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Patterns and Outcomes of Restorative Treatment in Primary Teeth in Germany

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1. Introduction

1.1 Caries Epidemiology

Dental caries is a localized, irreversible and complex disease of calcified tooth tissue, initiated on the tooth surface by destruction and decalcification of the tooth's enamel followed by enzymatic lysis of organic structures, leading to cavity formation that, if left untreated, penetrates the enamel and dentin and may reach the pulp [Roberson and Lundeen 2002, Sivapathasundaram and Raghu 2009]. Caries progression and pulpal pathology result in pain and complicated dental treatment is necessary [Roberson and Lundeen 2002, Kidd et al. 2008].

According to the World Health Organization Oral Health Data Bank, over the past decades, many epidemiological studies documented a decline in dental caries prevalence among children in the majority of developed countries [WHO 2000]. This pattern of change is considered the result of effective public health measures, including several factors of which the most important are improved oral hygiene, a more sensible approach to sugar consumption, effective use of fluorides and establishment of school-based oral health preventive programmes, coupled with changing living conditions, healthy life styles and improved self-care practices and improved access to dental care [WHO 2000, WHO 2010]. Contrary to this development, increasing levels of dental caries have been found in some developing countries, especially for those countries where preventive programmes have not been established [Petersen and Razanamihaja 1996, WHO 2000].

Despite the caries decline, dental caries remains a major public health problem and one of the most common diseases in humans. Even with promising changes that were achieved by health promotion and disease prevention programs, it must be stressed that dental caries, as a disease, is not eradicated but only controlled to a certain degree and dental restorations are still needed [WHO 2000, Ismail et al. 2001].

1.2 Dental Restorations, History, Definition, Properties

With the second industrial revolution era of human history which took place in Europe and the United States in the middle of nineteenth century [Ismail et al. 2001, Gladwin and Bagby 2009], major advances in understanding the biology and pathology of diseases in humans started to emerge. During this time, dentists were confronted with increasing demand to conserve teeth from the damaging effects of dental caries; and the field of restorative dentistry benefited significantly from the revolutionary advances in new dental materials and the invention of the dental air turbine handpiece in 1946 [Ismail et al. 2001, Gladwin and Bagby 2009]. These advances have led to the provision of sophisticated restorative care through removal of demineralized enamel or dentin and through use of synthetic materials which, consequently, led to the saving of teeth [Bayne et al. 2002, Gladwin and Bagby 2009].

A dental restoration or dental filling is a dental restorative material designed to repair or replace tooth structure to restore the function, integrity and morphology of missing tooth structure, and consists of all synthetic components including adhesive agents, liners, cement bases, amalgam, resin-based composites, compomers, hybrid ionomers, cast metals, metal-ceramics, ceramics and denture polymers. The structural loss typically results from caries or external trauma. It can also be removed intentionally during tooth preparation to improve the aesthetics or the physical integrity of the intended restorative material [Anusaice 2003, Gladwin and Bagby 2009].

When the restorative treatment is required, dental professionals attempt to restore destructive dental tissue with dental material. The substituting restorative material should mimic the replaced dental tissue in all aspects, including the function, morphology and the ability to withstand the same harsh surrounding oral environment [Combe 1986, Gladwin and Bagby 2009].

It is of utmost importance for the successful selection of replacement material to understand what effects the material will have on its environment and what effects the oral environment have on the replacement material. Therefore, based on the material's interactions with its environment, the dental material science divided the material properties into four categories [Combe 1986, Anusaice 2003, Powers and Wataha 2008]:

- Mechanical properties: describe a material's ability to resist forces, such as biting forces that may fracture teeth and replacement material

- Physical properties: describe interactions of a material with its environment, such as temperature changes that cause restoration to contract and expand differently than teeth, causing leakage around the restoration, as well as tooth sensitivity
- Biological properties: describe the effects of the materials on living tissue, such as biocompatibility
- Chemical properties: describe the setting reactions as well as the decay or degradation of materials, such as metal corrosion

Unfortunately, the ideal restorative material that has characteristics identical to those of the natural tooth structure does not exist and usually a compromise regarding one or more of these properties cannot be avoided. The extent to which these properties can be compromised depends on what the requirements are for a particular restoration, for a particular tooth and patient. Typically, in practice, determining what is required and what best meets the clinical situation is a complex decision [Bayne et al. 2002, Gladwin and Bagby 2009].

1.3 Restorative Dentistry for Children

Restorative treatment for children's teeth is still an important aspect of dentistry, since caries remains a significant oral health problem; the treatment should be executed at the highest standard possible [WHO 2000, Ismail et al. 2001]. It has been reported that in Germany only 53% of primary teeth caries is treated in 5- to 6-year-olds [DAJ 2010], and other findings from the UK showed the care index in 11-year-old children was approximately 41% on average but could be as low as 20% in some parts of the country, and the figures are much worse for primary teeth in 5-year-old children and can be as low as 10-12%, dropping as low as 5% in some areas [Pitts et al. 2005, Pitts et al. 2006].

Untreated dental caries in children's dentition can lead to pain and infection which may be detrimental to the general health of children. This may include interference with nutrition, loss of sleep, behavioural disturbance and poor aesthetics [Fayle et al. 2001, Sheiham 2006]. These results indicated very clearly the demand for treating caries to improve the quality of life of children and any general policy of non-intervention is wrong and unjustifiable [Duggal 2011].

This conclusion was adopted by the American Academy of Paediatric Dentistry guidelines to assist the practitioner in the restorative care of children. These guidelines state that the

objectives of restorative treatment are to repair or limit the damage from caries, protect and preserve the tooth structure, re-establish adequate function, restore aesthetics and provide ease in maintaining good oral hygiene; pulp vitality should be maintained whenever possible [AAPD 2007].

1.4 Factors Influencing the Success of Child Dental Restorative Therapy

Unfortunately, the long-term clinical restorative therapy success is attributable to diverse factors that related to the restored tooth itself, the patient, the clinician and the properties of the selected restorative materials [Mjör et al. 2000b, Manhart et al. 2004, Mejare et al. 2009, Goldstein 2010].

1.4.1 Extent of Caries and Strength of Remaining Tooth Structure

Literature review strongly recommends stainless steel crowns as treatment of choice when restoring primary and young permanent teeth that show extensive caries attack including multiple surfaces, in comparison to other materials available. The results of studies showed that the failure rate of stainless steel crowns after 5-years and more range between 12% and 0% [Messer and Levering 1988, Roberts and Sherriff 1990, Wong and Day 1990, Einwag and Dunninger 1996]. These numbers are explained by the properties of stainless steel crowns, which are extremely durable, with full crown coverage and relatively insensitive to oral condition during application [Seale 2002, AAPD 2007].

In spite of these advantages, the metal appearance of these crowns causes a problem with children's and parents' acceptance where aesthetics are concerned [Zimmerman et al. 2009]. Nowadays, veneered or open-faced crowns are available, but are more difficult to adapt to tooth structure and subject to fracture or loss of facing [Ram et al. 2003, Beattie et al. 2011].

However, in Roberts and Sherriff 10-years prospective evaluation, annual failure rate for class I amalgam restorations in primary teeth was 4.4% [Roberts and Sherriff 1990]. Another three-year longitudinal study reported that amalgam fillings in primary teeth had an annual failure rate that reached up to 5%, regardless the restoration class-types [Qvist et al. 1997]. In cases with large cavities and class II restorations where the proximal box is large and the intercuspal isthmus is narrow, amalgam fillings showed a high annual failure rate of 11.6% and values increased up to 33.4% after 5 years [Roberts and Sherriff 1990]. This data

indicated the suitability of amalgam fillings to restore the primary molar teeth with small-sized cavities, like in conventional class I/II that are expected to exfoliate within 1 to 2 years.

1.4.2 Clinician Capability

Child dental restoration therapy has been evaluated in many studies to clarify the role of dental practitioners in relation to success and failure of the therapy. Restorations survivals in primary molar teeth in Roberts and Sherriff study revealed that there is a lower annual failure rate of the amalgam restorations (class I=5.3%, class II=6.7%). In this study, the authors explain the amalgam failure rates results with the case selection or studied materials and also with the specialist rather than general practice setting [Roberts and Sherriff 1990].

There is a large body of evidence showing that stainless steel crows have excellent outcomes in restoring primary molars and, once completed, only seldom need replacing [Hickel et al. 2005, AAPD 2007, Kindelan et al. 2008]. In recent years in Indiana, USA and Manchester, UK, studies were conducted to evaluate utilization of stainless steel crowns by the general dentist in children with high caries rate. Unfortunately, the results imply that stainless steel crowns are significantly underutilized in general dental practice. Reasons given for not using stainless crowns were that they are inappropriate for many children, difficult to manipulate and that the dentists were not well trained in the use of this technique. This demonstrated that previous experience with a given technique and procedure is important for clinical success [Threlfall et al. 2005, Kowolik et al. 2007].

Next to the ability to perform dental therapy, mastering the clinical handling of dental materials is another factor mentioned by dental professionals that plays a role in the success of restorative therapy. A multicentre study, which was conducted in Sweden in 1997, evaluated the longevity of compomer class II restorations in primary teeth. The compomer material showed a high failure rate in this study with a large operator variation in failure rate, that is to say that dentists had different failure rates, which indicated the technique sensitivity of the study material [Andersson-Wenckert et al. 1997]. A 7-year randomized study in the Danish public dental health services compared the longevity of three resin modified glass ionomer cements and one compomer materials with and without their respective cavity conditioners. In the study, restored class II cavities in primary teeth placed by 15 clinicians were examined. The statistical analysis showed that the differences in longevity among the studied materials with and without conditioner were less than the intra-individual differences between clinicians; the clinician variable was more important in determining a successful

restoration outcome than the use of conditioner [Qvist et al. 2004b]. A systemically reviewed study on longevity of different restorations of class II cavities in primary molar teeth by Chadwick and Evans focusing on results for coloured restorations in primary teeth, showed a higher success rates when the restoration was conducted by specialist operator rather than a non-specialist; in other words, it showed that "some operators are better than others" [Chadwick and Evans 2007].

1.4.3 Primary and Permanent Teeth

Data from many practice-based studies documented that filling materials tend to have poorer prognosis when they are used to restore the primary teeth rather than the permanent teeth. The results of these studies covering success of dental restorations in both primary and permanent teeth are summarized in Table 1.

Table 1: Summary of practice-based studies on dental restorations survival in primary and permanent teeth

Authors, Publication year, Study place	Failed restoration number	Adult Permanent Teeth		Young Permanent Teeth		Primary Teeth	
		Amalgam	Colored fillings	Amalgam	Colored fillings	Amalgam	Colored fillings
Qvist et al., 1999a, Denmark	4,932	Median survival time > 8-yrs		Median survival time < 4-yrs		Median survival time < 2-yrs	
Qvist et al., 1999b, Denmark	2,542		Median survival time > 6-yrs		Median survival time < 2-yrs		Median survival time < 1-yr
Papathanasiou et al. 1994, UK	210					Median survival time > 5-yrs	C.(32-months) G.I.(12-months)
Wendt et al, 1998, Sweden	1,416			13% replacement		29% replacement, 4% extraction	
Alm et al., 2004, Sweden	214					31% replacement	
Mjör et al., 2000, Norway	11,800	Median survival time 11-yrs	C.(8-yrs) G.I.(3-yrs) R.M.G.I.(2-yrs)	Median survival time 5-yrs	C.(3-yrs) G.I.(2-yrs) R.M.G.I.(2-yrs)		
Mjör et al., 2002, Norway	2,281					Median survival time 3-yrs	Median survival time 3-yrs

C.; resin-based composite**, G.I.**; glass ionomer**, R.M.G.I.**; resin modified glass ionomer.

Of the studies in Table 1, cross-sectional surveys of restorative treatments in Denmark in 1990, found that half of the failed restorations in adult permanent teeth were more than 8 years old for amalgam, and 6 years old for composite and the corresponding numbers for permanent teeth in children up to 16 years old were 4 years old for amalgam and 2 years old for composite. In primary teeth, amalgam restorations showed shorter longevity than in permanent teeth and half of the tooth-colored restorations, mainly glass ionomer cements, were replaced within 1 year [Qvist et al. 1990a-b].

In a retrospective report by Papathanasiou and his colleagues, the survival rates of restorations in primary teeth were evaluated over a period of 2 years. Data were selected by use of multistage, stratified, a random sampling technique. In this study; the life table method of survival analysis showed that the median survival time for amalgam restorations was more than 5 years and the 5-year survival estimate was 60%. For tooth-colored restorations, the median survival time was 32 months for composite resin and 12 months for glass ionomer. The 4-year survival estimate was 40% and 5% for the restorations of composite resin and glass ionomer respectively [Papathanasiou et al. 1994].

Replacements of restorations in the primary and young permanent teeth in Sweden were studied in 1998. According to study design, data were extracted from 11 public dental health clinics and 6012 restoration records for 8-year- and 19-year-old children were evaluated. In 8-year-old children, the 5-year treatment period (from 3 to 8years of age) showed that in primary dentition, the most common restorative materials were compomer and glass ionomer cement, and 29% of the restorations had been replaced and 4% of the teeth with restorations had been extracted. Thus, 33% of the restorations in the primary dentition failed. In 19-year-old children, the 13year treatment period (from 6 to 19 years of age) showed that in young permanent dentition, the composite and amalgam were the most common restorative materials and 13% of the restorations had been replaced [Wendt et al. 1998]. A similar percentage of restoration replacement in primary teeth (31%) was also recorded in Alm et al.'s study. In this study, the aim was to investigate what treatments had been made in the primary teeth of 12-year-old Swedish children when the children were between 7- and 12-year-olds [Alm et al. 2004].

Two practice based studies in Norway analysed restoration replacements in permanent and primary teeth in general dental practices. The first published data reported that the median age of restorations in adult (above 18 years of age) permanent teeth that was 11 years for

amalgam, 8 years for composite resin, 4 years for glass ionomer and 2 years for resin modified glass ionomer, while for the permanent teeth of 18-year-old and younger patients a median age of 5 years for amalgam, 3 years for composite resin, 2 years for both glass ionomer restorations was recorded. In the second publication, the data showed that the median age of amalgam restorations in primary teeth was 3 years, and 2 years for tooth colored restorations [Mjör et al. 2000a, Mjör et al. 2002a].

The observed shorter life of restorative materials in primary teeth could be attributed in part to differences in tooth morphology between primary teeth and permanent teeth. The anatomical analysis showed that the mesiodistal diameter of a primary molar crown is greater than the cervicoocclusal dimension, and the buccal and lingual surfaces converge toward the occlusal. Also, the cervical enamel rods slope occlusally, ending abruptly at the cervix instead of being oriented gingivally, gradually becoming thinner as in permanent teeth [AAPD 2007]. Unfortunately, this affects the ability of these teeth to adequately support and retain restorations with this shorter clinical crown height. And this is clinically approved since the most frequent reasons for replacement of failed amalgam restorations in primary teeth were fracture and loss of fillings whereas secondary caries accounted as another main reason. In permanent teeth, the findings were reversed; secondary caries was the most frequent reason for replacement followed by marginal discrepancies and fracture of fillings [Qvist et al. 1990a].

It has been demonstrated in previously mentioned investigations that tooth-coloured restorations in primary dentition had higher failure rate compared to those in permanent teeth, and this inferiority in longevity is also noticeable when compared with amalgam restorations in similar teeth. This can be explained based on histological structure of primary teeth, which can affect adhesion and integrity of coloured restorations and eventually leads to microleakage, gap formations around restoration margins and filling loss with or without secondary caries.

The enamel of primary teeth was described as having a thin structure and thick prismless at the tooth surface in comparison to that of permanent teeth [Eisenmann 1994]. This property affects etching pattern and timing, because of the difference in mineral qualities and distributions and will eventually reduce the total surface area available for adhesion [Rontani et al. 2000].

In addition, dentin of primary teeth is different from that of permanent teeth; it has lower density and diameter of dentinal tubules with lower permeability [Koutsi et al. 1994]. This will cause incomplete infiltration of the adhesive resins with primary teeth dentin. Resin infiltration within dentinal tubules is responsible for formation of resin tags that will increase adhesive bonding strength through tubule wall hybridization, especially with new generations of adhesive agents [Meerbeek et al. 2001].

The calcium content in dentin structure is another factor which affects adhesive bond strengths. As dentin approaches the pulp, calcium level decreases which subsequently leads to lower bond strength [Bordin-Aykroyd et al. 1992]. Since primary teeth have relatively larger pulp and thinner dentin structure than permanent teeth, this may explain the lower bond strength of adhesive in primary teeth [Jumlongras and White 1997].

Additionally, It has also been reported that peritubular dentin of the primary teeth is two to five times thicker than that of the permanent teeth [Hirayama 1990]. Since an increase in thickness of peritubular dentin leads to a decrease in available amount of intertubular dentin, which presents the primary area where bonding occurs, this could explain why the primary teeth display a thinner hybrid layer with dentin adhesive agents compared to permanent teeth [Jumlongras and White 1997, El Kalla and Garcia-Godoy 1998].

The peritubular dentin is hypermineralized tissue and is relatively resistant to acidic conditioning solutions and therefore, to increase resin penetration within this tissue, it is necessary to increase application time of conditioning solutions [Nor et al. 1996, Meerbeek et al. 2001]. Increasing conditioning time of dentin may cause demineralization of intertubular dentin down to a depth that might be inaccessible to complete resin penetration and this will dramatically weaken the hybrid layer that is another important parameter for the strength and durability of the resin-dentin bond [Sano et al. 1999, Meerbeek et al. 2001].

Based on the previously mentioned characteristics of enamel and dentin, in comparison to permanent teeth, primary teeth show less shear bond strength with adhesive systems and higher microleakage values with composite restorations [Jumlongras and White 1997, El Kalla and Garcia-Godoy 1998, Swift 1998].

1.4.4 Patient Characteristics: Cooperation, Oral Hygiene Status

The patient's age at restoration placement is usually mentioned as an important factor in the long-term clinical success of a restoration in primary teeth. Several authors found an average

longevity of less than 2 years for amalgam restorations in children 4 years old and younger. The lifespan of composite restorations in this age group dropped to only 1 year [Holland et al. 1986, Qvist et al. 1986a-b].

The high failure rate of filling restorations in primary teeth, especially in small children, could be related to a difficulty in children cooperation during operative procedures and its effect on moisture contamination of the cavities during the placement of the restorative material [Holland et al. 1986, Roberts and Sherriff 1990, Eidelman et al. 2000]. Therefore, it is emphasized that child cooperation is a crucial element during dental therapy, as it allows better moisture control and visual access and aids in proper tooth preparation and placement of the restoration [Papathanasiou et al. 1994].

