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1 Summary (English)

The aim of this study has twofold. First, to investigate characteristics of paediatric patients seeking emergency dental care and the according treatment in a specialised dental service. The second aim, to propose a data-based guidance for management of dental emergency in children including pain management without traumatizing the child and with a clear differentiation of dental emergency patients.

Records of the demographic and clinical characteristics of 332 children (mean age 8.2 ± 4.2 years) who attended the Department of Preventive and Paediatric Dentistry at the University of Greifswald in 2018 without an appointment seeking emergency dental care were collected. Statistical analysis was carried out using descriptive statistics and Chi-square tests. Based on the data a proposal for management of emergency/pain patients was performed.

Pain patients were high caries risk children (mean: 4.59 ± 3.65 dmft, 1.65 ± 2.73 DMFT). The main clinical diagnoses of pain patients in all different age groups were dental caries and caries-related complications such as reversible and irreversible pulpitis or periapical periodontitis (63.6%), while dental trauma contributed (8.4%). In general, the most frequent treatment was extraction (41.0%), most of these extractions needed to be rendered under either nitrous oxide sedation or general anaesthesia (57.3%).

This study has shown a clear association between the dental emergency management plan (delay of the dental treatment) and other factors such as, the required treatment (invasive or not invasive) $P < 0.05$, the need of sedation $P < 0.05$ and child's previous dental experience (first visit to the dental clinic) $P < 0.001$. Most of the extraction procedures were not rendered immediately in the emergency/pain visit, rather they were delayed to be performed in the next treatment session (70%), with the majority of these procedures planned to be rendered under sedation. On the other hand, most of the restorations (65.5%) were performed in the emergency/pain visit, with need of sedation for only (8.3%) of these procedures. In addition, the majority of treatments of children who were visiting the dental clinic for the first time were postponed (71.6%; $n=63$). The correlation analysis shows a higher tendency to postpone the treatment when the required treatment is invasive, need to be rendered under sedation or when

it was the child's first visit to the dental clinic. These findings indicate the strong impact of child's cooperation on the emergency management plan.

Based on these data the guidance for management of paediatric dental emergency patients was developed including pain management without causing negative affect of the child's future cooperation (Figure 10).

2 Zusammenfassung (Deutsch)

Das Ziel dieser Studie ist ein zweifaches. Erstens, die Charakteristika pädiatrischer Patienten, die eine zahnärztliche Notfallversorgung suchen, und die entsprechende Behandlung in einem spezialisierten zahnärztlichen Dienst zu untersuchen. Das zweite Ziel ist es, einen datenbasierten Leitfaden für das Management von zahnärztlichen Notfällen bei Kindern vorzuschlagen, einschließlich der Schmerzbehandlung ohne Traumatisierung des Kindes.

Es wurden die demografischen und klinischen Merkmale von 332 Kindern (mittleres Alter $8,2 \pm 4,2$ Jahre) erfasst, die im Jahr 2018 ohne Termin die Abteilung für Präventiv- und Kinderzahnmedizin der Universität Greifswald aufsuchten, um eine zahnärztliche Notfallversorgung zu erhalten. Die statistische Auswertung erfolgte mittels deskriptiver Statistik und Chi-Quadrat-Tests. Basierend auf den Daten wurde ein Vorschlag für das Management von Notfall-/Schmerzpatienten erstellt.

Schmerzpatienten waren Kinder mit hohem Kariesrisiko (Mittelwert: $4,59 \pm 3,65$ dmft, $1,65 \pm 2,73$ DMFT). Die wichtigsten klinischen Diagnosen der Schmerzpatienten in allen verschiedenen Altersgruppen waren Karies und kariesbedingte Komplikationen wie reversible und irreversible Pulpitis oder periapikale Parodontitis (63,6 %), während ein Zahntrauma 8,4 % ($n=28$) ausmachte. Im Allgemeinen war die häufigste Behandlung die Extraktion (41,0%), wobei die meisten dieser Extraktionen entweder unter Lachgas-Sedierung oder Vollnarkose (57,3%) durchgeführt werden mussten.

Diese Studie hat einen klaren Zusammenhang zwischen dem zahnärztlichen Notfallmanagementplan (Verzögerung der zahnärztlichen Behandlung) und anderen Faktoren wie der erforderlichen Behandlung (invasiv oder nicht invasiv), der Notwendigkeit einer Sedierung und der vorherigen zahnärztlichen Erfahrung des Kindes (erster Besuch in der Zahnklinik) gezeigt. Die meisten Extraktionsverfahren wurden nicht sofort in der Notfall-/Schmerzsprechstunde durchgeführt, sondern auf die nächste Behandlungssitzung verschoben (70 %), wobei die meisten dieser Verfahren unter Sedierung geplant waren. Auf der anderen Seite wurden die meisten Restaurationen (65,5 %) in der Notfall-/Schmerzsitzung durchgeführt, wobei nur bei (8,3 %) dieser Eingriffe eine Sedierung erforderlich war. Darüber hinaus wurden die meisten Behandlungen von Kindern, die zum ersten Mal die Zahnklinik besuchten, verschoben (71,6%; $n=63$). Die Korrelationsanalyse zeigt eine höhere Tendenz, die

Behandlung zu verschieben, wenn die erforderliche Behandlung invasiv ist, unter Sedierung durchgeführt werden muss oder wenn es der erste Besuch des Kindes in der Zahnklinik war. Diese Ergebnisse weisen auf den starken Einfluss der Kooperation des Kindes auf den Notfallmanagementplan hin.

Basierend auf diesen Daten wurde ein Leitfaden für das Management pädiatrischer zahnärztlicher Notfallpatienten entwickelt, der ein Schmerzmanagement beinhaltet, ohne die zukünftige Kooperation des Kindes negativ zu beeinflussen (Figure 10).

3 Introduction

3.1 Objective of the study

The aim of this study has twofold. First, to investigate characteristics of paediatric patients seeking emergency dental care and the according treatment in a specialised dental service. Second, to propose a data-based guidance for management of dental emergency in children including pain management without causing negative effects on the patients' cooperation.

3.2 Motivation for the study

The number of patients seeking emergency dental care is increasing annually (Ladrillo et al. 2006; Lee et al. 2012; Martens et al. 2018; Hong et al. 2011) and therefore, it is a relevant challenge in dentistry. However, there is a lack in the published literature regarding this subject (Souza and Martins 2016; Martens et al. 2018).

The purpose of providing the optimal treatment for the patient is particularly challenging in cases of emergency paediatric patients, whereas, rendering the required treatment become affected by multiple factors, most noticeable is pain which usually one of the main symptoms of patients seeking emergency care, the possibility of low cooperation and young age of the child imposing additional pressure on the dental practitioner, and the nature of emergency visit which is usually non-scheduled appointment, when time is both limited and valuable in dental practice (Gerbershagen 1995), as well as, (clinical diagnosis, medical history, dental status and caries level, Etc). All these factors, in addition to the absence of clear guidelines for management of emergency paediatric dental patients (Martens et al. 2018), makes it necessary and relevant to perform further research in this field.

3.3 Study design and clinical value

This retrospective study comprised the records of 332 paediatric patients who attended the Department of Preventive and Paediatric Dentistry at the University of Greifswald of the year 2018 without an appointment seeking emergency dental care. Data regarding demographic and clinical characteristics of these patients were analysed in an attempt to recognise the main factors affecting the treatment provided

for these cases. Afterwards, based on the results of this analysis a guidance for management of paediatric emergency patients was developed with clear differentiation between emergency and pain patients.

This proposed guidance serves the purpose of providing the child with the best treatment option possible to manage the pain condition without negatively affecting future cooperation or severely traumatizing the child. Furthermore, the guidance was developed and designed to be easily adopted even in non-specialized dental clinics with the intention of organizing the decision-making process and providing the child with the optimal treatment option.

4 Literature review

4.1 Odontogenic pain

Dental pain still has a high prevalence worldwide with noticeable negative impact on the patient's quality of life (Peretz and Sarnat 2010; Boeira et al. 2012). These negative effects apply to everyone, but they are more impactful on the child's life (Gherunpong et al. 2004). Such effects have negative impact on their feeding, sleep, social interactions and absenteeism from school (Feitosa et al. 2005; Souza and Martins 2016; Edelstein et al. 2006).

A dentist is expected to be able to recognise and treat odontogenic pain, which is pain initiating from the teeth or their supporting structures, the mucosa, gingivae, maxilla, mandible or periodontal membrane (Renton et al. 2011). However, this task becomes more complicated with underaged uncooperative children who react to pain with a heavy load of anxiety and in different ways due to their immature nervous system (Cameron and Widmer 2013). In fact pain by children is a multifactorial and complex feeling strictly connected to the psychological status of the subject, and its perception and intensity can be influenced by the mental status (Lamart et al. 2019). Other factors that influence assessing the pain in children which includes age, developmental level, social and medical factors as well as previous pain experience (Cameron and Widmer 2013).

Odontogenic pain may be of pulp and/or periodontal origin. Both are classified as a deep somatic pain with the dental pain being difficult for the patient to locate the affected tooth (Renton et al. 2011). Furthermore, the experience of pain can vary between individuals. This variation is explained, among other factors, by difference pain threshold and tolerance, as well as the effects of patient's genetic (related to the nociceptive system and pain modulation), emotion (fear, anger, anxiety and depression) and culture (learning and previous experiences) (Faraco JR et al. 2001). Thus, a proper evaluation of the signs simplifies the identification of the etiology and represent a key parameter in monitoring the evolution of a possible pathology, leading to a better management of pain. This is important because it indicates that a successful pain management in the facial region is the result of a proper diagnosis and a proper

characterization of the symptoms, i.e. careful anamnesis and clinical examination along with radiographic examination when indicated (Lamart et al. 2019; Kevin Mackway-Jones et al. 2014)

Gerbershagen (1995) identified the main key points that should not be missed in the pain analysis:

- Main location of the pain (where the pain started and where extends to).
- Quality or character of the pain.
- Intensity of the pain, first appearance of pain or time since pain started, frequency and duration of pain.
- Relief of pain over time.
- Pain relieving factors, previous therapy attempts, type and scope of drug therapy.
- Inability to work.

These factors should enable a more precise limitation of the respective pain phenomenon and lead to a diagnosis or at least a working hypothesis with subsequent targeted diagnosis.

4.2 Emergency/pain visit

4.2.1 Definition

Providing the optimal treatment for patients is the intention of every dental practitioner, and in order to achieve this purpose it is important for health care systems to have a general understanding of what constitutes a dental emergency to ensure that patients have access to essential care. Practitioner need to understand the critical elements of administering emergency dental care, the factors which may influence patients to seek out care, and the optimal plan appropriately for treating emergency cases (Fiehn et al. 2020). However, there is no widely accepted definition of the term “dental emergency” (Martens et al. 2018).

The ADA (American Dental Association) and the AAOMS (American Association of Oral and Maxillofacial Surgeons) defined 'dental urgency' as "Jaw- or alveolar bone fractures, avulsions, teeth luxation, teeth fractures with pulp involvement, acute alveolar abscess, injury of upper airways, laceration of oral mucosa, acute toothache, bleeding infection and uncontrolled (DeLuke 1976; Jung et al. 2016). The American Society of Oral Surgeons (ASOS) defined dental emergency as "The management or treatment of haemorrhage, upper airway impairment, trauma, acute infection, or acute inflammation involving the teeth and dento-alveolar processes which threatens the person's life or substantially impairs the functioning of such structures" (DeLuke 1976). (Shqair et al. 2012) defined an intervention as 'urgent' "If treatment delay has a negative influence on health or final treatment." While (Agostini et al. 2001) defined the emergency visit as the care of patients who present oral problems that interfere in their lives or with organ function. However, all these definitions can not accurately apply on the wide variety of children attending the emergency dental care.

Martens et al. (2018) stated that neither International Association of Paediatric Dentistry (IAPD), and the European Academy of Paediatric Dentistry (EAPD), nor American Academy of Paediatric Dentistry (AAPD) have a policy document on this essential issue, which indicate the importance of defining a clear guideline and treatment protocol of dental emergency for paediatric patients.

4.2.2 Prevalence worldwide

Dental visits to the emergency departments have increased over the past decade. (Hong et al. 2011; Ladrillo et al. 2006; Lee et al. 2012). There are about 2 million annual emergency department visits in the United States alone for nontraumatic dental problems (National Hospital Ambulatory Medical Care Survey: 2010). Furthermore, there was a rise detected in the number of paediatric emergency visits over the past years (Wong et al. 2012; Martens et al. 2018; Madan et al. 2010; Brecher et al. 2016). Nevertheless, the literature on pediatric dental emergency is rather scarce (Martens et al. 2018). Most of current literature has focused on either dental injuries specifically due to dental trauma (Díaz et al. 2010; Bücher et al. 2013) or emergency care in a hospital setting (Cohen et al. 2003; Rowley et al. 2006; Slack-Smith et al. 2009).

Yet another concerning aspect is that previous studies have shown that most emergency departments are not equipped to provide definitive dental care for dental conditions such as pulpal or periapical lesions, cellulitis or abscess, injuries, and pain (Pennycook et al. 1993; Pajewski and Okunseri 2014; Davis et al. 2010), whereas the management of dental problems consists primarily of the management of pain and infection through analgesics and antibiotics (Hocker et al. 2012).

