Development and application of an innovative-methodological approach to the design of frameworks for targeted School Dental Service programmes; using empirical predictive data

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DEDICATION

To my parents, Talal Alsharif and Adlyah Aqeel. Without their prayers and continual support, this thesis would not be what it is today.

To my shining armor, amazing & loving husband, Dr. Khalid, whose sacrificial care for me and our children made it possible for me to complete this work.

To my children, AlWaleed, Reem and Noor, who are indeed a treasure from God. For their eternal love and understanding.

To my brothers and sisters, for being there for me throughout the entire process.

‘Science, like art, is not a copy of nature but a re-creation of her’.~ Jacob Bronowski
ABSTRACT

BACKGROUND AND AIM: This thesis sought to analyse a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with socio-demographic characteristics, insurance coverage, economic cost and future projected admission rates. This thesis has also developed and tested a model system of service prioritisation, based on risk, using identified risk indicators, and state-of-the-art geographic tools.

MATERIAL AND METHODS: This study analysed the data obtained for 43,937 child patients under the age of 15 years, hospitalised for an oral-health related condition, as determined by principal diagnosis (ICD-10AM), using the Western Australian Hospital Morbidity Dataset for the period 1999–2000 to 2008–2009. Primary place of residency, age, gender, insurance status, Indigenous status and socioeconomic status were also analysed. The Australian Refined Diagnosis Related Group (AR-DRG) version 5.1 was used to calculate the direct cost. An analysis of costs was broken down by the previously mentioned risk indicators. Two separate methods (Linear method and the exponentially weighted moving average method) were used to project future cases through to the year 2026. Both methods accounted for the projected increase in both the population and the incidence of these conditions over time, using ten years’ worth of data. The residential location of each child hospitalised due to an oral-condition during the study period, and socioeconomic data in relation to existing services (School Dental Service clinics), at metropolitan areas of Perth were geocoded and mapped using Quantum Geographic Information Systems (QGIS).
**RESULTS:** The total DRG cost of these admissions, both public and private, was approximately AUS $92 million over ten years. Most of these funds went towards treating ‘dental caries’ and ‘Embedded and impacted teeth’ conditions of children under the age of 15 years. ‘Dental caries’ were the most common in non-Indigenous patients, with ‘pulp and periapical’ most prevalent in Indigenous patients. The Age Adjusted Rate (AAR) of hospitalisation for Indigenous children in the last decade increased to reach that of non-Indigenous children in 2009. When insurance status was considered, a total of 47.3% of children reported lack of dental insurance coverage. Lack of health insurance coverage was strongly associated with Indigenous children and children living in Remote areas. Disparities in dental insurance coverage are also evident by socioeconomic status. Moreover, a clear specific geographical areas, where no services are located, but where high hospital-admission rates are occurring, especially among school-age children. The least-disadvantaged areas and areas of high rates of school-age child hospital-admissions were more likely to be within 2km of the School Dental Service clinics than not. More of high-risk-areas (socioeconomically deprived areas combined with high oral health-related hospital admissions rates), were found within 2km of the clinics than elsewhere. The projected admission rate increase was 43% from 2000 to 2026. The admission rates are expected to more than double over time for those children living in metropolitan areas.