Regardless of the restorative material or technique used, patient oral hygiene and dental caries history represent another patient-related factor influencing the restorative material's longevity. This is in agreement with reported data that the recurrent caries is one of the most frequently recorded reasons for replacement of failed restorations [Burke et al. 2001, Mjör et al. 2002b]; the overall range was between 25-50% of all recorded restoration replacements [Qvist et al. 1986a, Qvist et al. 1990a, Mjör et al. 2002a].

Several studies have found a statistically significant correlation between recurrent caries and poor patient oral hygiene and have concluded that the oral hygiene status has a strong effect on the risk of recurrent caries [Goldberg et al. 1981, Eriksen et al. 1986]. In their clinical evaluation of recurrent enamel caries, Goldberg et al. emphasized that the marginal restoration integrity coupled with conscientious oral hygiene increases the longevity of restorations and decreases the need for replacement [Goldberg et al. 1981]. Also, in another cross-sectional clinical study by Erikson et al. that assess the quality of amalgam restorations, oral health and prevalence of recurrent caries indicated that measures improving the oral health may be of major importance in preventing recurrent caries and thereby increase the durability of amalgam restorations [Eriksen et al. 1986].

In a long-term prospective study, class II amalgam fillings were made and evaluated focusing on the reasons for re-restoration which were either true failures, caused by poor restorative technique, or false failures, not caused by poor restorative technique. The study came to the conclusion, that the origin of the false failures was caries, which seemed to be more related to patient factors like caries activity, caries susceptibility and oral hygiene [Akerboom et al. 1993].

In addition, with conclusions from a study by Wendt et al., it appears that restorations often fail because of caries and that the development of secondary caries is not prevented by replacement of an old restoration. The study indicates that more attention should be paid to preventive dental care for patients with restorations in the primary, as well as in the young permanent dentition [Wendt et al. 1998].

1.4.5 Properties of Restorative Material

Recently, dental professionals have a wide range of materials available for restoring primary and young permanent dentitions. In addition to amalgam and preformed metal crowns or stainless steel crowns, glass polyalkenoate cements (GICs), resin-based composite, resin-modified glass ionomer cements (RMGICs) and polyacrylic acid modified composites (compomers) have become available [Berg 1998, AAPD 2007].

1.4.5.1 Dental Amalgam

For many decades, amalgam has been the standard restorative material in paediatric dentistry. Popularity of this metal filling material is founded in its properties [AAPD 2007]. Amalgam is strong and durable enough to withstand the pressure of chewing; it has a high wear resistance to preserve its anatomic form. It is also easy to place and more economic, that is to say relatively inexpensive for the patient [Levering and Messer 1988a-b, AAPD 2007].

One of the major reasons amalgam has long been the most widely used restorative material is its relatively low technique sensitivity compared to other dental restorative materials [Jordan 1991]. However, variations in mixing, placement, and contamination are not generally as critical as with most other restorative materials [Brackett et al. 1987]. It has been shown that moisture-contaminated amalgam may have reduced physical properties and a shorter lifespan, but still provides reasonable service [Letzel et al. 1989]. Amalgam was more often used in patients with high DMF-T value and caries activity [Vidnes-Kopperud et al. 2009].

Amalgam remains an appropriate choice of material for the restoration of the primary dentition. However, factors other than durability are increasingly influencing its use in clinical practice [Tran and Messer 2003, Kilpatrick and Neumann 2007]. Concerns about mercury toxicity, potential environmental pollution and aesthetics have decreased the use of amalgam in paediatric dentistry [Dodes 2001, AAPD 2007]. Improvement in adhesive restorative materials and restorative techniques have allowed more conservative cavity preparations, leading to minimized designs and a decrease in amalgam use, since these

amalgam restorations often require removal of healthy tooth structure to achieve adequate resistance and retention [Tran and Messer 2003, AAPD 2007].

1.4.5.2 Glass Ionomer Cement

These filling materials used most frequently as an alternative to dental amalgam for restorations in primary teeth [Qvist et al. 1990b, Wendt et al. 1998], have several properties that make them favourable to use in children, such as adhesion to tooth structure through chemical bonding while removing only a minimal amount of sound tooth substances. Also, their thermal expansion is similar to that of the tooth, they have good biocompatibility and a shade similar to that of the tooth [AAPD 2007]. Besides, these materials are very effective against caries attacks, especially in patients with high caries risk. The evidence showed that glass ionomers are able to uptake and release fluoride and that may produce a cariostatic action to the surrounding enamel and dentin, resulting in a tooth that is less susceptible to acid challenge [Tyas 1991, Tam et al. 1997, Forsten 1998].

Compared to resin materials, glass ionomers are hydrophilic and tolerate a moist environment [Quackenbush et al. 1998], exhibit significantly less polymerization shrinkage with relatively less technique sensitivity, meaning a simplified application [Tolidis et al. 1998, Beznos 2001]. These advantages make glass ionomer materials one of the options for uncooperative patients or patients with special health care needs for whom traditional cavity preparation and/or placement of traditional dental restorations are not feasible or need to be postponed [Yao et al. 1990, Zanata et al. 2003].

Although glass ionomer cements have many attractive features, it was evident that early generations of glass ionomer restorations are brittle and underwent greater loss of anatomical form with both erosion or wear forces and are consequently not an appropriate alternative to amalgam, especially in load- bearing restorations areas. As clinical studies proved, this is particularly true for conventional and metal-modified glass ionomer cements; both materials recorded high annual failure rates in class I (17%) and class II (25.8%). Qvist et al. reported a failure rate of 37% after 3 years and up to 60% according to another study by Ostlund et al. [Ostlund et al. 1992, Qvist et al. 1997].

This poor long-term performance likely depends on chemical composition of these materials and their related slow acid-base setting reaction. The slow-rate setting makes these materials more susceptible to moisture contamination or dehydration during the early stages of the

setting and finally effects the material maturation with lower fracture resistance, inferior flexural strength and poorer resistance to wear [Mount 1995, Berg 2002, Sidhu 2011].

In contrast, resin-modified glass ionomer cements (RMGICs) have been developed to improve the mechanical properties. These materials have a better wear resistance, higher moisture resistance, higher fracture toughness and a longer working-time. Unlike original glass ionomers, which set through slow acid–base reaction, RMGICs initially set through resin polymerization from exposure to visible light, followed by additional hardening through an acid–base reaction [Berg 2002, Sidhu 2011].

Clinical behaviour of different glass ionomers was compared in many studies and results indicated that Vitremer™ (RMGIC) had the overall best performance over others glass ionomer materials and was the most durable and reliable material to use for different classes of restorations in primary teeth. Espelid et al., in a 3 year study found that only one of the RMGICs had failed compared to 13 (26.5%) of the metal-modified glass ionomer cement restorations [Espelid et al. 1999]. In a retrospective evaluation by Croll et al., of a total of 864 RMGICs 92.6% of the class I restorations were successful, 93.3% of the class II restorations, 100% of the class III restorations and 98.0% of the class V restorations [Croll 2001]. In another clinical report, the cumulative success rate of the Vitremer™ restorations was 94% and that of the Fuji II® (conventional) restorations was 81%. The difference is statistically significant. The risk of a failed restoration was more than five times higher with Fuji II® than with Vitremer™ as the restorative material [Hübel and Mejàre 2003].

1.4.5.3 Resin-Based Composite

An alternative to dental amalgam in primary teeth restorations are resin-based composite materials. The properties of composites have improved continuously during the past decades, and today a number of composites can be used for anterior and posterior stress-bearing restorations. Composites are superior in aesthetics and allow the practitioner to be conservative in tooth preparation while avoiding the traditional “extension for prevention” removal of healthy tooth structure. In addition, composite resin has good wear properties and its adhesive character may enhance tooth strength [Craig 1993].

Composite restorations in primary teeth are widely studied to evaluate their efficiency. The studies showed that composite materials are not a preferable material to restore teeth cavities subjected to high stress forces or with class I and II restorations extending beyond the tooth line angels [Craig 1993, Donly and Garcia-Godoy 2002]. A 6-year follow up of

proximoclusal composite restorations in primary teeth revealed a cumulative success rate that declined from 86% after one year to 38% after six years. Fractures occurred early and recurrent caries was found during the second year of the follow up [Varpio 1993]. Guelmann et al. found that a pulpotomized primary molar restored with resin-based composites showed a 26% failure rate with average follow-up time of 21 months [Guelmann et al. 2005]. The annual failure rate for this material was calculated at 15% when taking longevity of occlusally-stressed restorations in posterior primary teeth into account [Hickel et al. 2005]. A clinical evaluation study by Al-Eheideb and Herman that assessed the integrity and longevity of restorative procedures performed on the primary teeth under general anaesthesia and calculated the following survival rates: 71% of the class III, IV and V composite restorations, 70% of the strip crowns and 50% of the class II composite restorations [Al-Eheideb and Herman 2003].

Successful composite restorations require proper sealing of the cavity margins area through mechanical and chemical adhesion of the material to the tooth structure, which is accomplished by pretreatment of enamel and dentin. The complete polymerization of the composite material is another necessity for a successful restoration as well as minimizing the polymerization shrinkage effect, which happens during material setting, through an incremental filling technique, especially in cases of large cavities [Craig 1993, Bayne and Taylor 1995, Deliperi and Bardwell 2002].

The studies mentioned above reflect the technique sensitivity of composite restorations, which demand highly skilled clinical technique, a longer time for application and, to properly complete this procedure, complete isolation of saliva, due to moisture's unfavourable effect on adhesion to tooth structure [Deliperi and Bardwell 2002, Guelmann and Mjör 2002]. Therefore, in cases where isolation or patient cooperation is compromised, resin-based composite may not be the restorative material of choice [Papathanasiou et al. 1994, Donly and Garcia-Godoy 2002, AAPD 2007].

The difficult handling of these composites could explain inferiority compared to the clinical durability of other composite restorations and does not make it a recommendable replacement for amalgam [Deliperi and Bardwell 2002, Burgess et al. 2002].

1.4.5.4 Polyacid-Modified Resin Composite (Compomer)

Compomers are restorative dental materials which produced as a hybrid of two other dental materials: dental composite and glass ionomer cement. They possess properties similar to

composite resin and they are able to release fluoride (but less than released by glass ionomer cements [Gjorgievska et al. 2009]). Compomers are superior to glass ionomer cements group of materials with their good mechanical properties, in particular fracture and wear resistance. Also compomers are superior concerning aesthetics and finishing and polishing procedures; they match almost perfectly with the surrounding tooth structure, unlike glass materials which sometimes look chalky and opaque [Craig 1993, Bayne et al. 2002].

Favourable clinical performance and low failure rate have been reported over years for compomers, suggesting they are an 'amalgam alternative' in restorative paediatric dentistry. One study's goal was to evaluate the clinical performance of two compomers, Hytac and Dyract, and to compare the results to those reported for other intracoronal restorative materials. Evaluations after 24 months showed that two compomers have performed well with a low failure rate, 7%, and 4% for the two materials, and suggested that compomers are a suitable alternative to amalgam or other, tooth-colored materials when used as class II restorations in primary teeth [Gross et al. 2001]. A similar result was reported by Daou et al. [Daou et al. 2009]. A success rate of 91% after 5 years was demonstrated for compomer materials in a Wendt et al. survey in 11 clinics in Sweden [Wendt et al. 1998].

Since the compomers are chemically more similar to composites than to glass ionomers, prior to the application of the compomers, the enamel and dentin need to be primed by a bonding agent, to obtain optimum adhesion and bond strength to the hard tooth tissues. Therefore, isolation of the operating field is a key factor in compomers clinical longevity, like composite resins [Craig 1993, Bayne et al. 2002, AAPD 2007]. To use compomers in restorative treatment of paediatric patients, good compliance is still mandatory. It allows a few minutes of adhesive pretreatment and layering with rubber-dam isolation, which should be utilized, if possible, to prevent cavity moisture contamination. If this is not the case, compomers make no sense [Andersson-Wenckert et al. 1997, Marks et al. 1999, Krämer and Frankenberger 2007]. Luo et al. reported that pretreating or etching the cavity with 36% phosphoric acid, significantly improved the adaptation of the compomer and adhesion to dentine compared with no etching. The marginal quality at the enamel-compomer interface was not affected by the conditioning method used [Luo et al. 2000]. The survival analyses showed significant longevity of compomer and RMGIC materials when utilized with their respective cavity conditioners in class II restoration of primary teeth as indicated in Qvist et al. report [Qvist et al. 2004b]. In a study by Gjorgievska conditioning prior to the application of the fluoride-releasing restorative materials including Dyract® proved to be beneficial. These data could

raise the need for further investigation to properly assess the role of conditioning tooth substance prior to material placement for the longevity of compomers materials [Gjorgievska 2011].

A recent interesting review by Qvist et al. in 2010, aimed to determine which restorative material would be the best alternatives to amalgam in primary teeth, summarized the evidence-based data of four published practice-based studies, which lasted for 7-8 years, in which study materials were placed in everyday practice in the Danish public dental health service [Qvist et al. 2010a]. These long-term studies reached the conclusion that resin modified glass ionomers and compomers were similar and appropriate alternatives compared to amalgam as both were good for stress-bearing restorations [Qvist et al. 2004b], whereas conventional glass ionomer restorations showed significantly shorter longevity than other studied materials, and their use should be limited to restore cavities without or with minimal stress, like in class III/V [Qvist et al. 2004a-c]. These reports evaluated the cariostatic effects of fluoride-releasing studied materials on adjacent teeth in comparison to amalgam restorations. Results revealed a reduced rate of caries development and progression was found on adjacent proximal surfaces in contact with all fluoride-releasing materials [Qvist et al. 2004a-c, Qvist et al. 2010b]. This is another very useful conclusion; these studied materials can especially be used for the type of paediatric patients with high caries activity as it reduces the need for operative treatment of adjacent teeth in near future.

1.5 Child Dental Health Care in Germany

Dental care in Federal Republic of Germany is part of general health care system that is covered by the health insurance benefit plans. The health insurance is mandatory for everyone, including all family members, husband/wife and children, who live, work or study, either permanently or temporarily [Healthcare in Germany 2014, Germany health insurance system 2014]. The health care suppliers are public or private:

- National Health Insurance, Gesetzliche Krankenversicherung (GKV), presents the most common type and is a basic health insurance for the largest part of the population in Germany (with more than 70 million people insured, collectively representing over 87% of total German population [G-BA 2014a]). The GKV provides a standard wide range of health services coverage under the German legislation according to the SGB V.

- Private Health Insurance, Private Krankenversicherung (PKV), is an optional health insurance for higher income- and self-employed people with the advantage of additional benefits included in covered health care services.

A minority of the workforce and some very small population groups, like undocumented immigrants, receive their health care directly through social welfare insurance that has limited covered services.

Organization and monitoring of dental care provision in Germany is under responsibility of the Association of National Health Insurance Dentists, die Kassenzahnärztliche Bundesvereinigung (KZBV), which is a public corporation supervised by the Federal Ministry of Health, and their main duty is to negotiate contracts with the national health insurance funds to specify the rights and duties of national health insurance fund dentists, on the basis of which insured persons are to be supplied with dental treatment.

The KZBV has 17 affiliates throughout Germany that present the different state associations of national health insurance dentists. And every dentist must be a member of his or her state's association of the KZBV in order to accept national health insurance patients in a given locale and receive compensation for the treatment via the patient's health insurance [KZBV 2014a]. The responsibilities of the KZBV and of their member organizations are derived from the social legal obligations of SGB V and include [KZV-Berlin 2014, KZBV 2014a]:

- Ensuring the quality of dental care; the dentist's services are tested regarding technical and economic aspects, according to conditions set by the legislator to assure that the dental care is in accordance with national and contractual provisions
- Representing the interests of the dentists and their patients to the public, supervisory authority, the national health insurance funds and the other actors in the health sector
- Providing information to ministries, agencies and legislators in all aspects of dental health policy and regularly negotiating with health insurance companies about the scope and the contract fees of dental treatments
- Protecting the rights of their members; advising them in issues of contract law, social law, billing and assurance of quick and adequate compensation for the dentist's from the health insurance companies
- Providing advice to the insured persons by answering questions about dental bills, cost plans and all other questions about dental and oral health, also arranging dental emergency service at night, during weekends and holidays

Policies that govern dental benefit plans for insured persons and their co-insured family members in the national health insurance are regulated by the Federal Joint Committee, Gemeinsamer Bundesausschuss (G-BA), which is the highest body of the joint self-administration in health care in Germany under the legal supervision of the Federal Ministry of Health. The major tasks of the G-BA include the development of guidelines on issues of health care services offered under the national health insurance in accordance with legislation set in the SGB V. Another task, regarding their responsibility for quality assurance and quality management, is to specify which services in medical and dental care are reimbursed by national health insurance [G-BA 2014b].

Dental coverage of children enrolled in national health insurance is secure through specifically defined diagnostic, preventive and corrective dental measures in the comprehensive G-BA regulations that cover any and all intervention therapy procedures that a child needs to prevent disease and promote oral health, restore healthy oral structures and functions; it also regulates treatment of emergency conditions including relief of pain and infections [G-BA 2003a].

The variety of G-BA conditions, criteria and limits of specific, covered, preventive and conservative restorative dental interventions procedures include aspects that are described in the remainder of this chapter.

1.5.1 Dental Preventive Measures for Children

There are community preventive programs in schools and kindergartens/day care centres, Zahnärztliche Gruppenprophylaxe, which enables the children to participate in any form of prophylaxis for example learning and practicing proper brushing. In addition, they receive a daily fluoride application in age-related dosages, education on good or harmful diet for healthy teeth and a dental examination by a dentist visiting the childcare centre periodically [G-BA 2003b-c]. In dental practices all children go through the same basic and intensive prevention measures, individual prophylaxis program, Individualprophylaxe (IP), which are tailored according to the child's age, oral health status and caries risk at the time of the examination or visit. The measures of this program aim to:

- Complete the activities of the community preventive measures in a useful and continuous manner, especially for the insured child that is not part of a prophylaxis groups program.
- Detect dental, oral and jaw diseases early on.
- Promote and maintain the oral health.

- Prevent new infections or disease progression if possible.

1.5.1.1 Dental Preventive Measures in Dental Practice for Children under 6-years

Insured children, between 30- and 72-month-olds, and their parents/guardians are encouraged to participate in the child dental screening examinations, Früherkennungsuntersuchung (FU), in dental practices. The maximum number of child screening examinations that are covered by insurance is three (FU1-3), the screenings being at least 12 months apart. The dental measures during screening examination include [G-BA 2003b]:

- Inspection of the oral cavity to detect dental and oral diseases, and assessment of caries risk in children using the dmf-t caries index
- Diet and oral hygiene advice to the parent/guardian with the aim of germ count reduction through improved daily oral hygiene practice with a proper brushing technique and also with the goal of reducing consumption of sugary foods and drinks
- Recommendation of appropriate fluoridation, such as fluoridated table salt and toothpaste

Further, the child can get additional dental examinations after the screening examination once every six months until the next set of screening dates is eligible. This aims to inspect the oral cavity and update the caries risk assessment. Also, additional dental preventive measure of local fluoridation of teeth is recommended for the children, who have high caries risk according to the German Working Groups of Youth Dental Care, Deutsche Arbeitsgemeinschaft für Jugendzahnpflege e.V. (DAJ). The criteria for high caries activity assessment are featured in Table 2, by periodical application of fluoride varnish at regular intervals once every three months for purpose of caries prevention and inactivation of early caries lesions.

