dental caries remains common and the extent appears to have increased. The periodontal health of Hong Kong children remains unsatisfactory. Recently, enamel defects/dental fluorosis have considerably reduced. Information about malocclusion in Hong Kong

children is limited.

Conclusions: Since the 1960s, following public health policies, health promotion activities, and the introduction of a School Dental Care Service, improvements in the oral health of schoolchildren are evident. Nonetheless, the oral health of preschool children remains a concern. Policies and practices to improve the oral health of preschool children in Hong Kong are required.

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Introduction

Over the past 50 years, a number of dental public health measures and policies have been established by the government in Hong Kong to help improve the oral health of the population. Children have been the focus for many of these dental public health practices since the 1960s and these have included prevention strategies, oral health education, and the provision of the School Dental Care Service (SDCS).

Historical development of Hong Kong's public health measures for children

Water fluoridation is one of the most successfully implemented dental public health measures in Hong Kong. The project was launched in 1961 and has remarkably reduced the prevalence of dental caries in Hong Kong.¹ All areas with a centralised water supply are fluoridated. Prior to its implementation, the natural fluoride concentration of drinking water in Hong Kong was less than 0.13 parts per million (ppm). Several adjustments have been made to the water fluoride level in Hong Kong since its implementation: from 0.7 ppm for summer months and 0.9 ppm for winter months in 1961, to 1 ppm in 1967; then reduced to 0.7 ppm in 1978; and further to 0.5 ppm in 1988 because of concerns of an increased

prevalence of dental fluorosis in the population.

In late 1979, the SDCS was introduced to provide prevention and dental treatment to primary schoolchildren in Hong Kong. The SDCS also aims to promote oral health by delivering oral health education to schoolchildren. Preschool children in Hong Kong are not routinely eligible for the SDCS. They receive oral health care and treatment largely from dentists working in the private sector. Oral health education for preschool children was introduced through the 'Brighter Smiles for the New Generation' programme by the government in 1993. This programme promotes oral health awareness by educating children aged under 6 years about good oral health-related behaviour. It also aims to increase their teachers' and parents' oral health care knowledge.

The community is served by registered professional oral health care personnel. The Faculty of Dentistry at the University of Hong Kong was established in 1981 and began training dentists and supporting dental personnel in the same year. More than one third of local practising dentists have been educated in Hong Kong.² The number of practising dentists currently serving the community has increased to about 2310 personnel, a per capita ratio of 1:3125.³ Before 1973, there were only about 440

practising dentists, a per capita ratio of 1:9000. In the past, it was often only the economic affluent who sought treatment from private dental practitioners. For many others, teeth were considered a dispensable commodity.² Although this situation has improved, access to dental care for the Hong Kong population remains inadequate.

Oral health care products (fluoridated toothpaste, mouth rinses, toothbrushes, and floss) are now widely available in Hong Kong.⁴ These easily accessible fluoride-containing products provide an additional benefit to the oral health of the Hong Kong population. Most locally available toothpastes have a fluoride concentration of 1000 to 1500 ppm, while those for children have 600 ppm. Mouth rinse with 0.05% sodium fluoride is also freely available, though its use among children is not common and it is not recommended for the very young.

Over the years, dentistry in Hong Kong has advanced and oral health care has greatly improved under several government public health policies. Although children have been the primary target of such initiatives, information and review of the effects of the changes and trends in the oral health of Hong Kong children are limited. This is in part due to the limited dissemination of findings, particularly those of earlier government reports. Understanding the trends and current oral health condition of Hong Kong children is important. It can provide a historical and epidemiological overview of dental activity and inform the planning of future public health measures, prevention, and services for children. It may also help set future oral health targets and specific goals.

This paper reviews all available oral health epidemiological data and information of Hong Kong children from published literature before 2014 through electronic database searches, supplemented with information accessed from government-archived oral health reports. Reference lists of articles retrieved from the electronic databases were hand-searched for any other articles that might provide information relevant to the objectives of this paper. Major oral health problems of Hong Kong children—including dental caries experience, periodontal health, enamel defects, malocclusion, and orthodontic treatment need—are described.

