Effect of dental caries and treatment strategies on oral and general health in children
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General Discussion and Conclusions
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The aim of this thesis was to establish the effects of dental caries and dental treatment on the general health of children. More insight in this relationship would rationalize the optimal treatment strategy for caries in the primary dentition. Especially for less privileged countries where priorities in health care have to be made, a negative systemic effect of dental caries might place dental health care in a more prominent position.

The results of this study are compiled in the seven preceding chapters, each comprising one sub study. Before overall conclusions can be drawn, based on the results of these different sub studies, below some general considerations are discussed that are considered important for a proper interpretation of the overall study.

Population and study design

In general, environmental conditions are highly decisive for the course of the project. Although all efforts were undertaken to adhere to the protocol, unexpected and unpredicted circumstances inevitably required some flexibility. On the other hand, field studies in general suffer from the same possible biasing elements.

Another aspect that should be included in this general discussion is the population type involved. The Surinamese child population differs substantially from other, for example Asian or Caucasian populations. These differences include caries prevalence, behavioural aspects during dental treatments, dietary habits but also ethical demands. The results of the presented studies are therefore not necessarily the same for other population groups, who live in different countries or communities.

This study was performed in the rain forested Interior of Suriname. The advantage of such a rural environment is that it harbours a child population that has no or very little dental experience. On the other hand, it does bring certain limitations. Regarding the examination of the blood samples, for example, some valuable determinations were not carried out because necessary equipment or storage possibilities were not available.

Furthermore, due to the absence of electricity, no intraoral radiographs could be taken, which means that one possible diagnostic tool for the examination of dental caries is excluded [40]. Although it is well established and universally taught that diagnosis of dental caries, whether in the dental office, or during a field survey, should be carried out by visual examination of tooth surfaces, using a mouth mirror and perhaps a dental probe. This method has also been recognized by the World Health Organization [55]. Clinicians do not generally recognize this method as being perfect [26, 27, 44]. However, in a representative systematic review it was shown that, for proximal surfaces, radiographs had an overall sensitivity of 50% and a specificity of 87% [3]. The surplus value of radiographs can thus be disputed and the lack of it in the current study...
was therefore not regarded as a substantial shortcoming. Moreover, a possible underestimation of dental decay would be the same for all participating subjects, at all evaluation time points because one calibrated dentists performed all the examinations.

**Dental treatment strategies**

Within the Basic Package of Oral Care (BPOC), extractions are prescribed in case of dental pain. However, the BPOC does not suggest a valid tool to assess dental pain. Pain is a very subjective indicator for dental treatment. Moreover, pain is a complex, multidimensional emotion and therefore its objective assessment is challenging [4, 16, 49, 50, 52]. Pain experience, pain perception and pain behaviour differ between individuals. Studies indicated an ethnic variation in pain response as well [7, 10, 33, 43]. In the current study, dental pain was only assessed by self report of the children. Although this method has a proven validity [51], other measures for a reliable pain assessment could have been included in the study. However, the currently available methods that have proven sufficiently high sensitivity and specificity, such as the Dental Discomfort Questionnaire [49, 50], can generally not be implemented in primary oral health care programs due to practical reasons such as the illiteracy of the population involved. Emphasis should be placed however, on the applicability of a simple diagnostic tool, for example the visual analogue scale of facial expressions [4, 53], for the clinical observational assessment of dental pain within the perspectives of primary oral health care. The age of the patient and his or her cognitive abilities should be encountered.

In chapter 3 it has been described that, with respect to the oral health of children, a comprehensive dental treatment was preferred. Appropriate oral health care should at least 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. When caries has already progressed into the dental pulp of primary teeth, the latter objective can generally not be fulfilled. Especially under field conditions, extraction of deeply carious teeth is often inevitable. Moreover, when dental infection has led to the formation of dental abscesses and/or fistulae, extraction should not be left undone, with respect to the serious consequences these infections can have. Besides damage on the developing permanent teeth, brain abscesses, orbital cellulitis and recurrent fever have been ascribed to chronic dental abscesses [39].

