Effectiveness of the ICCMS caries management system for children: a 3-year multicentre randomised controlled trial

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ABSTRACT
Objective: This 3-year multicentre randomised controlled trial compared, in 6-7-year-old Colombian children, the effectiveness of the ICCMS (International Caries Classification and Management System) with a conventional caries-management system (CCMS) in terms of individual caries-risk, caries lesions, and secondarily, oral-health-related knowledge/attitudes/practices, and number of appointments.

Material and methods: With ethical approval, 240 6–7-year olds from six Colombian clinics were recruited. Trained examiners conducted the following baseline/follow-up assessments: Caries risk (Cariogram-ICCMS); caries severity/activity staging (ICDAS-merged combined radiographic/visual); sealants/fillings/missing teeth, and oral-health-related knowledge, attitudes and practices. Children received their randomly allocated (ICCMS/CCMS) care from dental practitioners. Outcomes: caries-risk control (children); caries-progression control (tooth surfaces); oral-health-related knowledge/attitudes/practices improvement (parents/children), and appointments’ number (children). Descriptive and non-parametric/parametric bivariate analyses were performed.

Results: Three-year-follow-up: n = 187 (77.9%; ICCMS: n = 92; CCMS: n = 95) disclosed a baseline-to-3-year overall high-caries-risk children decrease (ICCMS: 60.9–0.0%, p < .001; CCMS: 54.7–5.3%, p < .001) (p > .05). ICCMS versus CCMS showed: fewer tooth-surface caries progression (6.2% vs 7.1%, p = .010) and fewer active-caries lesions (49.8% vs. 59.1%, p < .05); higher proportion of children with ≥2/day fluoride-toothpaste tooth-brushing practice (p < .05); similar mean number of appointments (10.9 ± 5.9 vs. 10.0 ± 3.8, p = .15).

Conclusion: Both caries-management systems showed similar effectiveness in caries-risk control, with ICCMS more effectively controlling tooth-surface caries progression and improving toothbrushing practices.

Background
Historically, conventional clinical management of dental caries has focussed on restoration of cavitated caries lesions (tooth decay) combined with population-level preventive measures [1]. This Conventional caries management system (CCMS) is standard care within Colombian dental services [2]. However, current evidence suggests focussing on long-term health, specifically on the preservation of tooth structure, maintaining sound teeth as sound, and controlling caries progression from initial caries stages [1]. Caries management programmes focussing on non-operative approaches have been able to demonstrate better effectiveness in controlling caries progression in schoolchildren [3] and adults [4] than conventional approaches, and in avoiding dental pain/infection in young children [5]. Consequently, Colombian dental schools agreed in 2013 on a consensus for undergraduates’ cariology teaching curriculum with a more preventive/minimally interventive focus [6].

The International Caries Classification and Management System (ICCMS™) (2012) built upon the International Caries the Detection and Assessment System (ICDAS). ICCMS constitutes a best-practice approach that focuses on health outcomes and is a patient-centred, risk-based, preventively orientated, minimally interventive caries management system [7–9]. Figure 1 shows the ICCMS caries-care four-element cycle, which includes an individual- and a tooth-surface-level examination and respective synthesis/diagnosis and caries-care, as follows: 1D. Determine:
Caries risk assessment; 2 D. Detect and assess: caries-process staging combining visual with radiographic criteria (when available) and activity assessment with the ICDAS-merged system (Initial, Moderate and Extensive Active/Inactive caries lesions); 3 D. Decide: personalised patient and tooth-surface levels care plan, and 4 D. Do: individual-level risk-adjusted preventive care; tooth-surface level care of active caries lesions: non-operative care of initial caries lesions and moderate caries lesions (when radiographically located up to the outer external dentine third), and tooth-preserving operative care of extensive caries lesions (dentine cavitated), and in cases of moderate caries lesions (when radiographically located deeper than the outer dentine third) [7–9].

Since its launch, research using ICCMS has reported its use in multiple settings: for epidemiology and public health purposes [10–14]; evaluating its use among dental practitioners [15], students [16], and the former two plus educators [17]. A recent randomised clinical trial (2021) [18] comparing caries incidence in young adults after one year of either ICCMS or CAMBRA caries risk management found no significant differences (p > .05); a type II error of 0.80. The findings from four previous studies in which initial (non-cavitated) caries lesions received non-operative care sealants vs. no treatment, indicated a caries progression proportion of 0.41 in the control group and of 0.09 in the test group [19]. Thus, a sample size of 108 participants was required, plus a 20% increase to take into consideration dropout over three years, resulting in a sample size of 130 6–7-year-old children (65 in each arm). It was decided that each dental school clinic (centre) should enrol 40 participants (20 per arm) to keep the trial manageable.

Materials and methods

This multicentre two-arm parallel-RCT was registered on the Clinical Trials website (ClinicalTrials.gov number: NCT04676230; date: 03/05/2014), was conducted with ethical approval from the Ethics Committee at Universidad El Bosque (UEB 008-2014) and followed the CONSORT guideline. Both the trial protocol and Ethical approval are provided in Supplemental Appendix 1 (in their original language).

The sample size was calculated using the ‘Tamaño de Muestra’ Program® (version 1.1), taking into account the study conducted by Griffin et al. [19], considering a type-I error of 0.05; a type II error of 0.80. The findings from four previous studies in which initial (non-cavitated) caries lesions received non-operative care sealants vs. no treatment, indicated a caries progression proportion of 0.41 in the control group and of 0.09 in the test group [19]. Thus, a sample size of 108 participants was required, plus a 20% increase to take into consideration dropout over three years, resulting in a sample size of 130 6–7-year-old children (65 in each arm). It was decided that each dental school clinic (centre) should enrol 40 participants (20 per arm) to keep the trial manageable.

All ACFO (Colombian Dental School Association) dental schools (n = 25) were invited to participate through an online letter. Nine centres in six corresponding cities (Bogotá: n = 3; Barranquilla: n = 1; Bucaramanga: n = 1; Cali: n = 1; Cartagena: n = 2, and Manizales: n = 1) agreed to participate and went on to participate in training. Each centre had a coordinator, who also acted as baseline examiner, and one to two dental practitioners whose role was to treat the children following their randomly allocated management approach.