4.2.3 Emergency patients in time of COVID-19 pandemic

In the first half of 2020 infection rates of the novel coronavirus 2 disease (SARS-CoV-2) were escalating globally. Governments around the world have taken containment measures (including social distance regulations, contact restrictions, etc.) to hold back the spread of the pandemic (RKI - COVID-19 2021). However, paediatric dental emergencies have not taken a break in the times of the pandemic. In fact, a recent study in the University of Greifswald, Germany, has shown an increase in the number of emergency patients at the Preventive and Pediatric Dentistry Department between March 17th to April 30th in the year 2020 during the time of COVID-19 (Al Masri et al. 2021). Therefore, better understanding of the frequency of dental emergencies and the procedures performed during emergency visits can help providers and the medical system understand care provision needs both within and outside of the coronavirus disease (COVID-19) pandemic environment (Fiehn et al. 2020).

4.3 Reasons of dental emergencies

Children are most often visiting emergency dental care clinics for acute pain caused by infection or dental trauma (Wilson et al. 1997; Tulip and Palmer 2008). Although, there are some other reasons that can cause children and parents to seek emergency dental care.

4.3.1 Emergency visit due to dental caries or MIH

Untreated dental caries (tooth decay) in permanent teeth is the most common health condition according to the Global Burden of Disease 2017. Worldwide, it is estimated that 2.3 billion people suffer from dental caries of permanent teeth and more than 530 million children suffer from caries of primary teeth (James et al. 2018). In low-income

countries almost all of young children are affected with dental caries, decreasing to more than 50% in Europe (Jin et al. 2016; Kassebaum et al. 2017; Petersen et al. 2005). Data shows an impressive decline in dental caries, but this decline is not the complete picture (Splieth et al. 2016). There are significant number of exceptions to this global trend, with pockets of patients affected with caries specially in low socio-economic groups as the recent literature have showed (Schwendicke et al. 2015; Schmoeckel et al. 2019).

Dental caries also known as dental decay is a localized infectious oral disease seen as a process of chronic demineralisation of dental hard tissues involving the interaction of multiple biological factors such as the host (teeth and saliva), the agent (biofilm/dental plaque) and substrate (diet) over time and might affect dentate individuals a lifelong (Pschyrembel et al. 2007). Carious lesions can cause a series of complications, toothache is the most common in dental clinical practice. Toothache in turn could manifest in many forms such as tooth ache, pulpal ache, acute apical periodontitis (Lamart et al. 2019).

Molar-incisor hypomineralization (MIH) is a condition of qualitative change in enamel that, initially, is of normal thickness, ranging from localized opacity through opacity with discoloration and obvious poor quality to post eruptive enamel breakdown. Often affected teeth are extremely sensitive (Elhennawy and Schwendicke 2016). The prevalence ranged widely, however, it lies between 10% and 15% in many countries around the world with about 5% of the proportion being severely affected. MIH can affect any teeth in the permanent dentition, however, prevalence of the affected first molar is the highest (Cameron and Widmer 2013).

4.3.2 Emergency visit due to dental trauma or soft-tissue lesions

The prevalence of dental trauma is extremely high, with nearly one out of three persons of the world's population experiencing a dental injury during their lifetime (Moule and Cohenca 2016; Nalliah et al. 2015). Oral injuries can cause aesthetic, psychological, social, functional and therapeutic problems and can cause irreparable dental loss, at the time of accident, and also during the post treatment period (Marcenes et al. 2000). Thus, it is particularly important for the dental practitioner to

have a precise diagnosis and to render the correct treatment intervention to minimize undesired complications and to achieve favourable survival rates for the injured teeth (Bücher et al. 2013).

Worldwide, studies have shown that dental trauma represent one of the most common reasons for seeking emergency dental treatment. (Cortes et al. 2001; Wong et al. 2012; Naidu et al. 2005). Furthermore, dental trauma is one of the most common ceases presented in a paediatric dental clinic (Cameron and Widmer 2013), luxation injuries to upper anterior teeth are most common because children frequently fall during playing and the attempts to learn to walk. Generally, traumatic dental injuries in children and adolescents are associated with damage to surrounding oral soft-tissues. Studies report that 40 to 50% of patients with dental trauma also suffer from oral soft-tissues injuries (Davis et al. 2010; Sae-Lim et al. 1995).

Other causes than caries-related complications or dental trauma to seek emergency dental care could be due to orthodontic emergency, soft tissue lesions such as (gingivitis or periodontitis), and exfoliation/eruption problems which commonly occur in children with mixed dentition (Hodgdon 2013). Another reason for an emergency visit is primary herpetic gingivostomatitis which is the most common cause of severe oral ulceration in children. This may lead to difficulties in eating and drinking and typically drools. It usually occurs after 6 months of age, and the peak incidence is between 12 and 18 months of age (Cameron and Widmer 2013).

Pain associated with dental decay, trauma, soft tissue injuries or any of the previously mentioned conditions may lead to higher level of anxiety in the parents and appear to motivate to make use of an emergency visit (Díaz et al. 2010).

4.4 Factors associated to treatment of emergency paediatric patients

4.4.1 Pain association to emergency ceases

The definition of dental emergency varies in the medical literature ranging from life threatening conditions (DeLuke 1976), to the attendance of patient to dental clinic without an appointment seeking dental care due to some kind of oral pain. However, treating urgent emergency that threatens the patient's life differs from treating an odontogenic pain patient.

Generally, pain is the most common complaint in the dental emergency visit (Hammel and Fischel 2019; Bastos et al. 2008; Takahashi et al. 2019; Shqair et al. 2012). While truly life threatening cases are rare in these visits (Oliva et al. 2008). Thus, it is important for physicians to be well prepared in the evaluation and management of these issues (Hammel and Fischel 2019).

Unfortunately, pain is commonly under-recognised (regarding diagnosis and assessment), not optimally managed, and treatment may be delayed without a clear reason behind such a decision (Todd et al. 2002). This is especially true in children due to their lack of communication abilities at young ages (Petrack et al. 1997).

4.4.2 Treatment options

4.4.2.1 Treatment of dental infections

Dental infections range from simple caries to more severe abscesses and necrotizing gingivitis. However, young patients may have difficulties communicating their experience of pain (Wilson et al. 1997). Thus, it is often the case that the child or parent only become aware of the need to seek dental care at a late stage, when the pain is already severe. Symptoms of severe, prolonged, spontaneous or nocturnal pain suggests irreversible pulpitis or even a dental abscess (Cameron and Widmer 2013).

Treatment of pulpitis may involve filling of the dental cavities, pulp treatment and root canal treatment (Hammel and Fischel 2019). Endodontic management should be considered within the overall context of occlusal development, with consideration to occlusal guidance and space maintenance. Elective extraction may be considered within 3 years of anticipated exfoliation, because accelerated eruption of the permanent successor can be expected (Cameron and Widmer 2013). When the tooth is considered non-restorable, it should be extracted (Dhar et al. 2017).

Pulpotomy is the most frequently used technique in the primary dentition. The aim of pulpotomy in the primary dentition is to amputate the inflamed coronal pulp and preserve the vitality of the radicular pulp, thereby facilitating the normal exfoliation of the primary tooth (Cameron and Widmer 2013). However, pulpotomy cannot be performed if the pulp is necrotic. Therefore, in cases of pulp necrosis in any carious

primary tooth, or severe exposure of vital primary incisor a pulpectomy should be considered. This comprised the complete removal of the entire pulpal tissue from the tooth. Pulpectomy can only be considered for primary teeth that have intact roots. Evidence of root resorption is an indication for extraction. Furthermore, severe infections including acute facial cellulitis associated with primary teeth do not respond well to pulpectomy. Extraction is usually recommended in these cases (K. Hargreaves et al. 2011).

4.4.2.2 Treatment of dental trauma and other soft-tissue lesions

Crown fractures and luxations are the most commonly traumatic dental injuries (Diangelis et al. 2012). Proper diagnosis, treatment planning and follow-up are important for improving the outcome. Therefore, the international association of Dental traumatology (IADT) has developed a guideline for management of traumatic dental injuries. Treatment depends mainly on the extent of the injury and whether the involved teeth are primary or permanent. The aim of the emergency care provided is to identify all injuries, initiate treatment to preserve the function of the tooth, and prevent infection to the extent possible (Hammel and Fischel 2019).

Traumatic dental injuries in children and adolescents are generally associated with damage to surrounding oral soft tissues. In some of the published literature, lesions to oral soft tissues are presented in almost half of all dental trauma cases (Sae-Lim et al. 1995). And in other studies, the prevalence of patients with oral soft tissues injuries was one-third of all patients that seek emergency treatment for oral injuries (Petersson et al. 1997; Caldas et al. 2008).

Soft-tissue lesions are also one of the reasons for seeking dental care due to the pain or discomfort that can inflict to young children. Primary herpetic gingivostomatitis which is the most common cause of severe oral ulceration in children is one of these lesions. The disease is self-limiting and the ulcers heal spontaneously without scarring within 10-14 days, and the management is mainly a symptomatic care. When severe ulceration in young children occurs, chlorhexidine can be swabbed over the affected areas with cotton wool swabs (Cameron and Widmer 2013).

4.4.2.3 Treatment of molar incisor hypomineralization (MIH)

Molar incisor hypomineralisation (MIH) is a developmental, qualitative enamel defect caused by reduced mineralisation, inorganic enamel components which leads to enamel discolouration and fractures of the affected teeth (Weerheijm et al. 2003).

Regarding the therapy of MIH, various problems dominate the approach. Mainly it is difficult to determine the exactly needed extension of preparation prior restorations in hypomineralised enamel. Furthermore, it is difficult to assess whether discoloured but not-yet damaged enamel will not fracture in the near future. (Steffen et al. 2017). However, a comprehensive concept of the treatment plan was developed by (Steffen et al. 2017) according to the MIH classification.

The MIH treatment need index (MIH TNI):

- Index 0: No MIH, clinically free of MIH
- Index 1: MIH without hypersensitivity, without defect
- Index 2: MIH without hypersensitivity, with defect (post-eruptive breakdown)
 - 2a <1/3 defect extension
 - 2b >1/3<2/3 defect extension
 - 2c >2/3 defect extension or/and defect close to the pulp
- Index 3: MIH with hypersensitivity, without defect
- Index 4: MIH with hypersensitivity, with defect (post-eruptive breakdown)
 - 4a <1/3 defect extension
 - 4b >1/3 <2/3 defect extension
 - 4c >2/3 defect extension or/and defect close to the pulp

The treatment plan based on the MIH-TNI in patients with low caries and high caries risk patients according to Wuerzburger MIH treatment concept is shown in Figure 1 and 2 respectively (Steffen et al. 2017).

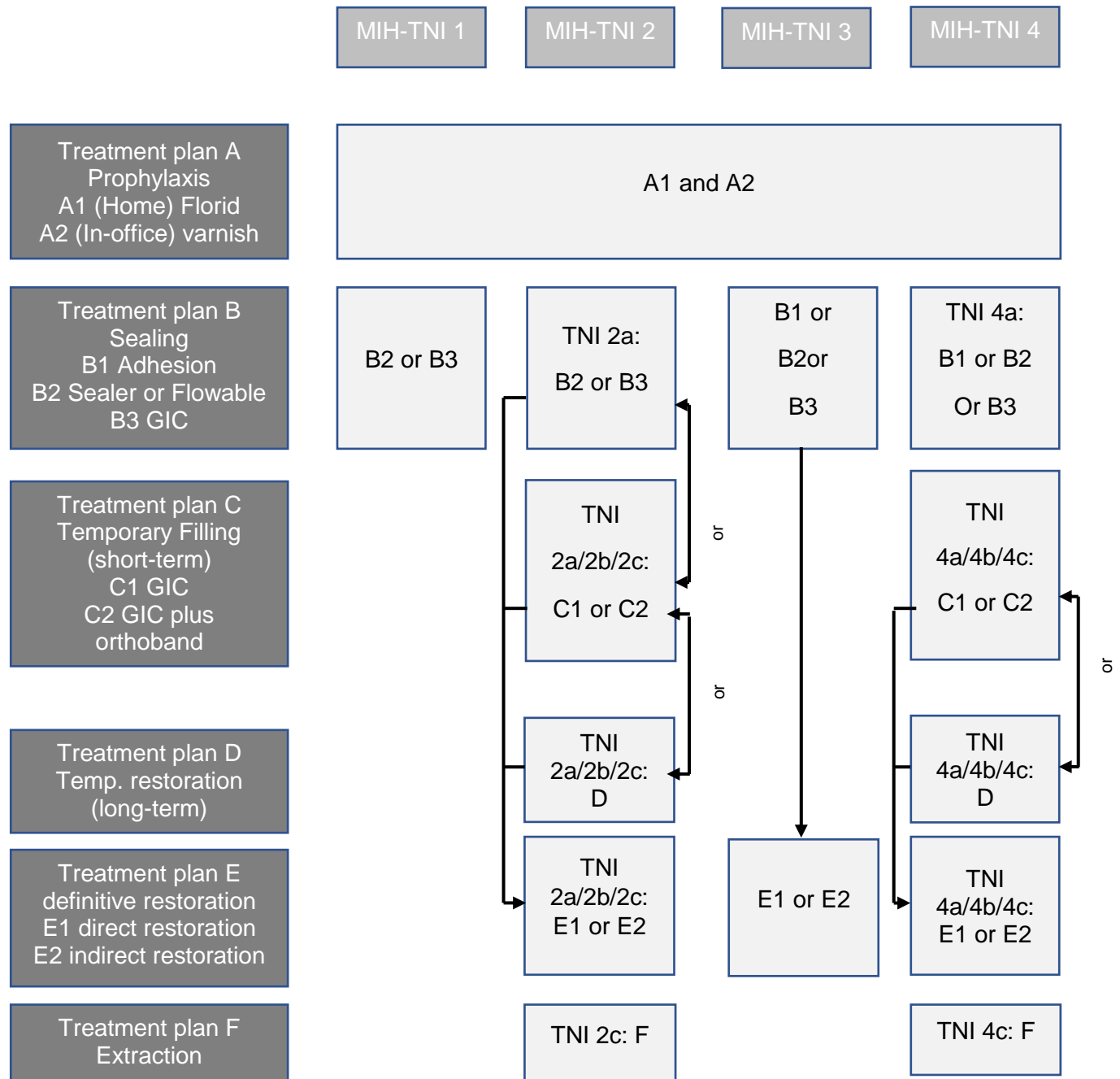


Figure 1: Flow-chart of the Wuerzburger MIH treatment concept for low caries risk patients. Adopted according to (Steffen et al. 2017)