Table 2: DAJ criteria to identify the children with high caries activity risk

Child age	dmf-t score
age to 3 years	dmf-t > 0
age up to 4 years	dmf-t > 2
age to 5 years	dmf-t > 4
age up to 6 years	dmf-t > 5

1.5.1.2 Dental Preventive Measures in Dental Practice for Children from Age 6-years on

The basic and intensive dental preventive measures applied to children and adolescents through ages 6 to 18 aimed to continue the individual prophylaxis program of preventive care which is covered by national health insurance [G-BA 2003c]. The insured children and adolescents have the possibility to get the individual prophylaxis measures once every six months per calendar year with exception for extra local fluoridation application, which they can receive twice every six months per calendar year in case of high caries risk. These dental preventive measures include:

a. Dental examination, Zahnärztliche Untersuchung (01): The objectives of this examination are mainly to check the teeth's status regarding presence or absence of dental caries. It also assess the caries activity risk level through calculation of the DMF/dmf values for permanent and primary teeth (Table 3) and checks the mouth, jaw for occlusion and related dental diseases. Stating a need for bitewing radiographs for caries diagnosis may be a result of this examination.

Table 3: High caries risk indicated by the following values of the caries index DMF-T/S

Child Age	DMF-T/S score
Age to 7 years	DMF-T/dmf-t > 5, or d-t > 0
Age to 8-9 years	DMF-T/dmf-t > 7, or d-t > 2
Age to 10-12 years	DMF-S to proximal/smooth surfaces > 0
Age to 13-15 years	D-S to proximal/smooth surfaces > 0 and/or more than 2 carious lesions*
*This also applies to insured persons under the age of 18 years.	

b. Oral hygiene status, Mundhygienestatus (IP1): it includes assessing the oral hygiene and gingival condition, the identification and assessment of plaque-retentive areas as well as the collection of appropriate indices for tooth colouring with plaque disclosing materials. The appropriate indices are the Papillary Bleeding Index (PBI), the Approximal Plaque Index (API) or the Quigley-Hein Index. The results from these indices should be properly

documented in the dental record and the selected index is maintained throughout the following prophylaxis program visits.

c. Oral health education, Intensivmotivation (IP2) und Remotivation (IP3): In the individual prophylaxis program, the content and scope of oral health education is determined according to the individual circumstances of each case, that is, based on the identified findings of prophylactic measures 01 and IP1. This means that for insured persons, who do not have a high risk of tooth decay, the prevention measures shall be limited according to the level of risk of the patient, IP2 and IP3 may not be necessary, as well as more motivational and training measures. The oral health education measure should include:

- Education about the causes of caries, gingivitis, dental trauma and how to avoid them
- Dietary and oral hygiene advice, taking into account the measured values of selected oral hygiene indices
- Recommendation on the use of appropriate fluoridation, such as fluoridated salt, fluoridated toothpaste and fluoridated jellies
- Practical exercise of oral hygiene techniques, including the cleaning of the interdental spaces is part of IP2
- The explanations and practical exercises are to be repeated for Remotivation (IP3). At what point and to what extent Remotivation is required, the dentist has to base his decision on individual hygiene status findings

d. Local fluoridation of the teeth, Lokalfluoridierung (IP4): as an accompanying measure, if necessary, the local teeth fluoridation with fluoride lacquer or gel is recommended. To achieve a good result, the requirement for local fluoridation is the thorough removal of plaque and the draining of the teeth in order to ensure uniform wetting of the enamel with fluoride.

e. Fissure sealing of caries free 1st and 2nd permanent molars, Fissurenversiegelung der Molaren 6 und 7 (IP5): Sealing of caries-free pits and fissures of the 1st and 2nd permanent molars with thermosetting plastics is one of preventive measures of dental care that is included in the patient's insurance and compensated by the health insurance system in Germany. The sealing of fissures at risk should be done as soon as possible, even at breakthrough of the first molar before the age of six. The seal must include all caries-free

fissures of the tooth after proper removal of plaque and the draining of the teeth in order to achieve long-term protection of the teeth with fissure sealing.

1.5.2 Dental Conservative Restorative Interventions Measures for Children

As the dental care contract of health insurance indicates that the insured person is responsible to maintain their teeth in proper healthy condition not only through early participation in preventive dental care measures, but also through active involvement contributing to the dental interventions to prevent the entry of disease or overcome its consequences [G-BA 2003a]. Therefore, the dental treatments are essential in health insurance coverage, as are their policies governing comprehensive coverage of diagnostic and corrective dental treatment that restore dental and oral structures and functions. In addition, the benefit policies enable the dentist request and expect compensation from the health insurance for the provided interventions to insured person. However the provided intervention must meet the following regulations: the degree of medical necessities must be met but not exceeded and the diagnostic and treatment measures shall conform to the principle of economic efficiency.

1.5.2.1 Diagnostic Assessment and Diagnosis

The dental interventions basically begin with the examination for the detection of dental and oral diseases, and it includes all diagnostic measures that aim to determine whether a pathological diagnosis has to be made, or whether further diagnostic, preventative and /or therapeutic interventions are necessary [G-BA 2003a]. The content and scope of diagnostic measures should be properly documented in medical record and if required, the examination measures can be repeated at regular intervals.

In the contract dental care, x-ray diagnostic examinations are a part of insured diagnostic measures that is necessary when the clinical examination is not sufficient for a diagnosis or specific treatment steps require it. An x-ray should only be performed in accordance with the radiation protection regulations and when this is necessary for early detection of possible dental disease, for example if the suspicion of proximal caries is not clinically apparent.

1.5.2.2 Restorative Dental Treatment

According to the dental care insurance contract, the conservative dental interventions to restoratively treatment of diseased teeth should be chosen so that [G-BA 2003a]:

a. Each tooth that is capable and worthy of preservation and conservation is obtained.

b. Any defect in such a carious tooth is treated with consideration of the cavities; it is prepared in accordance with the substance of the tooth, to carefully preserve the healthy natural tooth structure as much as possible.

c. The dental caries is completely removed.

d. The maintenance of tooth pulp vitality is a priority in conservative dental interventions and is to be considered in the treatments:

- During restorative dental procedures, necessary measures are to be taken to protect the vital pulp, including using either the linear/base materials, direct or indirect pulp capping.
- A clinical and possibly a sensitivity test or radiographic control of the healing success is to be performed at appropriate intervals.
- In cases where a primary tooth's pulp vitality is questioned or definitively diagnosed, the conservative intervention should include the following treatment methods prior to the restorative procedures, if possible, to preserve the tooth: vital amputation (Pulpotomy) or root canal treatment (Pulpectomy) on teeth with pulpitis or necrotic pulp tissue.

e. The form and function of the teeth are restored.

f. The filling surfaces are smooth.

g. Treatments, which have purely cosmetic purposes, do not belong to the dental services covered in the insurance contract.

h. The extraction treatment is indicated as preferred treatment option for diseased teeth when the conservative dental treatment interventions have poor prognosis and/or it is not possible and sensible to preserve those teeth. These circumstances include:

- Extensive carious destruction of a tooth
- Advanced periodontal disease and traumatic tooth fractures
- Diseases of pulp and apical periodontium, for which an endodontic therapy is not available

Benefit plan policies of dental care in national health system allowed the insured children to receive fully covered conservative restorative treatments, in accordance with the guidelines explained above, for their primary teeth when the treatment is necessary so that it typically does not require prior authorization from insurance provider [KZBV 2014b]. Also, the insurance policies organize the process of dental treatment documentation and dentists' compensation claim submission in all dental practices. This is achieved through a preapproved uniform program to record and bill for the performed dental interventions. In

this uniform program, each dental intervention procedure has a fixed treatment code and a degree of complexity of this procedure is quantified [KZBV 2014c]. For restorative therapy in primary and permanent teeth, the treatment codes that can be utilized in describing and documenting the performed treatments by dentist are given in Table 4.

Table 4: Dental restoration treatment codes and their descriptions according to BEMA [KZBV 2014c]

Code	Description
F1	Involves one filled tooth surface including restoration finishing
F2	Involves two filled tooth surfaces including restoration finishing
F3	Involves three filled tooth surfaces including restoration finishing
F4	Involves more than three filled tooth surfaces or corner building in the anterior teeth, including the incisal edge and including restoration finishing

These treatment codes of restorative therapy are mainly designed, through standardization of surface descriptions of dental restorations, in order to quantify the complexity of the restorative therapy procedures. The standard surface descriptions of dental restorations include:

- The number of filled tooth surfaces which were restored with restorative material, including using the liner, after cavity preparation
- The definition of a tooth surface, which is the surface surrounded by the line angles, with the incisal edge of the front teeth considered a separate surface
- If separate surface restorations of one tooth are placed on the same surface of the same tooth within one same visit with the same material, they shall be enumerated as a single one tooth surface restoration.
- If separate surface restorations of one tooth are placed on different surfaces of the same tooth within one same visit, they shall be enumerated as separate one tooth surface restorations, irrespective of the material used.
- Similar principles apply to multiple tooth surfaces restorations on the same tooth.

The criteria of G-BA regulations of the contractual dental care indicated that there are special circumstances for the selection of appropriate restorative materials to restore the cavity of primary teeth [G-BA 2003a]:

- The selected materials should be recognized and proven as restorative materials according to the Dental Drug Commission of the Federal Dental Association, Zahnärztliche Arzneimittelkommission der Bundeszahnärztekammer, and KZBV.
- The selected restorative materials should be used according to their proper medical indication.
- The current usage instructions and technical information of selected restorative materials are to be taken into account.
- As a mean of preventive health care, the use of amalgam restorative material in restoration of primary teeth is to be avoided, due to possible harm to the child's organs through contamination with released mercury from amalgam restorations [BZÄK 2014b].

As a precautionary public health measure, to restrict the use of amalgam material, the KZBV data recommend compomer and glass ionomer cements, including their derivatives, as alternative materials for restoring the cavity of primary teeth if of advantages and disadvantages of both materials are considered. Also, the data indicated that compomer presents the best choice of material for any cavity location in both anterior and posterior primary teeth since the proved average durability for this restorative material reaches 4-6 years, whereas conventional glass ionomer cement has an average durability of 1-2 years [KZBV 2014d].

1.6 Dental Restorative Treatment in Primary Teeth in Germany

A literature review on dental restorative treatment and its barriers for the primary dentition in Germany reveals that a limited number of published clinical articles were available compared to article number on the same subject in permanent teeth. Those few available articles aimed mainly to assess clinical suitability and outcomes of restorative dental materials in restoring the primary teeth [Krämer and Frankenberger 2001, Buerkle et al. 2005, Krämer et al. 2014, Bücher et al. 2014b] or to assess different operative techniques during dental restorative

procedures and their effect on final outcomes of restorative treatment [Pioch et al. 2003, Santamaria et al. 2014, Alkilzy et al. 2015, Santamaria et al. 2015].

A small group of epidemiological cross-sectional surveys [Zerfowski et al. 1997, van Steenkiste et al. 2004, DAJ 2010] which aimed primarily for information on dental health and dental care of German children also reported data on dental restorative treatment (f-t) or the care index (ft/dt+ft). In a recent survey [DAJ 2010], data showed mean dmf-t values in 6- to 7- year-old children from 1.3 (in Saarland) to 2.56 (in Thüringen). On average, in Germany, about half of all carious primary teeth in those children were not restored and the proportion for untreated carious primary teeth showed a wide range from 38.8% to 57.7% for the different federal states. This is in line with an older epidemiogical survey in the Rhine-Neckar-District in south-western Germany where 45.6% of the 1,784 examined children age 7 to 10 years needed treatment in their primary teeth (mean dmf-t 2.68) [Zerfowski et al. 1997]. Van Steenkiste et al. [2004] collected information on dental health and dental care of 6- to 7-year-old children in Rems-Murr-district in Baden-Württemberg which showed a higher referral rate to dental treatment for children of immigrants than for German children (mean dmf-t 3.5 and 1.5, respectively).

Interestingly, a part of reported data in the survey of dental care status in Rhine-Neckar-District revealed that dentists were more successful in treating older children, although the results revealed a higher treatment need (dt:ft ratio) in younger age groups [Zerfowski et al. 1997]. Another survey by Splieth et al. [2009] aimed to detect barriers for dentists to treat primary teeth in 3- to 6-year-old children in Germany. In this survey, 320 dentists (184 West, 136 East Germany) were randomly selected from dental association registers, participated in a questionnaire survey about their view of the National Dental Health System and possible barriers for restoring primary teeth. They were also asked to provide information on their dental qualification. The survey findings revealed that the children anxiety and the inadequate reimbursement for dental fillings were considered clear barriers in dental treatment of primary teeth in 3- to 6-year-old children. It also showed that the parents of children did not constitute a barrier and that the dentists felt the need to restore primary teeth. In addition, the findings showed that only 35% of the East German dentists rated restoring primary teeth in small children as stressful in comparison to 65% in West Germany where male dentist found no time to treat children. This survey concluded that dentist can also be a considerable barrier to restorative treatment in small children, especially when lacking enough experience and adequate structural training in paediatric dentistry.

The reported outcomes from both surveys demonstrated clearly the role of the care provider (dentist) as an obstacle to affordable restorative dental care to children, especially in young ages, and come in agreement with findings from an international study that was conducted to explore whether dentists' beliefs of and attitudes toward providing preventive and restorative dental care for young children can form a barrier to the provision care [Pine et al. 2004]. In this international study, the collected information was gathered by mail questionnaire of 2,333 randomly selected dentist in 14 countries and the reported finding showed that two identified factors were found to be barriers in many countries: Firstly, in most countries, dentists agreed that young children's coping skills, fear and general responses to the dental environment and procedures limit their ability to accept dental care (i.e. age of child constitutes a barrier). Secondly, dentists agreed that providing care for children can be stressful and troublesome for the dentist and that they feel time constrained (i.e. dentist's beliefs constitutes a barrier). In addition, this study showed that the majority of dentists disagree with statements that suggest that there is little value in restoring caries primary teeth and, in general, parents' expectations about the care that they wish their child to receive do not constitute a barrier. The findings also revealed that differences in dentists' beliefs can be partly explained by their work profile: those treating children regularly and working in systems where they feel they can provide quality care, being least likely to identify barriers to providing preventive and restorative dental care for young children.

In spite of a moderate caries decline in the primary dentition in Germany during the past years, there is still a demand for further work on recent patters and outcomes of dental restorative treatment in primary teeth placed in everyday dental practice in the Germany National Health System.

2. Study objectives

The objectives of the present study were:

- To describe and compare the prevalence of caries and restorations in the primary teeth in children in Germany and Berlin according to the representative Germany surveys [DAJ 2010].
- To describe the frequency and distribution of restorative treatment performed in everyday dental practices in the primary teeth of 1- to 13-year-old children in Berlin from German National Health data (KZV-Berlin).
- To compare the patterns of filling placement in the primary teeth of 1- to 13-year-old children in Berlin to annual report of the German National Health System [KZBV Jahrbuch 2011].
- To evaluate the outcomes of restorative treatment performed in everyday dental practices to primary teeth of 1- to 13- year-old children in Berlin and to compare the results with randomised community data on the longevity of restorations in primary teeth in Denmark [Qvist et al. 2010a].

3. Material and Methodology

3.1 Study Population

3.1.1 Study Location

The study was carried out in the capital of the Federal Republic of Germany, Berlin. Berlin is one of the sixteen Germany federal states. Located in north-eastern Germany on the River Spree, it is in the centre of the Berlin-Brandenburg Metropolitan Region (Figure 1). With an area of 892 km^2, Berlin is Germany's largest city and ranks the second most populous city, with a population density of 3860 per km² in 2010 [Amt für Statistik Berlin-Brandenburg 2010].

Figure 1: Map of Berlin City: geographic location in relation to Germany (left) and Brandenburg Metropolitan region (right)

Source: Retrieved from https://www.google.com/search?q=berlin+location&rlz=1T4NDKB_enDE563DE564&source=lnms&tbm=isch&sa=X&ei=dCmDU660N7Kp7Aa8l4CIBQ&ved=0CAgQ_AUoAQ&biw=1536&bih=777 on 25/03/2014.

Source: Retrieved from http://en.wikipedia.org/wiki/Berlin/Brandenburg_Metropolitan_Region on 25/3/2014.

3.1.2 Socioeconomic Status

Due to the specific political situation after World War II, the economic situation in Berlin suffered during the years of the Cold War with geographic isolation of the west side of the

city and poor economic decisions made by East Germany's socialist regime that governed the east side of Berlin. Furthermore, the city faced reduction in all economic aspects and social life quality which only changed after the beginning of Berlin and Germany reunification [Economy of Berlin 2009]. Throughout this time, the official government reports showed a dramatic increase in the number of unemployed people in the city and a higher percentage of people who were living on social welfare benefits. Data showed that the unemployment rate in 2005 reached 18.1% of total city population and that in 2006 36.1% of all children in Berlin, aged 15 and younger, lived in relative poverty and received social allowance [Amt für Statistik Berlin-Brandenburg 2006, Amt für Statistik Berlin-Brandenburg 2010].

Currently, fast growing sectors of Berlin's economy, which has been growing continuously above the German average in the last years, improve several issues that are part of the Better Life Index, including the quality of its educational system, economic wealth (11% unemployment rate in 2013), living conditions quality, public health interventions and progress in medical care. Besides having renowned universities, research institutes and significant high technology industries, since 2010, the well-established modern health infrastructures in Berlin recorded 79 hospitals in the city and 7765 active medical physicians (and 3844 dentists in 2009) [Amt für Statistik Berlin-Brandenburg 2014].

3.1.3 Population Structure and Distribution

According to the 2011 Census of the statistical offices of the Federation and the Länder, 4.1% of the total Germany population, more than three million registered inhabitants in Berlin, an area of 892 km^2. The city's population density is 3691 inhabitants per km^2, which exceeds well above the average German population density (224.7 inhabitants/km^2) [Statistischen Ämter des Bundes und der Länder 2013].

The population of Berlin and Germany with the respective distribution of gender and migration background based on data from the 2011 Census is illustrated in Table 5.

