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ORIGINAL ARTICLE

The effect of different dental treatment strategies on the oral health of children: a longitudinal randomised controlled trial

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Abstract The aim of the present study is to verify which strategy is the most effective in the treatment of dental decay of the deciduous dentition in a moderate to high caries child population under remote field conditions. This study was carried out in the rain forest of Suriname. Three hundred and eighty schoolchildren, mean age 6.1 years (SD 0.5, range 5.1–7.1 years), were randomly assigned to four different groups: full dental treatment, only extractions, only restorations (ART) and no treatment. Parameters for oral health were defined as caries prevalence (dmft), caries increment, sequela to dental caries and dental pain. Restorative dental care of the primary dentition, by means of ART, resulted in a caries increment from a dmft of 5.48 (SD 3.2) at baseline to 6.35 (SD 2.6) after 2 years ($p<0.001$). Extensive dental treatment, performing only extractions, or no treatment did not render significant changes in the caries prevalence of children ($p>0.05$). Full dental treatment should be the strategy of choice whenever oral health care programmes are developed. However, when priorities are required due to situational, practical or economical reasons, extraction of severely decayed teeth is an effective treatment strategy.

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Introduction

Despite great improvements in the global oral health status, dental caries still remains one of the most prevalent diseases [3, 25, 26, 32, 33, 35, 47]. Although dental caries is seldom life threatening, its detrimental effects adversely influence people's quality of life, and therefore, active caries receives adequate treatment [12]. Several strategies for the management of dental caries in the primary dentition have been proposed.

Extraction is the most basic way of managing dental caries. However, among other possible side effects, extraction of teeth might induce space problems by drifting of other primary or permanent teeth [12, 30]. Another approach is conventional restoration of all cavities [9, 12, 24], although this treatment option is currently under debate, and there seems to be an unmistakable tendency to minimise the invasive approach of carious lesions to a preventive non-operative treatment [10, 21, 22, 24, 29, 37, 40]. The use of fluoride is an effective measure in the prevention of dental decay [4, 5, 46]. However, studies have shown that, in the absence of fluorides, dental decay could also be adequately prevented by means of oral hygiene instruction and frequently repeated professional tooth cleanings [1, 2]. Unfortunately, preventive strategies on their own are rarely sufficient to re-establish oral health and function in children with active caries and must often be supplemented with curative oral care [12].

To summarise, there is no consensus on what strategy is preferred to treat the diseased deciduous dentition adequately. Treatment decisions are not only guided by clinical

considerations but also by attendance patterns, parent's wishes and socio-economic background [19, 20, 36-41]. Furthermore, and this accounts especially for disadvantaged countries and communities, treatment decisions often depend on available budgets, adequate material and trained personnel. Although oral diseases are qualified as a major public health problem in these countries, oral health care is often highly underrepresented within a total health-care system [14, 44]. The scarcely available funds must be utilised efficiently, and priorities for an acceptable level of oral care must be established.

Appropriate oral health care should comprise the prevention of new dental decay, arrestment of existing carious lesions, prevention of pain and discomfort for children and prevention of early loss of deciduous teeth. The aim of the present study is to verify which of several dental treatment strategies is the most efficient and effective with regard to the above-mentioned clinical objectives in the treatment of dental decay of the deciduous dentition in a moderate or high carious child population under remote field conditions.

Materials and methods

Study population

This study basically followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines of a randomised controlled trial. The study was carried out in the rain forest of Suriname, a former Dutch colony located at the Northern coast of South America. It is divided into urban, rural and the interior areas in terms of population and economic activity. The interior rain-forested area, comprising about 80% of the country, is sparsely populated by tribal communities (12% of the total Suriname population), mainly Creole Bushnegroes (80%) and Amerindians (20%). The rain forest lacks an adequate infrastructure, electricity and running water [31]. Epidemiological data regarding the caries prevalence in this area have been reported in a separate study [42].