Dental caries experience

A number of population-based oral epidemiological studies involving children have been conducted in Hong Kong since the 1960s. Available epidemiological data regarding dental caries experience and the extent/severity of dental caries among Hong Kong children are summarised in Table 1.⁴⁻²⁰ These studies employed different sampling methods as criteria of assessment differed prior to the 1970s. More recent surveys have followed World Health

從歷史和流行病學角度概述香港兒童的口腔健康狀況

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目的：從歷史和流行病學角度概述香港兒童的口腔健康狀況。

方法：利用電子數據庫和人手檢索找出在2014年前出版與香港兒童口腔健康有關的文獻，並輔以香港政府檔案報告中有關口腔健康的資料。回顧有關香港兒童的蛀牙經驗、牙周健康狀況、牙齒琺瑯質發育缺陷和牙頷畸形的描述或數據。

結果：自六十年代起，香港學齡兒童和少年的蛀牙病患率和嚴重程度均有下降現象。然而，蛀牙問題在學前兒童當中仍很普遍；近年學前兒童的蛀牙嚴重程度更似乎有所上升。香港兒童的牙周健康狀況仍未達滿意水平。牙齒琺瑯質發育缺陷/氟斑牙在近年已大幅減少。然而，有關香港兒童的牙頷畸形的描述或數據相當有限。

結論：隨着六十年代開始在香港逐步推行公共衛生政策、口腔健康的推廣活動和學童牙科保健服務，本港學齡兒童的口腔健康顯著改善。然而，學前兒童的口腔健康狀況仍然令人憂慮，須考慮推行有助改善學前兒童口腔健康的政策和措施。

Organization's criteria for caries assessment.

Dental caries experience of schoolchildren and adolescents (aged 6-18 years)

To date, there are 13 population-based epidemiological studies reporting the prevalence and extent of dental caries experience among Hong Kong schoolchildren and adolescents. A remarkable decrease in caries experience and severity among schoolchildren and adolescents has been observed since the 1960s.

The earliest report of dental caries experience among schoolchildren and adolescents was carried out in 1960, a year before the implementation of water fluoridation.⁵ The epidemiological findings gave cause for concern. Almost all children aged 6 to 11 years who participated in the study (aged 6-8: 97.5%; aged 9-11: 93.4%) had dental caries. The mean number of decayed, missing, or filled permanent teeth (DMFT) in 6-8-year-olds and 9-11-year-olds was 2.7 and 4.4, respectively; the mean decayed, missing, or filled primary teeth (dmft) in 6-8- and 9-11-years-olds was 9.2 and 3.8, respectively. Decayed teeth constituted the major component (>90%) of the dmft/DMFT index in both dentitions, and extracted and filled teeth components were minimal. This signified that there were no systematic dental care services available at the time and with limited preventive measures.

In 1962, the second population-wide oral health survey was conducted using similar sampling methodology to the 1960 survey,⁶ 1 year after the implementation of water fluoridation. There was a reported slight decrease in the prevalence of