Table 5: Population of Berlin and Germany including gender and migration background distribution [Statistischen Ämter des Bundes und der Länder 2013]

Area	Population on 09 May 2011				
	Total	of whom are		of whom have	
		Male	Female	no migrant	a migrant

				background	background
Berlin	3,292,365 (100%)	1,599,840 (48.6%)	1,692,530 (51.4%)	2,488,330 (76.1%)	780,950 (23.9%)
Germany	80,219,695 (100.0%)	39,153,540 (48.8%)	41,066,155 (51.2%)	64,635,410 (81.1%)	15,016,960 (18.9%)

As illustrated in Table 5, the demographic survey of 2011 showed that the gender distribution of Berlin's population was approximately even (48.6% male and 51.4% female) and very similar to national German data [Statistischen Ämter des Bundes und der Länder 2013].

The official statistics regarding the foreign background of Berlin's residents indicated that national and international migration into the city has a long history. In the 2011 Census, almost eight hundred thousand of Berlin's residents were of foreign nationality and came from 190 different countries [Amt für Statistik Berlin-Brandenburg 2011]. Table 5 shows that the percentage of residents with migrant background in Berlin presented around 24% of the city's total population. This percentage is slightly higher (4% more) than the recorded percentage of residents with migrant background in Germany.

The age distribution of Berlin's residents and Germany's correspondingly are given in Table 6. Interestingly, the data revealed that, although nearly 40% of Berlin's population is more than 60 years old, the residents under the age of 18 years makes up only 15% of the total population, or 494,160 residents in absolute figures. The largest age group of those residents is composed of children with age range between 6 years and less than 15 years (7.2% of the total population). The percentage of preschool children is estimated at 5.5% of the total population. Also, the data showed that the estimated percentages of different age groups in Berlin and Germany are more or less similar [Statistischen Ämter des Bundes und der Länder 2013].

Table 6: Age distribution in Berlin and Germany [Statistischen Ämter des Bundes und der Länder 2013]

Population on	Berlin	Germany

09 May 2011 (Aged … to < … years)	frequency	%	frequency	%
under 3	94,330	2.9	1,982,950	2.5
3 – 6	86,990	2.6	2,020,500	2.5
6 – 15	238,400	7.2	6,777,130	8.4
15 – 18	74,440	2.3	2,358,000	2.9
18 – 25	274,470	8.3	6,576,550	8.2
25 – 30	260,850	7.9	4,815,140	6.0
30 – 40	465,470	14.1	9,493,590	11.8
40 – 60	539,300	16.4	13,345,280	16.6
60 – 65	624,090	19.0	16,333,080	20.4
65 – 75	376,200	11.4	9,041,320	11.3
75 and more	257,840	7.8	7,476,130	9.3
Total	3,292,365	100	80,219,695	100

3.2 Study Design

In the first part of the present study the prevalence of caries and restorations in the primary teeth in children in Germany and Berlin were described and compared using the data from the representative German surveys [DAJ 2010]. The aim of this part was to assess if caries values and the degree of dental treatment in Berlin were similar to the mean German values. This ensures that the in depth analysis of KZV data from Berlin have a high potential to be extrapolated and generalized to the situation in all of Germany. The repetitive German DAJ surveys [2010] use representative samples from the different federal states which are examined in a standardized and calibrated manner resulting in very comparative data.

In the second part, the frequency and distribution of restorative treatment performed in everyday dental practices in the primary teeth of 1- to 13-year-old children in Berlin were

analysed using German National Health data (KZV-Berlin) generated for this retrospective, cross-sectional study.

The KZV-Berlin, Kassenzahnärztliche Vereinigung Berlin, is one of affiliates of the federal organisation KZBV and has similar responsibilities. It has 3,500 active registered dentist members working in nearly 2,600 dental practices. Furthermore, the KZV-Berlin is responsible for the dental health care provision for members of the statutory health insurance and their co-insured family members, which means approximately three million people, around 83% of Berlin's population, as the 2,014 official KZV-Berlin data showed [KZV-Berlin 2014].

The specific study data were extracted from the data base of the KZV-Berlin: Data concerning all dental treatment provided for the children insured in the National Health System in Berlin. The period for analysis was 01.01.2010 till 01.01.2011.

In the third part, the patterns of filling placement in the primary teeth of 1- to 13-year-old children in Berlin were compared to the annual report of the German National Health System [KZBV Jahrbuch 2011], which contains data on every dental treatment performed in Germany within the National Health System. The data allow an analysis of the different restorative treatments such as one-, two-, three and more than three-surface fillings.

In the last part, the outcomes of restorative treatment performed in everyday dental practices to primary teeth of 1- to 13- year-old children in Berlin were analysed after collection of data including the follow-up treatment, such as replacement of fillings, pulp treatment or even extractions from the KZV-Berlin data. This was followed by a comparison to the results of community data on the longevity of restorations in primary teeth in Denmark [Qvist et al. 2010a].

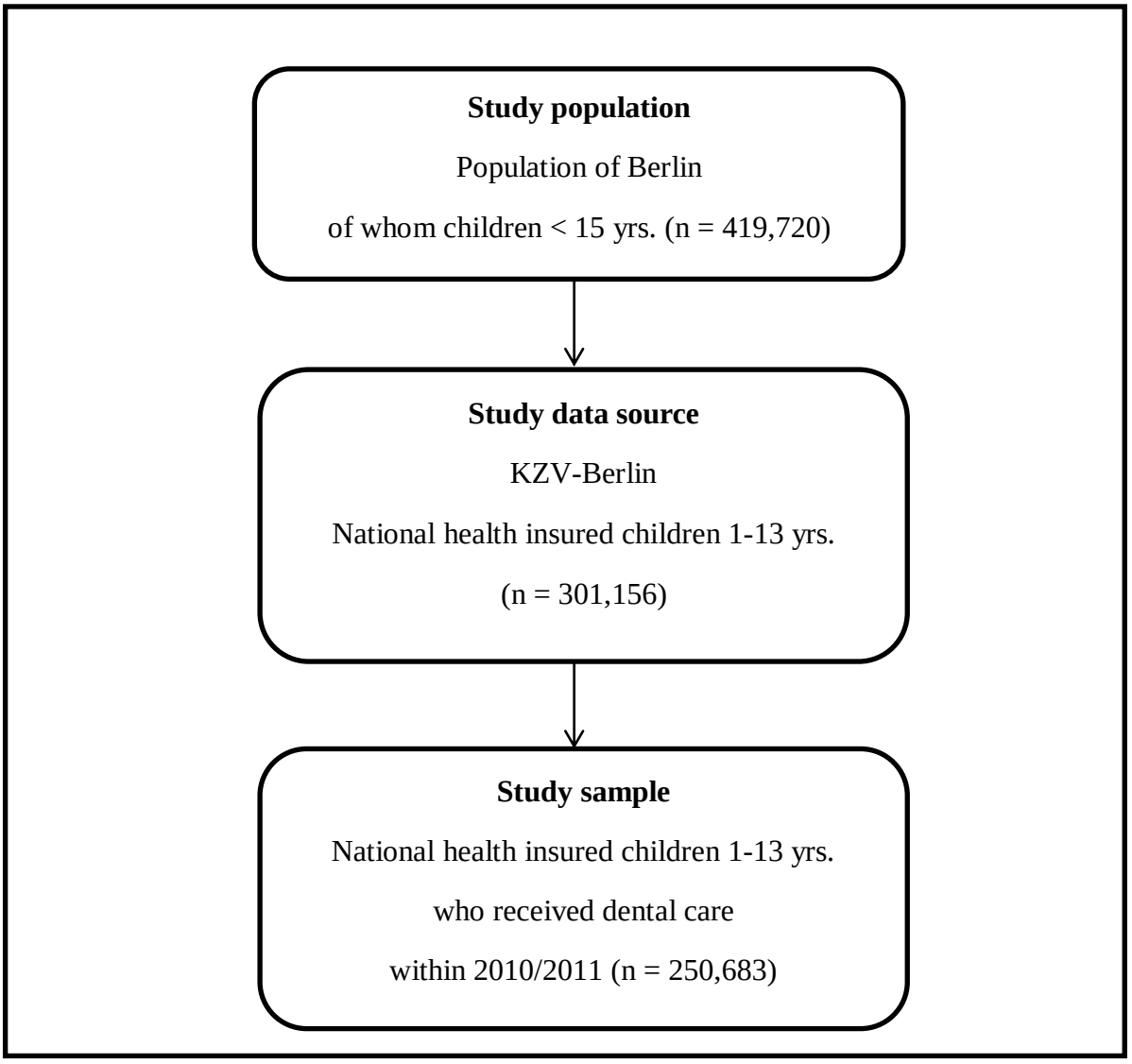
3.3 Study Sample Selection

Generally, all children in Berlin, as in Germany, are entitled to complete dental care under the benefit plans of a health insurance system which, in most cases, is public national health insurance. According to the Census dated May 2011, of 3,292,365 Berlin residents, 419,720 (12.75%) are children under 15 years of age (Table 6).

Concerning the evaluation of dental treatments in primary teeth, the focus in the present study was, firstly, on children that are enrolled in public national health insurance and whose age ranges between 1 and 13 years. Data of KZV-Berlin revealed that the number of registered 1-13 year-old insured children during the evaluated study period was 301,156 (Figure 2).Those children represent an average of almost 72% of all children under 15 years of age in Berlin; this percentage, however, varies between the particular child age groups, for example the percentage reaches up to 84% in the child age group 3-5 years of age (Table 3).

As the data for this study were extracted from registered treatment records, the study target, more specifically, were insured children who received dental care during the evaluated study duration 2010/2011. Thus, of those 301,156 national insured 1- to 13-year-old children, the KZV-Berlin data showed that, 250,683 (83.24%) had received dental care during the study period and were thus particularly included in this investigation (Figure 2).

Figure 2: Study sample



3.4 Measurements

According to the objectives of the present study, the following data were collected from KZV-Berlin data on 1- to 13-year-old national insured children who received dental care during one year period that extend from 01.01.2010 till 01.01.2011.

- Number and age distribution of children who received dental care, regardless the type of dental intervention provided

- Number and age distribution of children who received restorative treatments in primary teeth during dental care visits

- Number and age distribution of children with restored primary teeth according to total performed fillings account per child

- Number and age distribution performed restorations in primary teeth including their distribution according to number of tooth surfaces that were restored as utilized in dental restoration treatment codes descriptions in Table 4

- Number and age distribution performed primary tooth restorations as retreatment to existing restorations including information on the age of existing restorations in days. The restorative retreatments were performed either to repair or replacement existing restoration; due to secondary caries or primary caries elsewhere on the tooth not associated with the original restoration. The existing restoration age was defined as the period from initial placement to time of retreatment and was recorded in days

- Number and age distribution performed stainless steel crowns (SSC) as retreatment to existing fillings including information on the age of existing fillings in days

- Number and age distribution performed retreatments to existing restorations that needed pulp treatment including information on the age of existing restorations in days

- Number and age distribution performed extractions as follow-up treatment for fillings including information on the age of their existing restorations in days

3.5 Statistical Analysis

For the comparison of data on caries prevalence and restorative care of Berlin and that of the DAJ [2010] study for Germany, mean values of the dmf-t and its single components were analysed.

After data on restorative treatment in Berlin were extracted from the dental records of the KZV-Berlin and transferred into Microsoft Office Excel 2010 (Microsoft Office Professional Plus 2010 for Windows, Microsoft Corporation, Redmond, WA, USA), the evaluation consisted mainly of a descriptive analysis of the prevalence and outcome of primary teeth restorative treatments in 1- to 13-year-old children using frequency distribution tables and graphs for each study measurement. The descriptive statistics included also percentages, mean values and ranges. For the analysis and evaluation of the retreatment of restorations, mean value for the age of the existing restorations was calculated in days and presented in frequency tables.

Furthermore, data were entered into GraphPad Prisma data entry system (Prisma 6 for Windows, version 6.02, 1992-2013 GraphPad software, Inc., La Jolla, CA, USA) for additional analysis and comparison of differences amongst the age groups. Chi-square test was used to test the statistical significance between frequencies of different children age groups. Besides, a one-way analysis of variance (ANOVA) was used to test the statistical significance between the ages of restorations in different age groups of children. A linear correlation was used to identify any relationship between study measures and children's age. The findings were reported through correlation coefficients (r), coefficient of determination (r-squared), p-values and 95% confidence interval (CI). In all applied tests, statistical significance was considered when the p-value was < 0.05.

3.6 Description of the Representative Germany Surveys by DAJ

Like in any other state in Germany Federal Republic, the residents of Berlin benefitted from the introduction of the new dental health insurance regulations into the Social Security Statute Book V, Sozialgesetzbuch V (SGB V), in 1989. The new regulations were adopted as a consequence of poor oral health recorded in children and adolescents in Germany compared to other industrialized countries in the mid-80s. The regulations aimed, firstly, to improve dental preventive care of school children through financing of the group prophylaxis by

health insurance (§ 21 SGB V) and, secondly, to incorporate the specified individual prophylaxis in the dental practice (§ 22 SGB V). In 1993, as important step to improve the structural quality of the dental prophylaxis in different Federal states of Germany, the nationwide documentation and effectiveness evaluation of prophylactic measures was carried out by the German Working Group of Youth Dental Care, Deutsche Arbeitsgemeinschaft für Jugendzahnpflege e.V. (DAJ) [DAJ 2010].

To achieve these goals, the DAJ epidemiological surveys on monitoring group prophylaxis, Epidemiologische Begleituntersuchungen zur Gruppenprophylaxe, targeted the oral health of school children in all participating federal states. Periodical dental examinations were performed for:

a. 6- to 7-year-old children in the first class of primary school.
b. 9-year-old children in the third class of primary school (in surveys starting in 2004, due to significant improvement in dental health of permanent 1^{st} and 2^{nd} molar teeth, this group was replaced by 15-year-old adolescents in the ninth class of secondary school).
c. 12-year-old children in the sixth class of secondary school.

For time and economic reasons, as required by DAJ, representative random samples were selected from each state and should account for 10% of the school children of the respective age groups. The net sample should account for approximately 5% of the respective state populations.

Within the survey's dental examination, the dental parameters of caries prevalence (DMF-T and dmf-t indices) were determined for both primary and permanent teeth, and then recorded in survey documentation sheets that include:

a. Number of decayed teeth (Permanent teeth: DT, Primary teeth: dt).
b. Number of filled teeth (Permanent teeth: FT, Primary teeth: ft).
c. Number of missing teeth (Permanent teeth: MT, Primary teeth: mt).
d. In addition, starting from surveys in 2000, the number of sealed permanent teeth (SV) was recorded.

The dental findings were collected and assessed using the standardized electronic data processing program, GPR system, in all states. Then, the processed data were subjected to further assessment in the data processing site for centralized evaluation by the GPRZ program. The final results of the epidemiological surveys were presented in form of tables

and charts for all DMF-T and dmf-t parameters of statistical analysis. Additionally, the mean number of sealed teeth and the significant caries indices (SiC), which is the mean DMF-T or dmf-t of the third of the study group with the highest caries score, were calculated for all surveyed school children.

4. Results

4.1 Prevalence of Caries and Restorations in the Primary Teeth in Berlin and Germany

The epidemiological DAJ surveys from 1997 to 2009 which employed calibrated examiners provided representative data for the federal states such as Berlin and for Germany as a whole.

Tables 7-10 present the comparison of the data for Berlin and Germany from 1995 to 2009.

Table 7: Mean dmf-t values of primary teeth in 6- to 7-year-old children in Berlin and Germany according to results of DAJ surveys from 1994/95 to 2009 [DAJ 2010]

Area	Measurement	1994/95	1997	2000	2004	2009
Berlin	mean dmf-t	3.1	2.64	2.33	2.74	2.4
Germany	mean dmf-t	2.89	2.39	2.21	2.16	1.87
	Federal States dmf-t range	2.4 – 4.0	1.9 – 3.2	1.6 – 3.27	1.58 – 2.91	1.3 – 2.56

In 1994/95 survey data (Table 7), the 6- to 7-year-old children of primary schools in Berlin had a mean dmf-t value of primary teeth 3.1 which declined over the following 14 years to a mean value of 2.4 dmf-t in 2009. This means that a reduction of 22.6% was recorded in the mean dmf-t values of primary teeth between both surveys. This indicates improvement in dental health status. For all of Germany, a similar improvement in dental health of primary teeth of 6- to 7-year-old school children was observed between 1994/95 and 2009. The initial dmf-t value was slightly lower, with a mean of 2.89, the caries reduction a little higher, at 36.8%, finally resulting in a lower mean dmf-t of 1.87. Thus, Berlin, with a reduction of 22.6% was at the lower end of the range for the different federal states, which includes values from 22.6% to 43.5%.

The analysis of the single components of the dmf-t and the Significant Caries Index (SiC) for Berlin and Germany (Table 8) reveals that decayed (d-t), filled (f-t) and missing teeth (m-t) were slightly higher in Berlin than the German mean data. Interestingly, the relative distribution of decayed, filled and missing teeth showed almost equal values in both Berlin and Germany.

Table 8: Components of the dmf-t (mean and percentage) and Significant Caries Index (SiC) of primary teeth in 6- to 7-year-old children in Berlin and Germany [DAJ 2010]

Area	Measurement	dmf-t		d-t		f-t		m-t		SiC
		number	%	number	%	number	%	number	%	
Berlin	Mean	2.4	100	1.12	46.7	1.04	43.3	0.24	10	6.12
Germany	Mean	1.98	100	0.92	46.46	0.87	43.94	0.19	9.60	5.17
	Fedral States range	1.3-2.6	___	0.6-1.3	___	0.4-1.2	___	0.1-0.4	___	3.7-6.5

The proportion of caries-free 6- to 7-year-old school children (dmf-t = 0) increases in Berlin (Table 9) but increases to a slightly higher extent in all of Germany. Restorative therapy (f-t) was the more common rehabilitation care provided to carious primary teeth compared to extraction therapy (m-t). The calculated relation of filling to extraction therapy was about 4:1. Berlin and Germany are in the same range here.

Table 9: Proportion of 6- to 7-year-old children with caries-free primary teeth (dmf-t = 0) in Berlin and Germany [DAJ 2010]

Area	Measurement	1994/95	1997	2000	2004	2009
Berlin	Children	36.4%	41.3%	46.6%	40%	45.5%
Germany	Mean	35.07%	43.21%	46.64%	47.94%	51.74%
	Federal States range	20.0% – 45.9%	30.7% – 53.9%	33.0% – 59.1%	40.0% – 59.6%	42.7% – 62.3%

Through the years from 1995 to 2009, Berlin exhibited a consistently slightly higher caries values than the German mean, but caries trends and distributions are constantly similar.

The proportion of untreated primary teeth in 6- to 7-year-old children was almost identical in Berlin and all of Germany throughout the surveys from 1994/95 to 2009 (Table 10).