Training of each centres’ personnel

Baseline examiners/Centre coordination

Baseline examiners were asked to study the ICCMS Guide for Practitioners and Educators in preparation for further training
They were clinically trained and calibrated in the visually assessed ICDAS caries severity criteria (Sound: ICDAS 0 and caries lesions: ICDAS 1–6) by an ICDAS expert (SM); this helped to assure inter-/intra-examiner reproducibility [20,21]. The 3-day training and calibration included theoretical, pre-clinical and clinical sessions and discussions followed by the clinical assessment and re-assessment of over 100 preregistered tooth surfaces in 10 patients from which weighted Kappa were calculated. Afterwards, these baseline examiners participated in further one-day training to cover the remaining outcomes. This included assessment of ICDAS caries activity criteria [8,20], using the ICDAS-merged caries criteria for radiographs [8,20] and how to determine ICDAS-merged radiographic-visual combined severity and activity caries stages (Table 1). This training day also covered the ICCMS-Cariogram assessment of individuals’ caries risk assessment [8,20,22] and using a questionnaire to assess parents’ knowledge, attitudes and practices in relation to children’s oral health [23]. For the study coordination part of their role, they were trained in the study protocol, emphasising the ICCMS group interventions (described in Figure 2) and the completion of the clinical record form and the excel database. Their roles also included training and monitoring the dental practitioners in their centre.

**Dental practitioners**

The dentists in the trial were also asked to study the ICCMS Guide for Practitioners and Educators in preparation for their training [8,20]. Together with their centre coordinator, they attended a one-day training conducted centrally, either in Bogotá, Cali or Cartagena. The training focussed on the two caries management strategies which they would be using in the trial. Emphasis was given to differentiating between the ICCMS system [8,20] – whose concepts were introduced to Colombian dental schools in 2013 [6], and the standard of care in Colombian dental services - the CCMS system [2]. ICCMS was thoroughly discussed, considering the child-level caries risk assessment and caries lesion diagnosis (1D, 2D), decision making (3D) and delivery of care plan (4D). Dental practitioners were asked to adhere to the detailed protocol for each patient’s randomly assigned trial arm, these thorough written descriptions of activities for each system, which were discussed to ensure clarity of understanding. The training also included the completion of the clinical record form and the excel database. They received further local training and monitoring by their centre coordinator.

After these training events, three dental schools retired from the project. One closed down (Fundación Universitaria San Martín, Barranquilla) and two, due to their inability to achieve the agreed recruitment timeline (Universidad Santo Tomás, Bucaramanga; Pontificia Universidad Javeriana, Bogotá).

The study took place between March 2014 and November 2017, at six centres, corresponding to dental school clinics: two located in the Northwest on the Caribbean coast (Universidad de Cartagena, Cartagena and Corporación Universitaria Rafael Núñez, Cartagena); one in the West coffee-
growing region (Universidad Autónoma de Manizales, Manizales); one in the South West coffee-growing region (Universidad del Valle, Cali), and two in the centre and capital city of Bogotá (Universidad Colegio Odontológico Colombiano and Universidad El Bosque). The study flowchart is depicted in Figure 2. Children between 6 and 7 years of age attending the participating centres were invited to participate (from March to November 2014) by the local researchers. They were sequentially recruited until the sample size quota of 40 eligible children per centre was reached. Inclusion criteria were children to be receiving dental care only at the centre for the following three years, absence of systemic diseases or motor/cognitive/physical disabilities, and not undergoing orthodontic treatment. Those who met the eligibility criteria and consented to take part were enrolled from April to November 2014 (Figure 2), assent was obtained from each child. All assessments and care of the 240 enrolled children were performed in each trial centre.

**Baseline assessments**

Before random assignment of children to their intervention group, baseline child-level caries risk assessment and caries lesion assessment were recorded by the baseline examiner.
(Figure 2). The child-level caries risk assessment was done by interviewing the parent and clinically assessing the child. The ICCMS/Cariogram caries risk factors \([8,20,23]\) assessed were: related diseases (reported hyposalivation); diet content (\(\geq 2\) daily fermentable carbohydrate food/beverage) and frequency \( (>5 \) food/beverages daily intakes); fluoride programme (community fluoridation programme, periodic professional fluoride application); dental biofilm index (Silness and Löe modified) \([24]\); saliva secretion (no clinical signs of hyposalivation); clinical judgement (corresponding here to symptomatic attendance to the dentist); presence of \( \geq 1 \) cavitated (Extensive) caries lesion or a number of teeth with caries experience (dmft plus DMFT: decayed –d/D Moderate and Extensive caries lesions; due-to-caries missing –m/M and filled –f/F teeth in primary and permanent teeth) which was higher than the national average for their age, with the national figures summing up the dmft and the DMFT corresponding to 2 for the 6-year olds, and 4 for the 7-year olds \([25]\). The visual caries lesions’ detection, severity staging and activity assessment was conducted on cleaned teeth (after supervised toothbrushing) using the ICDAS-merged visual-only caries severity criteria: Sound (ICDAS 0), Initial caries (ICDAS 1–2), Moderate caries (ICDAS 3–4), Extensive caries (ICDAS 5–6), and the caries lesion’s Active/Inactive status assessment based on the severity of caries (non-cavitated vs. cavitated), the colour (whitish/yellowish/black) and opacity (loss of lustre vs. shiny), the tactile sensation (rough vs. smooth and in cavitated lesions soft vs. hard), and if located in a plaque stagnation area \([8]\) (Table 1). Missing teeth (m/M) and filled surfaces (f/F) were registered, as well as pits and fissure sealants. The radiographic assessment of caries lesions was conducted using bite-wing radiographs according to the ICDAS-merged caries radiographic criteria: Sound (No radiolucency), Initial caries (Initial Enamel/Dentine Radiolucency), Moderate caries (Moderate Radiolucency), Extensive caries (Extensive Radiolucency). Combined ICDAS-merged caries scores were derived by comparing visual-only plus radiographic ICDAS scores following ICCMS guidance selecting the most severe one, classifying each lesion into Initial, Moderate or Extensive Active/Inactive \([8]\) (Table 1).

Parents’ knowledge, attitudes and practices in relation to children’s oral health were assessed with a questionnaire based on a validated instrument \([23]\). This included six items: (1) Knowledge about the feasibility of preventing dental caries; (2) Attitude about the parent’s responsibility for the child presenting with caries, and four items related to practices: (3) Symptomatic dental attendance; (4) Brushing the child’s teeth twice-a-day with fluoridated toothpaste, (5) Parents actively participating in the child’s toothbrushing, and (6) Number of daily sugary food/beverage intakes.