**RECOMMENDATIONS AND CONCLUSION:** Dental caries, embedded and impacted teeth, and pulp and periapical conditions were and will continue to remain the mostly preventable causes of admission throughout this time. Better understanding of disparities in access to care among children, the socioeconomic divide in oral health and
insurance coverage, will be critical to improve Australian children’s oral health and reduce financial burden on health budgets.
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAR</td>
<td>Age Adjusted Rates</td>
</tr>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>AIHW</td>
<td>Australian Institution of Health and Welfare</td>
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<tr>
<td>AR-DRG</td>
<td>Australian Refined Diagnosis Related Group.</td>
</tr>
<tr>
<td>ARIA</td>
<td>Accessibility/Remoteness Index of Australia.</td>
</tr>
<tr>
<td>AUD</td>
<td>Australian Dollar.</td>
</tr>
<tr>
<td>CD</td>
<td>Collection Districts.</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval.</td>
</tr>
<tr>
<td>DALY</td>
<td>Disability Adjusted Life Years</td>
</tr>
<tr>
<td>DMFT</td>
<td>Decayed, Missing and Filled permanent tooth.</td>
</tr>
<tr>
<td>Dmft</td>
<td>decayed, missing and filled deciduous tooth.</td>
</tr>
<tr>
<td>ECC</td>
<td>Early Childhood Caries.</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System.</td>
</tr>
<tr>
<td>ICD-10AM</td>
<td>International Classification of Diseases Tenth-Australian Modification.</td>
</tr>
<tr>
<td>INDIGENOUS</td>
<td>Aboriginal and territory Islander.</td>
</tr>
<tr>
<td>MTDP</td>
<td>Medicare Teen Dental Plan</td>
</tr>
<tr>
<td>SDS</td>
<td>School Dental Services.</td>
</tr>
<tr>
<td>SEIFA</td>
<td>Socio-Economic Index of Areas.</td>
</tr>
<tr>
<td>SPSS</td>
<td>Software Package for Social Sciences.</td>
</tr>
<tr>
<td>SLA</td>
<td>Statistical Local Area.</td>
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<tr>
<td>USA</td>
<td>United States of America.</td>
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<tr>
<td>WA</td>
<td>Western Australia</td>
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<tr>
<td>WHO</td>
<td>World Health Organization.</td>
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Finally, a special thanks to my children, sisters and brothers, who have made sacrifices in their lives so that I may achieve my ambitions and goals. Throughout my journey, they have provided me courage, support and motivation to never let your dreams die.
Statement of Candidate Contribution

I hereby declare that all of the included work in this thesis is entirely my own. The research was conducted under the supervision of A/Professor Estie Kruger, W/Professor Marc Tennant and Professor John McGeachie. For the co-authored published work, my contribution was 80%. Contributions with other colleagues are mentioned accordingly and listed as co-authorships in the published papers.

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Publications Arising from Thesis


These chapters have been formatted to the same layout of the thesis. In addition, the references for these chapters are incorporated in the bibliography; published versions have been included in Appendices B, C, D, E & F.
Chapter One

1. Introduction
1.1. Introduction

Oral Health is fundamental to overall health, wellbeing and quality of life. The impact of oral disease on people’s everyday lives is subtle and invasive, influencing eating, sleeping, working and social roles (Australian Institute of Health and Welfare, 2004). Over the past 20 years, the prevalence of caries among school children has diminished. This can be attributed to improved oral health care, water fluoridation, lifestyle changes and the introduction of School Dental Services (SDS) as preventive and early intervention centres.

In the 1970s the Australian Government established the SDS to provide a range of oral health care for registered school age children who are unable to obtain treatment from private dentists. The Government funded the development of infrastructure and the education of dental therapists as the workforce for SDS (Australian Dental Association, 2010). These services achieved wide coverage of the target primary school population in most Australian States and Territories aiming at reducing the occurrence of dental caries among school children (Australian Dental Association, 2010). Shortly after, most SDS were then extended through the secondary school population. School children had access to free dental checkups at least once every year and covering basic restorative and preventive care, and some limited orthodontic care. The SDS is considered to be effective in reaching a substantial percentage of children. The unit cost of the services is low and the health outcomes continue to improve, providing an excellent base on which the oral health of Australians can be built.

Although significant improvements have occurred in the oral health of children in the last 30 years, high levels of oral disease and disability among a minority of Australian children still
persist (Australian Institute of Health and Welfare, 2004). Since the late 1990s, a clear and increasing trend of caries in the deciduous dentition of children attending SDSs has been observed (Australian Research Centre for Population Oral Health, 2011). In 2004, this trend has become apparent (Australian Research Centre for Population Oral Health, 2011), as these services only reach a little less than 30% of enrolled school children (Spencer, 2012). By 2006, there was an increase of 28% in deciduous caries experience (Australian Research Centre for Population Oral Health, 2011). The mean decayed, missing and filled deciduous surface (dmfs) was 2.28±6.00 of preschool age children (Hallett & O'Rourke, 2002). In contrast, 49% and 57% of children aged 5-6 years and 12-15 years respectively, had had some history of tooth decay, (Australian Institute of Health and Welfare, 2006a). The 10% of children with the most extensive history of permanent tooth decay had between 5 and 8 permanent teeth affected, which was about 4.5 times the national average (Australian Institute of Health and Welfare, 2006a).