Table 10: Proportion of untreated carious primary teeth in 6- to 7-year-old children in Berlin and Germany from 1994/95 to 2009 [DAJ 2010]

Area	Measurement	1994/95	1997	2000	2004	2009
Berlin	Untreated caries teeth %	52.6%	55.5%	53.4%	50.4%	46.7%

Germany	Mean	57.42%	57.25%	56.6%	51.32%	46.5%
	Federal States range	43.9% – 68.7%	43.9% – 68.3%	48.7% – 64.6%	45.3% – 60.0%	38.8% – 57.7%

For both Berlin and all of Germany untreated carious teeth outnumbered the filled teeth in 1995, with a value slightly over 50% (range: 43.9% - 68.7%), while this could be reduced to 46.7% in 2009 (range: 38.8% - 57.7%). This reveals that in Berlin and Germany about half of the carious primary teeth are not treated and only marginal improvements can be detected from 1995 to 2009. Thus, the treatment pattern in Berlin and Germany seems to be comparable.

4.2 Number and Age Distribution of Children with Dental Treatment in Berlin

The frequency and percentage frequency distribution of 1- to 13-year-old nationally insured children in Berlin who received dental care in everyday practice within the study period 2010/2011 is given in Table 11. The dental care received by insured children includes, in this study, all interventions with conservative and surgical dental treatments: routine dental examinations, other diagnostics, prevention, fillings or extractions.

Table 11: Frequency (f) and percentage (%) distribution of 1- to 13-year-old nationally insured children who received dental care (conservative and surgical treatment, KCH**) within 2010/2011

Children's age* (years)	Insured children		
	Total	Of whom received conservative and surgical treatment (KCH **)	
		f	%
1	26,440	9,543	36.09
2	26,190	14,556	55.58
3	25,383	17,744	69.91
4	24,016	19,167	79.81
5	23,043	20,435	88.68
6	22,939	21,987	95.85
7	21,972	21,881	99.59
8	21,931	21,931	100.00
9	21,675	21,675	100.00

10	22,240	21,738	97.74
11	21,941	20,783	94.72
12	21,572	19,954	92.50
13	21,814	19,113	87.62
Total (1-13)	301,156	250,683	83.24

* Age determination was defined by the date 01.01.2011

** Konservierende und chirurgische Leistungen (KCH)

Of all 1- to 13-year-old children insured within the National Health System in Berlin, 83.24% received dental care in everyday practice within the study period 2010/2011. In younger children the visits at the dentist were lower and increased gradually with increasing age. More than 90% of insured children in the age groups from 6 years to 12 years received dental care. The highest frequency of children (21,931; 100%) was recorded in the 8 years age group, whereas the lowest frequency of children (9,543; 36.09%) was recorded in the 1 year age group.

4.3 Number and Age Distribution of Children who Received Restorative Treatments in Primary Teeth in Berlin

Table 12: Frequency (f) and percentage (%) distribution of 1- to 13-year-old insured children in Berlin with or without restorative treatments in primary teeth in 2010/2011

Children age (years)	Children received dental care				
	Total	of whom **received not** dental restoration treatments in primary teeth		of whom **received** dental restoration treatments in primary teeth	
		f	%*	f	%*
1	9,543	9,125	95.62	418	4.38
2	14,556	12,661	86.98	1,895	13.02
3	17,744	13,176	74.26	4,568	25.74
4	19,167	11,840	61.77	7,327	38.23
5	20,435	11,695	57.23	8,740	42.77
6	21,987	11,818	53.75	10,169	46.25

7	21,881	11,196	51.17	10,685	48.83
8	21,931	11,173	50.57	10,920	49.43
9	21,675	11,938	55.04	9,751	44.96
10	21,738	14,435	66.40	7,303	33.60
11	20,783	16,635	80.04	4,148	19.96
12	19,954	18,289	91.66	1,665	8.34
13	19,113	18,561	97.11	552	2.89
Total (1-13)	250,683	172,542	68.83	78,141	31.17

* calculated in relation to total number of children received dental care

Out of a total of 250,683 children who received dental care in everyday practice by dentists registered in the National Health System, 31.17% received dental restoration treatments in primary teeth. The frequency of children that had been to a dental visit without receiving restorative treatment in primary teeth was twice as high and their frequency percentage out of total number of children is 68.83%.

This indicates that the majority of children attend the dentist for check-ups, counselling and prevention and it correlates with the data in Table 9, where 45,5% of the 6- to 7-year-old school children in Berlin have a caries-free primary dentition (dmf-t = 0). In Table 12, 53.75% of the 6-year-old children who received dental care in 2010/2011 had no restorative treatments in primary teeth.

The majority of children (n = 64,895, 83.04% of total) who received restorations in primary teeth were between 4- and 10-year-olds, 6- to 8-year-olds comprised the biggest group with 40.65% of the total (n = 31,774). Considering Table 12 a gradual increase in children treated with restorations in the primary dentition from age 1 (4.38%) to 8 (49.43%) can be detected. This decreases with the exfoliation of the primary dentition, while the dental visits stay high.

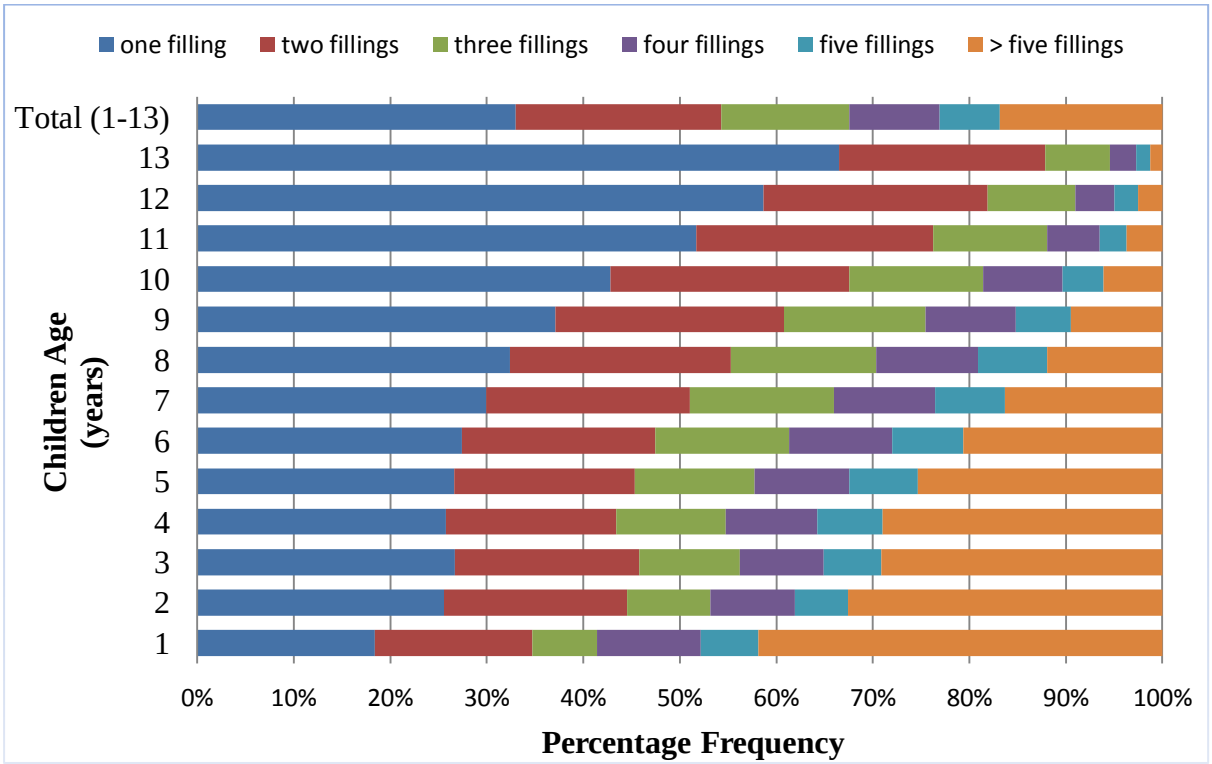
The statistical analysis with a two-tailed Chi-square-test found an association between the age and the frequency of treated children with restored primary teeth ($p < 0.01$). Interestingly, the result of the calculated correlation coefficient value showed a strong positive and significant linear relationship ($r = 0.96$, r-squared = 0.93, two-tailed $p < 0.01$, 95% CI: 0.82 to 0.99) between frequency of children with restored primary teeth and the children's age from 1 year to 8 years, whereas linear relationship for children 8 to 13 years showed a significant strong

negative correlation coefficient value (r = -0.99, r-squared = 0.98, two-tailed p < 0.01, 95% CI: -1.0 to -0.91).

4.4 Mean Number of Fillings per Child in Restorative Treatment in Berlin

Figure 3 exhibits the distribution of 1- to 13-year-old insured children who received restorative dental treatments in their primary teeth within dental care visits in relation to total performed fillings account per child. The categories are one, two, three, four, five and more than five fillings.

Figure 3: Percentage distribution of 1- to 13-year-old children with restored primary teeth according to total performed fillings account per child



Of the 78,141 children who received restorative treatments in their primary teeth, an overall average of 32.97% received only one filling, 21.30% received two fillings, 13.26% three fillings, 9.38% four fillings, 6.23% five fillings and 16.85% more than five fillings. This revealed that within the study period, the most frequently performed number of fillings per child was one filling, whereas a high number of fillings was very seldom in primary teeth.

This is only true for the age groups of 6- to 13-year-olds. In the age groups younger than 5-year-olds, the frequency of children with more than five fillings dominated: For example,

41.87% of the 1-year-olds had more than five fillings and only 28.98% of the 4-year-olds. While there is a decrease in the more than five fillings percentages, the number of one-filling treatments increases (at 1 year of age: 18.42%, at 4 years of age: 25.78%).

4.5 Distribution of Restorations in Primary Teeth According to the Number of Filled Tooth Surfaces

During the study period 2010/2011, dental treatment records from 78,141 children showed a total of 260,547 restorations in primary teeth of those children during their dental care visits. The distribution of those performed primary tooth restorations in relation to both children's age, from 1-year to 13-year-olds, and the number of tooth surfaces that were restored are outlined in Table 13. The number of tooth surface restorations are one (F1), two (F2), three (F3) or more than three (F4).

Table 13: Frequency (f) and percentage (%) distribution of performed restorations in primary teeth of 1- to 13-year-old children including their distribution in relation to number of filled surfaces [one- (F1), two- (F2), three- (F3), more than three- (F4) surface restoration]

Children Age* (years)	F1			F2			F3			F4			Total (F1-F4)		
	f	% to Total (1-13)	% to Total (F1-F4)	f	% to Total (1-13)	% to Total (F1-F4)	f	% to Total (1-13)	% to Total (F1-F4)	f	% to Total (1-13)	% to Total (F1-F4)	f	% to Total (1-13)	% to Total (F1-F4)
1	512	0.74	35.78	273	0.19	19.08	136	0.44	9.50	510	3.17	35.64	1,431	0.55	100
2	3,522	5.11	42.31	2,070	1.43	24.87	927	3.03	11.14	1,805	11.22	21.68	8,324	3.19	100
3	9,319	13.51	44.45	6,597	4.55	31.47	2,458	8.02	11.73	2,589	16.10	12.35	20,963	8.05	100
4	12,188	17.67	37.04	13,777	9.51	41.86	4,086	13.34	12.42	2,858	17.76	8.68	32,909	12.63	100
5	11,214	16.26	29.67	19,807	13.67	52.40	4,435	14.48	11.73	2,344	14.57	6.20	37,800	14.51	100
6	8,856	12.84	23.91	22,394	15.46	60.47	4,020	13.12	10.86	1,762	10.95	4.76	37,032	14.21	100
7	7,337	10.64	20.91	22,587	15.59	64.36	3,930	12.83	11.20	1,241	7.71	3.54	35,095	13.47	100
8	6,289	9.12	19.13	21,600	14.91	65.70	3,881	12.67	11.80	1,108	6.89	3.37	32,878	12.62	100
9	4,790	6.95	18.01	17,612	12.16	66.21	3,275	10.69	12.31	925	5.75	3.48	26,602	10.21	100
10	2,961	4.29	17.85	11,051	7.63	66.64	2,017	6.58	12.16	555	3.45	3.35	16,584	6.37	100
11	1,421	2.06	18.25	5,083	3.51	65.28	1,032	3.37	13.25	251	1.56	3.22	7,787	2.99	100
12	429	0.62	17.24	1,610	1.11	64.71	345	1.13	13.87	104	0.65	4.18	2,488	0.95	100
13	126	0.18	19.27	403	0.28	61.62	89	0.29	13.61	36	0.22	5.50	654	0.25	100
Total (1-13)	68,964	100	26.47	144,864	100	55.60	30,631	100	11.76	16,088	100	6.17	260,547	100	100

*age was taken into account from the date of start treatment.

Of restorations performed in primary teeth in Berlin two-surface restorations were most common (55.60%) followed by one-surface restorations (26.47%). More extended restorations such as three- or more than three-surfaces fillings were less frequent (11.76% and 6.17%, respectively).

This is mirrored by the data of the KZBV [2011] for all of Germany where for a total of 54,708,000 fillings in both primary and permanent teeth, 28.2% were performed as one-surface, 40.0% as two-, 19.8% as three- and 12.0% as more than three-surface fillings [KZBV Jahrbuch 2011]. The fillings performed in primary teeth in Berlin represented only 0.48% of all fillings in Germany.

Variations were noted between Berlin and Germany data regarding the percentages of different tooth surfaces restorations that were performed. The recorded percentages of extensive tooth surface restorations, three and more than three surfaces, were almost two times lower in Berlin than in all of Germany. This could suggest that there were differences in treatment of primary teeth compared to treatment of permanent teeth. That means: for primary teeth whose tooth structure was extensively damaged, other dental treatments, such as extractions and stainless steel crown restorations (SSC), were preferred over restorative treatments. Contrary to this observation, for permanent teeth, which represent the major part in KZBV data, the restorative treatments were preferred and provided over other dental treatments. Supporting this suggestion is the KZBV data of 2010 that showed a continuous reduction of the ratio of performed extractions to performed restorations, compared to early data in 1991. This was contributed to improvement in oral health throughout Germany [KZBV Jahrbuch 2011]. Furthermore, both data sets showed that the percentage of two-surface restorations, which was most frequently performed, was remarkably higher in Berlin than that of all Germany.

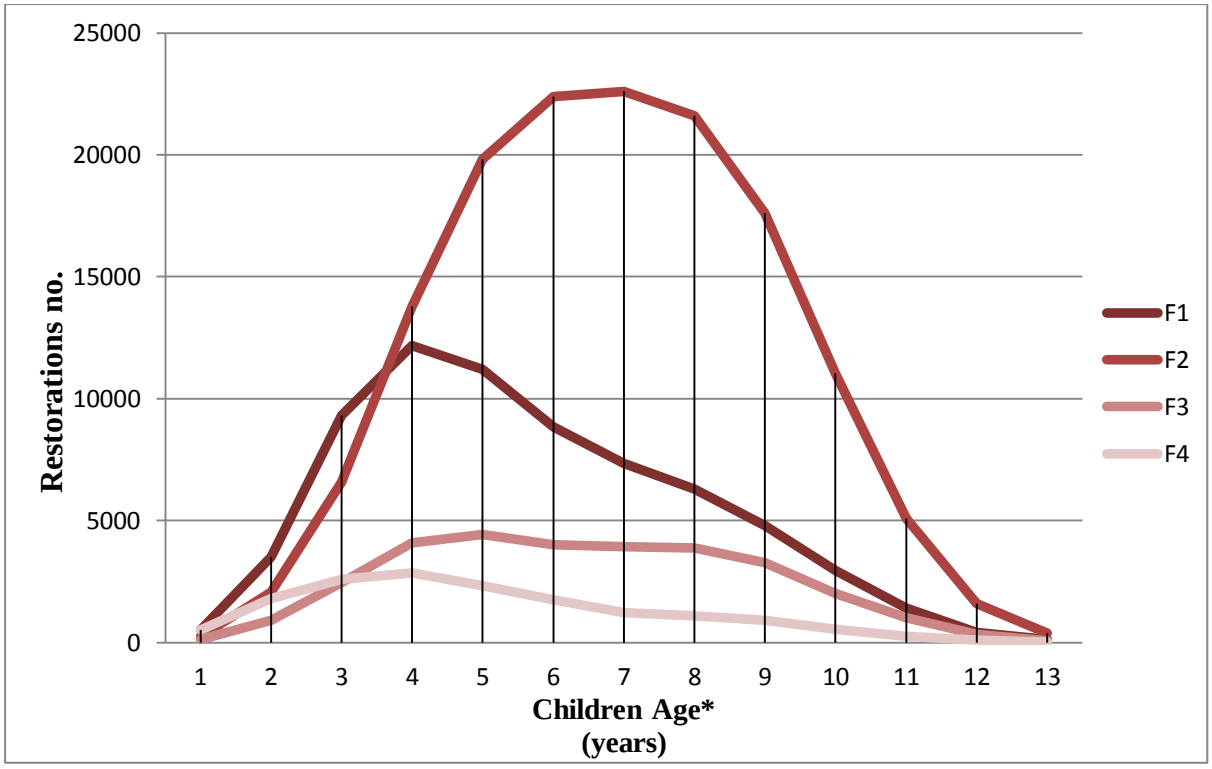
A comparison to KZBV data, which showed the position of different restorative and surgical dental treatments on a scale of dental care expenses in Germany revealed the following results: The restorative and surgical dental treatments consumed 54.9% of the total dental care budget in Germany in 2010, and the expenses of two-surface restorations accounted for 10.6% of restorative and surgical treatment expenses in the same year [KZBV Jahrbuch 2011]. So, the remarkably higher percentage of performed two-tooth surfaces restorations in primary teeth in Berlin will entail an increase in their treatment costs. Thus, this type of dental treatment will occupy a higher position on the scale of restorative and surgical dental

treatment expenses in Berlin, especially in provided dental care to children, compared to all of Germany.

The group's total performed restorations, total F1-F4, is set in relation to and compared to the recorded frequencies of performed one-, two-, three- and more than three-surface restorations within the different age groups in Table 13. The two-surface restorations were the most frequent type of performed restorations within the age groups from 4- to 13-year-olds (percentage frequency range: 41.86% for 4-year-olds, 66.64% for 10-year-olds). The more than three-surface restorations were the least frequent type (percentage frequency range: 3.22% for 11-year–olds, 8.68% for 4-year-olds). In contrast, within the younger age groups, more than two thirds of the restorations performed in 1-year-old children were the one- and more than three-surface restorations (35.78% and 35.64% respectively). Both two- and three-surface restorations combined showed frequencies of 28.58% for the 1-year-olds. For the 2- to 3-year-olds groups, however, the frequencies of the two- and three-surface restorations were increased but still the one-surface restorations recorded higher frequencies in both age groups with a decrease of frequencies for the more than three-surface restorations.