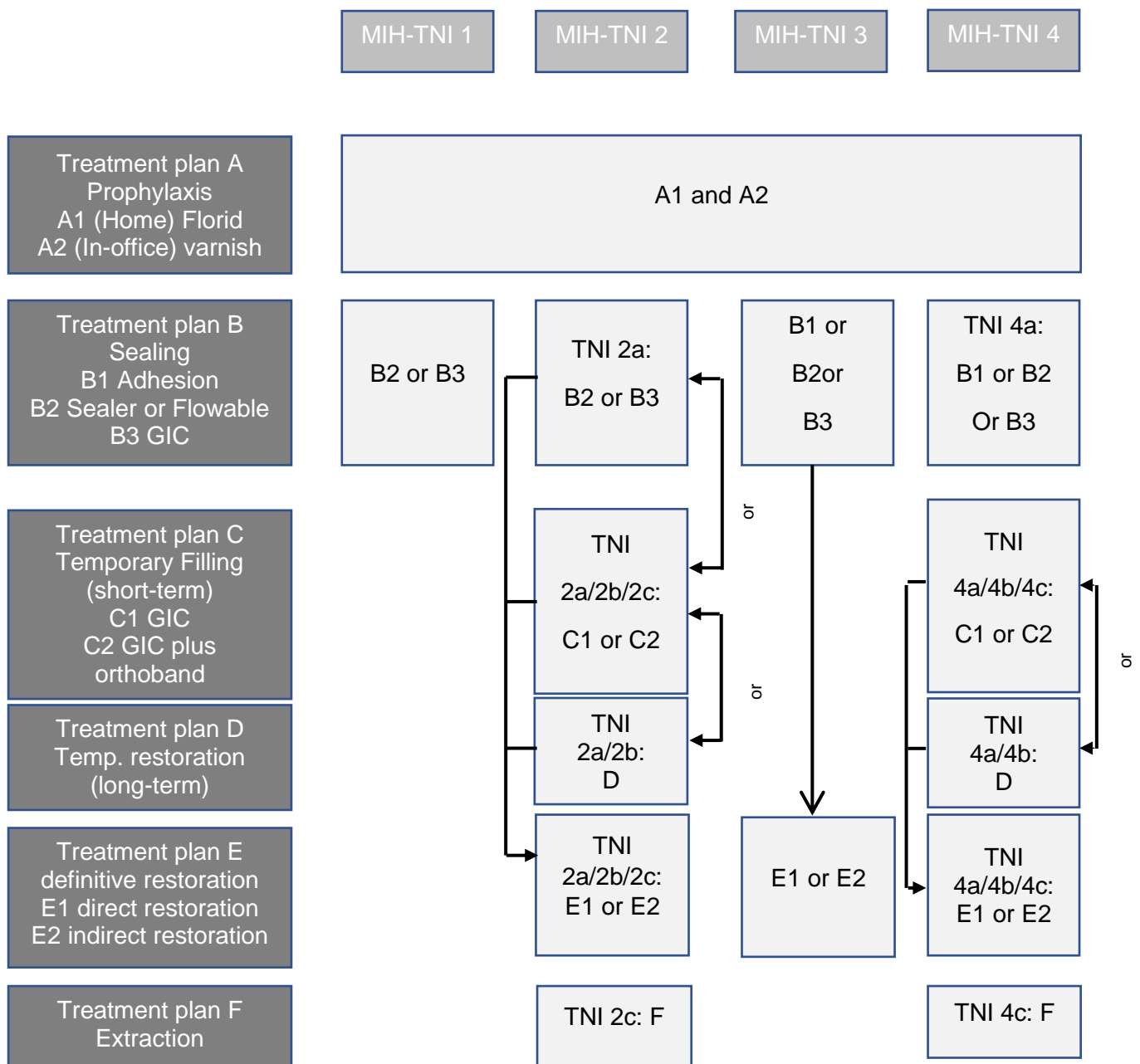


Figure 2: Flow-chart of the Wuerzburger MIH treatment concept for high caries risk patients. Adopted according to (Steffen et al. 2017).

4.4.3 Child cooperation and dental fear

Fear of dental treatment and low cooperation of the child can lead to negative consequences. Studies have shown that fear of dental treatments in children may lead to management difficulties (Holst et al. 1988). Dental pain can also complicate the situation in which it causes negative dental experience for the child leading to the development of fear and anxiety, which in turn can lead to the avoidance of further dental treatment (Hosey et al. 2002). Another serious consequence of the child's behaviour problem which can impair active intervention in cases of pain caused by odontogenic infection, dental practitioners tend to describe antibiotics without a clear indication (Cherry et al. 2012; Al-Malik and Al-Sarheed 2017; Peedikayil 2011).

Dental fear which is frequently associated with dental behaviour management problem poses a serious problem for paediatric dentists (Klingberg et al. 1995). However, the knowledge on factors that play a significant role in the development of dental fear and on which children will develop fear it is limited (Thomson et al. 2000). Well-known dentally related behaviour management problems are earlier negative treatment experiences, particularly injection, drilling and extraction (invasive treatments) which have been shown to carry the most negative emotional loads (Holst and Crossner 1984; Holst and Ek 1988).

Thus, investigating the relevance of the patient's cooperation to the management of paediatric emergency cases and the most important factors influencing the cooperation was one important aspect in developing the proposed guidance for management of dental emergency in this research project.

5 Methodology

5.1 Research design and ethical approval

For this retrospective analysis, data was collected from patients' digital records of the Department of Preventive and Paediatric Dentistry at the University of Greifswald.

The Greifswald University Institutional Review Board approved this retrospective evaluation of clinical interventions carried out in the Department of Preventive and Paediatric Dentistry (Internal Reg.Nr.: BB 028/16).

Primarily, patients' dental records were searched using the key word "Schmerz" which means "pain" in English for the time period between 01.01.2018 and 31.12.2018. The search resulted in 591 patients who had the word "Schmerz" in their digital dental records. Next, those 591 dental records were screened for eligibility using the following inclusion and exclusion criteria:

Inclusion criteria:

- patients visited the university clinic without an appointment seeking emergency dental care due to pain between 01.01.2018 and 31.12.2018.

Exclusion criteria:

- if the patient had no pain.
- patient older than 18 years of age.
- insufficient documentation

The flow-chart of the study from identification to final inclusion of participants is shown in Figure 3.

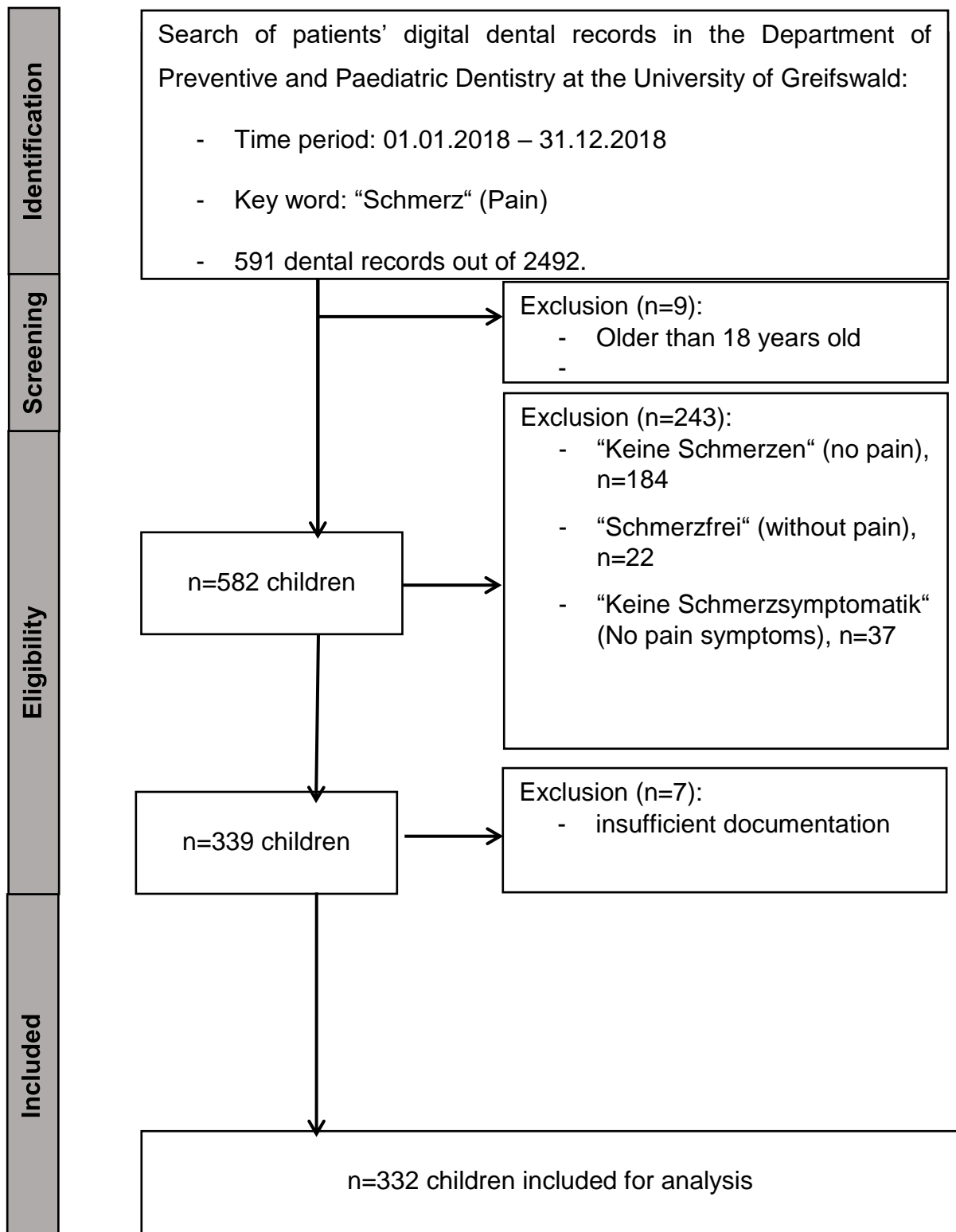


Figure 3: Flow-chart of the study from identification to final inclusion of participants

5.2 Data collection process

Based on the above mentioned inclusion criteria, a total of 332 dental records could be identified of children who underwent medical examination due to pain or at least sever discomfort in the oral cavity.

The following information was collected:

- Demographics (age, gender, place of residence)
- Dental status and caries levels (dmft/DMFT)
- The main complaints reported by parents/children and the potential cause of the pain
- The affected teeth
- Clinical diagnosis
- The treatment performed
- The need of general anaesthesia or conscious sedation in the treatment plan.

In addition, data concerning the quality management in the university clinic, distance to the dental clinic, the referring reason if the case was referred to the clinic and the type X-ray used in the diagnosis process were also documented.

In order to allow for a structured and consistent data collection from the dental records, an excel data sheet was created containing all of the above listed factors. Furthermore, the excel data sheet served as a base for the later statistical analysis, along with graphical illustrations.

Next, the data sheet was viewed by a dental research expert to ensure that all the important and relevant information are included and hat in case of unclear documentation or ways of coding 2nd researcher was asked and the case was discussed to find consent; after that, feedback and comments were adopted, and the data sheet was adapted accordingly.

Finally, the variables were numerically coded for data analysis. For data quality purposes, check sums were included, and major programmed data processing steps were verified by manual calculations.

5.3 Calibration

Dental caries was evaluated after an oral examination based on visual inspection using examination tools, without using compulsory x-ray to investigate proximal caries. Dental caries was recorded when a lesion in a pit or fissure, or on a smooth tooth surface, has an unmistakable cavity, undermined enamel, or a detectably softened floor or wall. A tooth with a temporary filling, or one which is sealed but also decayed, was also included in this category.

This recording of dental caries experience in the primary (dmft) and the permanent dentition (DMFT) was examined and calculated according to World Health Organization standards (WHO 2013)

- DT/dt: permanent or primary teeth with carious defects,
- MT/mt: missing teeth due to caries (or extracted because of caries)
- F/f: filled teeth with one or more fillings or with stainless steel crown
- dmft: for primary teeth in both of deciduous and mixed dentition stage
- DMFT: for permanent teeth in both of mixed and permanent dentition stage

The DMFT values can range between 0 and 28, while dmft values range between 0 and 20.