TABLE I. Dental caries experience in Hong Kong children⁴⁻²⁰

Study (year)	Age (years)	Sample size	Prevalence of dental caries experience		Mean (dmft / DMFT)	
Medical and Health Department, Hong Kong (1960) ⁵	6-8	4063	dmft > 0	97.5%	dmft	9.2
			DMFT > 0	85.4%	DMFT	2.7
	9-11	4472	dmft > 0	72.0%	dmft	3.8
			DMFT > 0	93.4%	DMFT	4.4
Medical and Health Department, Hong Kong (1962) ⁶	6-8	2645	dmft > 0	96.4%	dmft	8.4
			DMFT > 0	78.9%	DMFT	2.2
	9-11	3041	dmft > 0	66.2%	dmft	3.1
			DMFT > 0	90.0%	DMFT	3.5
Wong (1968) ⁷	3-8	1633	dmft > 0	83.8%	dmft	5.0
			DMFT > 0	32.4%	DMFT	0.6
	9-14	1633	dmft > 0	77.1%	dmft	1.8
			DMFT > 0	67.2%	DMFT	2.0
	15-19	326	DMFT > 0	84.0%	DMFT	4.6
Law (1981) ⁸	6-8	3431	dmft > 0	77.5%	dmft	4.0
			DMFT > 0	30.5%	DMFT	0.6
	9-11	3334	dmft > 0	55.4%	dmft	1.8
			DMFT > 0	51.7%	DMFT	1.3
King et al (1986) ⁹	12	662	DMFT	-	DMFT	2.8*
					DMFT	1.7†
Lind et al (1986) ¹⁰	15-19	-	DMFT > 0	-	DMFT	1.7
Wong (1987) ¹¹	6-8	2645	dmft > 0	67.1%	dmft	3.0
			DMFT > 0	18.3%	DMFT	0.3
	9-11	3041	dmft > 0	48.2%	dmft	1.4
			DMFT > 0	46.1%	DMFT	1.0
Lo et al (1990) ¹²	6-8	625	DMFT > 0	77.0%	DMFT	0.4
			9-11	701	DMFT > 0	53.0%
	12	157	DMFT > 0	40.0%	DMFT	1.5
Kwan (1992) ¹³	13	381	DMFT > 0	55.0%	DMFT	1.3
			15	379	DMFT > 0	56.0%
Evans and Lo (1992) ¹⁵	6-12	1483	dmft > 0	68%	-	-
			6	175	-	-
	7	220	-	-	dmft	3.1
	8	230	-	-	dmft	2.9
	9	216	-	-	dmft	2.3
	10	228	-	-	dmft	1.3
	11	257	-	-	dmft	0.7
	12	157	-	-	dmft	0.2
Wei et al (1993) ¹⁸	5	1105	dmft > 0	63.0%	dmft	3.2
Chu et al (1999) ⁴	4-6	658	dmft > 0	42.0%	dmft	1.6
Yiu et al (2001) ¹⁴	15	373	DMFT > 0	51.0%	DMFT	1.4
Hong Kong Department of Health (2002) ¹⁶	5	67 300	dmft > 0	51.0%	dmft	2.3
			12	67 100	DMFT > 0	37.8%
Lo et al (2009) ¹⁹	3	368	dmft > 0	31.0%	dmft	1.2
			4	747	dmft > 0	36.0%
	5	228	dmft > 0	42.0%	dmft	2.0
	3-5	1343	dmft > 0	35.0%	dmft	1.5
Chu et al (2012) ²⁰	4	239	dmft > 0	41.0%	dmft	1.9
			5	338	dmft > 0	48.0%
	6	123	dmft > 0	64.0%	dmft	2.6
	4-6	700	dmft > 0	51.0%	dmft	2.2
Hong Kong Department of Health (2012) ¹⁷	5	52 300	dmft > 0	50.7%	dmft	2.5
			12	56 900	DMFT > 0	22.6%

Abbreviations: dmft = decayed, missing, or filled primary teeth; DMFT = decayed, missing, or filled permanent teeth

* Chinese

† Non-Chinese

dental caries experience (for those aged 6-8 years: 96.4%; for those aged 9-11 years: 90.0%). The mean dmft and DMFT showed a significant decline of approximately 20% (mean DMFT: 2.2 for those aged 6-8 years and 3.5 for those aged 9-11 years; mean dmft: 8.4 for those aged 6-8 years and 3.1 for those aged 9-11 years). As in the 1960 survey, decayed teeth constituted the major component of the DMFT, showing limited change in the provision/usage of dental care services. As this survey was conducted a year after water fluoridation, the decrease in dental caries could not be fully explained by exposure to fluoridated water. No report on the difference in dmft/DMFT among children who had received fluoridated water for the whole time, intermittently, or not at all was provided.

The third oral health survey of Hong Kong was completed in 1968, 7 years after the introduction of water fluoridation.⁷ The sampling method differed to the earlier surveys. Subjects aged 3 to 54 years were selected. The dental caries experience in the primary dentition was 83.8% (mean dmft: 5.0) for 3-8-year-olds, whereas the dental caries experience in the permanent dentition was 67.2% (mean DMFT: 2.0) for 9-14-year-olds, and 84.0% (mean DMFT: 4.6) for 15-19-year-olds. It represented a significant decrease in both caries experience and its extent among children when compared with previous surveys. This favourable change was attributed to water fluoridation as there were no other widely available caries preventive measures or systematic dental care services in the 1960s.

In 1980, another population-based dental health survey collected baseline data for future evaluation of the SDCS.⁸ The majority of schoolchildren (aged 6-11 years) examined were caries-free in their permanent dentition. The mean DMFT was <1 for children aged <9 years and 1.5 for 11-year-olds. The caries experience in the primary dentition of the children was high, however. The mean dmft for 6-year-olds was 4.3. The number of extracted and filled teeth for both dentitions was low. More than 90% of decayed teeth were untreated, indicating the lack of utilisation of dental services and a very high unmet treatment need.