The individual caries risk was calculated using the Cariogram® software, classifying the patient into low, moderate or high caries risk \([22]\). The final clinical severity of caries lesions used the combined radiographic and visual score, as well as its activity/progression status as Active/Inactive \([8,20]\).

The dmfs and DMFS indices were obtained to present epidemiological data, including the Initial ICDAS-merged caries lesions within the d/D component (ICDAS-dmfs and ICDAS-DMFS) \([10,26]\).

Random allocation
The random allocation of individuals to their trial arm was conducted using the Stata® 10.0 statistical software (Stata Corp LP, College Station, TX, USA), stratifying by location with a 1:1 allocation with randomly permuted blocks of random sizes of 2, 4, and 6. Researchers were blind both to the ordering of blocks as to their respective size. This random allocation sequence process was prepared and supervised independently by one of the authors (LFG). Each centre enrolled a total of 40 participants (20 per arm). The baseline assessments were conducted by the examiner prior to the assignment of children to either management system to guarantee examiner’s blindness to intervention. The children’s assignment to the intervention was afterwards led by the same examiner with sequential closed dark randomisation envelopes and under the presence of an external assistant. The closed-dark envelopes were opened by each child’s parent, together with the dental practitioner.

Caries care
At each dental school clinic, all enrolled children received the intended treatment, according to the child’s assignment to either ICCMS or CCMS system. The examiner and the dental practitioner planned together the child’s respective care plan according to the trial protocol for their randomly allocated trial arm (Figure 2). The ICCMS caries management system \([8]\) corresponded to child-level caries management approaches, with homecare alone for low caries risk, and combined with clinical approaches for moderate and high caries risk. Motivational interviews were used in the dental office to improve inadequate oral hygiene and dietary habits. These use empathic interactions to develop patient’s motivation to improve behaviours \([27]\). ICCMS also included caries lesion care according to their severity and activity status, with either active monitoring (AM), non-operative care (NOC) or tooth-preserving operative care (TOPC), as described in Figure 1 and with detail in Figure 2, including the recall intervals \([8,20]\). The CCMS caries management system followed the current conventional standard of care, including at the child-level care, systematic caries prevention for all children with generalised oral health education, periodical fluoride gel application and oral biofilm control, and fissure and sealants on all occlusal surfaces; at the tooth-surface level, operative care of cavitated dentine caries lesions (ICDAS Extensive) \([2]\) (Figure 2).

The dental practitioners, who delivered both caries care systems, conducted the randomly assigned care on each patient, recording in the oral health record the date and procedure/s conducted at each appointment. Neither the participants/parents nor the dental practitioners were blinded to the intervention.
In this study, the child’s caries-risk progression control was defined in terms of a change from a baseline high/moderate caries risk to a 3-year lower caries risk, or a 3-year maintenance of a baseline low caries risk. Caries progression at the tooth-surface level was defined in terms of a change from a sound or sealed surface to a caries lesion, a filling or a missing tooth; from an existing caries lesion to a more severe caries score and/or an active status; from a filling to a caries lesion or a missing tooth. At the tooth-surface level progression control corresponds lack of progression.

Outcomes

The outcomes of this study were: the proportion of children whose caries risk status progression was controlled; the proportion of tooth surfaces with control of caries progression; the proportion of participants with improved oral-health-related knowledge, attitudes and practices, and the number of dental appointments over the three years.

Statistical analysis. Weighted kappa was used to express the levels of inter-/intra-reproducibility of baseline and follow-up examiners. Minimum required weighted kappa values were 0.7.

Descriptive statistics were used with proportions to express the demographic characteristics, the prevalence of caries experience (ICDAS-dmfs/DMFS), and the variables child-level caries risk (low/moderate/high), lack of progression of caries (lesion severity and activity), and parents’ knowledge, attitudes and practices regarding children’s oral health. The caries experience (dmfs, DMFS, dmf + DMFS, and ICDAS-dmfs, ICDAS-DMFS, ICDAS-dmf + ICDAS-DMFS) and the number of dental appointments were calculated with mean number and standard deviation.

In this study, an intention-to-treat analysis was conducted [28]. T-test, paired t-test, U-Mann Whitney test, prtest and Chi-square test were used to determine differences among the variables between trial arms and between baseline and 3-year follow-up, as well as for baseline demographic and clinical characteristics.

The T-test or U-Mann Whitney test were used to compare, between the two systems, the baseline mean number of surfaces with caries experience (ICDAS-dmfs + ICDAS-DMFS) of those children who left the study during the follow-up period with that of those who remained in the study for the 3-year period.

All analyses were performed using Stata® 10.0 statistical software (StataSE Corp LP, College Station, TX, USA).

For the caries progression analysis, baseline tooth surfaces of unerupted first permanent molar teeth were considered as sound; on the other hand, 3-year follow-up exfoliated primary teeth were considered as their surfaces’ after-basic management given score.

Results

A total of 240 children from six centres were recruited, randomly allocated to ICCMS (n = 120) or CCMS (n = 120) and all received the intervention. Children’s mean age at baseline was of 6.5 ± 0.5 years. Table 2 shows children’s baseline characteristics.