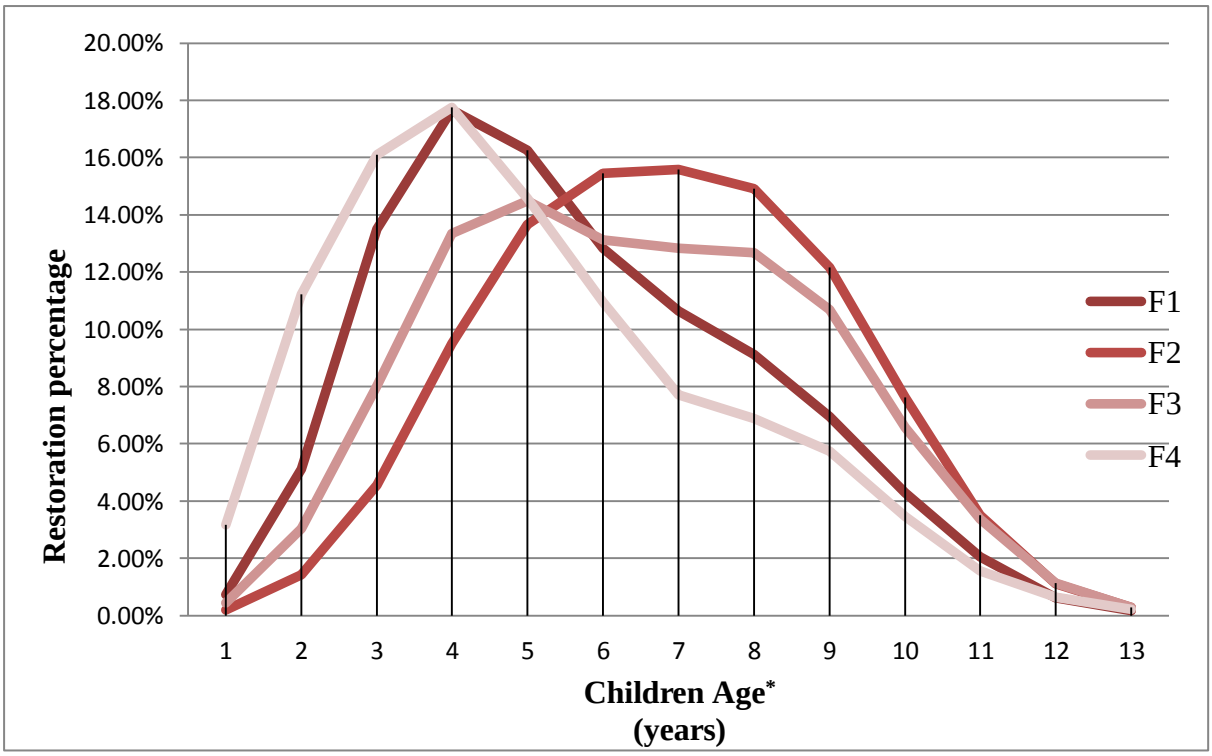
Figure 4 presents the frequencies of performed one-, two-, three- and more than three-surface restorations in primary teeth according to age. Amazingly, the highest number of very large fillings (more than three-surface restoration) is performed in very young children (Figure 4) and also the proportion of larger fillings is highest at a young age (Figure 5).

Figure 4: Frequency distribution of different types of performed surface restorations in primary teeth within the children age groups from 1- to 13-year-olds [one- (F1), two- (F2), three- (F3), more than three- (F4) surface restoration]



*age was taken into account from the date of start treatment.

Figure 5: Percentage distribution of different types of performed surface restorations in primary teeth among the children age groups from 1- to 13-year-olds [one- (F1), two- (F2), three- (F3), more than three- (F4) surface restoration]



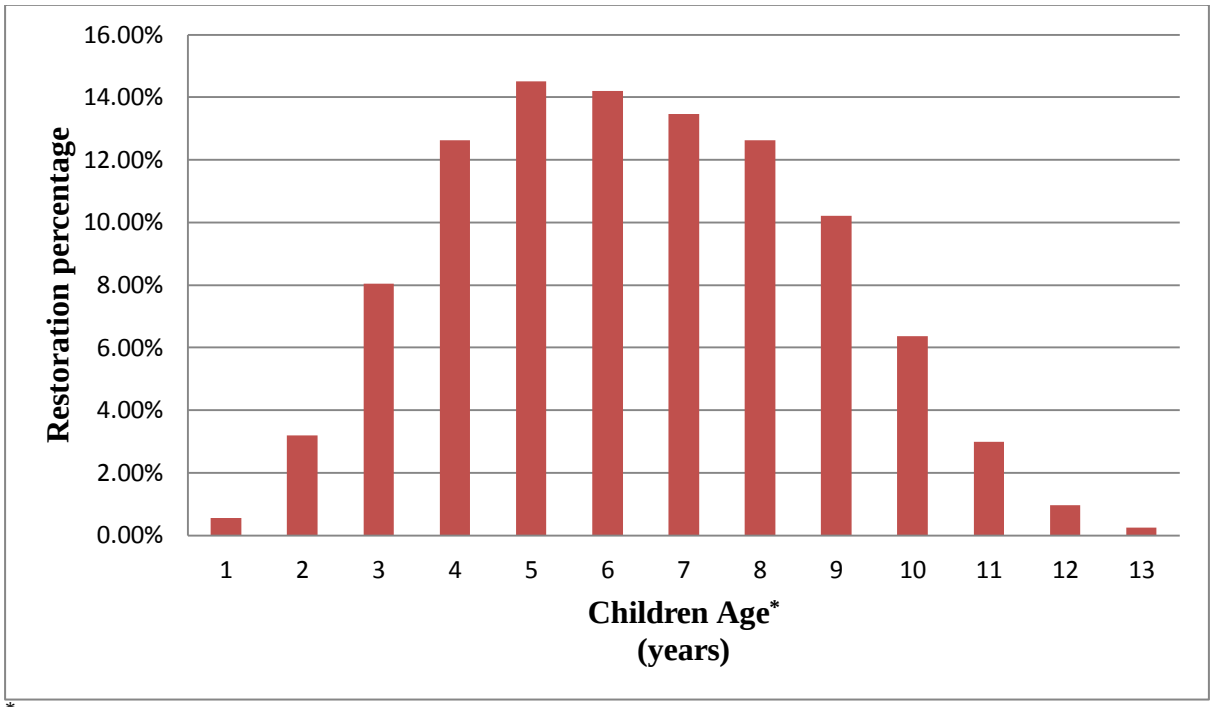
*age on the date of the start of the treatment was taken into account

Figure 5 illustrates that for all types of fillings performed the percentages increase with age to a certain break point after which it decreases.

All break points occurred between ages 4 and 7 years where a maximum of fillings was recorded. The one- and more than three-surface restorations peaked when the children were at an age of 4 years. For the 5-year-olds, the three-surface restorations showed a maximum. The two-surface filling had its break point with children at an age of 7 years.

Over the life course of the primary teeth, the maximum number of fillings was incorporated at age 5 (Figure 6). The majority of the fillings in primary teeth are placed during the period of a mixed dentition (> 60%). The changes with age proved to be statistically significant (two-tailed Chi-square test, $p < 0.01$). Result of calculated correlation coefficient showed that the changes in frequency of performed surface restorations between children age groups from 1- to 5-years had a strong positive and significant linear relationship ($r = 0.99$, r-squared = 0.98, two-tailed $p < 0.01$, 95% CI: 0.86 to 1.0), whereas the changes in frequency of performed surface restorations between children age groups from 5- to 13-years had a strong negative and significant linear relationship ($r = -0.96$, r-squared = 0.93, two-tailed $p < 0.01$, 95% CI: -0.99 to -0.85).

Figure 6: Percentage distribution of total performed surface restorations (F1-F4) in primary teeth among the children age groups from 1- to 13-year-olds



*age on the date of the start of the treatment was taken into account

The mean number of restored surfaces in the primary dentition was 3.33 surface restorations, with amazingly higher numbers for younger children. A maximum of 4.59 surface restorations per child and year is reached when the children are 3-year-olds. This is continuously reduced to 1.18 surface restorations by the time the children are 13-year-olds.

Table 14: The mean number of performed tooth surfaces restorations in primary teeth per child within the age groups from 1- to 13- year-olds

Age group (years)	Number of treated children with primary teeth restorations	Number of performed surfaces restorations	Mean surface restorations/child
1	418	1,431	3.42
2	1,895	8,324	4.39
3	4,568	20,963	4.59
4	7,327	32,909	4.49
5	8,740	37,800	4.32
6	10,169	37,032	3.64
7	10,685	35,095	3.28
8	10,920	32,878	3.01
9	9,751	26,602	2.73
10	7,303	16,584	2.27
11	4,148	7,787	1.88
12	1,665	2,488	1.49
13	552	654	1.18
Total (1-13)	78,141	26,0547	3.33

Considering the results of the DAJ [2010] survey for Berlin in 2009, 46.7% of the carious decay in the primary dentition of 6- to 7-year-old children was not treated (Tables 8 and 10). Thus, almost the total number of 37,032 fillings for the group of 6–year-olds in Berlin needs to be almost doubled to ensure a full treatment of all carious defects.

4.6 Number and Age Distribution of Retreatment for Fillings in Berlin

In this analysis the retreatments of existing fillings in the primary teeth of 1 to 13 year old children was carried out for 2010/2011. The data from KZV-Berlin included every reason for replacements. In addition, the age of the existing filling since the initial placement was calculated in days (Table 15).

Table 15: Frequency (f) and percentage (%) distribution of restorative retreatments for existing fillings of the total performed fillings in primary teeth of 1- to 13-year-old children in 2010/2011 and mean age of existing fillings in days

Children's age* (years)	Performed fillings on primary teeth				Mean age of fillings at retreatment (days)
	Total fillings F1-F4	Of which were performed as retreatment			
		f	% of total replacements from age 1- to 13-years	% to of all fillings F1-F4	
1	1,431	14	0.07	0.98	41
2	8,324	200	1.00	2.40	135
3	20,963	734	3.68	3.50	160
4	32,909	1,935	9.69	5.88	200
5	37,800	3,217	16.11	8.51	220
6	37,032	3,707	18.57	10.01	236
7	35,095	3,199	16.02	9.12	256
8	32,878	2,867	14.36	8.72	255
9	26,602	2,175	10.90	8.18	260
10	16,584	1,216	6.09	7.33	262
11	7,787	507	2.54	6.51	253
12	2,488	159	0.80	6.39	268
13	654	33	0.17	5.05	232
Total (1-13)	260,547	19,963	100	7.66	214

*age from the date of the performance of the repeated therapy was taken into account

Of the 260,547 total performed fillings in primary teeth, 19,963 fillings were performed as restorative retreatments to existing fillings in 2010/2011 in all 1- to 13-year-olds in Berlin. Thus, 92.34% of all fillings in the primary dentition were the first placed fillings and only 7.66% were secondary fillings to retreat existing fillings.

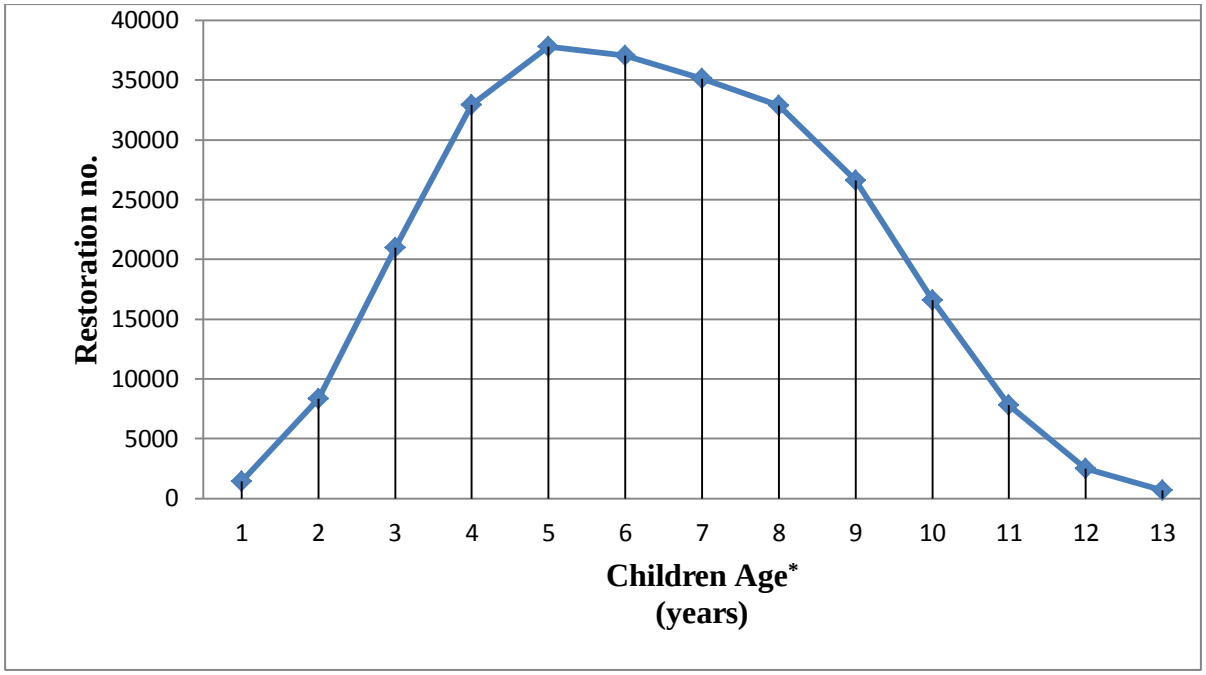
In the Danish Public Dental Health Service (PDHS) where 99.9% of children and adolescents are regularly treated four longitudinal and prospective studies also examined retreatment of fillings for 5- to 8-years [Qvist et al. 2004a-c, Qvist et al. 2010a]. Total sample in these studies consisted of 1,807 restorations inserted in the earlier studies and further 476 restorations. The complete restorations included 398 amalgam, 406 conventional glass ionomer cement, 805 resin modified glass ionomer and 674 compomer fillings which were placed in different tooth restoration classes (mainly in class II) in primary teeth of 307 treated children aged 2.6 – to 15.3-years [Qvist et al. 2010a].

The percentage of retreatments in the last study, which lasted 5 years, was in total 23% [Qvist et al. 2010a]. The mean annual failure rate of the restorations of 7.66% at a mean age of 214 days (Table 15) indicates that some of the primary teeth restorations in Berlin had a worse prognosis and did not last as long as fillings in Denmark.

On the other hand, tracing the cumulative survival curve in Qvist et al. [2010a], at 1 year the survival curve of fillings has a value of about 94%. Thus, a failure rate and retreatment rate of 6% can be deducted, which is similar to the Berlin data.

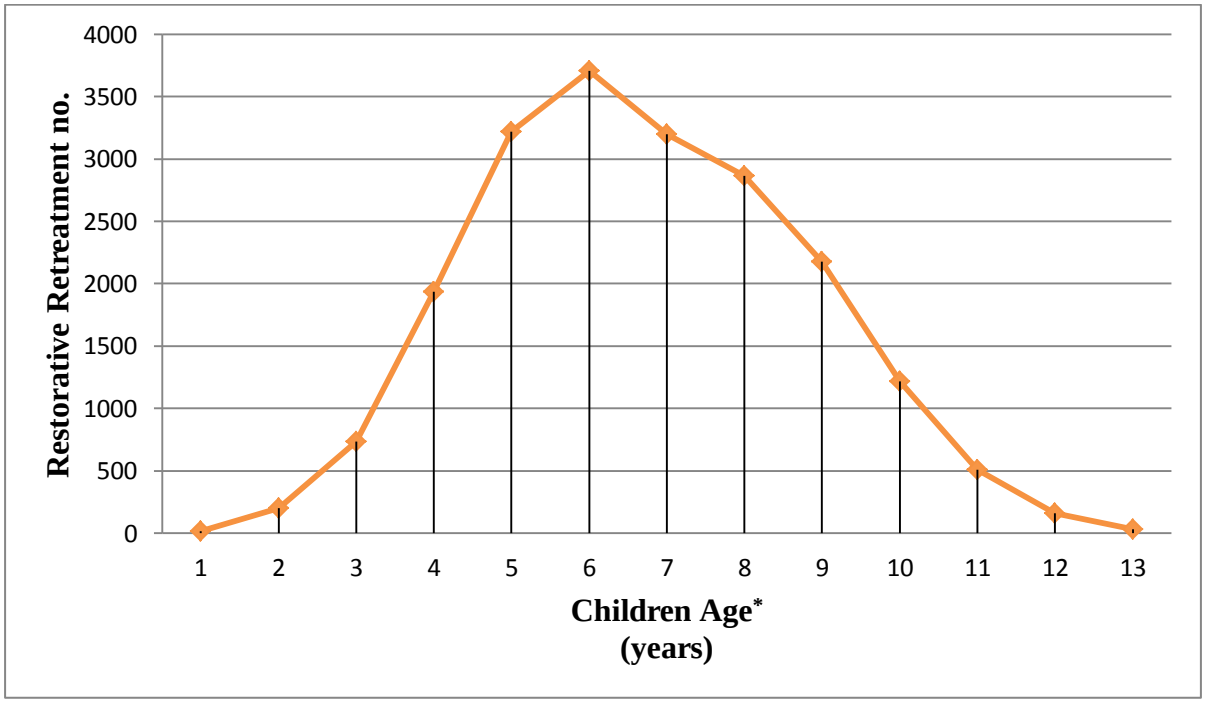
Figure 7 and 8 illustrate the frequencies of fillings and their retreatments for the different age groups in Berlin.

Figure 7: Linear graph illustrating the frequency distribution of total performed fillings in primary teeth of 1- to 13-year-old children who received dental care within 2010/2011



*age from the date of the start of the treatment was taken into account

Figure 8: Linear graph illustrating the frequency distribution of performed retreatments to existing fillings of the total performed restorations in primary teeth of 1- to 13-year-old children who received dental care within 2010/2011



*age from the date of the performance of the repeated therapy was taken into account

The frequency curve for fillings peaks with 5-year-old children while the retreatment has a maximum at 6-year-old children.

The estimated percentage of performed retreatments to existing fillings of the total performed fillings in primary teeth from children 1- to 13-years of age (Table 15) exhibited a wide range: between 0.98% and 10.01%. Highest rates were found with children 5- to 9-years of age which implies that the number of retreatment decreases with exfoliation of the primary dentition; it also decreases with only recently placed fillings at a very young age.

The distribution curve for the estimated percentage values of the different age groups was prepared and presented in Figure 9.

Figure 9: Percentage distribution of performed retreatments to existing fillings in primary teeth of 1- to 13-year-old children in 2010/2011 in relation to their group's total performed restorations (total F1-F4)

*age from the date of the performance of the repeated therapy was taken into account

Most replacements of fillings take place at an age of 6 years (10.01%).

