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ORIGINAL ARTICLE

Caries status in young Colombian children expressed by the ICCMS™ visual/radiographic combined caries staging system

Andrea Cortes[a,b], Kim Rud Ekstrand[b], Luis Fernando Gamboa[a], Lynda González[c] and Stefania Martignon[a]

[a]UNICA – Caries Research Unit, Research Vice-rectory, Universidad El Bosque, Bogotá, Colombia; [b]Cariology and Endodontics, Department of Odontology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark; [c]Dental School, Universidad El Bosque, Bogotá, Colombia

ABSTRACT

Objective: To report (1) the caries experience prevalence and mean, and the caries severity and distribution patterns, expressed clinically and combined with radiographs with the conventional and ICCMS™ systems in young children from Bogotá, Colombia; (2) the contribution of including radiographs to the clinical caries scoring and (3) in which surfaces the radiograph adds to the clinical caries registration.

Material and methods: Six hundred children from kindergartens/schools were enrolled: Cohort A: 2-year ($n = 200$), Cohort B: 4-year ($n = 200$) and Cohort C: 6-year ($n = 200$) olds. Radiographs were taken of the 4- and 6- year olds. Children were examined clinically using the Clinical (*C*) and Radiographic (*R*) ICCMS™-epi Caries Scoring Systems, staging caries lesions (*d*) as: Initial (C_{epi}/R_A), Moderate (C_M/R_B) or Extensive (C_E/R_C). Caries experience including missing (*m*) and filled (*f*) surfaces was expressed as follows: clinical conventional ($Cd_{ME}mfs$); clinical ICCMS™ ($Cd_{epiME}mfs$); combined conventional ($C + Rd_{ME}mfs$) and combined ICCMS™ ($C + Rd_{epiME}mfs$).

Results: The prevalence of $Cd_{ME}mfs$ was: Cohort A: 32%; Cohort B: 59%; Cohort C: 67.5%, increasing to 73.5%, 99.8% and 100%, respectively, with the $C + R\ d_{epiME}mfs$. The $Cd_{ME}mfs$ means doubled when initial caries lesions (Cd_{epi}) and radiographs (*R*) were included. The *d* component corresponded to over two-thirds of the caries experience. Findings on the radiographs significantly raised caries experience prevalence and means ($p < .02$), detecting primarily approximal lesions. Surfaces with highest caries frequency were occlusal/approximal of molar teeth and buccal of upper incisor teeth.

Conclusion: Participants' caries experience was high. The radiographic assessment significantly contributed to caries experience. Molar and upper incisor teeth were most prone to caries.

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KEYWORDS
Dental caries; primary dentition; radiography; ICCMS™; epidemiology

Introduction

The WHO goal for 2000 of at least 50% of 5-year-old children with no caries experience ($dmft = 0$), considering the *d* component at the cavitated or conventional level,[1] has not yet been achieved in Colombia. This was highlighted in the 4th National Oral Health Survey reported in 2015 (4th NOHS),[2] which revealed a prevalence of conventional caries experience ($dmft > 0$) in 5-year olds in Colombia of 38% and of 40% in the city of Bogotá. Furthermore, a study conducted with 3- to 4-year-old children in Bogotá showed that at that age 30% already had a $dmft > 0$.[3] In countries with similar conditions to Colombia, in terms of national health system, diet and sociobehavioural parameters like Mexico, Brazil and Chile, the prevalence of caries experience is also of over 50% at the age of four.[4,5] In Denmark, a country recognized for its comprehensive children's Public Dental Health System,[6] national data on 5-year olds showed that the prevalence of $dmfs = 0$ had risen from 66% in 1989 to 87% in 2014.[7] However, data also indicate that as children become older, half of the 9-year olds in 2006 had one or more restorations due to caries,[8] with the restorations mainly located on occlusal and approximal surfaces in primary molar teeth. As mentioned, the *d* component in these studies is at the cavity level.[1] The fact that radiographs have not been involved in the above-mentioned studies suggests that the prevalence and mean of caries experience are being underestimated.[9]

The development of caries lesions' registration systems as ICDAS,[10] which among its six caries severity levels includes non-cavitated lesions, has raised interest and impact at the clinical, research, educational and public health levels.[2,11–13] The ICDAS Foundation has further in 2013 developed the International Caries Classification and Management System (ICCMS™) [13,14], in order to allow for a simpler manner of reporting caries lesions clinically, radiographically or in combination, as well as guiding best clinical practice caries management. The ICCMS™ system considers three ICDAS-merged caries severity levels: initial stage caries lesions (ICDAS 1, 2), moderate stage caries lesions (ICDAS 3, 4) and extensive stage caries lesions (ICDAS 5, 6).[13,14] Further, for purposes beyond this paper, the ICCMS™ system facilitates the clinical caries management of the patient, with

CONTACT Stefania Martignon martignonstefania@unbosque.edu.co UNICA – Caries Research Unit, Universidad El Bosque, Av. Cra 9 No. 131 A – 02, Edificio de Laboratorios, 2o Piso, Bogotá, Colombia