The epidemiological studies conducted in the 1980s after the commencement of SDCS to monitor the effect of fluoride on dental caries experience of Hong Kong schoolchildren and adolescents after over 20 years of water fluoridation showed a further decrease in caries experience and severity. The reported mean DMFT of schoolchildren and adolescents in these surveys ranged from 0.3 to 2.8⁹⁻¹² and the mean dmft was 2.2.¹¹ The caries experience was >65% in primary dentition and 18.3% to 77% in permanent dentition.^{11,12} The major component of the DMFT of the children of this time was decayed teeth, demonstrating that there was still a high

unmet need for dental services, although the SDCS was already enacted. Caries was mostly experienced in molar teeth for children aged 9 to 12 years.

The caries prevalence and extent among Hong Kong schoolchildren and adolescents continued to show improvements. Kwan¹³ reported the first survey of schoolchildren aged 13 and 15 years who joined the SDCS in 1992. The dental caries experience was approximately 55%, with a mean DMFT of 1.3 for 13-year-olds and 1.6 for 15-year-olds. The result corresponded to a study by Yiu et al¹⁴ that reported a caries experience of 51% and a mean DMFT of 1.4 among 15-year-olds. In 1992, Evans and Lo¹⁵ also studied the effects of the SDCS on the dental status of primary teeth among a sample of Chinese children aged 6 to 12 years. The caries experience was 68%, with dmft indices for 6-, 7-, 8-, 9-, and 10-year-olds being 2.8, 3.1, 2.9, 2.3, and 1.3, respectively. The ratio of decayed-to-filled teeth decreased from 3.2 at age 6 to 1.0 at age 9. The mean number of filled teeth was the major component of the dmft index in these surveys, indicating that many children had received dental care.

The Hong Kong SAR Government conducted a population-based survey of the oral health status of 12-year-old children in 2001 and 2011.^{16,17} More than one-third (37.8%) of the children in 2001 had a caries experience in their permanent dentition and in 2011, 22.6% of the children had a caries experience. The extent/severity of caries was low (mean DMFT: 0.8 in 2001, 0.4 in 2011). Most of the decay experience was attributed to the filled component. The proportion of untreated decay was also rather low, with only 5.4% reported to have untreated decayed teeth in 2011. This positive development in oral health was associated with reported better oral health knowledge and oral care habits in both parents and children. A large number of the participants claimed they had regular dental check-ups.

In the past 50 years, for Hong Kong schoolchildren and adolescents, the prevalence of dental caries experience in permanent teeth has reduced from more than 90% (in the 1960s) to approximately 50% in the 1980s/90s and to less than 25% currently. The mean number of DMFT has also declined from over 4 in the 1960s to approximately 2 in the 1980s/90s, and to less than 1 currently.

Dental caries experience of preschool children (aged ≤5 years)

There were seven epidemiological studies reporting dental caries experience among preschool children. Improvement among preschool children is less since the 1960s, compared with improvements among schoolchildren and adolescents and it remains a considerable problem.

The earliest oral health survey that involved young children was the population-based survey

conducted in 1968.⁷ The prevalence of dental caries experience among 3-8-year-old children at that time was over 80%, with a dmft of 5. One quarter of the primary teeth of the children were decayed. The second report of preschool children caries experience in Hong Kong was drawn up by Wei et al.¹⁸ Conducted between 1986 and 1988 among approximately 10% of 5-year-old children, the percentage of children with caries in their primary dentition was 63%. The mean dmft was 3.2. Dental caries experience was higher for children from socio-economically disadvantaged families. Over 70% of the children had never visited a dentist.

The caries experience of Hong Kong preschool children further decreased to about 50% in the late 1990s.⁴ The mean dmft of children (4-6-year-olds) was 1.6. More than 90% of the dmft score was attributed to decayed untreated teeth. Similar to the findings of Wei et al,¹⁸ the children's caries experience was associated with underprivileged socio-economic background, and parental educational level, dental knowledge, and attitudes.

In the recent decade, no great changes among preschool children caries status have been observed. The caries prevalence in preschool children remains similar, with a reported prevalence of 35% to 51%.^{16,17,19,20} The extent/severity of caries, however, showed a slight increase when compared with the late 1990s (mean dmft of children aged 3-5 years ranged from 1.5 to 2.5). Over 90% of the decayed teeth of the children were untreated. Almost one tenth of the children presented with abscess, with a higher percentage reported in the 2011 survey than in the 2001 survey.^{16,17} These recent surveys also found that children's caries experience was associated with their place of birth, socio-economic background, and dietary habits.