The target population was 400 6-year old school children with untreated dental decay and a non-contributory medical history. A power analysis indicated that with 80% power, 5% significance level and at least a medium effect size (W= 0.30 or f=0.20), 100 patients per group were sufficient [7]. Seventeen schools, located in two different regions of the rain forest and selected from the database of the Medical Mission, participated in the study. Ethical clearance was obtained from the Director of the Suriname Ministry of Health. All schools were informed about the study and the objectives. The teachers were obligated to inform the parents. The parents or the teacher, in case the parents were illiterate, gave their approval for participation of a child by signing an informed consent letter. Without this approval, children were excluded from the study.

Oral examination and oral health parameters

Oral examination, using a headlamp, mouth mirror and dental probe, took place in the classroom whilst the child was lying on a table. Parameters for oral health were defined as caries prevalence, caries increment, sequela to dental caries and the presence of dental pain. The criteria of the World Health Organisation (WHO) were used for the assessment of caries in the deciduous dentition [45]. To ensure that criteria were followed, all children were examined by one of the authors (MGS) who was calibrated with a gold standard (kappa 0.89). This gold standard was developed by consensus between two experienced investigators, using the WHO criteria, for 25 pictures of molars with and without dentine carious lesions. Caries prevalence was measured using the decayed, missing and filled teeth (dmft) index [45]. In case a carious lesion had progressed into the dental pulp or when pulpal exposure could rationally be expected following total excavation, the tooth was marked on the dental chart as "pulp". Abscesses and/or fistulas (AbFi) as a result of this dentogenic infection were indicated, as was the presence of root remnants (RR). Dental pain was assessed by self report.

Randomisation and treatment groups

The children were collected from their classroom by one of the participating health-care workers (HCWs) who was not familiar with the sequence of group allocation of the children. Upon entrance, the children received a number which corresponded with a specific group number on a computerised random list that was in the possession of the dentist who performed the oral examination of the children (MGS). In this way, all children were randomly assigned to four different treatment groups. Children in group 1 received full dental treatment of their primary dentition: all cavities that did not show signs of dentogenic infection nor gave rise to any pain complaints were restored according to the atraumatic restorative treatment (ART) approach [13]. Teeth with deep carious lesions, where pulpal exposure was likely to be expected in case of total excavation, were extracted. Children in group 2 did not receive any restorative care. Only carious primary teeth with pulpal involvement were extracted. Children in group 3 only received ART restorative care of cavities that did not show pulpal involvement, while deep caries lesions were left untreated. Children in group 4 received neither restorative treatment nor extraction of any of their carious primary teeth. In all groups, cavities in permanent molars were restored according to the ART approach. When a child reported dental pain

and the perpetrating tooth was not involved in the initial treatment plan, they were treated by extraction, irrespective the treatment group.

Dental treatment

Treatment plans were made by the dentist who performed the initial oral examination (MGS). Thereafter, the children were allocated sequentially to one of the four other dentists who performed the prescribed dental treatments. These Dutch dentists were extensively trained in ART prior to the study. Six Suriname medical HCWs, selected by the Medical Mission of Suriname, assisted the dentists during the treatment. These HCWs graduated an ART Master class prior to the initiation of the project. Dental treatments were carried out in an unoccupied classroom.

Evaluation

Six months (T1), 1 (T2), 2 (T3) and 3 years (T4) after their initial visit and dental treatment, the children were evaluated. During these evaluations, the same examiner (MGS) recorded the dental status of the children as described earlier. Dental treatments were performed by other dentists immediately after the evaluations according to the allocated group. Children that were absent at an evaluation could reappear on the next evaluation and were not regarded as lost to follow-up. When a child had missed three or more evaluation visits, he or she was excluded from the study. From the first evaluation, all children received classical oral health instructions and dietary advices. These instructions were given by the HCWs and repeated on every evaluation visit. Teachers were stimulated to repeat the classical oral health instructions during their daily classes.

Statistical analysis

Statistical analyses were performed using SPSS for Windows, version 12.0.1. All significant differences were detected at a 95% confidence level.