### Table 2. Baseline demographic and clinical characteristics of children enrolled in the study.

|                | ICCMS (n = 120) | CCMS (n = 120) |
|----------------|-----------------|----------------|
| Age            |                 |                |
| 6 years        | 64   53.3 55 45.8 | 56   46.7 65 54.2 |
| 7 years        | 56   46.7 65 54.2 |               |
| Sex            |                 |                |
| Female         | 58   48.3 54 45.0 | 62   51.7 66 55.0 |
| Male           | 62   51.7 66 55.0 | 56   46.7 65 54.2 |
| Socioeconomic level |          |                |
| Low            | 29  24.2 30 25.0 | 21  17.5 25 20.0 |
| Middle         | 84  70.0 84 70.0 | 78  65.0 82 70.0 |
| High           | 7   5.8  6 5.0  | 8   6.7  9 7.5  |
| Caries risk    |                 |                |
| Low            | 36  30.0 45 37.5 | 30  25.0 45 37.5 |
| Moderate       | 22  18.3 25 21.7 | 22  18.3 25 21.7 |
| High           | 32  26.7 35 33.3 | 32  26.7 35 33.3 |
| Prevalence of caries experience (dmfs/DMFS) |       |                |
| Primary teeth  |                 |                |
| (dmf)          | 70.0 65.0        | 70.0 65.0       |
| Permanent teeth (DMF) | 23.3 20.0       | 23.3 20.0       |
| Primary and permanent teeth combined (dmf/DMF) | 75.0 70.0       | 75.0 70.0       |
| Number of surfaces with caries experience (dmfs/DMFS) |       |                |
| Primary teeth  |                 |                |
| (dmfs)         | 5.4  6.8  4.3  5.9 | 5.4  6.8  4.3  5.9 |
| Permanent teeth (DMFS) | 0.4  0.9  0.4  1.0 | 0.4  0.9  0.4  1.0 |
| Primary and permanent teeth combined (dmfs + DMFS) | 5.8  6.9  4.7  6.0 | 5.8  6.9  4.7  6.0 |
| Number of surfaces with ICDAS caries experience (ICDAS-dmfs/DMFS) |       |                |
| Primary teeth  |                 |                |
| (ICDAS-dmfs)   | 9.6  8.6  8.5  7.9 | 9.6  8.6  8.5  7.9 |
| Permanent teeth (ICDAS-DMFS) | 2.0  2.7  1.9  2.5 | 2.0  2.7  1.9  2.5 |
| Primary and permanent teeth combined (ICDAS-dmf + ICDAS-DMFS) | 11.6 9.9 10.4 9.1 | 11.6 9.9 10.4 9.1 |

| Mean | SD  | Mean | SD  |
|------|-----|------|-----|
| 58.3 | 55.0 | 58.3 | 55.0 |
| 90.0 | 82.5 | 90.0 | 82.5 |
| 10.0 | 9.1  | 10.0 | 9.1  |

dmfs and DMFS: caries experience index at the surface (s/s) level for primary teeth and permanent teeth, respectively; decayed (d/D), missing (m/D), filled (f/F); ICDAS-dmfs/DMFS: dmfs/DMFS caries experience indices including initial and Moderate caries lesions.

Three-year follow-up

Three-year follow-up assessments were conducted in all centres. Assessments were the same as those conducted at the baseline. A local trained research assistant (dentist)-blinded to the intervention-assessed child-level caries risk and knowledge, attitudes and practices. Five new examiners (follow-up examiners) from the leading research team (also blinded to the intervention) conducted the ICDAS visual and ICDAS radiographic assessment of caries, calculating the radiographic-visual combined severity and activity caries stages (ICDAS-merged codes). For this study, the ‘follow-up examiners’ were re-calibrated in the ICDAS visual caries criteria prior to undertaking assessments (2016) [20]. In addition, these examiners had previous experience in conducting ICDAS visual caries criteria training and calibration courses – being themselves calibrated before [20,21]. They were also trained in the other assessments [20–23].

Child’s caries risk and tooth-surface progression control

In this study, the child’s caries-risk progression control was defined in terms of a change from a baseline high/moderate caries risk to a 3-year lower caries risk, or a 3-year maintenance of a baseline low caries risk. Caries progression at the tooth-surface level was defined in terms of a change from a sound or sealed surface to a caries lesion, a filling or a missing tooth; from an existing caries lesion to a more severe caries score and/or an active status; from a filling to a caries lesion or a missing tooth. At the tooth-surface level progression control corresponds lack of progression.
demographic and clinical characteristics. No statistically significant differences were found between groups \((p > .05)\).

No adverse events related to caries management were reported in any of the groups and there were no exclusions of participants after the initiation of the study.

At the 3-year follow-up, the sample corresponded to 187 children (77.9%) (ICCMS: \(n = 92\); CCMS: \(n = 95\); 90 girls and 97 boys) \((p > .05)\). Few of the children recruited were entirely free of any caries experience at baseline (ICDAS-dmfs + ICDAS-DMFS) with 91.9% having caries, fillings or missing teeth due to caries and this was 99.4% after three years. The overall mean number of surfaces with ICDAS caries experience was high, both in the primary teeth at baseline \((7.7 \pm 8.3)\); ds-Initial: \(3.4 \pm 3.4\); ds-Moderate: \(0.8 \pm 1.3\); ds-Extensive: \(1.8 \pm 3.1\); ms: \(1.0 \pm 3.1\); fs: \(0.7 \pm 1.8\) and after three years \((9.1 \pm 7.9)\); ds-Initial: \(4.4 \pm 4.2\); ds-Moderate: \(0.3 \pm 0.6\); ds-Extensive: \(0.6 \pm 1.2\); ms: \(1.8 \pm 4.8\); fs: \(2.0 \pm 3.0\), as in the permanent teeth at baseline \((1.5 \pm 2.0)\); DS-Initial: \(1.2 \pm 1.7\); DS-Moderate: \(0.2 \pm 0.6\); DS-Extensive: \(0.1 \pm 0.4\); FS: \(0.0 \pm 0.2\) and after three years \((4.6 \pm 3.7)\); DS-Initial: \(3.7 \pm 3.3\); DS-Moderate: \(0.4 \pm 0.7\); DS-Extensive: \(0.1 \pm 0.3\); FS: \(0.4 \pm 0.9\).

**Dropouts**

The 3-year dropout corresponded to 53 children (22.1%), with a similar number in each trial arm (ICCMS: \(n = 28\), 23.3%; CCMS: \(n = 25\), 20.9%) \((p > .05)\). The baseline mean number of tooth surfaces with ICDAS caries experience in both the primary and permanent teeth (ICDAS-dmfs + ICDAS-DMFS) of children who remained in the study did not show significant differences from that of children who dropped out during the 3-year follow-up (ICCMS: \(9.5 \pm 9.1\) vs. \(9.0 \pm 8.4\), respectively; \(p = .81\); CCMS: \(8.9 \pm 8.7\) vs. \(8.0 \pm 7.2\), respectively; \(p = .65\)).

**Examiners reproducibility**

The inter-/intra-examiner reproducibility weighted Kappa values for the ICDAS visual caries criteria were \(\geq 0.7\) for all baseline and follow-up examiners (Table 3).