Periodontal health status

Detailed information about the periodontal status of Hong Kong children is less readily available when compared with information about dental caries experience. Different assessment criteria have been used to assess periodontal health among children and adolescents, making it difficult to compare surveys.

The earliest report of the periodontal health status of Hong Kong children (aged 3-19 years) was drawn up by Wong in 1968.⁷ Wong⁷ reported that "oral hygiene was only fair in 70% of the children" and that "over 60% of the children had inflamed gingiva, and material alba was found on over 90% of the teeth surfaces". Inflamed gingiva (gingivitis) is the reversible and non-destructive form of periodontal disease. This suggested that the children had poor periodontal health, though the criteria of assessment were not defined.

Law⁸ provided more specific details about the

periodontal health status of 5-14-year-old Hong Kong children. Approximately 85% were reported to have soft deposits (assume plaque), of whom approximately one (19.2%) in five had 'intensive gingivitis' (inflamed gingiva). Calculus was observed among over a quarter (26.4%) of the children, and the percentage of calculus deposits increased with age.

Epidemiological studies conducted in the late 1980s employed the Community Periodontal Index (CPI) to assess the periodontal health status. It is the standard epidemiological index for assessing periodontal health,²¹ and results of the surveys were comparable. The epidemiological studies reporting periodontal health status of Hong Kong children using the CPI are shown in Table 2.^{10,11,13,14,16,17} The majority reported periodontal health status of adolescents. Among adolescents (13-18 years old), two of three studies^{10,13,14} reported that less than 10% had 'healthy' periodontal status (CPI=0) and more than half had evidence of calculus in some parts of the mouth (CPI=2). This showed that the periodontal health of Hong Kong adolescents was unsatisfactory.

For Hong Kong schoolchildren, the first detailed report of their periodontal health status was conducted by Wong¹¹ among 7882 primary schoolchildren (aged 6-11 years) in 1987. More than half of the sextants (3.9) of the children had healthy gingiva (CPI=0). Nonetheless, more than half (56.1%) of the children had bleeding gingiva (CPI=1) or calculus deposits (CPI=2).

Two population-based oral health surveys among schoolchildren (12-year-old children) were conducted by the government in 2001 and 2011.^{16,17} The 2011 survey showed an improvement in periodontal health status. More schoolchildren were found to have healthy gingiva (CPI=0) in 2011: 13.8% compared with 5.5% in the 2001 survey; and less children had calculus deposits (CPI=2) in 2011: 22.4% compared with 59.5% in the 2001 survey. Of note, more than half of their sextants had either bleeding gingiva or calculus deposits in 2001 and an average of two of the sextants had these problems in 2011.

Studies that applied the Visible Plaque Index to assess periodontal health of Hong Kong preschool children are shown in Table 3.^{16,17,22} Such Index was introduced by Ainamo and Bay²³ as a standardised assessment of oral hygiene status. It is simple and reliable to use and has been employed in surveys as a proxy of gingival health, representing the site prevalence of 'clearly visible dental plaque' at the gingival margin. The oral hygiene of the preschool children in Hong Kong was poor.^{16,17,22} Almost all 5-year-old children (97%) had at least one site with 'clearly visible dental plaque'.^{16,17} The mean percentage of tooth surfaces with visible dental plaque was 22.1% in 2011 and 23.5% in 2001. A study conducted among

TABLE 2. Periodontal health status of Hong Kong children^{10,11,13,14,16,17}

Study (year)	Age (years)	Sample size	Community Periodontal Index		
			Ratings*	Prevalence (%)	Mean No. of sextants with the rating
Lind et al (1986) ¹⁰	15-19	563	0	2.0	1.1
			1	2.0	4.9
			2	70.0	4.4
			3	26.0	1.1
			4	1.0	<0.1
Wong (1987) ¹¹	6-11	7882	0	39.9	3.9
			1	40.4	1.5
			2	15.7	0.3
Kwan (1992) ¹³	13	381	0	27.3	3.8
			1	34.9	2.2
			2	37.8	0.9
	15	379	0	25.6	3.6
			1	24.0	2.4
			2	50.4	1.3
Yiu et al (2001) ¹⁴	15	373	0	7.0	2.1
			1	9.0	3.9
			2	80.0	2.8
			3	4.0	0.1
Hong Kong Department of Health (2002) ¹⁶	12	66 600	0	5.5	2.6
			1	35.0	1.8
			2	59.5	1.6
Hong Kong Department of Health (2012) ¹⁷	12	55 900	0	13.8	3.5
			1	63.8	2.1
			2	22.4	0.4