Results

Study population

The study started in February 2001. The original sample consisted of 490 children (mean age 6.1 years, SD 0.5, range 5.1–7.1). The flowchart in Fig. 1 represents details about the enrolment and allocation of the children. At the enrolment, 76 children were excluded because they appeared to be free of dental decay. Thirty-four children were excluded from the study after the group allocation, two because they showed a contributory medical history and 32 because they had received dental treatment before. The remaining 380 children showed an equal distribution of males (192) and females (188) over the four treatment groups (χ^2=4.21, df=3, p=0.24), and no differences in mean age amongst the groups were seen ($F_{(3,376)}$=0.43, p=0.73). The demographic characteristics of the sample are presented in Table 1.

During the course of the study, an increasing dropout was seen, though equally distributed among the different groups at each evaluation as proven by non-significant chi-square tests.

A total of 25 children (6.6%) did not show up at three or more evaluations, and they where considered lost to follow-up. The main reasons for absence were illness, moving to another district, or work of the parents in the fields.

Caries prevalence

The caries prevalence in the deciduous dentition of the children is presented in Table 1. Because dmft showed a skewed distribution, it was regarded as a non-parametric variable. None of the participating children received any form of dental treatment prior to this study; the baseline dmft consisted of the decayed factor only. A Kruskall–Wallis (KW) test showed a statistically significant difference in caries prevalence in the primary dentition between the four treatment groups at baseline (p_{dmft}=0.024). Post hoc Mann–Whitney U (MWU) tests showed that children in group 3 had a significantly lower dmft than children in group 4 (p=0.002).

Through the course of the study, the caries experience in the primary dentition in the four treatment groups showed various trends (Fig. 2). Separate Friedman tests indicated that within each group, the dmft scores differed significantly between all time points, except in group 1 ($p_{(\mathrm{group2})}$=0.001, $p_{(\mathrm{group3})}$=0.013, $p_{(\mathrm{group4})}$<0.001). Post hoc Wilcoxon Signed Ranks (WSR) tests were performed to describe the dmft changes between all time points separately for all four groups. Table 2 shows the statistically significant p values. Attention should be paid to the overall drop in dmft that was observed between T3 and T4 (Fig. 2). Given the fact that Negro children show an earlier eruption pattern than Caucasians [28], exfoliation is very likely to have accounted for this pattern. To correct for possible bias, the authors choose to take T3 as the last evaluation time point instead of T4. Between T0 and T3, an increase in dmft is observed in group 3 (p<0.001).

Dentogenic infections

The presence of dentogenic infections at T0 and T3 is presented in Table 3. KW test showed significant differ-