The publically funded SDS face additional challenges especially among isolated communities and in most disadvantaged geographical areas. Poor oral health in Australia is most evident among Indigenous peoples, rural and remote populations, particularly people with low incomes (Australian Institute of Health and Welfare, 2004; 2007a). Children in low socioeconomic groups experience almost twice as much caries as those in high socioeconomic groups (An Advocacy Kit for Community & Welfare, 2010). About half of children from low income families experienced dental decay. Most of preschool children and those living in the rural and remote areas of WA have minimal access to dental services before they become registered with a publically funded School (Dogar, Kruger, Dyson, & Tennant, 2011; Kruger, Dyson, & Tennant, 2005). Hence, the prevalence of dental caries in
rural areas is higher than in metropolitan areas. Indigenous children have the highest prevalence of dental caries. Recent studies have also indicated that most Indigenous Australians children still do not have access to tooth brushes, and less than 5% of remote Indigenous pre-school children brush their teeth on a regular basis (Australian Institute of Health and Welfare, 2007b). Therefore, Indigenous children had consistently higher levels of dental caries in the deciduous and permanent dentition than their non- Indigenous counterparts at all ages between 4 and 14 years (Australian Institute of Health and Welfare, 2007b; Williams, Jamieson, MacRae, & Gray, 2011). Unfortunately, the oral health of Indigenous children has continued to worsen over recent decades, in contrast to the progress seen among non-Indigenous children. Indigenous children most affected were in socially disadvantaged groups and those living in rural/remote areas. Failure and delays in seeking treatment will lead to more complex conditions and thus hospitalisation might be inevitable.

Dental caries is the 5th most prevalent cause of hospitalisation in children in Western Australia (WA) (Tennant, Namjoshi, Silva, & Codde, 2000). During 1999- 2003, dental conditions accounted for nearly 26,000 avoidable hospital admissions (Kruger, Dyson, & Tennant, 2006). The majority of cases were for extractions due to dental caries, and they cost the WA State more than $40 million (Kruger Dyson, & Tennant, 2006). Admission for dental care is substantially more common in rural children compared to their metropolitan counterparts (Kruger Dyson, & Tennant, 2006; Australian Institute of Health and Welfare, 1998). In the 13-17 year age group, admission rates are more than 31 times higher among non- Indigenous, compared to Indigenous children (Kruger Dyson, & Tennant, 2006). Additionally, some children require a general anesthetic because they have comorbid health conditions; for others it is because their teeth are in such poor condition. Indigenous children
aged <5 years had almost 1.5 times the rate of hospitalisation for dental care compared with other Australian children (Australian Institute of Health and Welfare, 2007b). The rate of Indigenous children receiving hospital dental care increased with increasing geographic remoteness (Steele, Pacza, & Tennant, 2000). Many young remote Indigenous children experienced extensive destruction of their deciduous teeth which require complex treatment. Children aged less than 10 years, especially those at socioeconomic disadvantage, are substantially more likely to be hospitalised for dental conditions than other age groups (Australian Institute of Health and Welfare, 2007a). Hospitalisation could generally be avoided, when they are given early access to appropriate services.

This thesis will examine oral related hospitalisations to determine the trends in Western Australian children, and to determine the socio-demographic characteristics of at high risk groups of the population. Previously, Kruger Dyson, & Tennant (2006) determined that hospital admissions in children mainly included Indigenous and other disadvantaged children living in rural areas. Against the recent period of very rapid demographic change and changing patterns of oral disease in Australian children, current population-based studies become fundamental to determine time trends in hospitalisation rates and to identify those groups at high risk of hospital admissions. Therefore, this study analysed a decade of population hospital data of children aged between 0–14 years old (n=43,937), to establish the current trend of oral admissions, which will also help in identifying the sociodemographic characteristics of the minority of population at higher risk of admission. In Australia, oral and general health-care systems operate differently (in terms of funding and access), therefore differences between private health coverage of the same population should be addressed. As in privately driven markets (such as dental markets), where well-
insured patients are common, public dental care coverage in children alone will not be sufficient to remove disparities in dental care utilisation. For instance, wealthy individuals with private dental cover have better use of services and subsequently better oral health. By contrast, individuals with poor oral health and subjected to long waiting lists for public dental care are much less fortunate outcomes for uninsured counterparts (Haas & Anderson, 2005). These facts clearly indicate that different health coverage among the same population, may yield very different results. Previously, there have been no comparative studies of private oral health coverage among Western Australian children. Therefore, this study examines the disparities in dental insurance coverage among Western Australian children hospitalised due to oral health-related conditions. The study also investigates associated factors to address the inequalities that currently exist.