Due to the nature of the retrospective study and to avoid any misinterpretation of the data, all cases of dental caries and caries-related complications such as pulpitis or its reversal or peripheral gingivitis (abscess/swelling) caused by tooth decay were recorded in the study as dental caries without any differential diagnosis. Also, loss of restoration after carious defect was recorded as caries-related problems.

In cases of dental trauma an intraoral examination was carried out including inspection of teeth for fractures, as well as palpation for instability or tenderness. All intraoral tissues were also inspected and palpated, including gingiva, buccal mucosa, tongue,

frenulum, tonsils, and uvula. And the results of the examination were accurately recorded.

5.4 Data analysis

After the data collection process, the data sheet mentioned above was revised in terms of quality management, refined and adjusted to allow for proper and accurate data analysis. Afterwards, the different entries per variable were clustered and coded to avoid inconsistencies and also to ease the analysis process. Finally, to accomplish the purpose of this study, Patients' data were entered and analysed in SPSS for Windows (version 21.0; Chicago, IL, USA). Correlation between different factors were analysed using Kendall's tau -b correlation coefficient test, then multiple regression analysis was performed on the related factors to assess the strength of the relationship between variables.

Descriptive statistics and Chi-square test were performed to analyse the association between different variables when needed, with a significance level set as $P < 0.05$.

Based on the data the main factors which affect the treatment were determined and a proposal for management of pain patients was performed.

6 Results

6.1 General characteristics of the study sample

6.1.1 Characteristics of pain patients

Out of 2492 patients who were treated in the Department of Preventive and Paediatric Dentistry at the University of Greifswald in 2018, 332 patients (13.3%) were treated due to pain in unscheduled visit.

Table1 shows the general characteristics of the study sample of pain patients in the Department of Preventive and Paediatric Dentistry at the University of Greifswald in 2018.

Initially, a total of 322 patients' records (175 males and 157 females) aged 1–18 years were included in the final study. From these, fifty-nine patients (17.8%) were referred by a medical practitioner to the dental clinics at the University of Greifswald. The mean age was 8.2 years (SD= \pm 4.19).

The reason of the pain visit was recorded according to the child description or according to the parents when the child is too young or uncooperative.

The most frequent reason of seeking emergency dental care was toothache (50%; n=166). About 7% (n=23) of patients were seeking dental care due to dental trauma. In 118 cases, neither the children nor their parents were able to determine the location or type of pain, due to lack of cooperation of the children or their young age. Other reasons of seeking dental emergency care like gingivitis, temporomandibular joint pain due to bruxism or superficial mucosal lesions occurred in 7.5% of the children.

For 220 patients (66.3%) an x-ray was used in the diagnostic process divided to periapical x-ray (12.7%; n=42) and panoramic x-ray (53.6%; n=178), while in 33.7% of the cases no x-ray was taken or was not assessed to be necessary.

Table 1: General characteristics of the study sample (data based on number of patients).

Category	Total n=332		
	n	%	
Gender			
	Male	175	52.7%
	Female	157	47.3%
Health condition			
	Healthy	297	89.5%
	Chronic disease	35	10.5%
Location			
	Radius < 10 km	141	42.5%
	Radius 11 - 40 km	103	31.0%
	Radius 41 - 70 km	53	16.0%
	Radius > 70 km	35	10.5%
Reasons for seeking dental emergency care, according to the parents or child. Greifswald /2018			
	Pain from unidentified region in the oral cavity	118	35.5%
	Toothache	166	50.0%
	Dental trauma	23	6.9%
	Other reasons	25	7.5%
Age			
	≤ 5	95	28.6%
	6 - 12	179	53.9%
	≥ 13	58	17.5%
referral			
	Yes	59	17.8%
	No	273	82.2%
X-ray used in the diagnosis posses			
	Periapical x-ray	42	12.7%
	Panoramic x-ray	178	53.6%
	No X-ray was used in the diagnosis posses	112	33.7%
Patients treated before under sedation			
	General anaesthesia	29	8.7%
	N2O sedation	31	9.3%
	No experience with sedation	303	81.9%

Within the study sample consisted of 332 patients, the male : female ratio was 52.7% (n=175) : 47.3% (n=157) respectively. The majority of the patients (89.5%; n=297) were healthy and did not suffer from any type of chronic condition or disease. The remaining (10.5%; n=35) suffered from some sort of chronic condition such as asthma or mental disability. More than half of the patients (57.5%; n=191) do not live in the city of the clinic (Greifswald) itself, but rather on the outskirts (11-70 km). Only (10.5%; n=35) of the study sample came from a distance of more than 70 km away from Greifswald.

Eighteen percent of the children were treated under sedation/GA in the past (n=60). This was sub divided to 31 children treated with nitrous oxide and 29 children were treated under general anaesthesia.

6.1.2 Distribution of patients according to age

The most common age of patients who attend to the dental clinic without appointment as a “pain patient” was six years old (14.2%; n=47). Distribution of patients according to age is shown in Figure 4.

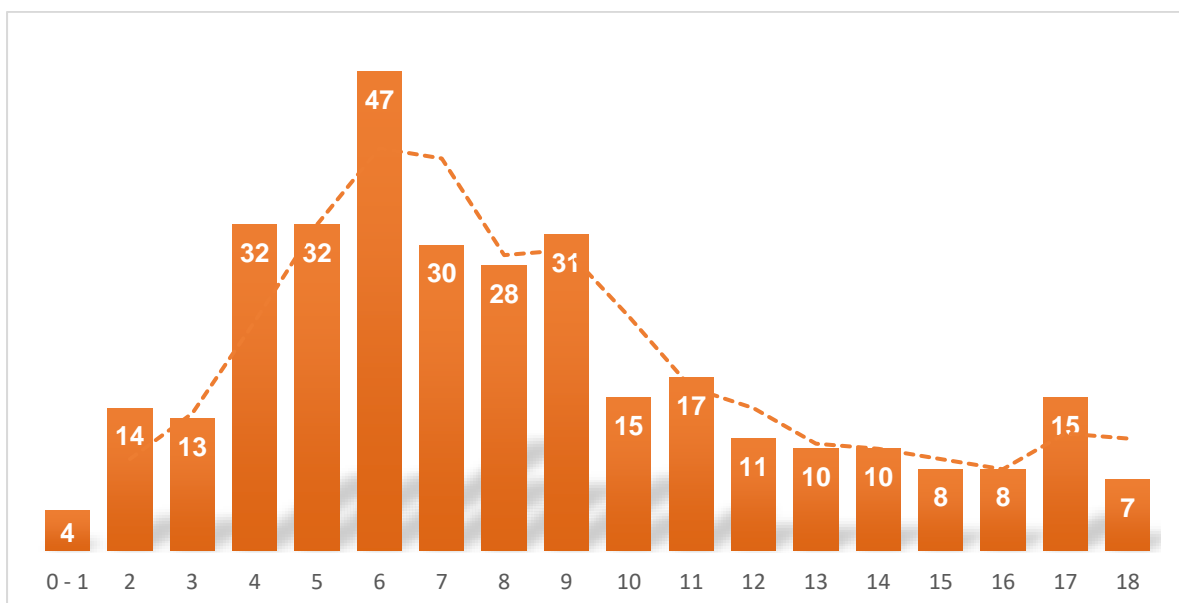


Figure 4: Distribution of pain patients according to age (years); n=332.

For further analyses pain patients are from here on shown separately regarding three age groups

- group 1 (infants/ pre-school children): ≤ 5 years
- group 2 (schoolchildren): 6 - 12 years
- group 3 (teenagers): ≥ 13 years.

6.2 Dental status

The caries experience of the sample is shown in Table 2. Pain patients in 2018 were high caries risk children with a mean dmft of 4.59 ± 3.65 and DMFT of 1.65 ± 2.73 .

Table 2: Caries experience in emergency/pain patients (mean dmft and DMFT \pm standard deviation) according to age group.

Caries experience	dmft	DMFT
Age group	mean (\pm SD)	mean (\pm SD)
≤ 5 years	5.81 (± 4.2)	-
6-12 years	3.94 (± 3.14)	0.78 (± 1.56)
≥ 13 years	-	4.31 (± 3.7)
Total	4.59 (± 3.65)	1.65 (± 2.73)

6.3 Association between referral patients and age

Distribution of referred pain patients to age groups is shown in table 3. It was found that about half of the referred patients were school children ($n=30$), and 44.1% were young children between one and five years ($n=26$), while only 5.1% of referred pain patients were thirteen years or older ($n=3$). A significant association between referral to the university dental clinic and younger age of the patients was found ($P < 0.001$).

Table 3: Distribution pain patients according to age groups and referral

		Total no. of patients		No. of referred patients	
		n	%	n	%
age groups	≤ 5 yr	95	28.6%	26	44.1%
	6-12 yr	179	53.9%	30	50.8%
	≥ 13 yr	58*	17.5%	3*	5.1%
Total		332	100.0%	59	100.0%

6.4 Clinical diagnosis of patients

Regarding the clinical diagnosis of the pain patients, the majority of the emergency visits were due to caries and their complications such as reversible and irreversible pulpitis or periapical periodontitis (63.6%; n=211, Fig. 4).

Molar incisor hypomineralization was diagnosed in 14 patients (4.2%), while dental trauma comprised 28 children (8.4%). In six children the reason of pain reported by the child or the parents was not found at the first clinical examination in the pain visit. Other diagnosis such as dental trauma and exfoliation/eruption related problems comprised about 20% of the clinical diagnoses.

Figure 5: Clinical diagnosis of emergency/pain patients

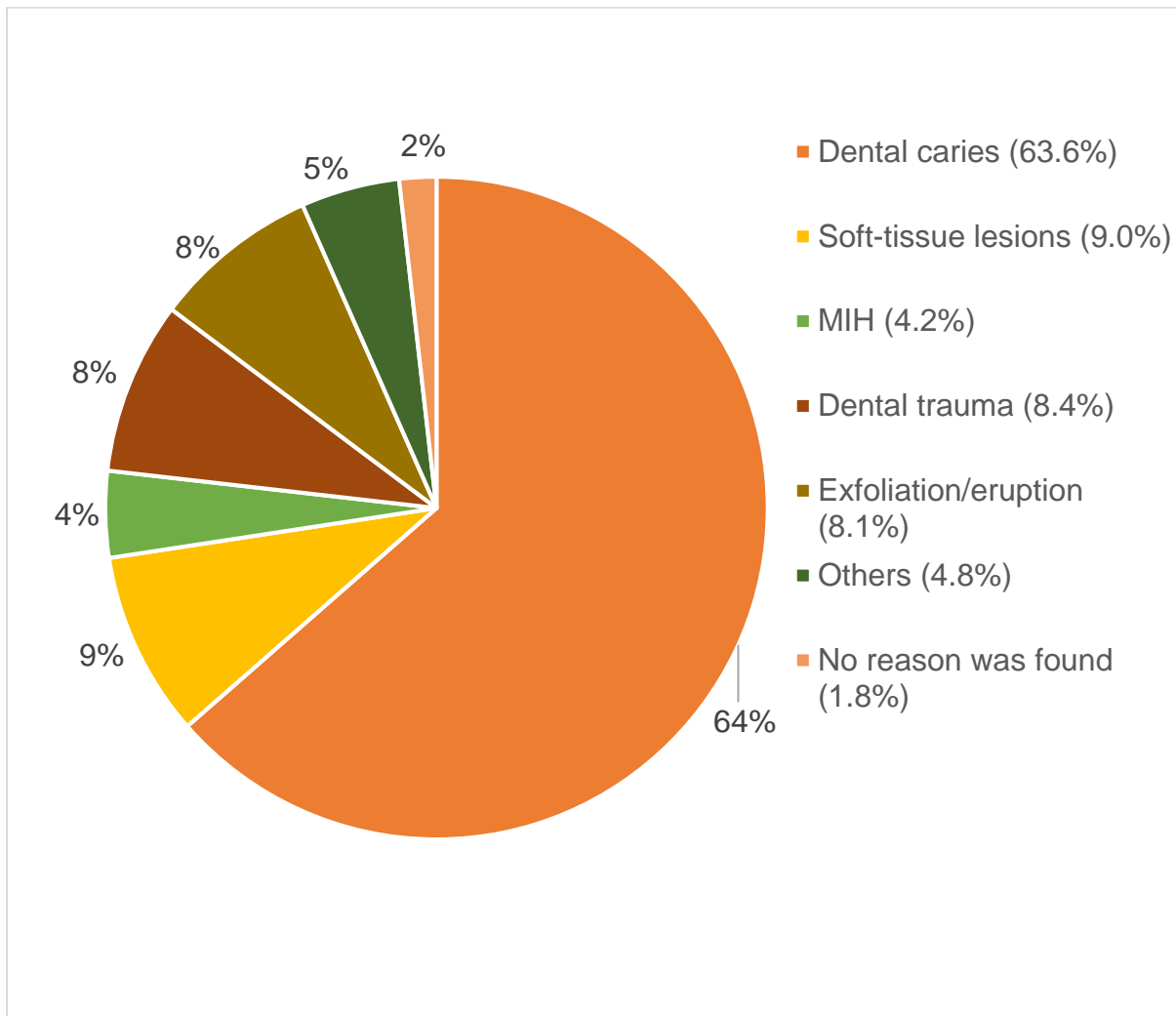


Table 4, shows the disruption of clinical diagnosis to the age groups, were it reveals that the main reason of causing dental pain by pre-school children was caries and caries-related complications such as reversible and irreversible pulpitis or Periapical periodontitis (73.4%; n=70), and even by school and adolescent groups the dental caries still the main reason for dental pain visit but with lower frequency about 59% (n=141).