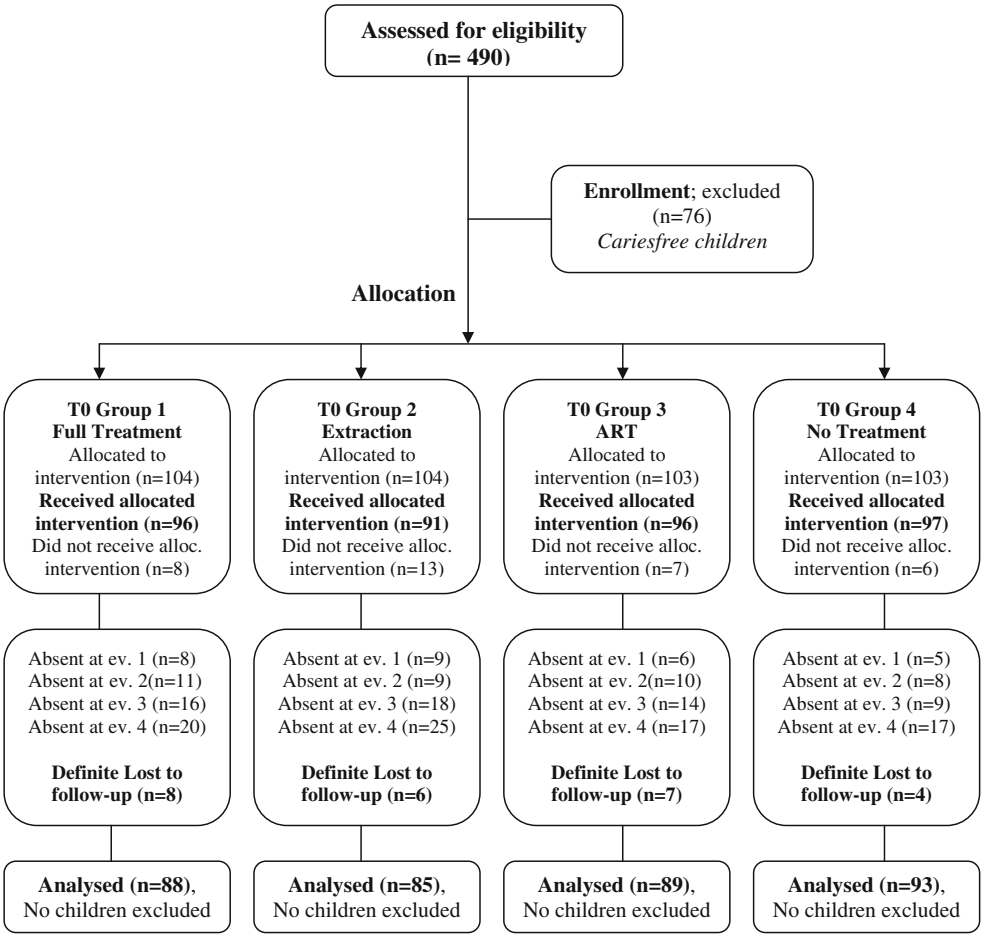

Fig. 1 CONSORT flowchart study population

ences between the four treatment groups regarding the mean number of carious teeth with "pulp" at baseline (p=0.044). Post hoc MWU tests showed that children in group 3 presented less "pulp" compared to children in group 1 (p=0.047) and children in group 2 (p=0.005). WSR tests showed that from T0 to T3, the mean number of carious teeth with suspected pulp involvement decreased significantly in groups 1 and 2 (p<0.001). An increase was seen in group 4 (p=0.002).

The presence of RR and AbFi showed a skewed distribution, and therefore, these variables were dichotomised into "not present" or "one or more present". At T0, 67.1% of the children (255) had one or more carious lesions which had advanced into the dental pulp. From these 255 children, 77 (30.2%) had one or more AbFi, and 30 (11.8%) had one or more RR. Pearson chi-square tests showed no significant differences between the four treatment groups regarding the presence or absence of RR (χ^2=6.61, df=3, p=0.086) or AbFi (χ^2=6.68, df=3, p=0.083) at baseline. McNemar tests showed that during the course of the study (T0-T3), the number of children that had one or more AbFi decreased in groups 1 and 2 ($p_{(group1)}$=0.021, $p_{(group2)}$<0.001), whereas an increase was observed in group 4 (p=0.031). The number of children that had one or more RR decreased in groups 1 and 2 ($p_{(group1)}$=0.004, $p_{(group2)}$=0.006) and increased in groups 3 and 4 ($p_{(groups3,4)}$<0.001).

Table 1 Demographic characteristics of the study population and caries prevalence at baseline

Group	1, Full treatment	2, Extraction	3, ART	4, No treatment	Total
All combined (n)	96	91	96	97	380
Sex (n)					
Male (%)	53 (55.2)	50 (54.9)	48 (50)	41 (42.3)	192 (48.6)
Female (%)	43 (44.8)	41 (45.1)	48 (50)	56 (57.7)	188 (51.4)
Mean age (SD, range)	6.11 (0.51, 5.12–7.06)	6.15 (0.48, 5.12–7.05)	6.07 (0.45, 5.15–7.09)	6.11 (0.48, 5.11–7.05)	6.09 (0.48, 5.11–7.09)
Mean dmft	6.42 (3.76, 1–17)	6.30 (3.23, 1–17)	5.48 (3.20, 0–16)	6.86 (3.37, 1–18)	6.26 (3.42, 0–18)