**Children with control of caries risk progression**

Figure 3 shows control of child-level caries-risk progression in both groups without significant differences between groups \((p > .05)\). There was a statistically significant baseline to 3-year decrease in the proportion of High-caries-risk children (ICCMS: \(60.9\%\), \(p < .001\); CCMS: \(54.7\%\), \(p < .001\)) and an increase in the proportion of Moderate-caries-risk children in both groups \((p < .001)\). With respect to Low-caries risk, there was a statistically significant increase of children in this classification only in the ICCMS group \((6.5\%\) to \(17.4\%\), \(p = .019\)).

**Tooth surfaces with control of caries progression**

Out of the total of tooth surfaces assessed at the 3-year follow, which could be sound, carious, sealed, filled or missing due to caries \((n = 20,196)\); ICCMS: \(n = 9936\); CCMS: \(n = 10,260\), the baseline to 3-year follow-up behaviour showed caries progression in 6.7% \((n = 1346)\) [95% CI, 6.3–7.0] of tooth surfaces, being significantly lower for ICCMS (6.2%) \((n = 617)\); [95% CI, 5.7–6.7] than for CCMS (7.1%) \((n = 729)\) [95% CI, 6.6–7.7] \((p = .01)\).

Figure 4 shows the proportion of caries lesions according to their activity status per trial arm at baseline (ICCMS: \(n = 703\); CCMS: \(n = 679\)) and after 3 years (ICCMS: \(n = 870\); CCMS: \(n = 899\)). It depicts that at baseline most caries lesions were Active Extensive/Moderate/Initial in both trial arms (ICCMS: 90.8%; CCMS: 90.3%) \((p > .05)\). At 3 years most caries lesions in ICCMS were Inactive Extensive/Moderate/Initial (50.2%) conversely to CCMS in which most caries lesions were Active (59.1%). There was a 3-year significant decrease in the proportion of active caries lesions within each system. In ICCMS this value corresponded to 41% [95% CI, 37–44] \((p = .019)\) and in CCMS to 31.2% [95% CI, 28–34] \((p = .002)\) with a significantly lower proportion of active caries lesions in ICCMS compared to CCMS \((p = .002)\), as well as of active initial caries lesions \((p = .001)\).

**Parents knowledge, attitudes and practices regarding children’s oral health**

The parents’ knowledge, attitudes and practices survey about their children’s oral health (Table 4), found a significant increase at the 3-year follow-up in the ICCMS group in relation to limiting sugars (two daily portions of sweetened beverages/foods); parents participating in the child’s toothbrushing, and children having their teeth brushed with fluoride toothpaste twice-a-day \((p < .05)\). The latter, with a significant 3-year difference between systems \((p = .02)\). Both groups showed a significant increase regarding non-symptomatic dental attendance as the reason for the last appointment \((p < .05)\).

**Number of appointments**

Both caries-care systems showed a similar mean number of dental appointments. In ICCMS this was of \(10.9 \pm 5.9\) [95% CI, 9.7–12.1] and in CCMS of \(10.0 \pm 3.8\) [95% CI, 9.2–10.8] \((p = .15)\).

**Discussion**

This multicentre RCT in schoolchildren compared the caries-controlling effectiveness of the ICCMS system with conventional caries management (CCMS). ICCMS acts through patient-centred risk-preventive care to control the caries risk, arrest early caries lesions with non-operative care, and uses minimally-invasive techniques when caries removal is necessary, with patient’s recall and review [8]. In comparison, CCMS applies systematic general preventative measures which are not individualised to the patient and usually involve operative care of cavitated caries lesions [2]. The ICCMS system was more effective than the CCMS in...
controlling caries progression at the tooth-surface level, without significant differences between systems at the individual level.

The better caries lesion control in the ICCMS group corresponded, first, to a lower proportion of tooth surfaces progressing either to a caries lesion, or to a more severe or an

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**Table 3.** ICDAS visual caries criteria inter- and intra-examiner agreements of baseline (E) and follow-up (FE) examiners (weighted kappa).

| Reproducibility | Baseline examiners (E) from each centre | Follow-up examiners (FE) from leading research team |
|-----------------|-----------------------------------------|-----------------------------------------------|
| Inter-examiner  | E1  | E2  | E3  | E4  | E5  | E6  | FE1 | FE2 | FE3 | FE4 | FE5 | FE6 |
| Weighted kappa values | 0.71 | 0.75 | 0.71 | 0.72 | 0.70 | 0.71 | 0.70 | 0.80 | 0.78 | 0.83 | 0.77 | 0.79 |
| Intra-examiner  | E1  | E2  | E3  | E4  | E5  | E6  | FE1 | FE2 | FE3 | FE4 | FE5 | FE6 |
| Weighted kappa values | 0.79 | 0.92 | 0.80 | 0.85 | 0.87 | 0.79 | 0.85 | 0.94 | 0.91 | 0.95 | 0.88 | 0.92 |

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**Figure 3.** Distribution of baseline and 3-year children according to its caries risk classification.

**Figure 4.** Distribution of baseline and 3-year caries lesions according to activity status and severity stage.
active caries lesion; second, to a significantly higher proportion of inactive caries lesions. This could be explained by the emphasis that ICCMS gives to tooth-preserving care prevention and control [1], or minimal invasive caries management, which goes far beyond the conventional surgical management of caries lesions -only considering those at a cavitated status [29], as in the CCMS [2]. In ICCMS, the diagnosis of caries lesions involves staging the lesion into a continuum of severity categories based upon the histological extent of the lesion within the tooth [7,9,20] and according to the progression status into an active (likely going through mineral loss) or inactive caries lesion [30–32], followed by synthesising its diagnosis and deciding upon appropriate care with preventively-oriented nonsurgical options whenever indicated (non-operative care) and including tooth-preserving management when operative care is needed (tooth-preserving operative care) [7–9,20,33]. In addition, after three years the significant increase in the ICCMS trial arm parents’ appropriate practices regarding their children’s oral health, related to dietary and toothbrushing habits, highlights the relevance that ICCMS gives to evidence-based practices and to the personal-toothbrushing habits, highlights the relevance that ICCMS regarding their children increase in the ICCMS trial arm parents at baseline in the primary-teeth when the children were 5–7 years old. The prevalence of caries (cavity)-free children ($d_3mf = 0$) of 35.9%, is below the 2000 WHO goal of 50% in 5-year-olds, and similar to more recent corresponding national figures in 5-year olds (37.9%) [37]. The caries burden is also clear from the baseline mean number of surfaces with caries experience, with a dmfs of $4.3 \pm 6.7$, in which the d component accounted for $2.6 \pm 4.4$, and when including Initial and Moderate caries lesions correspondent figures became even higher ($ICDAS$-dmfs: $7.7 \pm 8.3$; $ICDAS$-d: $5.9 \pm 7.8$). Second, both caries-care systems prioritise primary prevention and long-term health-maintenance: ICCMS, through a patient-centred risk-based care philosophy [20], and the CCMS by managing all children with preventive measures systematically [8].