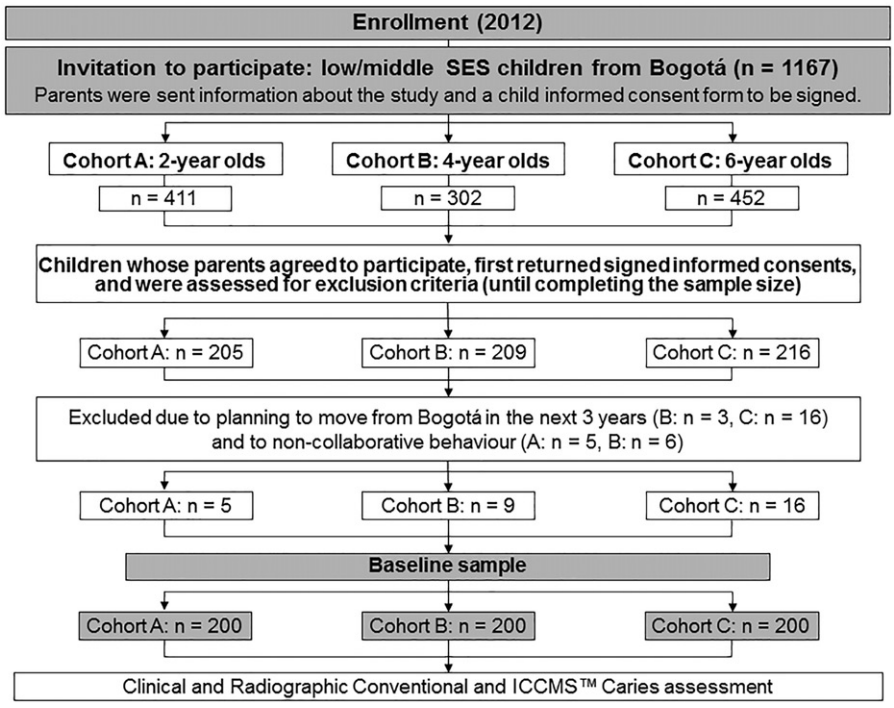

Figure 1. Study flow chart.

lesions' treatment decisions and the patient-level caries risk management.[13–17]

Why dental caries in the primary dentition is still a public health problem [18,19] remains to be explained in detail. In 2012, a collaboration between the University of Copenhagen, Denmark, and El Bosque University in Bogotá, Colombia, was established in order to gain knowledge regarding the caries experience prevalence and progression pattern in the primary dentition in a Colombian population. In order to achieve this goal, groups of children aged 2, 4 and 6 years have been followed in Bogotá from 2012 to 2014, when the children in the groups were 4, 6 and 8 years of age, respectively.

The aims of the present baseline study were to report (1) the prevalence of caries experience, the mean caries experience, the severity and the distribution pattern of caries, expressed both clinically and combined with radiographs with the conventional and ICCMS^{TM} systems in 2-, 4- and 6-year-old children from Bogotá, Colombia, (2) the contribution of including radiographs to the clinical caries scoring and (3) in which particular surfaces the radiographic caries scoring adds information to the clinical caries scoring.

Material and methods

The Research Ethics Board in El Bosque University approved the current study (UEB-77207-2011). The study followed the cohort-study STROBE Statement.

Sample

Three convenient samples of children aged 2, 4 and 6 years of age were included. The sample size calculation for each age group was based on a type-I error = 5%, a type-II error = 20% and a proportion of 70% [3], generating a sample size of 165 subjects per cohort, which was increased to 200 subjects per cohort, as a 20% dropout per cohort was expected after 1 and 2 years of follow-up.

Children from kindergartens and schools in municipalities in Bogotá were invited to participate. Figure 1 shows the flow chart of the study. The authors addressed in 2012 the leaders of three schools and seven kindergartens located in two low/middle socio-economic status (SES) municipalities in Bogotá. All schools and three kindergartens showed interest in participating in the project. A total of 1167 children aged 2 (Cohort A: $n = 411$), 4 (Cohort B: $n = 302$) and 6 (Cohort C: $n = 452$) years were invited to participate through a letter of invitation to their parents/caregivers in 2012. After receiving over 200 consent forms per cohort ($n = 630$), children whose teachers informed that were not going to remain in Bogotá for the following three years were excluded ($n = 19$). At the examination day, children with non-collaborative behaviour were also excluded ($n = 11$) (Figure 1).

Training of examiners in caries clinical and radiographic assessment

Prior to the clinical examination of the caries status, four examiners participated in a four-day theoretical and clinical training course in the ICDAS Clinical Scoring System (Table 1) [10] conducted by an expert trainer (SM). It included a theoretical course, pre-clinical and clinical exercise sessions with pre-scored primary and permanent teeth and two clinical sessions where the examiners assessed pre-scored surfaces in 10 child and adult patients and repeated this assessment in

Table 1. ICDAS clinical and radiographic scoring system.