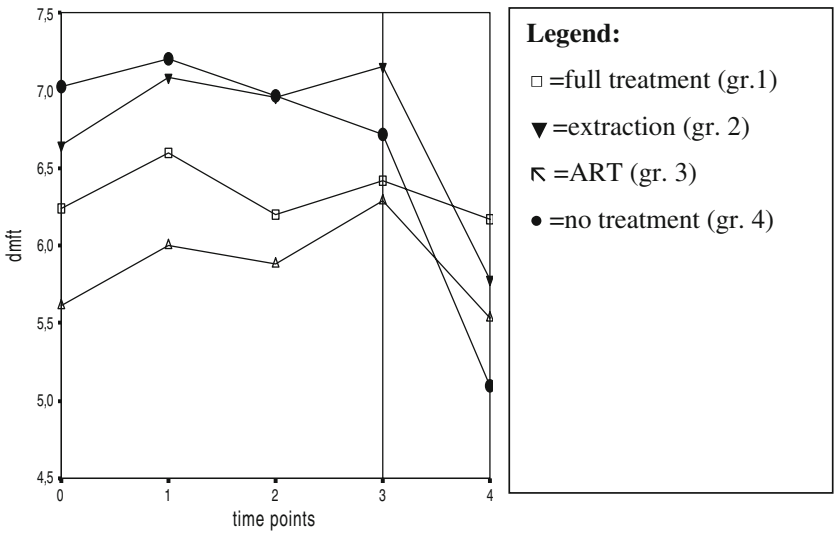

Fig. 2 Caries prevalence trends in the primary dentition per treatment group

Discussion

This study indicated that when only ART is performed in the primary dentition, a caries increment is seen. Full dental treatment, performing only extractions or no treatment, did not bring about significant changes in the caries prevalence of children.

In this study, dmft showed a skewed distribution and was regarded as a non-parametric variable. Consequently, only a comparison of variables between different groups at one time point or a comparison of the variables at different time points within one group was possible. For the purpose of this study, the latter comparison was preferred.

During the course of the study, only 25 children (6.6%) were lost to follow-up. This percentage is very low regarding the field conditions, and the effect on the power of the study is considered negligible.

Regarding the caries prevalence in the primary dentition at baseline, significant differences between the four treatment groups were observed that were regarded as a consequence of the randomisation. All children vary in their caries risk profile, not only based on different dietary habits or former caries experience but also due to a genetic variance in susceptibility to develop dental decay [6, 34]. Although a baseline disproportion of caries prevalence between groups is undesirable in a randomised controlled trial [18], in the current study it is considered to have had no or negligible influence on the results, whereas the trends in caries prevalence are described and evaluated per group separately, and no statistical comparisons between the groups were made, as stated in paragraph 2 of this discussion.

The current study lacks a true double-blind evaluation, whereas the same examiner performed the randomisation and the evaluations. Although the treatment group was not visible on the dental chart of the patient, any examiner could have identified the child's allocated group due to the treatment of the dentition. The examiner was not aware of information upon which dentist had performed the treatment.

As stated in the introduction, appropriate oral health care should comprise the prevention of new dental decay, the prevention of progression of carious lesions, the prevention of pain and discomfort for children, and the prevention of early loss of deciduous teeth. When the treatment strategies from this study are evaluated in the light of these clinical measures, one might conclude that both full treatment and performing only extractions fulfill three of the four objectives and can thus be regarded as the most effective treatment strategies with regard to oral health. In both treatment groups, no significant changes in caries preva-

Table 2 Results of the post hoc Wilcoxon signed rank tests, regarding the changes in caries experience between the various time intervals per treatment group (*p* values)

	Group	T0–T1	T1–T2	T2–T3	T3–T4	T0–T3	T0–T4
dmft	1	n.s.	0.023 ↓	n.s.	n.s.	n.s.	n.s.
	2	n.s.	n.s.	n.s.	<0.001 ↓	n.s.	0.012 ↓
	3	0.001 ↑	n.s.	0.018 ↑	n.s.	<0.001 ↑	n.s.
	4	n.s.	n.s.	n.s.	<0.001 ↓	n.s.	<0.001 ↓

n.s. Not statistically significant, ↑ increase in dmft, ↓ decrease in dmft

Table 3 Overview of the presence of dentogenic infections at T0 and T3: pulpal lesions (pulp) occurring in the study population, subdivided into present AbFi and RR