The Chi-square test showed that a statistically significant pattern for age and the frequencies of retreatments (two-tailed Chi-square test, $p < 0.01$). The linear correlation between the number of fillings and the number of retreatment was high ($r = 0.95$, r-squared = 0.90, two-tailed $p < 0.01$, 95% CI: 0.84 to 0.98).

The mean ages of fillings at retreatment was 214 days on average but ranged amongst the different age groups: from 268 days in the 12-year-olds to only 41 days in 1-year-olds highlighting the clear difficulty to place fillings in very small children.

The differences in recorded mean ages of existing restorations between different age groups were statistically analysed. The statistical comparison of different group means showed that no significant differences in the mean age of existing restorations were found between different age groups (two-tailed ANOVA, p value > 0.05). However, the analytical results showed that strong positive and significant linear correlation was found between the mean age of existing restorations and the children's age ($r = 0.79$, r-squared = 0.63, two-tailed $p < 0.01$, 95% CI: 0.44 to 0.93). And this, interestingly, indicated that advancement in children's age is associated positively with the increasing longevity of the restorations and vice versa.

4.7 Number and Age Distribution of Stainless Steel Crowns (SSC) as Retreatment for Fillings

The frequency and percentage frequency distribution of stainless steel crowns (SSC) as retreatments for fillings in primary teeth of 1- to 13-year-old children within 2010/2011 including the mean age of existing restorations in days are given in Table 16.

Table 16: Frequency (f) and percentage (%) distribution of stainless steel crowns (SSC) as retreatments for fillings in primary teeth of 1- to 13-year-old children who received dental care within 2010/2011 including mean age of replaced filling in days

Children age* (Years)	f	% of total with age (1-13 yrs.)	% of total fillings (F1-F4)	Mean age of replaced filling (days)
1	0	0	0	0
2	28	2.58	0.34	166
3	113	10.41	0.54	228
4	197	18.14	0.60	246
5	236	21.73	0.62	266
6	183	16.85	0.49	264
7	133	12.25	0.38	245
8	92	8.47	0.28	249

9	56	5.16	0.21	264
10	32	2.95	0.19	317
11	8	0.74	0.10	254
12	7	0.64	0.28	225
13	1	0.09	0.15	455
Total (1-13)	1,086	100	0.42	245

*age from the date of the performance of the repeated therapy was taken into account

Within the study period, a total of 1,086 stainless steel crowns (SSC) were placed on previously filled primary teeth of 1- to 13-year-old children.

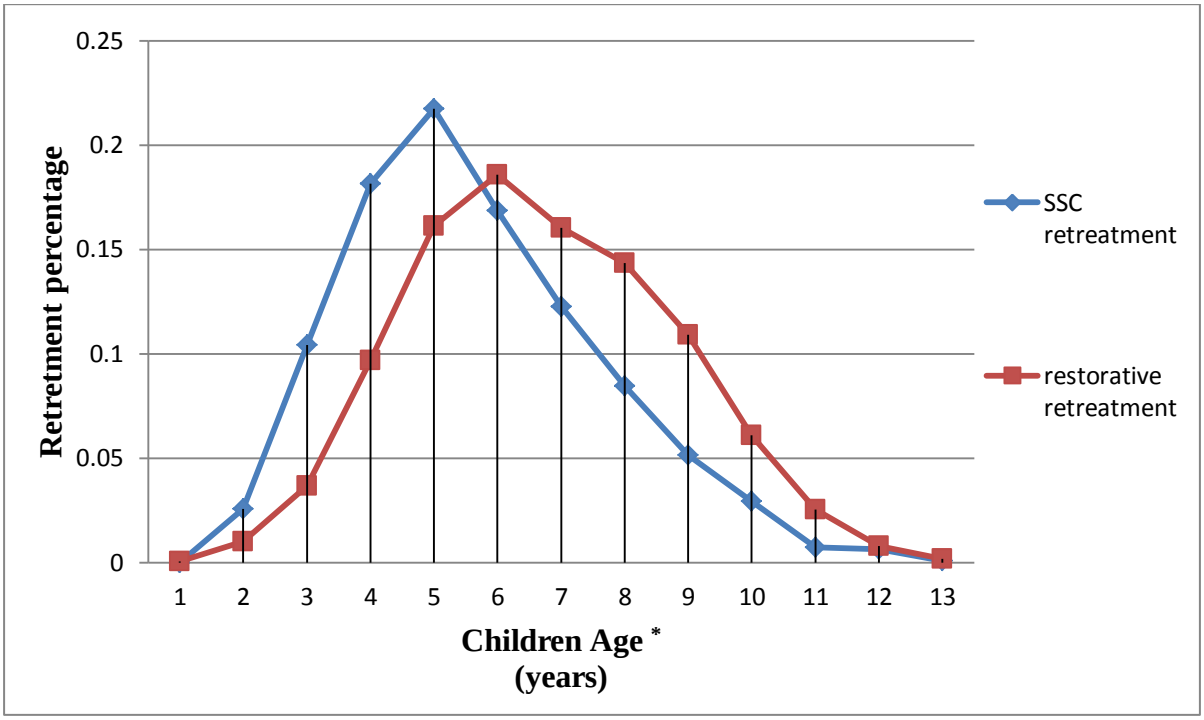
The percentage frequency of these SSC retreatments was less than 0.5% of all fillings (F1-F4) and it reveals a very limited use of SSC. Furthermore, the selection of SSC to retreat existing restorations in primary teeth was also less common compared to retreatments with fillings. As the data showed that out of 21,049 total performed retreatments during the study period, the performed retreatments to existing restorations in primary teeth with use of SSC only presented 5.16%, whereas the remaining 94.84% were accounted for by retreatments with use of fillings.

Frequency distribution of performed retreatments with SSC showed wide variations among different age groups and had range from 0 to 236 (Table 16). This was statistically significantly associated with age (two-tailed Chi-square test, $p < 0.01$).

Among the different children age groups, the majority of SSC as retreatment (82%) was recorded in children's age groups between 3- and 7-years with a peak in the 5-year-old age group. The correlation coefficient for the number of retreatments with SSC and the number of fillings was high ($r = 0.89$, r-squared = 0.80, two-tailed $p < 0.01$, 95% CI: 0.67 to 0.97).

A comparison of the percentage frequency distributions of retreatment with SSC and fillings reveals that SSC were mostly used in younger children with a peak at 5-year-old children, whereas retreatments with fillings was preferred for older children with a peak at 6-year-old children (Figure 10).

Figure 10: Percentage distribution of performed restorative and SSC retreatments to fillings in primary teeth of 1- to 13-year-old children who received dental care within 2010/2011 in relation to age of children



*age from the date of the performance of the repeated therapy was taken into account

The mean age of a filling that was replaced with a SSC was 245 days (Table 16).In very young children, group of 2-year-olds, the recorded mean age was 166 days and it increased with age up to 455 days which was clearly statistically significant (linear correlation, r = 0.63, r-squared = 0.40, two-tailed p = 0.03, 95% CI: 0.09 to 0.88).

4.8 Number and Age Distribution of Retreatments with Pulp Involvement

Table 17: Frequency (f) and percentage (%) distribution of retreatments with pulp treatment in primary teeth of 1- to 13-year-old children in 2010/2011 including mean age of existing fillings in days

Children age* (years)	Retreatment with filling or SSC for existing fillings				Mean age of existing filling (days)
	Total retreatments	Of whom were performed with pulp treatment			
		f	% of total pulp	% of total	

			involvement	retreatments	
1	14	1	0.04	7.14	222
2	228	17	0.72	7.46	178
3	847	87	3.67	10.27	218
4	2,132	257	10.83	12.05	252
5	3,453	393	16.56	11.38	252
6	3,890	448	18.88	11.52	287
7	3,332	433	18.25	13.00	292
8	2,959	333	14.03	11.25	262
9	2,231	226	9.52	10.13	269
10	1,248	124	5.23	9.94	288
11	515	36	1.52	7.00	295
12	166	17	0.72	10.24	235
13	34	1	0.04	2.94	581
Total (1-13)	21,049	2,373	100	11.27	279

*age from the date of the performance of the repeated therapy was taken into account

The number of retreatment for fillings which had pulp involvement was 2,373 in Berlin in 2010/2011. This comprised 11.27% of all retreatments. The retreatments with pulp involvement in primary teeth happened mostly with children between 5- and 8-years of age.

In comparison with the community data from Qvist et al. [2010a] the Berlin data are higher than the mean of 6% in Denmark. Only class II glass ionomer fillings showed a similar rate of 13% pulpal involvement in the Danish sample.

The mean age of the filling which resulted in pulp follow-up treatment in primary teeth in Berlin was 279 days with a range between 178 and 581 days for the different age groups. Apart from the extreme values, there was no age-dependent trend which was confirmed by an ANOVA analysis (two-tailed $p > 0.05$).

4.9 Number and Age Distribution of Extractions as Follow-up Treatment for Fillings

The extraction after a filling in primary teeth was computed for the years 2010/2011 in Berlin (Table 18). A total of 16,795 restored primary teeth had been extracted during the study period with an overall mean age of existing restorations in those extracted teeth of 333 days.

Table 18: Frequency (f) and percentage (%) distribution of extractions as follow-up treatment for existing fillings and mean age of existing fillings in days

Children age* (Years)	f	% of total (1-13 yrs.)	% of total of fillings (F1-F4)	Mean age of existing restorations (days)
1	17	0.10	1.19	125
2	65	0.39	0.78	194
3	190	1.13	0.91	287
4	554	3.30	1.68	287
5	1,059	6.31	2.80	347
6	1,629	9.70	4.40	400
7	2,153	12.82	6.13	403
8	2,638	15.71	8.02	388
9	2,880	17.15	10.83	370
10	2,571	15.31	15.50	389
11	1,770	10.54	22.73	386
12	916	5.45	36.82	381
13	353	2.10	53.98	373
Total (1-13)	16,795	100	6.45	333

*age from the date of the performance of the repeated therapy was taken into account

Extractions were mainly performed in children's age groups between 5- and 11-years of age, with the highest frequency recorded in the 9-year-olds group (17.15%). In contrast, the age groups below 5-years of age had a recorded frequency that did not exceed 5% of total extracted teeth.

In addition, fillings that were followed by an extraction had been placed more recently in younger children below the 5-years of age (mean 125 to 287 days) than in older children where the mean lifespan exceeded one year nearly in all groups.

In general, the numbers of extraction after filling therapy in primary teeth increased with the total number of fillings (F1-F4) with a mean of 6.45%. During the study period the estimated ratio of extracted restorations to performed restorations was 2:31. With an increase in age, the extraction seemed to be a more favoured treatment option due to the natural process of exfoliation. The estimated ratio of extraction to repeated fillings was 4:5 during the study period.

In the Danish community study [Qvist et al. 2010a], 65 of placed primary teeth restorations (476 restorations) remained intact without need of repair or replacement before exfoliation of the teeth for a 5-years follow up period. The dropout during the whole study period was 10%. This results in a mean loss of 16.96% of the restorations per year due to exfoliation or premature extractions. In the three original Danish studies, which lasted 7- to 8-years, the mean of lost teeth was about 12% per year [Qvist et al. 2004a-c]. Here, also, the process of natural exfoliation and premature exfoliation merge.

Compared to the present study with an overall mean of 6.45% extractions of filled teeth, the number of lost teeth in Denmark was higher. Taking into account that many fillings were placed and monitored in the mixed dentition in the Danish community studies, their rates of loss from 12 to 17 % are comparable with those of the 7- to 11-year-olds in Berlin with 6-23%.

The two-tailed Chi-square-test showed a very clear association for extractions and age group (two-tailed, $p < 0.01$) and there was also a strong positive and significant linear correlation between the children age and the mean age of the filling at the time of extraction ($r = 0.78$, r-squared = 0.61, two-tailed $p < 0.01$, 95% CI: 0.40 to 0.93).

5. Discussion

The caries decline in many industrial countries has resulted in changes in restorative treatment patterns in both the primary and permanent dentition. Improved dental health in children and adolescents lead to fewer and smaller carious lesions accompanied with lower progression rates of these carious lesions [Kidd et al. 2008, Mejare et al. 2009, Splieth 2011].

Due to high quality restorative materials and techniques, restorations should be able to last quite long or are needed less as the initial carious lesions can be treated by non-operative intervention which means that effective caries preventive measures are used on caries lesions to inactivate them [Kidd et al. 2008, Splieth 2011].

As changes in treatment patterns reflect all factors influencing caries and the subsequent restorative treatment, this complex process is of special interest for all countries. Apart from the individual perspectives of patients and clinicians, government agencies and insurance companies consider the extent, the distribution and the costs of the dental health care system [Qvist et al. 1986a, Qvist et al. 1990a, Qvist et al. 2004c]. The latter play an important role in health care systems which are financed by public funds, as is the case in Germany.

The treatment outcomes for the performed dental restorations are a major component in the assessment of dental restorative treatment [Qvist et al. 1990a, Wendt et al. 1998, Mjör et al. 2000a, Qvist et al. 2010a]. It involves the evaluation of the restoration's durability and longevity, since they are considered the most important parameter for the success of restorative treatment.

In light of present findings, assessment of dental restoration treatments in the permanent teeth is well documented in dental literature with ample available study data. However, recent data for the field of paediatric dentistry that attempted to assess dental restoration in primary teeth is scarce, especially from practice based studies. Almost all of the delivered information from such studies is directed to evaluate different dental restoration materials or techniques, and is only available for specific age groups so far [Pioch et al. 2003, Qvist et al. 2010a, Santamaria et al. 2014].

In light of an only moderate caries decline in the primary dentition and a persistently low care index in Germany during the past years [DAJ 2010], the present study aimed to assess the

frequency, distribution and outcome of restorative treatment in primary teeth performed in everyday dental practice.

5.1 Discussion of the Study Design

In this practice-based study, data were collected retrospectively from everyday dental practices in Berlin in order to give a true reflection of real-life patterns and outcomes of restorative treatment in primary teeth.

This design is contrary to the usual randomized longitudinal prospective design [Papathanasiou 1994, William et al. 2004, Levin 2007]. But RCTs are typically conducted in controlled environments, under well-defined conditions and performed by one or few calibrated clinicians with blinding and independent assessment of the restorations studied. Such trials have superior result accuracy over retrospective studies. However, there are only few clinicians included, the number of patients participating is limited and the conditions are almost ideal. Thus, the results cannot always be generalized for the national health system [Papathanasiou 1994, Mjör et al. 2002a, Chadwick and Evans 2007, Levin 2007, Shadish et al. 2008].

An advantage of cross-sectional, retrospective studies is that a complex and long organization of the study is avoided [Levin 2006]. Undoubtedly, this makes this study design a convenient method to obtain information about studied subjects. However, many uncontrollable factors can affect the final results. Patient characteristics, clinical conditions at the time of treatment placement and quality of the restorations are largely unknown [Papathanasiou 1994, Mjör et al. 2002a]. Variation in the treatment decisions of clinicians, due to lack of standardization and calibrations, is considered another limitation to these studies [Mjör et al. 2002a, Levin 2006].

In dental literature, it was assumed that through a large number of restorations placed in a broad spectrum of patients and by a large group of unselected dental clinicians in cross-sectional retrospective studies, a high confidence could be placed in the results of the study. In other words, findings of such studies provide a good basis for generalizing the findings [Qvist et al. 1990a, Martin and Bader 1997]. Therefore, as data in the present study include all restorations performed during the study period in primary teeth of nationally insured

children in all Berlin's dental practices, limitations and uncontrolled factors of the study's design are decreased and the reliability of the final results is increased.

In the numerous practices involved in the present study, many dental clinicians are working regardless of age and level of experience. These clinicians treat children, irrespective of their age, caries experience, cooperative level and different ethnic and cultural backgrounds. So, it is likely that the present results reflect the average type of performed treatments from these practices and, finally, give a realistic generalization of the treatment provided to the population studied [Thylstrup et al. 1986, Bigras et al. 2008, Davies and Macfarlane 2010].

The generalization of the present results for all of Germany is plausible because of the similarity in the population structure and distribution between Berlin and Germany (Table 5). The population structure is especially similar in children age groups below 15-years of age (Table 6). Another factor that qualifies the present results to be generalized for all of Germany is the standardization of dental care provision within Germany, including Berlin, by the G-BA regulations regarding quality assurance [G-BA 2003a, G-BA 2014b]. The G-BA regulations are a list of guidelines that control the provided diagnostic, preventive, corrective and surgical dental intervention measures by dental practitioners.

5.2 Discussion of the Study Results

5.2.1 Caries and Restorations in the Primary Teeth in Berlin

The comparison of the prevalence of caries and restorations in the primary teeth in children in Berlin and Germany in the representative national surveys [DAJ 2010] showed that caries values and degree of dental treatment in Berlin were similar to the mean German values (Table 7-10). This reveals a high potential for generalizing the present study results on patterns and outcomes of restorative treatment in primary teeth for all of Germany.

5.2.2 Distribution of Children with Dental Treatment in Berlin

In the present study, National Health System data in Berlin (KZV-Berlin) showed that the frequency and percentage of insured children who received dental care differed between the age groups within the study interval (Table 11). The observed differences amongst age groups are particularly clear comparing very young children with lower rates and children with 6-years of age and more with considerably higher rates. This reflects the existence of

barriers which interfere with the dental care intervention. The lower frequencies and percentages recorded in very young children's age groups were in agreement with reported data for all of Germany [Splieth et al. 2009]: Firstly, the age of children is a crucial factor in providing dental care in everyday practice due to the children's anxiety and fear interfering with providing dental care. And secondly, a problem in the dental health care system is in the attitude and the beliefs of care providers (dentists) in everyday practice. It appears that they do not always consider to provide dental care to the very young children, due to either lack of sufficient experience or knowledge.

In addition, a third explanation is possible: The lack of dental knowledge or compliance on the parents` side. They could not seek dental care for their children, not even for routine dental examination, before eruption of the permanent teeth at the age of 6- to 7-years. Still, they manage to present their children past the age of 6 years at about 100% to dental visits.

5.2.3 Distribution of Children with Restorative Treatment in Primary Teeth in Berlin

The present study revealed that the majority of all children visiting the dentist did not receive restorative treatments in primary teeth (Table 12). This is not surprising and is in accordance with recent German epidemiological surveys, which showed about more than 50% of the 6- to 7-year-old without caries experience [DAJ 2010].

Caries is considered the main reason for performing dental restoration treatment and also the most common reason for preforming retreatments in primary teeth [Wendt et al. 1998, Mjör et al. 2002, Hickel et al. 2005, Qvist et al. 2010a]. This suggests that the results of the present study support the data of German epidemiological surveys, especially within the study population of the present study. It also adds a positive value to the generalization of those survey findings, as this study was conducted on such a large scale and covers the primary teeth in a wide age range.