While dental caries was the main reason of causing the dental pain visit by all age groups the second frequent reason differ, when it was dental trauma by the pre-school children (11.6%), it was Exfoliation/eruption related problems by school children (13.4%), and by adolescent age group other problems like orthodontic related or post-

dental procedure related pain were the second most frequent reason for seeking dental emergency care.

The differences among age groups were compared using Chi square test, the association between age groups and dental caries was considered to be statistically significant $P > 0.001$. Also, the differences between age groups and Exfoliation/eruption related problems was considered to be extremely statistically significant $P > 0.001$.

Although that the children in the (≤ 5 years) age group had a higher number of pain visits due to trauma than the (6 – 12 years-olds, this difference was not considered to be statistically significant. In general, the proportion of clinical diagnosis of soft tissue lesion and hypomineralization (MIH) distributed to the three age groups remained relatively equal in the year 2018.

Males were more likely to visit the dental emergency service due to dental trauma than females, about 68% males to 32% females. However, this did also not reach the level of statistical significance ($P > 0.05$).

Table 4: Distribution of the clinical diagnosis regarding age.

Diagnosis	Age (years)					
	≤ 5 years		6-12		≥ 13	
	n	%	n	%	n	%
Dental caries*	70	73.7%	107	59.8%	34	58.6%
Soft-tissue lesions	9	9.5%	16	8.9%	5	8.6%
MIH	1	1.1%	10	5.6%	3	5.2%
Dental trauma	11	11.6%	11	6.1%	6	10.3%
Exfoliation/eruption*	1	1.1%	24	13.4%	2	3.4%
others	3	3.2%	6	3.4%	7	12.1%
No reason was found	0	0%	5	2.8%	1	1.7%
Total	95	100%	179	100%	58	100%

*The differences were considered to be extremely statistically significant $P > 0.001$

6.5 Clinical treatment of patients

6.5.1 The need for medical intervention

After all patients who visited the dental clinic due to pain without appointment underwent clinical examination and their medical condition was diagnosed, it was decided that 17% of patients didn't require any dental intervention (n=58). The distribution of patients according to the need of medical intervention is shown in Figure 6.

Most of the patients who need dental intervention received it in the pain visit (42%; n=139). 9% of the patients received temporary treatment in the pain visit (n=29), while the rest of patient (32%; n=106) did not receive their required treatment or any temporary treatment in the pain visit and their planned treatment was postponed to another treatment session.

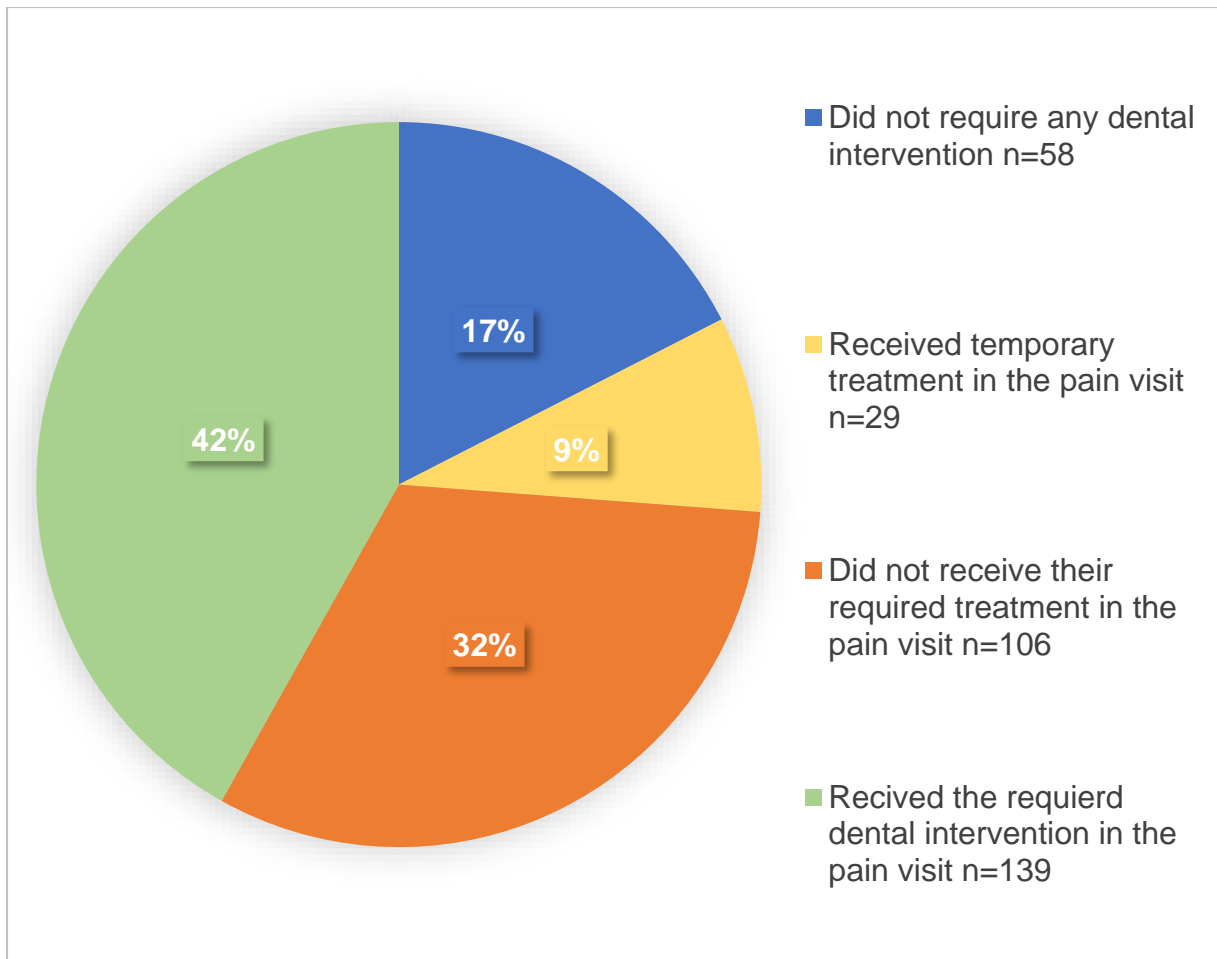


Figure 6: Distribution of patients according to the need of medical intervention.

6.5.2 Dental treatments performed

Over all the most frequently required/recommended treatment was extraction (41.0%; n=138). Extraction was also the most frequently required treatment for dental caries and caries-related complications such as reversible and irreversible pulpitis or periapical periodontitis (58.3%; n=123). Table 5 shows the treatment plan according to the clinical diagnosis and the need of sedation.

Regarding the invasive treatments (extractions, restorations and endodontic treatments), it was noticed that most of the extraction procedures were not performed immediately in the emergency/pain visit, rather they were postponed to the next treatment session (70%). About (75%) of these procedures were planned to be rendered with advanced behaviour management techniques (nitrous oxide sedation gas or general anaesthesia).

On the other hand, most of the restorations (65.5%) were performed in the emergency/pain visit, with a need of sedation for only 8.3% of these procedures. Finally, regarding the endodontic procedures, most of these treatments were rendered in the emergency/pain visit (66.6%). However, 75% of the delayed treatments were planned to be rendered under sedation, while only 12.5% of the endodontic procedures, which were rendered in the emergency visit needed to be performed under sedation. The association between the need of sedation and delaying the treatment was considered to be statistically significant ($P < 0.001$, Chi square test).

Table 5: Treatment plan according to the clinical diagnosis and the need of sedation

Diagnosis	Treatment plan			Treatment performed in the pain visit*	Treatment planned for the next session**	Need of sedation in the treatment plan (pain visit*/Planned visit**)	
		n	%			1st*	2nd**
Dental caries	Caries restoration	56	26.5%	37	19	1	4
	Endodontic procedures	24	11.4%	16	8	2	6
	Extraction	123	58.3%	34	89	10	69
	med/referral	2	0.9%	2	0	0	0
	ART/Oral hygiene instructions	6	2.8%	5	1	0	0
	Total	211	100%	94	117	13	78
Soft-tissue lesions	Instructions/follow-up	11	36.7%	11			
	Medication	19	63.3%	19			
	Total	30	100%	30	0	0	0
MIH	restoration	9	64.3%	6	3	2	1
	Extraction	2	14.3%	1	1	1	1
	ART/Oral hygiene instructions	3	21.4%	2	1	0	0
	Total	14	100%	9	5	3	2
Dental trauma	Instructions and accompaniment	15	53.6%	15	0	0	0
	restoration	8	28.6%	5	3	1	1
	Extraction	4	14.3%	0	4	0	2
	Splinting	1	3.6%	1	0	0	0
	Total	28	100%	21	7	1	3
Exfoliation/eruption	Instructions/follow-up	20	74.1%	20	0		
	Extraction	6	22.2%	5	1		
	referral	1	3.7%	0	1		
	Total	27	100%	25	2	0	0
others	Instructions and accompaniment	10	62.5%	10	0		
	Extraction	3	18.8%	1	2		
	Splinting	1	6.3%	1	0		
	referral	2	12.5%	2	0		
	Total	16	100%	14	2	0	0
No reason was found	Instructions and follow-up	6					
Total		332			100%		

6.5.3 The need of sedation for dental treatment

Most of the exodontic procedures needed to carry out under either nitrous oxide sedation or general anaesthetise (57.3%; n=83). On the other hand, the major number of restorative procedures where performed without any form of sedation (84.9%; n=64). When the difference between the groups on base of the need of sedation was calculated using Chi square test the different was considered to be statistically significant ($P < 0.001$) Table 6.

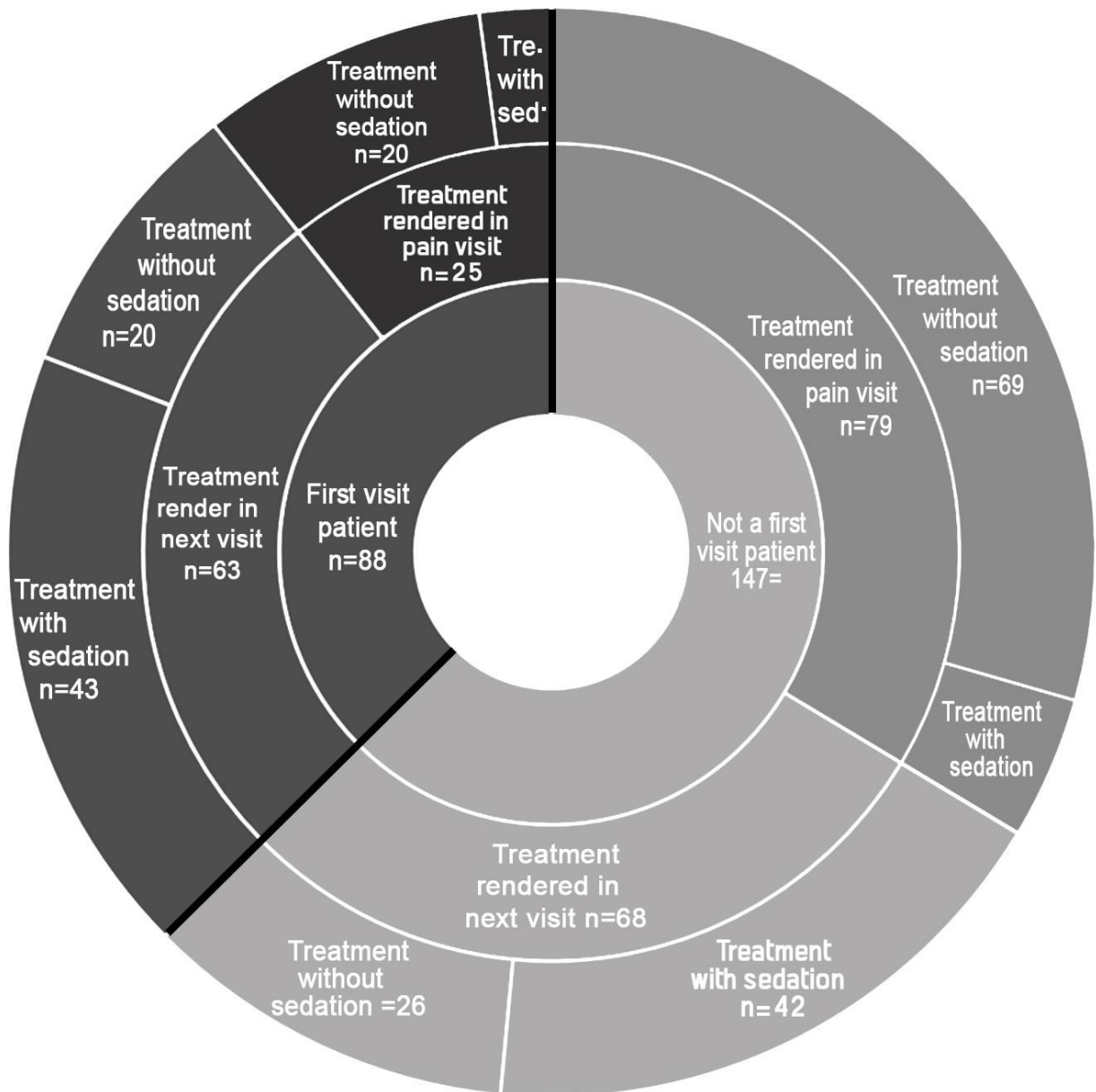
Table 6: Need of sedation by invasive dental treatment.