Other RCTs investigating caries management philosophies similar to ICCMS have also reported clinical effectiveness. Vermaire et al. [3], investigating 6-year-old Dutch children, reported a 3-year study, where there was a lower caries experience increment (DMFS) in the test group compared to the control group (standard of care: twice-a-year fluoride varnish; pits and fissure sealants on erupting occlusal surfaces of first permanent molar teeth). Curtis et al. [4], in Australian adults managed in private practices, found after two years a significantly lower DMFS increment in the test vs. the control group (‘standard’: conventional operative care, including of enamel caries lesions detected radiographically). In our study, the $df_{1/D3}$ threshold) increment after three years was higher than in the above studies [3,4], both for the ICCMS ($0.8 \pm 0.2$) and for CCMS ($0.8 \pm 0.6$). We did not use this indicator, due to the high mean number of untreated cavitated caries lesions (as well as non-cavitated) at baseline, and to express caries lesions’ progression considering their severity and their activity status [1,30–33]. Innes et al. [5], in 3–7-year-old children in the United Kingdom, with at least one primary molar with dentinal caries lesion, found no significant difference after three years in the number of episodes of dental pain and/or infection between sealing in carious tooth tissue restoratively versus conventional operative care or only individual-level care, with the first option being more cost-effective.

The ICCMS caries care philosophy (both at the child and at the tooth-surface level) has also been included in the recent ORCA-IADR terminology consensus [38], as well as in recent evidence on best practices and effectiveness of caries management [39–46].

For this study, the ICCMS protocol was adjusted locally as fluoride mouthrinse/solution, atraumatic restorative treatment (ART), and the Hall technique were not used. These adaptations have been referred as ‘Glocal’ in the ICCMS derived for the dental practice ‘CariesCare International’

### Table 4. Parents’ knowledge, attitudes and practices regarding children’s oral health.

| KAPs   | Question                                                                 | ICCMS (n = 92) | CCMS (n = 95) |
|--------|--------------------------------------------------------------------------|----------------|--------------|
|        |                                                                          | Baseline n (%) | 3-y follow-up n (%) | Baseline n (%) | 3-y follow-up n (%) |
| K      | In your opinion, is it possible to control and prevent tooth decay?      | Yes 91 98.9    | 91 98.9       | 92 96.8       | 94 98.9          |
|        |                                                                          | No 1 1.1       | 1 1.1         | 3 3.2         | 1 1.1            |
| A      | Do parents have a higher responsibility than the dentists/ teacher for   | Yes 69 75.9    | 76 82.6       | 69 72.6       | 77 81.1          |
|        | the child having tooth decay?                                           | No 22 23.9     | 16 17.4       | 26 27.4       | 18 18.9          |
| P      | Were dental symptoms the reason for the last patient’s appointment?     | Yes 36 39.1    | 0 0.0         | 26 27.4       | 0 0.0           |
|        |                                                                          | No 56 60.9     | 92 100*       | 69 72.6*      | 95 100*          |
| P      | How many times a day are the child’s teeth being brushed with fluoride toothpaste? | $\geq 2$ 80 87.0* | 91 98.9*      | 82 86.3       | 88 92.6*         |
|        |                                                                          | $< 2$ 12 13.0   | 1 1.1         | 14 14.7       | 7 7.4            |
| P      | Do the parents participate in the child’s oral hygiene?                  | Yes 29 31.5%   | 61 66.4a      | 39 41.1a      | 64 67.4          |
|        |                                                                          | No 63 68.5     | 31 33.7      | 56 58.9       | 31 32.6          |
| P      | How many portions of sugary beverages/foods does the child have per day?| $\leq 2$ 31 33.7a | 57 62.0a      | 31 32.6       | 49 51.6          |
|        |                                                                          | $> 2$ 61 66.3   | 35 38.0       | 64 67.4       | 46 48.4          |

KAPs: knowledge, attitudes and practices; K: knowledge; A: attitude; P: practice.

*Statistically significant difference between baseline and 3-year follow-up ($p < .05$).

*Statistically significant differences between groups at the 3-year follow-up ($p < .05$).

*Statistically significant difference between groups at baseline ($p < .05$).
Guide [33], as a watchword for successful local implementa-
tion. The CCMS protocol in this trial corresponded to the
standard of care as described in the National Health System
guidelines [2].

One limitation of this study could be that the same dental
practitioners conducted both caries care systems and this
could have led to not following it thoroughly. To ensure that
the dentists treated participants strictly as indicated in the
study protocol, monthly meetings and review of oral health
records (uploaded to the system) were conducted. In this
study adherence to each trial protocol seemed to be good.
For example, in relation to the use of sealants, in the ICCMS
group, where you don’t seal sound surfaces unless these are
at local risk of caries and other measures don’t seem to
work, only 1.7% of occlusal sound surfaces were sealed, 0.8%
corresponding to high-caries risk participants and only the
remaining proportion applied to other caries risk status chil-
dren against the protocol. In contrast, sealants on initial car-
ies lesions on buccal surfaces don’t follow the protocol in
the CCMS group. These were present only in 2.2% of buccal
surfaces with initial caries lesions, suggesting a very low con-
duct outside of the protocol.

Regarding the dropout, while we calculated a possible
20%, this ended up being of 22.3%; however, in our study,
the final sample was higher than the calculated sample size
(n = 187 vs. n = 130, respectively) as we worked with six
centres, each with 40 enrolled children at baseline. Children
in this study were representative of children attending dental
care in the National Health System in terms of their car-
ies status.