ICDAS clinical scoring system		ICDAS radiographic scoring system	
Score	Category	Score	Category
0	Sound	0	No radiolucency
1	First visual change in the enamel	RA 1	Radiolucency in the outer half of the enamel
2	Distinct visual change in the enamel	RA 2	Radiolucency in the inner half of the enamel ± enamel-dentine junction
		RA 3	Radiolucency limited to the outer third of the dentine
3	Localized enamel breakdown	RB 4	Radiolucency reaching the middle third of the dentine
4	Underlying dentine shadow		
5	Distinct cavity with visible dentine	RC 5	Radiolucency reaching the inner third of the dentine, clinically cavitated
6	Extensive cavity with visible dentine	RC 6	Radiolucency into the pulp, clinically cavitated

five patients. Discussions took part during the whole training process.

Same researcher trained another examiner in the ICDAS Radiographic Scoring System (Table 1).[10] The two-day training involved a theoretical session, discussion and assessment of caries lesions in pre-scored surfaces in 124 childreńs bitewing radiographs with the aid of the with the Mattsońs magnifying glass (Dental X-ray, Copenhagen, Denmark). Radiographs assessment was repeated randomly organizing films in a different order. For both trainings, the examiners' inter- and intrareproducibility Kappa values were pre-set to be $\geq$0.7.

Clinical examination

Clinical assessments of enrolled children were performed at the institutions during morning hours on portable dental units, using head light appliances, WHO ball-ended probes and dental mirrors. Cotton was used to dry the teeth, as three-in-one syringes were not available under this epidemiological field conditions. In order to follow ICDAS examination standards,[10] surfaces were cleaned through children's previous tooth brushing with fluoridated toothpaste, conducted by dental students. The clinical (C) assessment was performed on all surfaces, using the Clinical C ICCMS^{TM}-epi Caries Staging System, which includes: Sound surfaces (Cd_S); Initial-epi stage caries (Cd_{epi}), involving Initial stage caries lesions (ICDAS 1 & 2) only observed without air drying; Moderate stage caries (Cd_M: ICDAS 3 & 4) and extensive stage caries (Cd_E: ICDAS 5 & 6) (Table 2).[14] Filled surfaces (*Cf*) and extracted teeth due to caries (*C*m) were also registered.

Each clinical examination took around 5 min. Parents/caregivers received written information about the child's dental status and a note advising to take the child to the dentist for treatment if the child had lesions requiring operative intervention.

Radiographic examination

After the clinical examination, bitewing radiographs were taken on the 4- and 6-year-old children (Figure 1), following the EAPD radiograph protection-guideline standards for children.[20] Radiographs were taken using a mobile radiographic equipment (X-PORT II Model: EZX-60®) and with high-speed Kodak conventional films.

The radiographic (*R*) assessment was performed using the Radiographic R ICCMS^{TM} Caries Staging System, based on the ICDAS radiographic system,[10,14,21] which includes no radiolucency (Rd_S); initial stage caries (Rd_A), moderate stage caries (Rd_B) and extensive stage caries (Rd_C) (Table 2).[14] Filled surfaces (*Rf*) and extracted teeth due to caries (*Rm*) were also registered, as well as surfaces not assessable as unerupted, overlapping or not present in the radiograph. Mesial, distal and occlusal surfaces of the first and second primary molar and the first permanent molar teeth were assessed (36 surfaces per patient) using Mattsońs magnifying glass (Dental X-ray, Copenhagen, Denmark) and adequate light. Inadequate or failed X-rays were repeated.

Statistical analysis

Outcome variables included, both at the clinical level and at when combining clinical with radiographs: prevalence of caries experience, mean caries experience and caries experience distribution and severity according to surface. Caries experience included caries lesions (at the Conventional level: Obvious decay, as well as by means of the ICCMS^{TM} level including non-cavitated lesions: No obvious decay), fillings and missing due to caries teeth (Table 2) [14] as follows:

- Clinical conventional caries experience: $Cd_{ME}mfs \geq 1$
- Clinical ICCMS^{TM} caries experience: $Cd_{epiME}mfs \geq 1$
- Combined conventional caries experience: $C+Rd_{ME}mfs \geq 1$
- Combined ICCMS^{TM} caries experience: $C+Rd_{epiME}mfs \geq 1$.

For the registration of the *d* component within the combined caries experience, at both conventional and ICCMS^{TM} levels, if there was no coincidence between clinical *C* and radiographic *R* assessments, the most severe score was selected to represent the severity/depth of the caries lesion (e.g. when the clinical examination corresponded to Cd_{epi} and the radiographic to Rd_B, then $C + Rd_M$ was chosen).

Data were analysed descriptively for each age group.

For the 2-year olds, only the clinical data were presented, as no radiographic examination was conducted at that age.

For the 6-year olds, permanent teeth were included in the assessments, then using capital letters to represent them.