Group	1, Full treatment	2, Extraction	3, ART	4, No treatment	Total
T0					
N (total population)	96	91	96	97	380
Mean number of pulp (SD, range)	2.40 (2.56, 0–11)	2.59[a] (2.49, 0–10)	1.74[a] (2.23, 0–11)	2.21 (2.51, 0–10)	2.23 (2.46, 0–11)
N (children with pulp >0)	68	68	57	62	255
N 1/more AbFi present (% from children with pulp >0)	17 (25)	25 (36.8)	22 (38.6)	13 (21)	77 (30.2)
n 1/more RR present (% from children with pulp >0)	9 (13.2)	13 (19.1)	4 (7)	4 (6.5)	30 (11.8)
T3					
N (total population)	80	73	82	88	323
Mean number of pulp (SD, range)	0.18 (0.38, 0–1)	0.29 (0.70, 0–4)	1.84 (2.02, 0–10)	3.14 (2.41, 0–10)	1.43 (2.07, 0–10)
N (children with pulp >0)	14	14	55	73	156
N 1/more AbFi present (% from children with pulp >0)	4 (28.6)	1 (7.1)	17 (31.5)	25 (34.2)	48 (30.2)
n 1/more RR present (% from children with pulp >0)	0	1 (7.1)	23 (42.6)	19 (26)	43 (27)

[a] Statistically significant difference between groups at baseline

lence were observed, and the number of dentogenic infections decreased significantly which indicates that progression of lesions was controlled adequately. Moreover, pain and discomfort as a consequence of dental decay were prevented.

The fourth objective, the prevention of early loss of deciduous teeth, could not be met in either of these two strategies. In this study, extraction was indicated when a carious lesion had progressed onto the dental pulp. The diagnosis of existing or suspected dentogenic infection is difficult to assess based upon the clinical aspect of the lesion alone. The use of intra-oral radiographs is advisable, but unfortunately these were not available in the current study given the field conditions. In advanced general practices, various restorative options for the treatment of deep dental decay are advised [11, 15-18, 27, 28], which could not be performed under remote field circumstances.

Many controversies exist regarding extraction of primary teeth. Premature loss of primary molars can cause space problems such as tipping of the first permanent molars, crowding in the dental arch and impaction of the permanent predecessor [8, 30]. In the current study, no effect of the various dental treatments could be found on the dental arch measures (data not shown), but further investigation upon this subject is required.

Through the course of the study, the caries experience in the primary dentition in the four treatment groups showed various trends (Fig. 2). However, an overall caries increment was seen from T0 to T1. Although this increment was only statistically significant for children in the ART group, this is a strange phenomenon. A possible explanation might be that carious lesions that were initially unrecognised developed into visible defects. The chance for this to happen is highest during the first half year.

In this study, children in the ART group showed an increase in caries prevalence. Restorative treatment leaves the risk for new decay, either secondary caries along the margins of a restoration or new decay on originally sound tooth surfaces. Moreover, caries can develop on adjacent surfaces that were damaged during preparation [23]. In this study, only 4% of the ART restorations in the primary dentition failed due to secondary caries [43] which suggests that the greater part of the caries increment is probably due to new dental decay.

The clinical relevance of the results of this study goes beyond the interests of this specific Suriname population. In fact, it should be considered in any other situation where due to situational, economical, psychological or practical circumstances, choices have to be made regarding the most suitable treatment option with the most optimal prognosis under the given conditions.

Conclusion

Full dental treatment might be the treatment strategy of choice whenever uniform oral health care programmes are developed. However, when priorities have to be established

due to situational, practical or economical reasons, extraction of severely decayed teeth appears to be an effective treatment strategy.

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