Treatment planned	required LG		required GA		didn't require sedation		Total	
	N	%	n	%	n	%	n	%
Restoration	4	4,1%	5	11%	64	84,9%	73	100%
Endodontic procedures	8	25%	0	0%	16	75%	24	100%
Extraction	45	31,9%	38	25,4%	55	42,8%	138	100%

The differences were considered to be extremely statistically significant $P < 0.001$

Out of 235 patients who required invasive treatment (extraction, restoration or endodontic treatment), 88 patients (37.4%) were visiting the dental clinic for the first time, while (63.6%; n=147) had been in the clinics in the past for dental check-up or other dental treatments (Fig. 7). In addition, the majority of treatments of new patients were postponed (71.6%; n=63), while more than half of the patients who were already familiar with the clinics were treated in the emergency visit (53.7%; n=79). This association was statistically significantly different (Chi square test, $P < 0.001$).

Figure 7: Association between treatment plan, need of sedation and first visit of the patient



6.6 Association of different variables with the management plan

Overall, it was noted that most of postponed invasive treatments (extraction, restoration or endodontic procedures) were planned to be rendered under sedation (85.6%), while the majority of treatments performed in the pain visit were rendered without the need to any form of sedation (64.9%). Figure 8 shows the association between the treatment plan and the need of sedation. When the association between treatment plan and the need of sedation was calculated using Chi square test and the association was considered to be extremely statistically significant ($P < 0.001$).

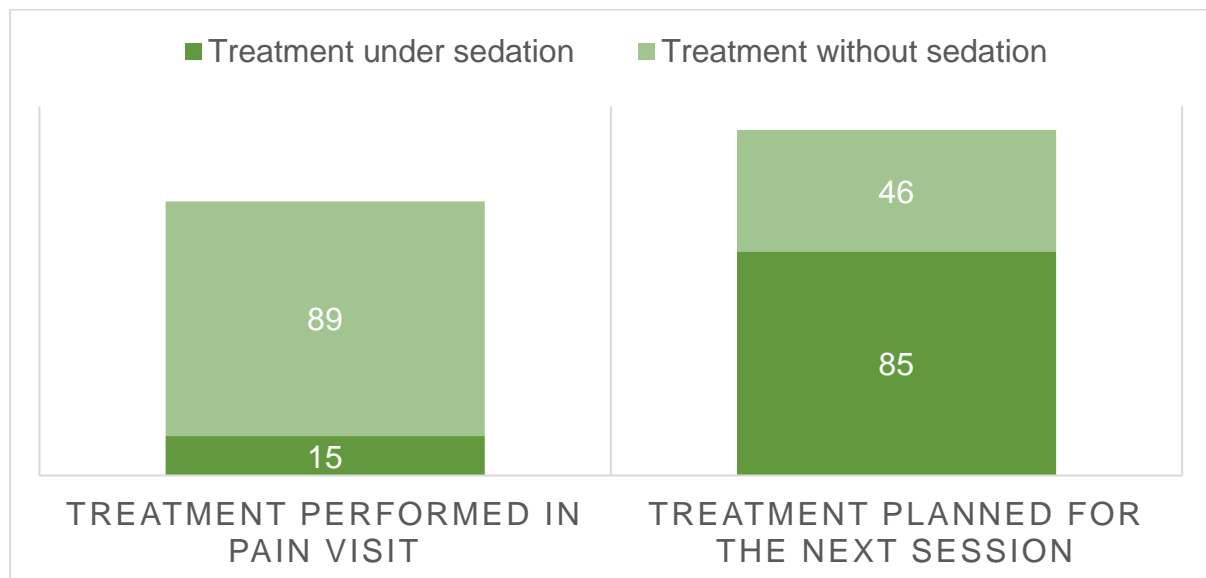


Figure 8: The association between the treatment plan and the need of sedation

An accurate clinical diagnosis along with consideration of the patient's medical history and oral status evaluation should lead to optimal treatment decision. However, especially in children, another important component is added, which is the child's cooperation. An invasive treatment can not be performed in an uncooperative child without traumatizing him. In agreements with this statement, the findings of this study show clearly an association between the delay of the dental treatment to the next session and other factors such as, the treatment required (invasive or not invasive), the need of sedation and child's previous dental experience (first visit to the dental clinic).

Therefore, the correlation between different factors (age, treatment required, need of sedation and the patient's oral status) were analysed using Kendall's tau -b correlation coefficient test (Figure 9, Table 7) with SPSS for Windows (version 21.0; Chicago, IL, USA), then multiple regression analysis was performed (Tables 8,9 and10) on the related factors to assess the strength of the relationship between the variables and the impact of these factors on the dental emergency management plan (immediate or delayed treatment).

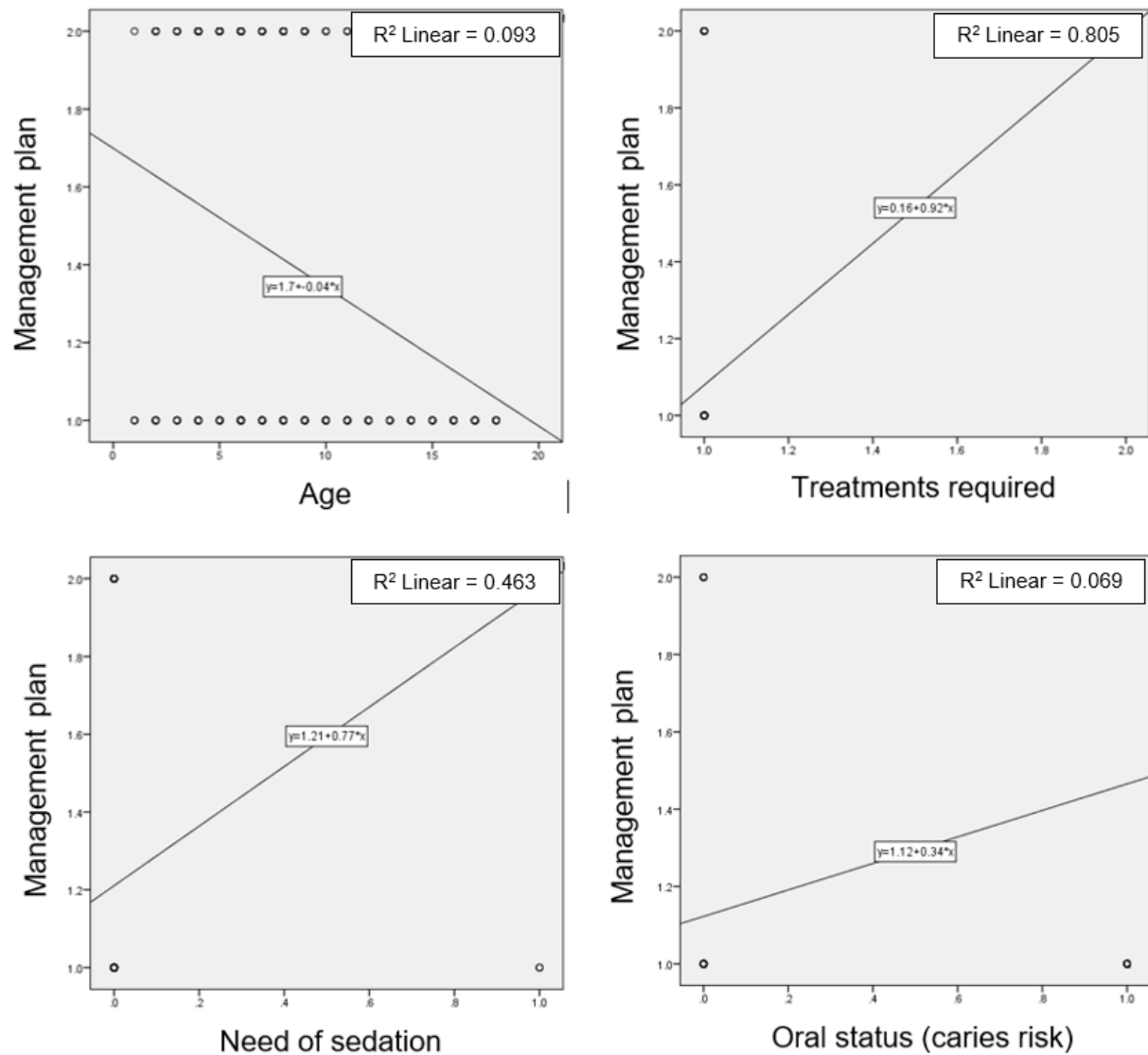


Figure 9: Linear correlation between different factors and the management plan

Table 7: Model of correlation coefficient of different variables to the management plan

			Correlations				
			Age	Treatment required	Need of sedation	Oral status (caries risk)	Emergency management plan
Kendall's tau_b	Age	Correlation Coefficient	1.000	-0.250**	0.288**	-0.017	-0.273**
		Sig. (2-tailed)	.	.000	.000	.719	.000
		N	332	332	332	332	332
	Treatment required	Correlation Coefficient	-0.250**	1.000	0.675**	0.238**	0.897**
		Sig. (2-tailed)	.000	.	.000	.000	.000
		N	332	332	332	332	332
	Need of sedation	Correlation Coefficient	-0.288**	0.675**	1.000	0.212**	0.681**
		Sig. (2-tailed)	.000	.000	.	.000	.000
		N	332	332	332	332	332
	Oral status (caries risk)	Correlation Coefficient	-0.017	0.238**	0.212**	1.000	0.263**
		Sig. (2-tailed)	0.719	.000	.000	.	.000
		N	332	332	332	332	332
	Emergency management plan	Correlation Coefficient	-0.273**	0.897**	0.681**	0.263**	1.000
		Sig. (2-tailed)	.000	.000	.000	.000	.
		N	332	332	332	332	332

** . Correlation is significant at the 0.01 level (2-tailed).

The results of the correlation analysis reveal the following:

The correlation between required treatment and management plan was positive, meaning whenever the required treatment was an invasive treatment the chance to delay the treatment increases. The correlation coefficient indicates a high correlation ($r = 0.897$).

The correlation between the need of sedation and management plan was positive, meaning whenever the child's need of sedation was necessary the chance to delay the treatment increases. The correlation coefficient indicates a moderate correlation ($r = 0.681$).

The correlation between age and management plan was an inverse correlation, meaning whenever the child is younger the chance to delay the treatment increases. However, the correlation coefficient indicates a low correlation ($r = 0.273$).

The correlation between oral status (caries risk) and management plan was positive, meaning whenever carries risk was higher the chance to delay the treatment increases. The correlation coefficient indicates a low correlation ($r = 0.263$).

Multiple regression analysis was performed on the related factors to assess the strength of the relationship and the impact of these factors on the dental emergency management plan (Tables 8,9 and10) using SPSS for Windows (version 21.0; Chicago, IL, USA)

Table 8: Model summary of the multiple regression analysis

Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.905 ^a	0.819	0.816	0.211

a. Predictors: (Constant), Age, Need of sedation, Oral status, Treatment required

The multiple correlation coefficient indicates a good level of prediction $R = 0.905$ and the coefficient of determination $R\text{ Square} = 0.819$ indicates that our independent variables explain 81.9% of the variability of our dependent variable.

Table 9: Analysis of variance

ANOVA^a

Model		Sum of Squares	Degree of freedom	Mean Square	F	Sig.
1	Regression	65.580	4	16.395	369.078	0.000 ^b
	Residual	14.526	327	0.044		
	Total	80.105	331			

a. Dependent Variable: Emergency management plan

b. Predictors: (Constant), Age, Need of sedation, Oral status, Treatment required

Table 9 shows that $F(4,327) = 369.078$, $p < 0.05$, therefore, the regression model is a good fit of the data.

Table 10: Estimated model coefficients

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.261	0.053		4.927	0.000
	Age	-0.005	0.003	-0.044	-1.740	0.083
	Treatment required	0.810	0.033	0.790	24.387	0.000
	Need of sedation	0.139	0.037	0.123	3.777	0.000
	Oral status (caries risk)	0.065	0.032	0.050	2.050	0.041

a. Dependent Variable: Emergency management plan

The results of the multiple regression analysis reveal the following:

The unstandardized coefficient of oral status was 0.065 (positive correlation), However, with sig=0.041, the results was statistically significant $p < 0.05$.

The unstandardized coefficient of need of sedation was 0.139 (positive correlation), sig=0.00, the results was statistically significant $p < 0.05$.

The unstandardized coefficient of treatment required was 0.810 (positive correlation), sig=0.00, the results was statistically significant $p < 0.05$.

The unstandardized coefficient of age was -0.005 (minimal inverse correlation), However, with sig=0.083, the results was not statistically significant $p > 0.05$.

According to the above-mentioned results, it can be concluded that type of treatment (invasive or non-invasive) has the most effect on the management plan (immediate or delayed) then the patient's need of sedation then oral status of the patient (caries risk).

6.7 Summary of the main results

Out of 2492 patients who were seen in the Department of Preventive and Paediatric Dentistry at the University of Greifswald in 2018, 332 patients (13.3%) were treated due to pain in unscheduled visit. These patients were high caries risk children with a mean dmft of (4.59 ± 3.65) and DMFT of (1.65 ± 2.73) .

The main clinical diagnosis of pain patients in all different age groups was dental caries and caries-related complications such as reversible and irreversible pulpitis or periapical periodontitis (63.6%). Over all the most frequently required treatment was extraction (41.0%; $n=138$), and most of these extractions needed to be rendered under either nitrous oxide sedation or general anaesthesia (57.3%).