* Community Periodontal Index ratings: 0 = healthy gingiva, 1 = bleeding on probing, 2 = calculus present with plaque, 3 = periodontal pocket ≥3.5 mm but <5.5 mm, and 4 = periodontal pocket ≥5.5 mm

TABLE 3. Periodontal health status of Hong Kong preschool children^{16,17,22}

Study (year)	Age (years)	Sample size	Visible Plaque Index (VPI)	
			Prevalence (VPI >0)	Mean VPI
Hong Kong Department of Health (2002) ¹⁶	5	67 300	97.6%	23.5%
Wu (2011) ²²	3-4	531	-	49.7%
Hong Kong Department of Health (2012) ¹⁷	5	52 300	97.4%	22.1%

531 children aged 3 to 4 years in 2009, however, reported that 49.7% of the tooth surfaces had visible plaque.²² In general, the gingival condition and tooth cleanliness of both schoolchildren and preschool children were unsatisfactory and required much improvement.

Dental fluorosis/enamel defects

Dental fluorosis consequent to exposure to fluoride

may develop during the formation of teeth in young children. Table 4 outlines the studies reporting dental fluorosis using Dean's Index in Hong Kong to date.^{5,6,10,11} Epidemiological studies reporting dental fluorosis showed that the level was low in the 1960s.^{5,6} Nearly all examined children aged 6 to 11 years had 'normal' enamel. Less than 1% were assessed as having a 'mild' or 'questionable' degree of fluorosis in 1960 or having a 'moderate' or 'questionable' degree of fluorosis in 1962.

TABLE 4. Dental fluorosis in Hong Kong children^{5,6,10,11}

Study (year)	Age (years)	Sample size	Fluorosis status (Dean's Index)	%
Medical and Health Department, Hong Kong (1960) ⁵	6-11	8835	Normal	99.8
			Questionable	0.1
			Very mild	<0.01
			Mild	<0.01
			Moderate	0.0
Medical and Health Department, Hong Kong (1962) ⁶	6-11	5686	Normal	99.8
			Questionable	0.1
			Very mild	0.0
			Mild	0.0
			Moderate	0.1
Lind et al (1986) ¹⁰	15-19	563	Normal	18.7
			Questionable	17.9
			Very mild	43.2
			Mild	15.3
			Moderate	4.8
Wong (1987) ¹¹	6-11	5401	Normal	52.3
			Questionable	9.8
			Very mild	24.5
			Mild	11.2
			Moderate	2.2
			Severe	<0.1

Dental fluorosis was reported to be more prevalent in the 1980s, particularly among adolescents.^{10,11} Over 80% of the 15-19-year-olds in the study by Lind et al¹⁰ exhibited signs of dental fluorosis; and approximately 50% of the 6-11-year-olds in the study by Wong¹¹ showed various degrees of dental fluorosis.

King²⁴ reported the prevalence of enamel defects among a random sample of 12-year-old children in Hong Kong. The prevalence of teeth with opacities was 99.6%; 82.8% had evidence of hypoplasia and 16.6% had discoloured teeth. The author believed that many of the enamel defects were likely to be related to dental fluorosis. The findings in the 1980s suggested a marked increase in the level of dental fluorosis since the introduction of water fluoridation in the 1960s and it was then advocated to lower the water fluoridated level.¹ The prevalence declined considerably over the decades when the level of fluoride in the water supply was adjusted and lowered.²⁵ At present the level of water fluoridation is optimal at 0.5 ppm. The trend of decreasing dental

fluorosis prevalence was evident in the study by Evans and Stamm.²⁶ The prevalence decreased from 64% to 47% across the cohort of children from older (aged 12) to younger (aged 7) born before and after reduction of fluoride level to 0.7 ppm in 1978.