Continuous remodeling of the primary oral health service (e.g. SDS) to meet changing demands is crucial. This is necessary in order to reduce the burden of oral related conditions on childrens’ secondary oral health service (hospitals) on both individual and population levels. A strategy to identify and address access issues should be based on relevant and reliable information (such as population based studies). In a dental public health context, the research undertaken for this thesis is aimed at understanding the oral health hospital admissions issues of children living in WA, and also to highlight associated system costs. This is designed to enable, or facilitate the determination of projected costs and utilisation of oral health services in the future, based on predicted demand for services, as well as the maximal utilisation of limited resources.
Thereby, this thesis aims to examine the optimisation of the current primary oral health service (SDS) to identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia, based on published hospitalisation data. It is proposed that this will lead to the development of a model to provide an understanding of the distribution of demand for primary oral health services (in this case SDS). This model may be used as a decision support tool to design/test new frameworks for targeted SDS approaches, to enable the community to have timely access to preventively focused dental care that meets the minimum standard benchmarks for oral health service provision.

In order to understand better the hypotheses tested and the specific aims of this research, some background on the Australian oral health system, oral health determinants, and the prevalence of oral health conditions reviewed in relevant detail. A summary of the oral related hospitalisation trends among children and the associated costs are presented in the following chapter.
Chapter Two

2. Literature Review
Chapter Two

2.1 Introduction

2.1.1 Impact of Poor Oral Health

Oral Health is a fundamental part of general health and quality of life. The impact of oral disease on people’s everyday lives is subtle and invasive, influencing eating, sleeping, working and social roles. It is evident that a quarter of Australians avoid eating some foods as a consequence of pain and discomfort caused by their poor oral health (Roger, 2011), and almost 25% of Australians report experiencing orofacial pain in the previous month (The Steering Committee for the Review of Government Service Provision, 2010).

When Begg et al. (2003) compared the Disability Adjusted Life Years (DALY) lost from oral conditions with other selected health problems; the results indicated that oral diseases were responsible for the loss of 24,507 DALY. When only quality of life is considered, the impact of oral conditions is estimated to be greater over a 12-month period than the effect of all infectious diseases combined. Furthermore, these data revealed that the effects were greater than either breast cancer or lung cancer (Begg et al., 2003). The total loss was predominantly a result of dental caries (12,008 DALYL), pulpitis and edentulism data were 6,497 and 5,264, respectively (Begg et al., 2003).

Poor oral health has also been linked to a range of health conditions. Despite the fact that many oral conditions and chronic disease share many other risk indicators. There is strong evidence that a small but significant relationship exists. Cullinan et al. (2009) provided a current understanding of the mechanisms involved in poor oral health to systemic diseases.
Their results revealed an increasing risk of respiratory conditions, cardiac disease and osteoporosis, as well as increasing rates of diabetes complications (Cullinan et al., 2009). Similarly, periodontitis contributes to poor glycaemic control among individuals with diabetes, which can place them at risk for diabetic complications (Taylor & Borgnakke, 2008).

The impact of poor oral health is not only on the individual through pain and discomfort, but also for the broader impact on their community through significant cost to the health system and associated economy (Australian Health Ministers’ advisory Council, 2004). Oral conditions are responsible for large numbers of acute preventable hospital admissions (The Steering Committee for the Review of Government Service Provision, 2013). Therefore, it is essential to improve preventable oral conditions at both individual and community levels.

This introductory chapter explores the following parameters: the oral health system and School Dental Service; Australian children’s oral health patterns; and potentially preventable oral health-related hospitalisation and associated costs, with a particular focus of at high risk population.

2.2. Australian Dental Health Care System and Infrastructure

The Australian health care system’s fundamental goal is to ensure individual accessibility to care based on need rather than ability to pay. However, this goal has not been entirely met in relation to oral or dental services. Historically, since the Australian Health Act (AHA) does not consider dental care as part of general health care, dental conditions are not subjected to publically-administered, universal, convenient, accessible and comprehensive service.
Although, medical services are mainly publicly funded, most dental services are provided by private practitioners and thus Australians are responsible for funding their own dental care.