The fact that around 27% of children presented at the 3-
year follow-up ≥ 1 Extensive Active caries lesions is rather
disappointing. The starting point seems to be an influencing
factor and would be probably related to national caries bur-
den indicators [37], as the studies in The Netherlands in chil-
dren [3] and in Australia in adults [4] show better oral health
indicators at both assessment times, while the one in the
United Kingdom in children [5] show worse ones.

The results of this study question that if CCMS is being
delivered across the country adequately following the
national guidelines, the children’s national caries burden
should be lower than what it currently shows [37]. We specu-
late this, based on the fact that while in national figures for
similar age group 36% of parents reported symptomatic
attendance as the reason for last appointment [37]. We found
in our study no report of symptomatic attendance at
3-year follow-up. In addition, Cortes et al. [10], in a two-year
caries-progression pattern epidemiological study in Bogotá
using the ICDAS-merged visual combined with radiographic
scores, also found in the 6-year-old cohort a high caries
increment (after two years) in the mean number of ICDAS-
dmfs/DMFS (10.5 ± 9.6 vs. 13.3 ± 16.9) compared to our study
in the CCMS group after three years (8.9 ± 8.7 vs. 13.4 ± 9.9),
but with a higher increment in the proportion of ms/MS in
the Bogotá study (1.9–31.6% after two years) vs. our study
(11.2–14.1% after three years).

If implemented widely, ICCMS would involve in the short
term probably a higher number of appointments (related to
the personalised risk management), even though this study
did not show significant differences in this aspect between
systems, probably due to the high baseline burden of caries.
Additionally, while in the CCMS group, there was a higher
proportion of sealants applied (26.4%) compared to the
ICCMS group (17.1%) (p < .05). However, the CCMS sealing
protocol adhered to the national standard of care [2] involv-
ing sealing sound surfaces of all molar teeth (primary and
permanent). This systematic approach does not adhere to
the current best practices and scientific evidence [2,33,47,48]
which instead recommends only sealing occlusal surfaces of
erupting first permanent molar teeth considered at risk of
caries, and sealing active initial (and when it applies also
moderate) caries lesions.

Finally, ICCMS is in accordance with the state of the art of
caries management [38–46]. There is a growing shift in ac-
cademia towards a similar approach to ICCMS in the dental
caries teaching curricula for undergraduates (e.g. the
European leading consensus; the cariology consensus
achieved in Colombia, the USA, and the Caribbean countries)
[6,49–52], together with the adoption of similar caries man-
agement behaviours in dental practice [17]. The CariesCare
International caries management guide derived from ICCMS
as a friendly version for the practice [33,53] and successful
ongoing global public health strategies such as the Alliance
for a Cavity Free Future [54] are examples of this shift. In
Colombia, the recent public health policy (2016) to imple-
ment a patient-centred risk-based strategy that is under
adoption also shows this trend [55].

After 3 years, both caries-care systems demonstrated control
of caries-risk progression within a similar number of
appointments, however, the ICCMS group benefitted from
better results in terms of caries lesion control and improve-
ments in oral-health practices.