However, when the pulp has not yet been infected, many other treatment options are available, even under field conditions. Atraumatic Restorative Treatment (ART) is suggested as the restorative treatment method of choice within the BPOC. Therefore, ART was also included in the current study. This minimal invasive treatment strategy has been proven a valuable restorative method and since its introduction in the mid-1980s, it has saved many carious teeth from early extraction [17-19, 22, 30, 38]. However, in the current study, the success of ART appears to be very low. Children that
receive ART restorative care are somehow prone to develop more new dental decay [chapter 4] and ART restorations perform extremely bad under the Suriname conditions [chapter 3]. Apparently, ART seems to be not suitable in every situation. The variable success of ART limits its indication area and should initiate further discussion about alternative treatment strategies, especially in those situations where choices have to be made with respect to a well-balanced cost-effective package of basic oral care.

A widely accepted treatment method for carious primary molars involving two or more surfaces is the placement of preformed metal crowns [15, 41, 42]. The novel variant to this method is the Hall technique: preformed metal crowns are cemented, using Glass Ionomer, directly over the carious primary molar without local anaesthesia, and without caries removal or tooth preparation. The Hall technique offers an effective treatment option for managing dental caries in primary molars and clinical trials have shown the technique to be effective, and well accepted by the majority of children, parents and clinicians [23-25].

Non-operative treatment strategies should also be considered. Although it might not be possible to predict dental caries, studies have indicated that it is possible to control the disease by the single use of preventive measures [1, 2, 8, 32, 35]. New knowledge of caries progression rates has led to substantial modification of restorative intervention thresholds and further handling of the disease. New diagnostic tools for caries lesion detection, caries risk assessment and focussed preventive treatments have decreased the need for early restorative interventions [9, 12, 13, 36, 54]. Overall, dentists are encouraged to use a more conservative and biological approach which means that secondary prevention and treatment should focus on management of the caries process over time for individual patients, with a minimally invasive, tissue-preserving approach [44].

**Primary prevention**

Based on the results of this study, it might be concluded that, although dental treatment is beneficial to oral health [Chapter 4], regarding general health there seems to be no evidence that general health conditions improve by dental intervention [Chapter 5 and 7]. Dental caries is a chronic infectious disease that can be controlled but not be eradicated, at least not with the treatment strategies that were applied in this particular project.

The only way to rule out possible systemic effects of dental decay seems to be the primary prevention of dental caries. Dental caries should not be given a chance to develop. Oral health education should be given prior to the eruption of the primary teeth. In other words, parents, and mothers in particular, should be educated in maintaining good oral health for their children and receive adequate dietary advices. This finding is in line with other studies. Thylstrup and co-workers concluded that early diagnosis of dental caries followed by appropriate non-operative treatment was the key to better oral health [47, 48]. An individualized, non-operative caries treatment strategy that was implemented in Nexø in 1987/91, based on these principles, proved...
to be highly effective [11]. A significant caries preventive effect of parental, and in particular maternal, education has been found in this Nexø-project and was confirmed in other studies [28, 29]. Within the Nexø-project, children receive individualized non-operative dental care, according to their individual caries risk. However, when high caries risk populations are involved, individual caries risk assessments are less important. Primary preventive measures should then be community-based and integrated into other health prevention programs based on the common risk factors of oral and other non-communicable chronic diseases. Oral hygiene could be implemented together with general hygiene measures such as cutting nails and washing hands. The WHO has designed approaches for the integration of oral disease prevention within the prevention of non-communicable chronic diseases, and global strategies are currently being implemented in all regions of the world [37]. Dietary advice and oral health instructions should be given, taking local environmental conditions, dietary habits and available materials, into account.

**Relationship oral and systemic health and disease**

In the current study, it was found that children with high levels of dental caries were significantly shorter than children with lower caries levels [Chapter 5]. Moreover, in children that showed severe dental decay with concomitant signs of dentogenic infection, a systemic response was observed in terms of elevated serum levels of C-reactive protein and neopterin [Chapter 7]. The finding that dental intervention did not bring about an improvement in general health, according to the outcome measures of this study, underlines that other factors are co-determining general health conditions. General health is a multifactorial construct. In this study, only a few parameters were included. These parameters were chosen on the basis of earlier studies and with regard to the feasibility within the limitations of the rural conditions. A possible bias from, for example, co-occurring infectious diseases or malnutrition cannot be ruled out. However, it is questionable if any future study would be able to determine systemic effects that can exclusively be ascribed to the occurrence of dental decay.