The required treatment for 41% of the emergency/pain patients was delayed to a future scheduled visit. The finding of this study has shown a clear association ($p < 0.05$) between the dental emergency management plan (delay of the dental treatment) and other factors such as, the treatment required (invasive or not invasive), the need of sedation and child's previous dental experience (first visit to the dental clinic).

Most of the extraction procedures were not rendered immediately in the emergency/pain visit, rather they were delayed to be performed in the next treatment session (70%), with the majority of these procedures planned to be rendered under sedation (nitrous oxide gas or general anaesthesia). On the other hand, most of the restorations (65.5%) were performed in the emergency/pain visit, with need of sedation for only (8.3%) of these procedures. In addition, the majority of treatments of children who were visiting the dental clinic for the first time were postponed (71.6%; $n=63$).

The correlation analysis shows a higher tendency to postpone the treatment when the required treatment is invasive, need to be rendered under sedation or when it was the child's first visit to the dental clinic. These findings demonstrate the strong impact of the child's cooperation on the emergency management plan.

7 Discussion

7.1 Discussing the clinical finding

7.1.1 Discussing the patients' profile and the main cause of pain

Dental pain was found to be the main complaint, and the main cause of this symptom was dental decay. This is in agreement with the recent studies in Germany which found that in contrast to the great success in caries prevention with the recent extraordinarily low caries levels in the permanent dentition of children, caries in primary teeth is still quite common (Jordan et al. 2016; Splieth et al. 2019; Schmoeckel et al. 2021).

The primary posterior teeth were most frequently affected by dental caries, being responsible for 144 (58.1%) out of 248 decayed teeth. The posterior teeth were also the most frequently affected in the permanent dentition. This is in line with results of previous studies involving children in a similar age range (Hong et al. 2011; Shqair et al. 2012). This is worrying, given the importance of these teeth in masticatory function and in preserving space for the successor teeth. It should be mentioned that all molar incisor hypomineralization (MIH) cases (n=25 teeth) were considered in this study as a part of the permanent decayed teeth, and all the MIH cases were affecting posterior teeth. While in general about 4% of pain patient of this study had MIH as the cause of pain.

The results of the present study which found that dental decay was the main cause of pain which is similar to the findings from Belgium (Martens et al. 2018), USA (Agostini et al. 2001), Brazil (Shqair et al. 2012) and the UK (Naidu et al. 2005). However, the proportion of children presenting with caries-related problems (63.6%) was higher compared to the above studies from Belgium and USA, which reported 50% and 30%, respectively. Still these values were lower than the above-mentioned Brazil and UK studies, which reported 78.6% and 74%, respectively.

Pain patients in 2018 in the specialised university clinic were high caries risk children (mean: 4.59 ± 3.65 dmft and 1.65 ± 2.73 DMFT). The standard deviation is in the range of the mean value, indicating a considerable amount of variation, which is typical for

the current caries distribution in Europe (Alkilzy et al. 2009). Because of the slow progression of dental caries, its treatment is relatively easy when it is diagnosed at early age. However, when left untreated, it may lead to pulpitis followed by necrosis and subsequent swelling, fistulae or diffuse cellulitis which typically goes along with pain (Cameron and Widmer 2013).

Therefore, preventive measures have the potential to significantly reduce the current number of emergency visits related to caries (Agostini et al. 2001). Due to the high number of emergency visits related to caries and subsequent complications (63.6%) future caries-preventive approaches are needed for the primary dentition, especially in early childhood.

7.1.2 Discussing dental trauma

The incidence of dental trauma in emergency/pain patients in the present study was 8.4%. This is similar to the results of previous study performed in Germany in a University clinic in Mainz which investigated all dental trauma patients presenting at the dental emergency service. It was found that the prevalence of dental trauma in emergency/pain patients was 8% and more than half of patients were under the age of ten (Mahmoodi et al. 2015). The incidence of dental trauma presenting as an emergency/pain in the present study was actually much less than in similar studies in the UK (Naidu et al. 2005), the USA (Agostini et al. 2001), Belgium (Martens et al. 2018) and Jordan (Al-Jundi 2002), which reported 16%, 27%, 26.7% and 31% respectively.

The Department of Preventive and Paediatric Dentistry at the University of Greifswald does not offer an out-of-hours service which may have influenced the apparent lower incidence of trauma-related dental emergencies. Furthermore, the socioeconomic factor may also play a role regarding the use of the service. A study performed in the UK in 2000 has shown that children who come from lower socioeconomic group are less likely to attend for emergency treatment of dental trauma, they are less concerned about the appearance of their teeth and they are less likely to attend for emergency treatment of dental trauma if they are not in pain (Blinkhorn et al. 2000).

Regarding gender of children with dental trauma males were more affected than females. The male: female ratio was 67.9% (n=19): 32.1% (n=9) respectively. This result is consistent with the published literature (Mahmoodi et al. 2015; Fleming et al. 1991; Naidu et al. 2005; Bae et al. 2011).

Moreover, this study confirms the published literature, in regard to the predilection of dental traumatic injuries for two specific age groups. The first trauma incidence peak occurs during the first 2-3 years of life (Levine 1982; Zeng et al. 1994; Martens et al. 2018) followed by the second incidence trauma peak between 6 and 12 years of age. The first peak could be explained because of the period of early growth and development when the child lack the motor coordination and has an exploratory behaviour (Bae et al. 2011) The children learn to stand and walk and potentially fall on their teeth. The second peak could be related to contact sports, which may increase the risk of traumatic injuries, bicycle accidents, strikes with objects and the increased overjet after eruption of the permanent central incisors (Martens et al. 2018; Lam et al. 2008).

7.1.3 Discussing other reasons of emergency/pain visit

Some of the complaints were due to causes that did not necessarily need immediate attention, such as problems with permanent tooth eruption and primary tooth exfoliation. After all patients who visited the dental clinic due to pain without appointment underwent clinical examination and their medical condition was diagnosed, it was decided that 17% of patients did not require any medical intervention (n=58). This is in agreement with results from a previous study on clinical care in which almost 15% of the children who sought treatment either had no major complaint or complained mainly about physiological events such as discomfort during normal exfoliation process (Sakai et al., 2005). This indicates the importance to differentiate between emergency and pain patients as not all unscheduled patients who seek dental care are necessarily an emergency patient who require immediate medical/dental intervention.

7.2 Discussing the management of emergency patients

7.2.1 Discussing the management plan for dental caries

7.2.1.1 Treatment concept

Extraction was the most frequently decided treatment for dental caries and caries-related complications such as reversible and irreversible pulpitis or periapical periodontitis 58.3%. Endodontic procedure was decided for 11.4% of the children, and restoration for 26.5% of children.

Because of lack of data and to avoid any miss interpretation of the results a clear diagnosis of the caries-related complications such as reversible and irreversible pulpitis or periapical periodontitis could not be set. Although, it is highly probable that the majority of children with dental caries in this study had pulp-related complications taking into consideration that these patients present them-selves for emergency visit with pain or symptoms.

Furthermore, the treatment concept in the Department of Preventive and Paediatric Dentistry at the University of Greifswald concentrates on the evaluation of the patients' complete oral status when planning comprehensive treatment. Thus, despite the absence of clear guidelines for treatment of pain patients, when a patient shows up in the department even as an emergency/pain patient a complete health and oral status evaluation is carried out, and only after proper diagnosis on patient and tooth level the treatment will be planned.

In this study the majority of children are high caries risk patients with multiple affected teeth and symptomatic tooth/teeth causing pain. In these cases, it is highly questionable if treating this single tooth currently causing pain e.g. via pulpectomy procedure is more favourable than an extraction. Furthermore, multiple outcomes of an effective pulpal therapy in the primary dentition must be met stabilizing the affected primary tooth and creating a favourable environment for normal exfoliation of the primary tooth, without harm to the developing enamel or interference with the normal eruption of its permanent successor. Where these outcomes cannot reasonably be

achieved over the clinical life of the primary tooth, it is appropriate to extract the affected tooth and consider alternative strategies for occlusal guidance and maintenance of the arch integrity. One more important aspect is the factor of time. All practitioners know, time is one of the deciding factors in dental practice, and emergency or pain visits which are usually non-scheduled appointments impose additional pressure on the dental practitioner, and extraction is in these cases more often time efficient. All these factors could explain the high number of extraction treatments provided in the Department of Preventive and Paediatric Dentistry at the University of Greifswald.

7.2.1.2 The impact of the child's cooperation on the dental caries management plan

In agreement to the previous discussed treatment concept we found that most of the extraction procedures were not rendered immediately in the emergency/pain visit, rather they were planned to be performed in the next treatment session (70%). About (75%) of these procedures were planned to be rendered under sedation (nitrous oxide sedation gas or general anesthesia). On the other hand, most of the restorations (65.5%) were performed in the emergency/pain visit, with need of sedation for only (8.3%) of these procedures.

This can be explained with the comprehensive treatment plan for these high caries risk children, whereas, more than one tooth needs to be treated. For this reason, the management plan reflects the fact that traumatizing the child by invasive tooth treatment on the current cause of pain could hinder his/her cooperation and thus negatively affect the results of any future dental intervention (Hosey et al. 2002).

7.2.2 Discussing the management plan of molar incisor hypomineralization

The planned treatment shifts in cases of molar incisor hypomineralization, where most of the cases were treated by restoration or stainless-steel crowns using a modified version of the Hall technique (9 out of 14). This shift could be explained by adopting

the Würzburg MIH treatment concept (Steffen et al. 2017) in the Department of Preventive and Paediatric Dentistry at the University of Greifswald.

7.2.3 Discussing the treatment plan of dental trauma and soft tissue lesions

After thorough clinical and radiographical examination most of dental trauma patients (15 out of 28) were managed conservatively (leave and observe approach). This is according to the treatment concept followed in the department the standard procedure and according to dentaltraumaguide.org for concussion and subluxation injuries with minor mobility.

One trauma case was managed with splinting, which is according to the same treatment concept is provided in cases of lateral luxation with moderate mobility or in cases of horizontally root fracture (except when the root fracture is in the apical part and few millimeters from the apex, often require no treatment). Then the tooth would be carefully observed to evaluate if a root canal treatment is required.

Restoration procedures were planned for 8 patients out of 28 trauma patients. Which is according to the treatment concept followed in the Department of Paediatric Dentistry at the University of Greifswald is the standard procedure for concussion or minimal mobility subluxation tooth with uncomplicated crown fractures with no pulpal involvement, taking into consideration that the restorative treatment will not be provided in the first emergency visit.

Soft-tissue lesions were also one of the reasons for seeking dental care due to pain or discomfort that can inflict young children. In this study eight children had primary herpetic gingivostomatitis which is the most common cause of severe oral ulceration in children. The disease is self-limiting and the ulcers heal spontaneously without scarring, within 10-14 days, and the management is mainly a symptomatic care. Medication like Kamistad Gel or Chlorhexidine (CHX) were applied for most of the patients who were diagnosed with severe ulceration or gingival irritation, chlorhexidine can be swabbed over the affected areas with cotton wool swabs (Cameron and

Widmer 2013). Regarding soft-tissue injuries related to oral trauma, unless significant soft-tissue damage is present, antibiotics are not required.

7.3 Discussing the association between the management plan and different factors

Overall, it was noted that most of postponed invasive treatments (extraction, restoration or endodontic procedures) were planned to be rendered under sedation (85.6%), while the majority of treatments performed in the pain visit were rendered without the need to any form of sedation (64.9%). This indicates the importance of providing the required treatment within the best possible conditions that relatively insure optimal behaviour management without negative affect on the future cooperation of the child.

Regarding the reasoning of postponing most of these invasive, sedation requiring treatments to future scheduled session, the explanation has two folds. First, when the child was not familiar with the dental clinic or was absent from the dental clinic for a long time, rendering a non-traumatic treatment in the first session (even if that session was caused by pain) is preferable according to the department of preventive and paediatric dentistry at the university of Greifswald. The second fold is technical, whereas, in the clinics only one nitrous-oxide system is available and cannot be always immediately used for the pain visit. This may also contribute to the process of decision making whether the treatment was rendered in the same visit or postponed. Another contributing factor is the availability of general anaesthesia in the clinic which is limited to approximately one to two times a month. However, in severe emergency cases (e.g. abscess in canine fossa) the patient will be send to the hospital (maxillofacial surgery) also for GA on the same day when needed.

Regarding the child's age, the relation between age and management plan found to be an inverse correlation, meaning whenever the child is younger the chance to delay the treatment increase, this in agreement with other studies which also found that dental fear and behaviour management problems decreased with age and that age, general emotional status and maternal dental anxiety were concomitant factors in the development of dental fear (Klingberg 1995; Brill 2000).

7.5 Data-based guide for management of paediatric pain patients

Referring to every patient seeking dental care due to pain as an emergency patient is not accurate especially in paediatric dentistry whereas not every child with oral pain is an emergency. This study refers to these patients as “pain patients”. However, any child with complaint of pain should be given a priority in the dental clinic and a clinical diagnosis should be performed as soon as possible. Then for the comprehensive long-term treatment plan for pain management a number of relative factors should be taken into consideration:

- Clinical diagnosis & the required treatment
- Oral health (e.g. caries risk, activity) and the need of further dental treatments
- Patient cooperation level and necessary treatment mode (e.g. the need of sedation or GA)
- Considering whether the pain visit is the child’s first visit to that dental clinic
- Option to use medication for adequate management of pain and/or infection

Findings in this study show clearly an association between the delay of the dental treatment to the next session with respect to previously mentioned factors. Still, postponing the treatment was always more likely whenever the required treatment needed to be rendered under sedation or when the “pain visit” was the child’s first visit to the dental clinic. This suggests a strong influence of the child’s cooperation level as well as the aspect whether the patient is new to the clinics and on the choice when and how to perform treatment (Tab. 5/ Fig. 7).