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References
[1] Pitts NB, Zero DT, Marsh PD, et al. Dental caries. Nat Rev Dis Primers. 2017;3:17030.
[2] Ministerio de Salud y Protección Social [Internet]. Bogotá: Todo lo que usted debe saber sobre El plan de beneficios – POS. [cited 2021 Dec 01]. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VF/RBC/todoloquesudedebesaber-sobre-el-plan-de-beneficios.pdf.
[3] Vermaire JH, Poorterman JHG, Van Herwijnen L, et al. A three-year randomized controlled trial in 6-year-old children on caries-preventive strategies in a general dental practice in The Netherlands. Caries Res. 2014;48(6):524–533.
[4] Curtis B, Warren E, Pollicino C, et al. The monitor practice programme: is non-invasive management of dental caries in private practice cost-effective? Aust Dent J. 2011;56(1):48–55.
[5] Innes NP, Clarkson JE, Douglas GVA, et al. Child caries management: a randomized controlled trial in dental practice. J Dent Res. 2020;99(1):36–43.
[6] Martignon S, Marín LM, Pitts N, et al. Consensus on domains, formative objectives and contents in cariology for undergraduate dental students in Colombia. Eur J Dent Educ. 2014;18(4):222–233.
[7] Pitts NB, Ekstrand KR, ICDAS Foundation.International caries detection and assessment system (ICDAS) and its international caries classification and management system (ICCMS) - methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol. 2013;41(1):e41–e52.
[8] Pitts NB, Ismail AI, Martignon S, et al. ICCMS™ guide for practitioners and educators [Internet]. London: King's College London; 2014 [cited 2021 Mar 11]. Available from: https://iccms-web.com/uploads/asset/592845add7ac8756944059.pdf.
[9] Ismail AI, Tellez M, Pitts NB, et al. Caries management pathways preserve dental tissues and promote oral health. Community Dent Oral Epidemiol. 2013;41(1):e12–e40.
[10] Cortes A, Ekstrand KR, Martignon S. Visual and radiographic merged-ICDAS caries progression pattern in 2-6 years old Colombian children: two-year follow-up. Int J Paediatr Dent. 2019;29(2):203–212.
[11] de Carvalho P, Bönecker M, Tello G, et al. Inclusion of initial caries lesions in a population-based sample of Brazilian preschool children: Impact on estimates and treatment needs. PLoS One. 2020;15(6):e0234122.
[12] Ghotane SG, Don-Davis P, Kamara D, et al. Needs-led human resource planning for Sierra Leone in support of oral health. Hum Resour Health. 2021;19(1):106.
[13] Nguyen TM, Tomnukayakul U, Calache H. Evaluation of an intervention to promote minimally invasive dentistry (MID) in an Australian community dental agency-pilot study. Int J Dent Hyg. 2021;1–8.
[14] Hammersmith KJ, DePalo JR, Casamassimo PS, et al. Silver diamine fluoride and fluoride varnish may halt interproximal caries progression in the primary Dentition. J Clin Pediatr Dent. 2020;44(2):79–83.
[15] Elgheaty A, Kolker JL, Guzmán-Armstrong S, et al. Management of initial carious lesions: Iowa survey. J Am Dent Assoc. 2019;150(9):755–765.
[16] Yin LS, Tamilselvam K, Abdulla AM, et al. Knowledge and practice of ICDAS and ICCMS in young children: a cross-sectional study among final-year dental students in Malaysia. Int J Clin Pediatr Dent. 2021;14(2):278–285.
[17] Abreu-Placeres N, Newton JT, Pitts N, et al. Understanding dentists’ caries management: the COM-B ICCMS™ questionnaire. Community Dent Oral Epidemiol. 2018;46(6):545–554.
[18] Khalaf YS, Hafez S, Shaalan OO. Evaluation of ICCMS versus CAMBRA caries risk assessment models acquisition on treatment plan in young adult population: a randomized clinical trial. Clin Cosmet Investig Dent. 2021;13:293–304.
[19] Griffin SQ, Oong E, Kohn W, et al. The effectiveness of sealants in managing caries lesions. J Dent Res. 2008;87(2):169–174.
[20] ICCMS. ICDAS-ICCMS [Internet]. 2020. [cited 2021 Dec 21]. Available from: https://www.iccms-web.com/content/resources/elearning.
[21] Martignon S, Castiblanco GA, Cortés A, et al. Reporte de una metodología de calibración de examinadores en el uso del sistema internacional de detección y valoración de caries (ICDAS). Universitas. 2015;34:159–173.
[22] Brathdal D, Petersson GH. Cariogram-a multifactorial risk assessment model for a multifactorial disease. Community Dent Oral Epidemiol. 2005;33(4):256–264.
[23] Martignon S, Bautista-Mendoza G, González-Carrera MC, et al. Instruments for evaluating oral health knowledge, attitudes and practice for parents /caregivers of small children. Rev Salud Publica. 2008;10(2):308–314.
[24] Loe H. The gingival index, the plaque index and the retention index systems. J Periodontol. 1967;38(6):Suppl:610–6.
[25] Ministerio de Salud. III Estudio Nacional de Salud Bucal [Internet]. 1999. [cited 2021 Sep 15]. Available from: https://www.visitaodon-tologica.com/ARCHIVOS/ARCHIVOS-NORMAS/SaludPublica_P_y_P/II_ESTUDIO_NACIONAL_SALUD_BUCAL.pdf.
[26] Martignon S, Usuga-Vacca M, Cortés F, et al. Risk factors for early childhood caries experience expressed by ICDAS criteria in ana-poina, Colombia: a cross-sectional study. Acta Odontol Latinoam. 2018;31(1):58–66.
[27] Yevlahova D, Satur J. Models for individual oral health promotion and their effectiveness: a systematic review. Aust Dent J. 2009;54(3):190–197.
[28] Tripepi G, Chesnaye NC, Dekker FW, et al. Intention to treat and per protocol analysis in clinical trials. Nephrolology. 2020;25(7):513–517.
[29] Pitts NB. Are we ready to move from operative to non-operative/ preventive treatment of dental caries in clinical practice? Caries Res. 2004;38(3):294–304.
[30] Ekstrand KR, Zero DT, Martignon S, Pitts NB. Lesion activity assessment. In: Pitts N, editor. Detection, assessment, diagnosis and monitoring of caries. Basel: KARGER; 2009. p. 63–90.
[31] Ekstrand KR, Gimenez T, Ferreira FR, et al. The international caries detection and assessment system - ICDAS: a systematic review. Caries Res. 2018;52(5):406–419.
[32] Drancourt N, Roger-Leroy V, Martignon S, et al. Carious lesion activity assessment in clinical practice: a systematic review. Clin Oral Investig. 2019;23(4):1513–1524.
[33] Martignon S, Pitts NB, Goffin G, et al. CariesCare practice guide: consensus on evidence into practice. Br Dent J. 2019;227(5):353–362.
[34] World Health Organization. Guideline: sugars intake for adults and children [Internet]. Geneva: WHO; 2015 [cited 2021 May 20]. Available from: https://apps.who.int/iris/bitstream/handle/10665/149782/9789241549028_eng.pdf?sequence=1.
[35] Walsh T, Worthington HV, Glenny AM, et al. Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst Rev. 2019;3:CD007868.
[36] Kuzmina I, Ekstrand KR. Outcomes 18 years after implementation of a nonoperative caries preventive program—the nexö-method—on children in Moscow, Russia. Community Dent Oral Epidemiol. 2015;43(4):308–316.
[37] Ministerio de Salud y Protección Social. [Internet]. IV Estudio Nacional de Salud Bucal. ENSAB IV: Situación en Salud Bucal. Para Saber como estamos y saber qué hacemos. Colombia; 2014 [cited 2021 Mar 26]. Available from: https://www.minsalud.gov.co/sites/
MacIulskiene V, Campus G, Carvalho JC, et al. Terminology of dental caries and dental caries management: consensus report of a workshop organized by ORCA and cariology research group of IADR. Caries Res. 2020;54(1):7–14.

Chen Z, Lu ZM, Schwendicke F, et al. Managing carious lesions: consensus recommendations on carious tissue removal. Zhonghua Kou Qiang Yi Xue Za Zhi. 2016;51(12):712–716.

Urquhart O, Tampi MP, Pilcher L, et al. Nonrestorative treatments for caries: systematic review and network meta-analysis. J Dent Res. 2019;98(1):14–26.

Ricketts D, Lamont T, Innes NPPT, et al. Operative caries management in adults and children. Cochrane Database Syst Rev. 2013;28:CD003808.

Innes NPT, Frencken JE, Bjørndal L, et al. Managing carious lesions: consensus recommendations on terminology. Adv Dent Res. 2016;28(2):49–57.

Tellez M, Gomez J, Kaur S, et al. Non-surgical management methods of noncavitated carious lesions. Community Dent Oral Epidemiol. 2013;41(1):79–96.

Twetman S. Caries risk assessment in children: how accurate are we? Eur Arch Paediatr Dent. 2016;17(1):27–32.

Tellez M, Gomez J, Pretty I, et al. Evidence on existing caries risk assessment systems: are they predictive of future caries? Community Dent Oral Epidemiol. 2013;41(1):67–78.

Schwendicke F. Less is more? The long-term health and cost consequences resulting from minimal invasive caries management. Dent Clin North Am. 2019;63(4):737–749.

Ahovuo-Saloranta A, Forss H, Walsh T, et al. Pit and fissure sealants for preventing dental decay in permanent teeth. Cochrane Database Syst Rev. 2017;31:CD001830.