In the current study, a genetically determined susceptibility for the formation of abscesses and/or fistulae as a result of dental caries was found. In chapter 7 it was described that the presence of a *CD14*-260:TT genotype was protective for the formation of abscesses and/or fistulae. It was therefore suggested that infection of the dental pulp would benefit from an up-regulation of immune factors such as *CD14*, resulting in a faster clearance of the bacterial products. Children who have the genotype *CD14*-260:TT are genetically protected to the formation of abscesses or fistulae as a consequence of severe dental caries compared to the *CD14*-260:CC or CT genotypes.

Nowadays dentistry follows the principles of evidence-based practice whereby risk assessment is an important component [20]. Based on scientifically determined risk factors, an individual’s probability of acquiring a disease could be assessed. Apart from environmental factors, genetic
factors are found to have an important contribution to dental caries progression and severity [5, 6, 21, 45]. Further studies on this subject should be undertaken.

In understanding the potential effects of oral disease on systemic health, it is important to consider a broader construct of health beyond that defined by just biomedical status [20]. The health-related quality of life of patients, comprises both clinician-based, and patient’s own subjective, assessments of his or her well-being and daily functioning. Thomas et al. [2002] failed to prove a relation between rampant caries and body growth, but reported a significant improvement, as reported by their parents, in the quality of life of the children after dental treatment. This finding is supported by other studies [31, 50]. However, due to a lack of consistency in the definition and measurement, literature shows a fragmented vision of the relation between oral health and quality of life [34]. Future studies should elaborate this subject before final conclusions can be drawn regarding the priority of oral care within general health care programs.

Conclusions

The aim of this thesis was to establish the relation between dental caries and general health in children. Primary outcome measures were systemic immune response and body growth. Based on the current study, the following conclusions can be drawn:

- **Atraumatic Restorative Treatment (ART)** is a valuable, minimal invasive treatment method for dental caries. It renders less discomfort to the children, compared to minimal intervention methods whereby rotary instruments are used. However, the success of the ART restorations is very variable. In this Suriname study, extremely low survival rates for single- and two-surface ART restorations in the primary and permanent dentitions were found. Furthermore it was found that children that received only restorative care (ART), showed a significantly higher caries increment, compared to children that were treated according to other strategies. The variable success for ART should initiate further discussions about alternative treatment strategies, especially in those situations where choices have to be made with respect to a well-balanced, cost-effective package of basic oral health care.

- Regarding **Oral Health**, full dental treatment (prevention, restorative care and extractions) 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.
Instead of ART restorative care, other minimal invasive or non-operative treatment options should be considered, thereby taking environmental conditions, patient related factors, and cavity size or location into account.

- Regarding **General Health**, severe dental caries can generate a systemic immune response. Moreover, dental caries was found to be inversely correlated with body proportions in this Surinamese child population. No significant effect of dental caries treatment was found on serum parameters and invasive dental treatment did not show a significant influence on the growth pattern of the Suriname children either. With respect to these results, it is suggested that caries activity is a negative predictor for body growth in children. Based on this, it is hypothesized that caries prevention, rather than caries treatment, benefits general health. Indications for a genetically determined susceptibility for the formation of abscesses and/or fistulae as a result of dental caries are found in this study. These results can have substantial implications for an individual risk assessment regarding the systemic impact of dental decay and could thus be decisive in the determination of a suitable treatment strategy.

**Overall Conclusion**
It has been well established in earlier studies that oral health has an impact on general health and vice versa. The results of the current study do not invalidate this statement. Treatment of dental decay does not only favour the oral health of children, as described in this thesis, it also improves their quality of life. Therefore, it is of prime importance that oral health care is integrated into primary health care. However, based on the outcome parameters used in this thesis, caries treatment does not seem to benefit general health, from a merely biomedical point of view. Therefore, the (Basic) Oral Health Care Programs should focus on the prevention of dental disease rather than on its cure. However, as long as there is no clear evidence that teeth with abscesses or fistulae can be left in the mouth without negative consequences, they should better be removed.

**Directions for future research**
- Future studies upon the relationship between dental caries and systemic health should focus on different populations; varying in ethnic background, dietary habits and caries experience. Particularly on populations with higher caries prevalence and incidence.
- Include pain assessment instruments.
- Include valid Quality of Life measurements.
- Include other, or more, systemic parameters and genetic factors.

The collective outcomes of these studies, could serve as an evidence-based foundation to plan adequate, efficient and effective oral health care for children.
References