The difference between the recorded percentage of children without caries experience in the DAJ survey and children who did not received restorative treatments in the present study could be related to the difference in sample size and the recruiting mechanisms of the two investigations. In the DAJ survey, the data were collected through dental examination of 2,249 school children with a representative approach compared to the KZVB data for the present study from registered treatment records of 21,987 publicly insured children in Berlin. On the other hand, this study comprises almost all school children in Berlin. Still, both study

found similar results for the proportion of children without treatment need or that did not receive restorative treatment.

A cross-sectional comparative study on children's dental health from eight European cities, including Berlin [Bolin 1997], revealed clearly better results for Stockholm/Sweden than for Berlin/Germany regarding dental health, treatment needs and attitudes to dental care The Swedish 5-year-olds had a mean dmf-t of only 0.80, the German 2.99 [Bolin et al. 1996]. The authors contributed this to the superiority of children's dental health, especially preventive measures from early on. Since 1994/95 caries values in Berlin have decreased by 22.6% [DAJ 2010]. Only a minority of the children in the present study received restorative treatment during their dental visit indicating a mainly preventive pattern of dental services which is accompanied by a significant caries decline in Berlin and Germany.

In-depth results of the present study highlighted differences for the various age groups (Figure 3). It became clear that a high number of fillings per child (more than five fillings) is very frequent in very young children (40% of the 1- to 4-year-olds), but less frequent in the older age groups. In spite of the elevated SiC index in primary teeth of children in Berlin (Table 8), no data were available for caries prevalence in preschool children in Berlin. Surveys on early childhood caries in other German cities showed a wide range of caries prevalence from 5.2% to 20.3% [Bundeszahnärztekammer 2014a]. The present study stresses that more preventive efforts are needed in small children in Berlin and possibly all of Germany. This could reduce the high demand for intensive restorative treatments in 1-4 year old children and in addition subsequently minimize the costs for restorative treatment in the German health care system.

5.2.4 Distribution of Surfaces in Restorations in Primary Teeth in Berlin

The German National Health System records the filled tooth surfaces differently from the classification by Greene Vardiman Black [G.V. Black Classification 2015], as it just counts the number of surfaces which reduces the comparison with most other studies.

In the present study two-surface restorations were the most frequent type of restoration performed in primary teeth of 1- to 13-year-old children. This is similar to findings from a German trial that clinically evaluated glass ionomer cement fillings in primary teeth of 3- to 11-year-old children [Krämer and Frankenberger 2001]. Here 65% of the restorations placed in primary teeth were class II restorations (mostly equivalent to two-surface restoration in

present study) and 35% of the restorations were class I restoration (partialy equivalent to one-surface restoration in present study).

A comparison with international data revealed similar results. A practice-based cross-sectional study in Norway on the placement and replacement of restorations in primary and permanent teeth [Mjör et al. 2002a] analysed 100 consecutively placed restorations in routine daily work from 243 Norwegian dentists in general practices in 1996 and 10 randomly selected Norwegian public dental clinics with 22 participating dentists who reported data on all restorations performed within 15 days, in 2001. In this study, a detailed analysis for the distribution of a total of 1,903 restorations in primary teeth revealed that two-surface restorations (class II and III) were the main type of restoration in the 1996 survey and in the 2001 survey (up to 57%). The eight-year multicentre study in the Danish public dental health clinics [Qvist et al. 2004c] also found a clear majority of class II fillings (70%).

A huge Swedish trial in public dental clinics with 49 dentists [Wendt et al. 1998] also found a dominance of class II fillings in 3,200 restorations placed in primary canines and molars (61%). A more recent, second Swedish study in 2003 analysing restorations performed in the canine and molar of primary teeth for children between 7- and 12-years [Alm et al. 2003] confirmed these results with two-surface/class II restorations being for frequent than one-surface restorations (classes I and V). The recorded percentage of two-surface restorations reached 74.75%, compared to one-surface restorations accounted for only 25.25%.

In summary proximal two-surface fillings seem to be the most prevalent restorations in the primary dentition in developed countries with low caries levels. This contrasts the findings from young children in India where one-surface restorations were more frequently applied in primary teeth [Retna 2000, Mahesh Kumar et al. 2005, Viragi et al. 2013]. Thus it seems that the predominant type and trends of dental restoration are associated with the levels of caries prevalence in a population.

5.2.5 Surfaces of Restoration in Primary Teeth in Relation to Children's Age

The distribution of different types of restorations was further assessed regarding the children's age (Figure 4-6) which varied considerably. This can be related to inherent and integrated factors associated with the times of tooth eruption and exfoliation. Thus, all restoration types were placed in 4- to 7-year-olds where both primary and permanent teeth exist in the children's oral cavity. On the contrary, in very young children (1-3-year-olds) and older children (8-13-year-olds), the number of those restoration types was a lot smaller and

very big fillings dominated either in children with lots of caries or on teeth that seemed to be essential. Another reason for the differences amongst age groups are differences of the location of commonly caries-affected tooth surfaces among primary teeth (anterior, posterior) and also within the different tooth surfaces of the primary tooth itself (occlusal/incisal, mesial/distal proximal, buccal/lingual smooth surface) [Varpio 1981, Douglass et al. 1995, Psoter et al. 2003, Elfrink et al. 2006, Maragakis et al. 2007, Ferro et al. 2009, Psoter et al. 2009]. These studies' data revealed that in young children one-surface restorations had a higher frequency than other restoration types, which is most probably due to isolated smooth/occlusal surface caries in anterior/posterior teeth. In older children's age groups two-surface restorations were recorded with a higher frequency than other restoration types, which is most probably due to proximal surface caries in anterior/posterior teeth. In Berlin, this seems to be true only for children from 4-7 years of age, while in the early primary and late mixed dentition different treatment patterns can be detected.

Regarding the mean values of fillings in primary teeth per child (mean 3.33) in the present study, all age groups demonstrated a reduction in their calculated values compared to previously recorded data of 2008 on children's primary teeth in Germany (6.4) [Alkilzy et al. 2015]. In general, this indicates that less treatment in the children's primary teeth is performed now compared to before.

5.2.6 Outcomes of Restorative Treatment in Primary Teeth

Another aim of the present study was to evaluate the outcomes and especially retreatment of fillings in primary teeth performed in everyday dental practices in Berlin. These data included retreatment with another filling or with a SSC and also pulpal involvement and extractions as a follow-up treatment for filled teeth.

5.2.6.1 Retreatment for Fillings in Berlin

In general, the present study recorded a relatively high rate of successful fillings in primary teeth in Berlin within the study period: More than 92% of the fillings in defective primary teeth were not recorded with retreatments through secondary restorations and only 7.66% required retreatment with fillings.

This is consistent with a clinical retrospective study from Munich [Bücher et al. 2014b] on the survival of fillings in primary teeth. Out of 2,388 fillings placed in a university setting without sedation or general anaesthesia, an annual failure rate of 10% was recorded. This slightly higher failure rate, compared to the present study, was probably due to younger age

and the higher caries activity of the participating children. In another trial from Munich [Bücher et al. 2014a], a reduced annual failure rate of only 4.2% could be achieved for restorations that were performed under general anaesthesia.

Another study on this matter is a prospective evaluation of restorations in primary teeth conducted in a dental practice for one year [Attin et al. 1998]. It showed that after 12 months of observation, 6.4% of the polyacid-modified composite resin (Compoglass) restorations in primary teeth had major clinical defects and needed to be replaced.

Here, a comparison to international data was also possible: Findings from two practice-based studies in Norway [Mjör et al. 2002a] showed that in the 1996 survey, 86% of primary tooth restorations were done in the treatment of primary caries, whereas 14% were replacements of failed restorations. In the 2001 survey, the percentage of restorations due to primary caries was 91%, whereas the rest of performed restorations (9%) were done as replacements. A similar observation was made in the Danish public dental health service where primary caries ranged from 77% (in 1993) to 88% (in 2004) during the study sample recruitment of the different studies. All remaining restorations were replacements of failed existing restorations [Qvist et al. 1997, Qvist et al. 2004c, Qvist et al. 2010a]. In comparison to the present study's results, it is demonstrated that performance of retreatments to existing restorations in primary teeth is lower in Germany than in Norway and in Denmark. This suggests that dental practitioners working in everyday dental practices in Berlin spent a large amount of their clinical time placing new restorations rather than doing retreatments of existing restorations in primary teeth. By comparison, dentists working within the public child dental service in Norway and in Denmark spent a relatively larger amount of time on replacing failed primary teeth restorations. This observation is very important because each retreatment to existing restorations requires time and materials and, therefore, raises the total cost for provided dental treatment services and each retreatment means further loss of tooth structure.

Interestingly, the results of the present study showed a sum of 10,123 performed treatments as retreatments to exiting restorations in primary teeth of children between 7- and 12-years of age. The percentages of these retreatments in relation to total performed restorations, (Table 15), reached 46.25%. This percentage is extremely high, compared to corresponding data from the Alm et al. [2003] study in Sweden with 31% retreatment in children between 7- and 12-years of age. One possible explanation to the higher rate of retreatment in Berlin could be the higher caries activity with a mean dmf-t of 2.4 in 6- to 7-year-olds [DAJ 2010] while the

Swedish children of 6-years had only a mean dmf-s of 1.9 [Alm et al. 2003]. Many studies finding secondary caries as most important reason with respect to failure of restorations in primary teeth[Wendt et al. 1998, Qvist et al. 1990a, Mjör et al. 2002a, Bücher et al. 2014a-b]. This also highlights the importance of preventive dental care for children even with restored teeth which could minimize the need for retreatment in primary teeth due to new primary or secondary caries.

5.2.6.2 Distribution of Stainless Steel Crowns as Retreatment

Stainless steel crowns represent a very durable and, therefore, successful option for the restoration of primary teeth [Guelmann et al. 2001, Seale 2002, Hickel et al. 2005]. They can also be used as alternative option to retreat defective fillings. In the present study, 1,086 fillings in primary teeth were retreated with a SSC which is less than 6% of the replaced fillings and giving a ratio of 19 retreatments with fillings to 1 SSC. Therefore, the present study shows that alternative SSC retreatment was not frequently used in routine work of every day practices to correct the defective restorations in primary teeth in Berlin. This finding is in accordance with data in most of Europe and all of Germany where SSC are seldom selected and they are not a very popular restoration technique in paediatric dentistry, compared to Anglo-American countries [Schulte 1999, Guelmann et al. 2001, Buerkle et al. 2005].

Due to the superior longevity and cost effectiveness of SSCs [Guelmann et al. 2001, Seale 2002, Hickel et al. 2005], the present study suggests to increase the use of SSC in restorative treatments to primary teeth in daily routine work by dental practitioners in Germany, especially high caries risk children.

5.2.6.3 Retreatment in Primary Teeth with Pulp Involvement

The study revealed that only a minority of retreatments required pulp therapy (11.27%) which is within the range of other studies (1%-13%) [Qvist et al. 1990, Mjör et al. 2002a, Qvist et al. 2004a-c, Qvist et al. 2010a]. These studies also showed that failure with pulp involvement dependent on the type of restorative materials and cavity class. The pulp complication occurred most frequently within the first year after primary restorative treatment and was closely associated with primary teeth that had previously received endodontic treatments, like pulp capping or pulpotomy. Interestingly, the reported data also revealed that not all restorations with pulp involvement were retreated again with restoration therapy. The extraction treatment was preferred because of anticipated exfoliation of the teeth in the near

future and, because of the difficulty of another endodontic therapy [Qvist et al. 2010a]. Based on those data, the percentage of retreatments with pulp therapy in the present study can actually be considered high. There is the possibility of misdiagnosis and improper decisions at the initial restorative treatment with respect to the status of pulp the pulp. This elucidates the importance of proper dental education programs for all dental practitioners in the field of paediatric dentistry regarding diagnosis and treatment of primary teeth.

5.2.6.4 Extractions as Follow-up Treatment for Fillings

Extractions of filled primary teeth were further evaluated in the present study as a possible outcome of restorative treatment. The primary teeth are, by their nature, subjected to extraction due to normal exfoliation. Thus, extraction is considered a viable dental intervention in primary teeth to treat the defective restorations, especially for severely affected teeth and those with restorations in need of replacement that are close to exfoliation [AAPD 2007].

Due to limitation of available data, the reason for performance of extraction treatments for restored teeth was not record in present study. Thereby, the study's ability to analyse the restorations that were extracted due to restoration failure, trauma or normal exfoliation is limited. However, the present study found only a lower frequency of formerly filled primary teeth.

5.2.6.5 Outcomes of Restorative Treatment in Primary Teeth in Relation to Children's Age

The wide range of children from 1- to 13-years of age gives the opportunity to assess the effect of children's age on outcomes of restorative treatment with fillings in primary teeth in Berlin. Most retreatment was performed from 5- to 8-years of age where also the higher for the placement of fillings was recorded overall. Thus, age was an important factor for the placement of fillings and their retreatment with fillings, while SSCs were preferred in younger children below 5-years of age. Extractions were naturally selected to older children (11-13-years of age).

6. Conclusions

Under the conditions of this retrospective study on the restorative treatment in primary teeth within the National Health System in Berlin and a comparison with representative German surveys [DAJ 2010] and Danish community data [Qvist et al. 2010a], it can be conclude:

- The prevalence of caries and restorative treatment in the primary dentition is comparable in Berlin and all of Germany [DAJ 2010] making similar patterns for restorative treatment very likely.
- The number of children visiting dentists within the National Health System in Berlin increases from 1- to 8-years of age to finally 100%. It seems that the system is well accepted with the eruption of the permanent dentition which results in low caries levels for the permanent dentition.
- For younger children preventive services are still missing in the Germany National Health System. A considerable number of children show clear signs of severe early childhood caries. This leads to restorative treatment in very young children with a high number and multi-surface fillings per child. It is most likely that most of these rehabilitations are performed under general anaesthesia at a high cost. A structured program for prevention in the primary dentition from the first tooth on which has been successfully implemented for the permanent dentition would be needed in Berlin and all of Germany.
- In older children, two-surface fillings are the most frequent restoration in the primary dentition in Berlin which is in line with the complete dental treatment performed in the German National Health System [KZBV 2011]. Most of these fillings are performed in primary teeth during the period of the mixed dentition. Thus, the problem of caries in the primary dentition is relevant well into to school age.
- The fillings performed within the National Health System in primary teeth in Berlin were very successful with a retreatment of only 7.66%. Most fillings were retreated at the age of 6 years and they were replaced with another filling. Very few teeth were retreated with stainless steel crowns which are heavily underutilized in Germany. Unfortunately, there is little international data on retreatment of fillings in the primary dentition, but the German data are comparable to data from Denmark [Qvist et al. 2010a], Norway [Mjör et al. 2002a] and Sweden [Alm et al. 2003].

- There seems to be a need for specialized paediatric dentistry, especially in younger children with high caries activity where intensified prevention, complete oral rehabilitations under GA and more durable treatments such as pulpotomies and stainless steel crowns are indicated.

7. Summary

Background: Restorative treatment for children's teeth is still an important aspect of dentistry. In the light of an only moderate caries decline in the primary dentition and a persistently low care index in Germany during the past years [DAJ 2010], there is still a demand for further work on recent patterns and outcomes of restorative treatments in primary teeth placed in everyday practices under the Germany National Health System.

Objectives: The present study aimed firstly to describe the prevalence of caries and restorations in the primary teeth in Berlin and Germany from the representative Germany surveys [DAJ 2010], secondly, to describe the frequency and distribution of restorative treatment in primary teeth performed in everyday dental practice in Berlin including children age groups from 1- to 13-years of age, thirdly, to evaluate the outcomes of restorative treatment performed in everyday dental practices in these children and finally to compare results of the present study with data from the German National Health System [KZBV 2011] and randomized community data on the longevity of restorations in primary teeth in Denmark [Qvist et al. 2010a].

Material and Methodology: In the first part of present study data from representative German surveys [DAJ 2010] were interpreted to describe and compare the prevalence of caries and restorations in the primary teeth in Berlin and Germany. For the second and third parts data generated from German National Health System in Berlin (KZV-Berlin) on fillings done in everyday practices in primary teeth of 1- to 13-year-olds during 2010/2011 were collected. This data included: distribution of children with dental treatment regardless of the type of intervention provided, of children who received restorative treatments in primary teeth during dental care visits including total number of fillings per child, the number of filled tooth surfaces, retreatment with another filling, stainless steel crowns, pulp involvement and extractions after prior filling therapy. Information on the age of the original fillings at the time of retreatment was also included. The collected data then were entered into a data base for descriptive and analytical analysis. The results were compared with equivalent data from the German National Health System [KZBV 2011] and randomized community data from Denmark [Qvist et al. 2010a].

Results: Result showed a high similarity in patterns of caries and restorative treatment in primary teeth in Berlin and all of Germany as reported in the representative German surveys [DAJ 2010]. About of 84% of 1-13-year-olds insured in the German National Health System in Berlin received dental care during 2010/2011, with considerably lower rates in very young children. Fillings in primary teeth were performed in 31.17% of all children attending the dentist. Most restorations were placed in 5-8-year-olds. In 1-13-year-olds mostly just one filling was placed, more than five fillings were per child were recorded on average for very young age groups (1-4-year-olds). 55.60% of all fillings in primary teeth were two-surface restorations, whereas more than three-surface restorations comprised 6.17% of all fillings and they were performed most frequently in young children of 1-4-years of age. Retreatment to fillings in primary teeth was 7.66% of fillings placed in 1-13-year-olds. Most retreatments took place from 5 to 9 years of age with a peak in 6-year-olds. In 1-3-year-old children fillings showed shorter mean age at the time of retreatment compared to 7-year-olds and above. Retreatment of fillings in primary teeth by stainless steel crowns was very limited with only 5.16% of all retreatments and it was preferred in children from 3 to 7 years of age. The retreatment with pulp involvement was 11.27% of all retreatments. Extractions were almost as often as retreatment as another filling (ratio 4:5), but they were preferred in older children due to the course of exfoliation.

Conclusions: Under the conditions of this retrospective study, the restorative treatment with fillings performed within the National Health System in primary teeth in Berlin was very successful with low rates of retreatment and the fillings shows comparable results to data on the longevity of restorations in primary teeth in Denmark. The study highlighted the need to a structured program for prevention in primary teeth, especially for very young children with high caries activity and possibly also different treatment structures with specialized dentists in this field who can perform oral rehabilitations with pulpotomies and stainless steel crowns.

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Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die vorliegende Dissertation selbständig verfasst und keine anderen als die angegebenen Hilfsmittel benutzt habe.

Die Dissertation ist bisher keiner anderen Fakultät, keiner anderen wissenschaftlichen Einrichtung vorgelegt worden.

Ich erkläre, dass ich bisher kein Promotionsverfahren erfolglos beendet habe und dass eine Aberkennung eines bereits erworbenen Doktorgrades nicht vorliegt.

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