In order to show the distribution of caries lesions (*d*), teeth lost due to caries (*m*) and fillings (*f*), at both conventional and ICCMS^{TM} levels, data from homologous pairs of teeth were merged (e.g. 55 and 65) to ease the readability of the data, based on a previous study that showed no significant differences in caries experience between similar upper and lower teeth.[22]

Table 2. Clinical, radiographic and combined ICCMS™-epi caries staging, and ICCMS™-epi and conventional clinical and combined caries experience.

Caries staging						Caries experience			
Clinical C ICCMS™-epi		Radiographic R ICCMS™		Combined C + R ICCMS™-epi (Clinical-epi & Radiographic)		ICCMS™-epi		Conventional (Basic WHO)	
Score	Category	Score	Category	Score	Category	Clinical C	Combined C + R (Clinical-epi & Radiographic)	Clinical C	Combined C + R (Clinical & Radiographic)
Cd_S	Sound (ICDAS 0)	Rd_S	No radiolucency	$C{+}Rd_S$	Sound	No caries experience: $Cd_{epiME}mfs = 0$	No caries experience: $C{+}Rd_{epiME}mfs = 0$	No caries experience: $Cd_{ME}mfs = 0$	No caries experience: $C{+}Rd_{ME}mfs = 0$
Cd_{epi}	Initial-epi stage caries (ICDAS-epi 1,2)	Rd_A	Initial stage caries (RA 1,2,3)	$C{+}Rd_{epi}$	Initial-epi stage caries	$Cd_{epiME}mfs \geq 1$	$C{+}Rd_{epiME}mfs \geq 1$		
Cd_M	Moderate stage caries (ICDAS 3,4)	Rd_B	Moderate stage caries (RB 4)	$C{+}Rd_M$	Moderate stage caries			$Cd_{ME}mfs \geq 1$	$C{+}Rd_{ME}mfs \geq 1$
Cd_E	Extensive stage caries (ICDAS 5,6)	Rd_C	Extensive stage caries (RC 5,6)	$C{+}Rd_E$	Extensive stage caries				

Table 3. Prevalence and mean of conventional and ICCMS™ caries experience in the three cohorts.

		Prevalence and mean of caries experience			
		Conventional		ICCMS™-epi	
Cohort	Caries experience	$Cd_{ME}mfs$	$C{+}Rd_{ME}mfs$	$Cd_{epiME}mfs$	$C{+}Rd_{epiME}mfs$
A: 2 years. ($n = 200$)	**Prevalence**	32.0%[i]	NA	73.5%[i]	NA
	Mean (SD)	2.2 (4.8)[n]	NA	4.8 (6.6)[n]	NA
B: 4 years. ($n = 200$)	**Prevalence**	59.0%[a,j]	73.5%[a,k]	88.5%[c,j]	99.8%[c,k]
	Mean (SD)	5.5 (9.0)[e,o]	5.7 (9.2)[e,p]	9.1 (11.8)[g,o]	10.8 (12.0)[g,p]
C: 6 years. ($n = 200$)	**Prevalence**	66.5%[b,l]	81.3%[b,m]	89.5%[d,l]	100%[d,m]
	Mean (SD)	5.5 (7.1)[f,q]	5.6 (7.3)[f,r]	9.7 (8.6)[h,q]	10.5 (9.6)[h,r]

SD: standard deviation. NA: not assessed.
[a,b] χ^2; $p = .02$.
[c,d] χ^2; $p < .001$.
[e–h] t-tests; $p < .001$.
[i–m] χ^2; $p < .05$.
[n–r] t-tests; $p < .05$.
[s]For the 6-year-old children permanent teeth (DMF) were included in the clinical and combined conventional and ICCMS™ systems.

Chi-square tests were used to investigate if radiographs added significantly to the prevalence of caries experience compared to if the examination only was done clinically. T-tests were used to investigate if radiographs added significantly to the mean caries experiences compared if the examination was done only clinically. A significant level of 5% was chosen.

Results

A total of 600 children ($n = 200$ per cohort) aged 2, 4 and 6 years were examined. The mean number of teeth present at the time of the examination was as follows: for the 2-year olds 18.1 (SD = 2.0), for the 4-year olds 20.0 (SD = 0.4) and for the 6-year olds 21.1 (SD = 2.1). In addition, for the 6-year olds, the mean number of permanent first molars available for examination was 2.9 (SD = 2.1). Bitewing radiographs were taken of all 4- and 6-year olds participants. Nine per cent of the radiographs were repeated due to failed images and a total of 8% of the surfaces were not possible to assess.

Examiners' reproducibility

For both the clinical ICDAS system and radiographic ICDAS system, examiners' inter- and intraexaminer reproducibility using weighted Kappa values ranged between 0.81 and 0.85.

Prevalence and mean of caries experience

Table 3 shows the clinical C and combined $C + R$ prevalence and mean caries experience for the three cohorts, both expressed with the Conventional and the ICCMS™-epi systems. For the cohort A only, clinical data are expressed.