The prevalence and severity of developmental defects of enamel (DDE) have also been studied. Cross-sectional surveys showed that the prevalence of diffuse opacities among random samples of 12-year-old children (based on maxillary incisors and assessed using standardised intra-oral photographs) declined from 89.3% in 1983 to 32.4% in 2001, but increased to 42.1% in 2010.²⁷ The mouth prevalence of DDE among maxillary incisor teeth of the children also decreased from 92.1% in 1983 to 35.2% in 2001.²⁸ Wong et al²⁹ also reported the prevalence of DDE among Hong Kong 12-year-old children at 90% in a 2010 cohort study (89.5% had diffuse opacities, 8.6% demarcated opacities, and 1.8% hypoplasia), using the modified version of the DDE index by FDI (Fédération Dentaire Internationale) to diagnose DDE.³⁰ The prevalence

TABLE 5. Malocclusion and orthodontic treatment need among Hong Kong children^{7,8,10,11,32,33}

Study (year)	Age (years)	Sample size	Malocclusion/orthodontic treatment need
Allwright and Burndred (1964) ³²	6-11	1123	40.9%*
Wong (1968) ⁷	6-11	8835	20.6%*
Law (1981) ⁸	5-14	3031	9.8%*
Lind et al (1986) ¹⁰	15-19	563	10.3%*
Wong (1987) ¹¹	6-11	7634	35.7%*
Wang et al (1999) ³³	12	888	37.0%†

Abbreviations: DHC = Dental Health Component; IOTN = Index of Orthodontic Treatment Need; WHO = World Health Organization

* Based on the WHO handicapping dentofacial anomalies criteria

† Definite orthodontic need, based on DHC of IOTN criteria

of molar incisor hypomineralisation was reported as 2.8% among Primary 6 Chinese schoolchildren in a 2006 retrospective study.³¹

Malocclusion and orthodontic treatment need

Epidemiological data on malocclusion and orthodontic treatment need among Hong Kong children are scant. Relatively few surveys have been conducted since the 1960s but details of the available studies are shown in Table 5.^{7,8,10,11,32,33} The studies were heterogeneous in terms of criteria used to assess dentofacial anomalies that require orthodontic intervention and age of the sampled children. Comparison and description of estimates of orthodontic treatment are difficult.

Earlier epidemiological studies of malocclusion and orthodontic treatment need among Hong Kong children suggested that dentofacial deformities requiring treatment intervention was ≤20%. More recent studies suggest orthodontic treatment need to be closer to 40%. It is estimated that about one third of children have a 'definite' orthodontic treatment need. A report by Allwright and Burndred³² provided the first published study of the prevalence of dentofacial anomalies requiring treatment intervention among Hong Kong children. Their study included 31% of the 6-11-year-old children who participated in the 1962 oral health survey⁶ and reported that 40.9% of the children exhibited certain dentofacial anomalies. The most common malocclusions were crowding (20.3%), maxillary overjet (14.5%), mandibular overjet (8.1%), overbite (6.9%), spacing (2.9%), and open bite (1.1%). The prevalence of handicapping dentofacial anomalies was higher among those aged 9 to 11 years (54.2%) than among those aged 6 to 8 years (36.4%).

Wong⁷ reported that approximately one (20.6%) in five of 5-14-year-old children had dentofacial

anomalies that required dental treatment. The most common dentofacial anomaly was crowding (17.6%), followed by maxillary overjet (9.5%), overbite (4.2%), mandibular overjet (2.7%), spacing (1.1%), and open bite (0.7%). The prevalence of anomalies was higher among those aged 9 to 15 years (28.2%) than among those aged 5 to 8 years (16.4%). The reduction in the prevalence estimates of malocclusion when compared with the 1960 study⁶ could be due to the participation of different examiners (orthodontists in 1960 study vs general dental practitioners in 1968 study) and the wider age range of children involved in the 1968 survey.⁷

In the 1980s, the reported prevalence of dentofacial anomalies that required treatment was 10% to 36%.^{8,10,11} The percentage of children with cleft palates and/or lip was approximately 0.2%, with a slightly higher proportion of children with cleft lip.^{8,11} The most common reported dentofacial anomalies that required treatment were crowding (3.3-18.5%), maxillary overjet (2.8-5.1%), cross-bite (2.4-7.5%), reverse overjet anomaly (1%), deep overbite (0.9-5.4%), and open bite (0.5-1.9%). The prevalence of dentofacial anomalies was higher among 9-11-year-old children (13-38%) compared with 6-8-year-old children (6.7-34%).^{8,11} Among all the reported studies, only Wang et al³³ used DHC IOTN (Dental Health Component of the Index of Orthodontic Treatment Need)³⁴ to assess treatment need. The prevalence of malocclusion was estimated to be 88% and over a third (37%) of the study sample were deemed to have a 'definite' orthodontic treatment need and 33% had a moderate need.