The cooperation level scale adopted in guidance proposed in this study is the Frankl’s behavior rating scale (Frankl et al. 1962), and we considered in the guidance levels 1 and 2 as uncooperative and levels 3 and 4 as cooperative in order to make this guidance relatively simple in the daily clinical practice.

Invasive treatment that we are referring to in this guidance are extractions, stainless steel crowns with extensive preparation, endodontic procedures and restorations

which require an extensive preparation (more than one surface). Non-invasive/ low-invasive treatments are considered e.g small restorations (one surface restoration), treatments with Hall technique and applying any material to minimize the pain or sensitivity such as silver diamine fluoride or glass ionomer cement (Splieth et al. 2020).

Considering whether the pain visit is in fact the child's first visit to the dental clinic is also related to the cooperation level of the child. Taking this factor into consideration serve the purpose of not traumatizing the child (when possible) by invasive treatment in the first visit to build up a trustful relationship and to enhance the cooperation for further treatment (Behavior Guidance for the Pediatric Dental Patient 2018 pp.254-267).

Based on these factors which were found to be relevant in the study, the author proposes the following classification of pain patients and guidance for treatment of paediatric pain patients.

Emergency patients

Children who require immediate attention in order to minimize the risk of serious medical complications or prevent long-term dental or medical complications are emergency patients. These cases such as:

- Traumatic dental injuries
- Rapidly increasing fever
- Uncontrolled dental hemorrhage after extraction
- Increasing swelling in the facial area and around the throat

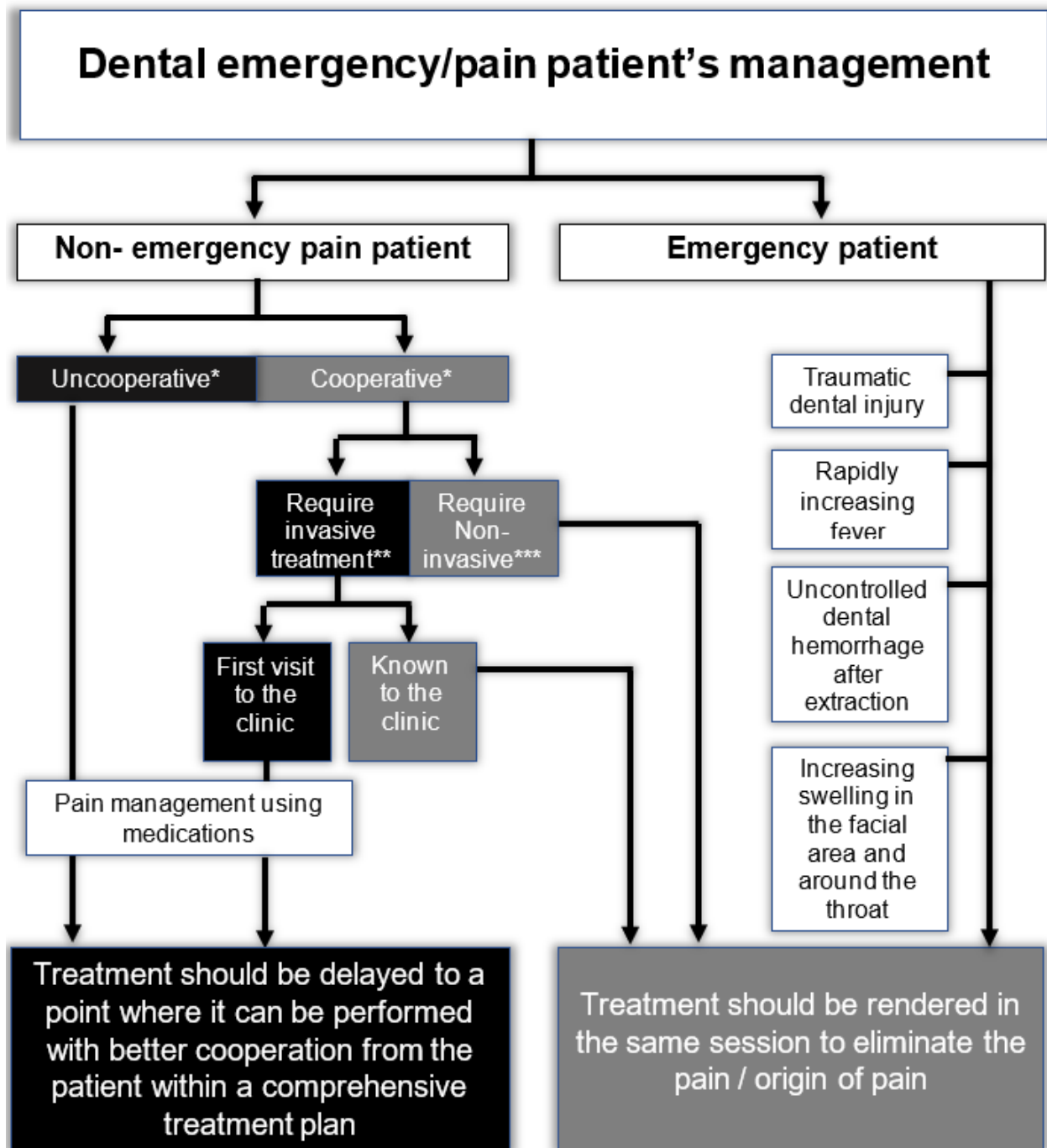
Non-emergency pain patients are considered

children who have any kind of pain caused by an oral problem. Most common causes of pain in children are:

- Caries and caries related complications
- Soft tissue infection
- Eruption or exfoliation problems
- MIH problems
- Complications related to the wisdom tooth

This newly developed guidance (Fig. 10) serves the purpose of providing the child with the best treatment option possible to manage the pain condition without negatively affecting future cooperation or severely traumatizing the child and will save the practitioner time by considering the possibility to delay the treatment to a future schedule appointment. However, even in cases of non-emergency uncooperative children, pain management is an important issue and has to be addressed.

Figure 10: Proposed guidance for management of pain patients according to status of emergency and cooperation level of the child



* Frankl's behaviour rating scale (1-2 uncooperative, 3-4 cooperative)

** extractions, stainless steel crowns with extensive preparation, endodontic procedures and restorations which require an extensive preparation (more than one surface).

*** Non/ low invasive such as small restorations (one surface restoration), treatments with Hall technique and applying any material to minimize the pain or sensitivity such as silver diamine fluoride or glass ionomer cement.

7.6 Pain management

Pain management is an important issue even in cases of non-emergency and has to be addressed. Pain should be assessed in detail: onset, severity, pattern, location and quality (Friedberg Barry et al. 2016). Furthermore, when assessing pain in a child, the patient's psychological status should be considered and the intensity and duration of pain that may be perceived from a given dental procedure should be considered (The assessment and management of acute pain in infants, children, and adolescents 2001). Management of pain may range from non-pharmacologic modalities to pharmacologic treatment. When the decision to postpone the final required treatment is made, pharmacologic pain management should be considered. Non-opioid analgesics such as paracetamol and ibuprofen have proven themselves in pain therapy. Ibuprofen is preferred to paracetamol because of its stronger analgesic effectiveness, higher therapeutic index, lower toxicity in the event of overdose and the duration of action of 8 hours (Moore et al. 2018)

Non-pharmacologic interventions may be effective alone or as adjuncts to pharmacological interventions in managing procedure-related pain, anxiety, and distress with minimal risk of adverse effects (Wilson et al. 1997; Sessle 2014; Landier and Tse 2010). The American Academy of Pediatrics (AAP) and the American Pain Society (APS) recommend that providers should reduce distress-producing stimulation and provide a calm environment for procedures to improve pain management (Pain Management in Infants, Children, Adolescents and Individuals with Special Health Care Needs 2018).

Distraction is an effective method of pain management in the pediatric patients (Lee et al. 2014; Davidson et al. 2016). Distraction can be cognitive (e.g., counting, non-procedural talk) or behavioral (e.g., videos, games), both of which aim to shift attention away from pain. Recent studies show significant decreases in pain perception during short invasive dental treatments by using virtual reality distraction technique (Shetty et al. 2019; Wismeijer and Vingerhoets 2005; Asl Aminabadi et al. 2012).

7.7 Use of antibiotics

Cases where antibiotic treatment is indicated during caries related complications endodontic treatment, as well as cases in which antibiotics are not indicated is shown in (table 11).

Table 11: Indication for systemic antibiotics as an adjunct during caries related complications (endodontic) therapies (Segura-Egea et al. 2017).

Indications		
Pulp / Periapical Condition	Clinical and radiographic data	Antibiotics as adjunct
Acute apical abscess in medically compromised patients	- Localized fluctuant swellings - Patient with systemic disease causing impaired immunologic function.	YES
Acute apical abscess with systemic involvement	- Localized fluctuant swellings - Elevated body temperature (>38°C) - Malaise - Lymphadenopathy - Trismus	YES
Progressive infections	- Rapid onset of severe infection (less than 24 h) - Cellulitis or a spreading infection - Osteomyelitis	YES
Persistent infections	- Chronic exudation, which is not resolved by regular intracanal procedures and medications	YES
Contraindications		
Pulp / Periapical Condition	Clinical and radiographic data	Antibiotics as adjunct
Symptomatic irreversible pulpitis	- Pain - No others symptoms and signs of infection.	NO
Pulp necrosis	- Non-vital teeth - Widening of periodontal space	NO
Acute apical periodontitis	- Pain - Pain to percussion and biting - Widening of periodontal space	NO
Chronic apical abscess	- Teeth with sinus tract - Periapical radiolucency	NO
Acute apical abscess with no systemic involvement	- Localized fluctuant swellings	NO

7.8 Discussing the strengths and limitations of the study

This study tried to give a valuable contribution to the underinvestigated field of pediatric dental emergency and was successful doing so by collecting the necessary information to determine the demographic and clinical characteristics of children who attended the Department of Preventive and Pediatric Dentistry at the University of Greifswald of the year 2018 without an appointment seeking emergency dental care due to pain, and recognize the most common reason of pain to good degree and the most common/planned treatment accordingly. Based on these data a guidance for management of pediatric dental emergency/pain patients was proposed. This could help improving the ability of managing pain patients and provide them with the best treatment option in dental office.

Furthermore, this study was able to detect clear association between many important factors regarding emergency patient management like treatment required, patient cooperation level, necessary treatment mode and whether the pain visit is the child's first visit to that dental clinic. Based on this data the guidance for management of pain patient was developed and designed to be easily adopted even in non-specialized dental clinics with the intention of organizing the decision-making process and providing the child with the optimal treatment option.

One of the limitations of this study was the lack of data regarding the differential diagnosis in cases of pulp-related complications such as reversible and irreversible pulpitis. Although, an attempt was made in the discussion to interpret the result according to the type of treatment and the treatment protocol followed in the Department of Preventive and Paediatric Dentistry at the University of Greifswald.

It is recognized that children from low-income families tend to receive episodic or emergency dental care, while those from higher-income households will visit the dentist more regularly for preventive check-ups (Edelstein et al. 2002). However, one of the limitations of this study is that no information on socio-economic conditions was collected. Further studies should assess the socio-economic profile of patients attending the dental emergency services and differences in dental service use between social classes.

Another obstacle we encountered during this retrospective study was the lack of data regarding an accurate assessment of the child cooperation level in the emergency visit. Therefore, association and correlation tests were performed on the reliable data to recognise the related factors to the management and cooperation of those children. That's how we were able to recognise the role that the child's cooperation plays in the management and based on these results and conclusions the management guidance was developed.

Clinical studies to validate this proposed guidance is recommended for the future.

8 Conclusions

This study contributes to the scarce scientific field of dental pain in paediatric dentistry, which is important to improve the common challenge of managing pain patients and to provide them with best treatment option by having a clear comprehensive treatment concept.

The aim of providing the child with the best treatment option available is not only achieved by choosing a tooth level treatment based on the clinical diagnosis of the affected tooth but rather by considering all factors affecting the children's oral health such as the complete oral status and the child's cooperation. A clear association between the management plan of emergency patients and child's cooperation was found, which made it inevitable to propose management guidance for treatment of pediatric dental emergency patients

The proposed guideline for management of dental emergency aims at improving management of paediatric pain patients within a comprehensive long-term concept that recognize the factors which may affect the child's cooperation such as, the treatment required (invasive or not invasive), the need of sedation and child's previous dental experience (first visit to the dental clinic). It is designed to be adopted not only in specialists' settings but also in any dental clinic that deal with the worldwide common problem of pediatric emergency/pain patients.

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10 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.

Datum Februar.2022

Unterschrift

11 LEBENS LAUF

BERUF

Zahnarzt

SCHUL- UND BERUFSAUSBILDUNG

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PERSÖNLICHE FÄHIGKEITEN

Sprachkenntnisse

- Deutsch
- Englisch
- Arabisch (Muttersprache)

- Sichere EDV-Kenntnisse (Microsoft Word/Excel/PowerPoint)

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