From the data concerning the prevalence of caries experience, it can be noted that in cohort A the prevalence of children with no conventional caries experience ($Cd_{ME}mf = 0$) was 68%, decreasing to a prevalence of children with no ICCMS™-epi caries experience ($Cd_{epiME}mf = 0$) of 26.5%. For cohorts B and C, 41% and 33.5% had $Cd_{ME}mf = 0$. When the initial (epi) lesions ($Cd_{epiME}mf$) were included, figures decreased to $Cd_{epiME}mf = 0$: 11.5% and 10.5%, respectively.

Radiographs $C + R$ raised the prevalence of children with one or more lesions significantly compared to when caries was scored clinically C alone ($p \leq .02$) (Table 3). The inclusion of initial stage caries lesions significantly increased all related prevalence of caries experience figures with the clinical (C) and the combined ($C + R$) systems ($p < .05$).

Figures for the conventional and ICCMS™ mean caries experience and standard deviations at the surface level in the three age groups are also displayed in Table 3. The contribution of radiographs added significantly to the mean caries experience figures compared to only clinically (C)

scored ($p < .05$). The inclusion of initial stage caries lesions significantly increased all related mean caries experience figures with the clinical (*C*) and the combined ($C + R$) systems ($p < .05$).

Internal analyses revealed that the mean number of teeth with conventional caries experience ($Cd_{ME}mft$) was 4.8 (SD = 6.6) in the 2-, 9.1 (SD = 11.8) in the 4-, and 9.7 (SD = 8.6) in the 6-year olds. Very few teeth were extracted due to caries (*C*m) in the three age groups. When the mean number of surfaces with ICCMS™ caries experience ($Cd_{epiME}mfs$) was used for the 2-year olds, 80% of the experience was related to the *d* component. With the conventional system ($Cd_{ME}mfs$) the *d* component accounted for 77%. For the 4- and 6-year olds, when using the combined system, the *d* component made up 79% and 76%, respectively, of the total caries experience observed ($C + Rd_{epiME}mfs$). With the conventional system ($C + Rd_{ME}mfs$) the *d* component accounted for 54% and 52%, respectively.

When using the combined system ($C + Rd_{epiME}mfs$), scores differed from each other in 89.8% of cases in occlusal and in 86.9% in approximal surfaces in Cohort B, and in 92.3% of cases in occlusal and 89.7% in approximal surfaces in Cohort C. Findings on the radiographs significantly raised caries experience prevalence and means ($p \leq .02$), detecting primarily approximal lesions.

Distribution of lesions, restorations and extracted surfaces related to tooth type and surface

Figure 2 shows the distribution of clinical *C* ICCMS™ caries experience ($Cd_{epiME}mfs$) for tooth surface pairs in cohort A (2-year olds), as data from corresponding types of teeth in the left and right side of the mouth were merged. The occlusal surfaces on the first primary molar teeth were the most frequently affected with caries experience (37% in the lower and 27% in the upper molar teeth). In both surfaces, the *d* component accounted for more than 85% of the caries experience. The majority of the caries lesions were initial-epi stage (Cd_{epi}). These surfaces were followed in ICCMS™ caries experience by the buccal surface on the upper first incisor teeth (22%). On these surfaces, about half of the caries lesions were at more mature stages (Cd_{ME}).

Figure 3 illustrates the distribution of ICCMS™-epi caries experience ($d_{epiME}mfs$) for tooth surface pairs in Cohort B, with caries lesions observed only clinically (*C*), coinciding clinically and radiographically ($C + R$) and only radiographically (*R*). The majority of the caries experience was found in the primary molar teeth, in particular in the lower jaw. Upper incisor teeth also had relative high caries experience. The most affected surfaces were the occlusal of the primary molar teeth. Of the occlusal surfaces of the lower second molar teeth, 1.25% were missing, 9% were filled and 35.5% with caries lesions. Of the caries lesions, 27.0% were recorded only clinically and they were largely initial stage caries lesions (Cd_{epi}); 8.5% were recorded radiographically, of which 2.5% were also recorded clinically and 6.0% only radiographically.

The distal surface of the first lower primary molar teeth had caries experience in 33.8%, of which 28.5% were caries lesions. Radiographs were able to detect 27.9% of the caries lesions. These were mainly staged as initial lesions (Rd_A). On the distal surface of the first and on the mesial surface of the second upper primary molar teeth, radiographic detection