Discussion

The introduction of water fluoridation in the 1960s resulted in improvements in dental caries in Hong Kong. Prior to its implementation, nearly all children in the population had dental caries, with a high

mean number of decayed, missing, or filled teeth because of tooth decay (mean dmft of 9.2 and DMFT of 4.4).⁵ The implementation of water fluoridation in the community led to a gradual decline in the caries experience and severity in children, as confirmed by the first three oral epidemiological studies in Hong Kong.⁵⁻⁷ The caries experience remained constant (plateaued) with approximately 50% of preschool children and 20% to 40% of schoolchildren since 1980s/1990s having a dental caries experience. This indicates that children in Hong Kong are benefiting from the continual effects of water fluoridation as well as exposure to fluoride from other sources, together with changing living conditions, lifestyles, and improved oral self-care habits in recent decades. The stable caries prevalence in recent years signifies that dental caries in children is controlled to a certain degree, but still remains prevalent, however.

Despite great improvements in the oral health of Hong Kong children over the past 50 years, dental caries remains an oral health burden in the community, in particular among preschool children where prevalence and incidence remain high. Although caries prevalence and severity among preschool children declined during the first 30 years following water fluoridation, the prevalence remains similar and its extent/severity has been even higher in recent decades.^{16,17,19,20} This suggests that there remain some preschool children for whom the current measures alone (water fluoridation and oral health education) are insufficient to ensure optimal oral health.

The dental caries prevalence and severity in preschool children tended to rise with increasing age.^{4,19,20} From the epidemiological studies, it is thus common to find a higher percentage of caries experience in children at the upper end of the preschool age range. Moreover, caries experience is not uniformly distributed within populations of children. Children from disadvantaged and socially marginalised populations had a higher caries experience and severity.^{4,18-20} Preventive measures and oral health education should start earlier among younger children and their parents or caregivers. In particular, efforts should focus on the underprivileged population in our community.

The dental caries condition among Hong Kong schoolchildren (12 years old) is relatively good by international comparisons. Dental caries affects 60% to 90% of schoolchildren in most industrialised countries.^{35,36} The current dental caries experience in 12-year-old Hong Kong children is relatively very low.^{16,17} Of note, most of the dental caries experience was related to filled teeth, few (approximately 1 in 20) had untreated decay. This pattern can be largely attributed to the contribution of the SDCS, which began in the 1980s as a school-based dental care system that effectively overcomes many social

barriers to dental care access by schoolchildren (eg family income, education, dental health awareness). Schoolchildren receive regular quality dental care and treatment through the SDCS. The observed low level of untreated dental caries among schoolchildren is in stark contrast to findings prior to the introduction of SDCS when most decay remained untreated or was treated by extraction.⁵⁻⁸ The SDCS has also raised awareness of oral health among schoolchildren. Education about the importance of oral health has likely changed children's lifestyle and improved their self-care practice and use of fluoride oral health care products.

Dental attendance among primary schoolchildren is high because of high participation in the SDCS,³⁷ but remains worryingly low among secondary school and preschool children. Many adolescents and their parents do not consider there to be a need for such care. Less than a third of such children reported regular attendance for dental check-ups, presumably because this group of children have to be seen privately to access dental care.^{10,13,16-20} Early and regular dental check-ups to enable preventive care should be advocated.

Conclusions

The introduction of a number of public health measures in Hong Kong, mainly water fluoridation and the SDCS, has improved the oral health of Hong Kong children over the past 50 years. There has been a decline in dental caries among schoolchildren and adolescents. Nonetheless, the dental caries experience has remained unchanged in recent decades for preschool children; even a slight increase in extent/severity has been observed. Although there is evidence of improvement, the overall periodontal health of Hong Kong children remains unsatisfactory. A decrease in the prevalence and severity of enamel defects among Hong Kong children was observed, but there has recently been a slight increase. In view of the limited data regarding malocclusion in Hong Kong children, epidemiological studies should be considered. The utilisation of dental services is low, especially among preschool children who are not covered by the SDCS. New policies to develop dental care protocols to ensure evidence-based standards of care, and to advocate regular access to dental care and preventive services may further improve the oral health of Hong Kong children.

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