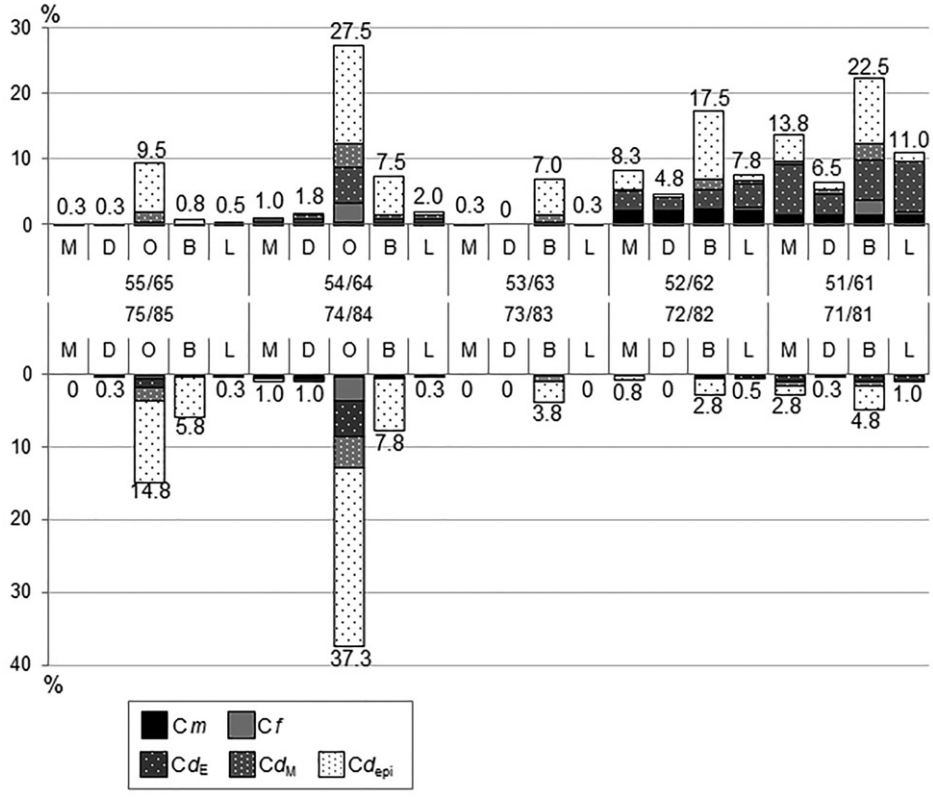

Figure 2. Distribution of ICCMS™-epi caries experience ($d_{epiME}mfs$) for tooth surface pairs in Cohort A with caries lesions observed only clinically (C).

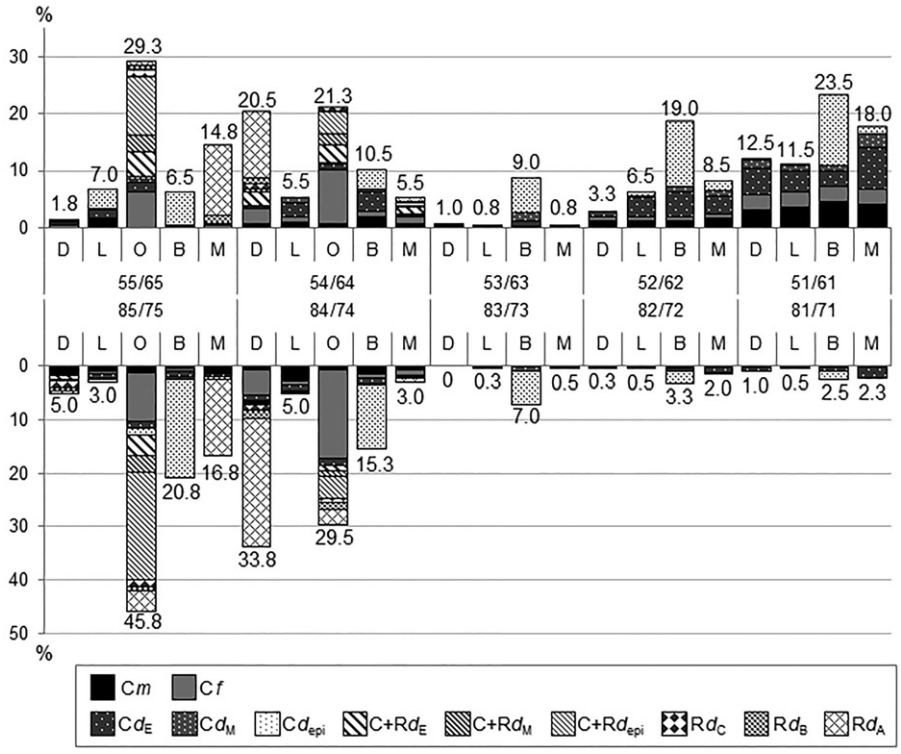

Figure 3. Distribution of ICCMS^{TM}-epi caries experience ($d_{epiME}mfs$) for tooth surface pairs in Cohort B, with caries lesions observed only clinically (*C*), coinciding clinically and radiographically ($C + R$), and only radiographically (*R*).

accounted for 77% and 100%, respectively, of the detected caries lesions. A total of 16.5% of the occlusal surfaces on the lower first primary molar teeth were filled. Primary incisors in the upper jaw were the most often missing teeth (extracted due to caries) among the 4-year olds (up to 5%).

Figure 4 corresponds to cohort C and it shows a similar distribution pattern concerning caries experience with respect to cohort B. Caries experience on the erupting first permanent molar teeth is very low. The primary molar teeth corresponded to those with higher caries experience. More surfaces, in particular on the lower molar teeth were filled, than among the cohort B. Again most of the carious lesions were recorded clinically, while on the approximal surfaces nearly all caries lesions were scored by radiograph.

Discussion

The current study presents the baseline caries data from a 2-year prospective epidemiologic study, showing in this child population a high prevalence and mean of conventional clinical caries experience with means increasing up to the double when initial stage (epi) caries lesions and radiographs were included. With the use of the ICCMS^{TM} system, this study allows the above-mentioned analyses and provides data for oral health workers to be able to develop individual preventive strategies and initial stage caries lesions' early management [13–17] targeted in controlling a national public health problem in many countries, namely dental caries in the primary dentition. This type of data would also be of benefit in countries with lower caries burdens.[8,15–17,23]

This baseline study gives an overview of the participants' caries experience, caries pattern and the contribution of the radiographic examination. It also shows the increment of the caries experience mean due to initial caries lesions, in accordance with increasing number of worldwide public health-based studies.[13,23]

The ICCMS^{TM} system has the advantage that it classifies the severity of the caries lesions, both at the visual (clinical) and at the radiographic level (and in combination) into three stages of caries: initial; moderate and extensive,[13,14] allowing for a simpler manner of reporting severity of detected caries lesions compared to the ICDAS system.[10] It is assumed based on histological data [14,24] that Cd_{epi} has a similar lesion depth as Rd_A; Cd_M as Rd_B and Cd_E as Rd_C. When the combined system was used $C + R$ if scores concerning severity differed between each other, the most severe score was eventually used for the individual classification of the caries lesion. In the present study, very often on occlusal surfaces it was the clinical score (*Cd*), which was the most severe because lesions constricted to enamel are not detectable on radiographs. Conversely, with approximal caries lesions, it was most often the radiographic score (*Rd*), which had the most severe score because the approximal lesion is often not assessable for visual assessment, due to the neighbour tooth.[25]

In the literature, radiolucency due to caries has often graded as being located in the enamel or in the dentine, both in primary and in permanent teeth.[9] According to the ICCMS^{TM} system developed from the ICDAS system, the radiographic scoring system operates with dividing the depth of the caries lesions into Rd_A (from outer enamel half to the outer third of the dentine), Rd_B (in the middle third of the dentine) and Rd_C (in the inner third of the dentine to the pulp) (Table 1). This is in accordance with the ICDAS

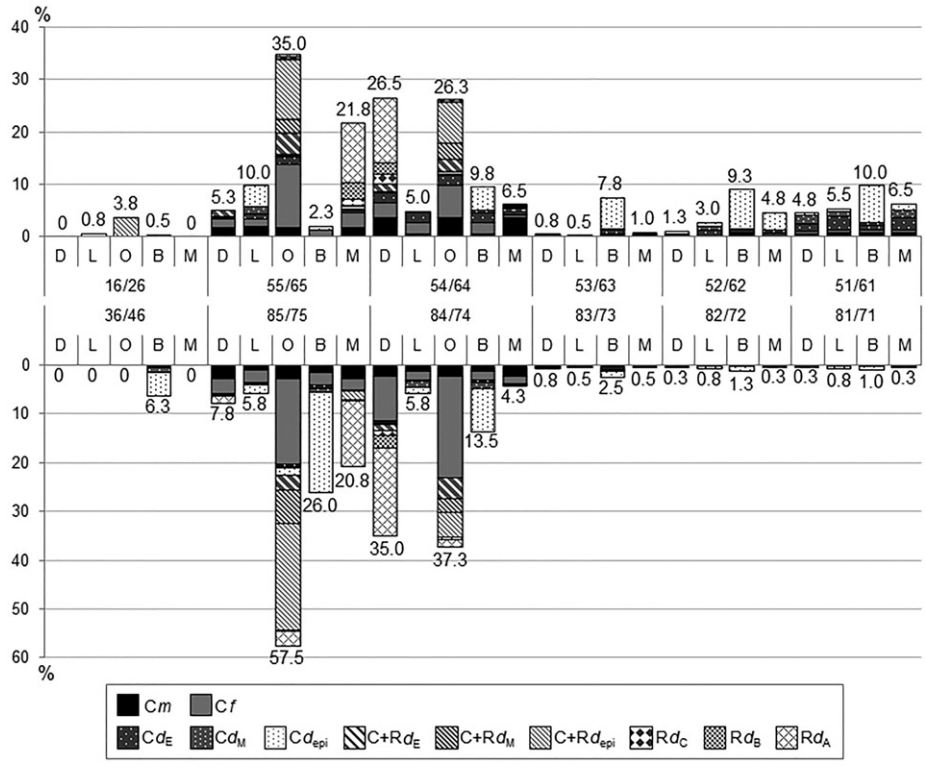

Figure 4. Distribution of ICCMS^{TM}-epi caries experience ($d_{epiME}mfs$) for tooth surface pairs in Cohort C, with caries lesions observed only clinically (*C*), coinciding clinically and radiographically ($C + R$) and only radiographically (*R*).

histologic correlation reported by Ekstrand et al. [24], that has shown both for permanent and primary teeth [21,24] that a clinically assessed initial stage caries lesion (ICDAS score 1 and 2) is histologically and radiographically correlated with a depth that can reach the outer dentine third.

The examiners' reproducibility when trained in the ICDAS clinical and radiographic scoring systems showed substantial kappa values in the present study ($\geq$0.81). However, the authors have great experience with the ICDAS classification system, also from a previous study using both primary and permanent teeth, and with a substantial level reached concerning intra- and inter-examiner reproducibility.[21]

In accordance with other studies [9,23,26,27] adding findings from the radiographs significantly raised the prevalence and the mean of caries lesions among the 4- and 6-year olds. Radiographs were particular useful to detect approximal lesions between molar teeth compared to when the same surfaces were only examined clinically.

Primary molar teeth were the risk teeth, in particular the occlusal surfaces and approximal surfaces between first and second molar teeth. Fewer upper incisor teeth surfaces presented caries lesions in the 6- than in the 4-year olds, which is explained by the exfoliation period among the 6-year olds.[18,19]

This study confirms that Colombia has not reached the year-2000 WHO stated goal of at least 50% of the 5-year olds having a *dmft* =0 [1], as the 4- and 6-year olds showed a clinical conventional prevalence of caries experience ($Cd_{ME}mf$) of 59% and 66.5%, respectively.

Even though the Colombian Health System includes both oral health promotion and caries preventive activities for children, results from this study suggest a related issue of access barriers, as also reported in the recent 4th NOHS.[2] With the high prevalence of moderate and extensive caries lesions seen on the children in this study, it is interesting that only about 10% of the children had one or more restorations. This probably reflects the fact that young children in Colombia visit the dentist only when they have pain or cavitated caries lesions.[2]

Regarding treatment needs and according to the ICCMS^{TM} caries classification and management guide,[14] in this study around 32% of the children from cohort A, 73% from cohort B and 81% from cohort C are in need of operative caries management as they were classified as having a $Cd_{ME}mfs > 0$, and around 42% of the children from cohort A, 26% from cohort B and 19% from cohort C are in need of non-operative caries management.

The caries experience of preschool children, very often expressed at the age of 5, has been reported before at the population level (Mexico, Brazil, Chile, Denmark and Colombia) as well as on samples from other parts of the world.[4,5,7,8,28–30] Little attention has been devoted to caries risk surfaces in the primary dentition in preschool children. Such information is important as it could provide the basis for cost-effective caries preventive strategies.[31] Pitts [32] has found in 1- to 4-year olds in United Kingdom that teeth being at risk were the upper incisor and the molar teeth. In the 4-year olds, about 10% of the molar teeth had one or more cavitated lesions and between 10–15% had enamel lesions. Kramer et al. [33] reported longitudinal caries data in 3 to 6 years old Swedish children participating in a national preventive programme free of charge. Very few children had teeth extracted during the three years of follow-up. At the age of 4 years, 38% had one or more caries lesions

(initial stage and/or cavitated stage of caries). Similar data were 50% when reported in the children as they reached the age of 6 years. Corresponding data from the 4- and 6-year olds in Bogotá, when $Cd_{epiME}mfs$ was used, were about 89%. The Swedish study also shows data of the caries distribution pattern at the surface level. Both in the 4- and in the 6-year olds, the occlusal surfaces in primary second molar teeth were the most caries-affected surfaces. Unfortunately, that study combined caries on all approximal surfaces in the dentition, impeding to discriminate which approximal surfaces were more prone to caries than others. Finally, if radiographs had been involved the distribution pattern of caries might have changed as more approximal caries lesions could have been identified.[9,26,27] In the present study, the additional benefit of including radiographs was significant at the level of prevalence as well as at the mean level (p values $<.02$).

In summary, the data from the present study showed that the prevalence and mean caries experience of the participants is high in the three cohort samples, whether expressed by only including dentine lesions $Cd_{ME}mfs$ or when combining clinical findings with radiographic findings and including initial lesions $C+Rd_{epiME}$mfs. The occlusal and the distal surfaces on the first primary molar teeth and the occlusal and mesial surface on the second primary molar teeth were to be considered as caries risk surfaces together with, but at a far lower level, the buccal surface on upper incisor teeth. The *d* component accounted for over 75% of the caries experience. More than 80% of the approximal lesions were not identified at the clinical level (Figures 3 and 4) but required radiographic examination to be detected, which is in accordance with data from other studies.[9,26,27]

The present data suggest that in preventive terms it should be considered to call in children and parents/caregivers to the clinic when the child is around age 1 to prevent caries in the incisor and first molar teeth. The children should benefit from caries risk related visits,[31] including radiographs taken no later than the age of 4 to control future caries development.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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