In Australia, dental health care is provided through private practice (this service’s costs are paid by private dental insurance or by paying directly out-of-pocket), or through government-subsidised programmes such as School Dental Services for children, or through public hospital clinics for adults (Haas & Anderson, 2005). This thesis will focus on children directed-oral health programs.

**2.2.1. Private Dental Practice and Private Dental Health Insurance**

Australians can attain private dental insurance by purchasing either hospital cover combined with an ‘extras’ option that includes dental services, or the ‘extras only’ option. Two levels of dental services coverage are provided: general dental and major dental coverage. General dental coverage normally includes services such as cleaning, removal of plaque, X-rays and small fillings. On the other hand, in addition to previously mentioned services, major dental coverage includes services such as orthodontics, third molar extractions, crowns, bridges and dentures. Although, owning private health insurance seems to be promising, it covers only a proportion of costs, based on the level of insurance; leaving the consumer to face a relatively high out-of-pocket cost for dental services. This section will emphasise private health insurance levels in Australian, however, out-of-pocket and treatment cost will be discussed later in this chapter.
In 1996, 40% of Australian children aged 5–11 years were covered by private dental insurance, (Bagramain et al., 2009). Despite the introduction of the Private Health Insurance Incentives Scheme (PHIIS) in 1997, dental insurance coverage among children 5–11 years declined to reach 35.6% in 1999 (Fisher-Owens, 2007). This scheme had a higher impact on families with adolescents due to the higher cost of dental care associated with orthodontic treatment. However, following the introduction of the 30% rebate scheme in 1999 and Lifetime Health Cover in 2000, private health insurance coverage increased to 42.1% in 2002 and 43.8% in 2005 among children aged 5–11, and from 45.7% (1999) to 51.7% (2002) in children aged 12-17 (Ellershaw & Spencer, 2009; Watt, 2007). From 1996 to 2005, the level of private dental coverage among Australians has increased by only 3.8% (Bagramain et al., 2009). In 2009, more than half (54%) of children aged 5–14 reported some level of private dental cover, with those living in urban areas (59%) having higher rates of insurance than those in rural and remote regions (47%) (Ellershaw & Spencer, 2009).

Insured children were more likely to have visited a dentist for a check-up within the previous 12 months compared to uninsured counterparts (Ellershaw & Spencer, 2009). Insured children are more likely to regularly visit a dentist for a check-up or preventable care than non-insured. Private dental coverage was similar among male and female children aged 5–11 years. Private dental insurance is an important factor modifying access to dental care. Insured children were significantly more likely to have visited a private practice than uninsured children (Ellershaw & Spencer, 2009). Furthermore, insured children are more likely to be hospitalised for proper treatment than uninsured counterparts who were more likely to receive extractions in dental clinics as out-patients and would have considerable difficulty paying a $100 dental bill.
The presence of private dental coverage increased the inequity in access to care, as wealthy individuals have better oral health and use more complex and expensive services (Haas & Anderson, 2005). Whereas waiting lists for public dental care have grown by 20% per year (Haas & Anderson, 2005), which leads to limited access to dental care and bears the greatest burden of untreated disease (An Advocacy Kit for Community & Welfare, 2010). There is a general agreement that most deprived families, Indigenous and children living in remote areas are the most marginalised groups by the current dental care system (An Advocacy Kit for Community & Welfare, 2010). However, to the best of the author’s knowledge, no published study has indicated the level of private insurance among those subgroups.

### 2.2.2. School Dental Services (SDS)

When one analyses the socioeconomic divide in oral health, different policies have been suggested to address those inequalities (Haas & Anderson, 2005). Several challenges face the public dental health services, especially among isolated communities and in disadvantaged geographical areas. Therefore, the Australian government has established SDS, which is a publically delivered children’s dental program, to address those inequalities.

Most children enroll in the SDS when they start school, usually at the age of 5 years (Government of Western Australia, 2008a) and continue to receive dental health care up to 17 years. The SDS aims at reducing the occurrence of dental caries among school children, mainly those unable to obtain treatment from private dentists. The services are available to government and non-government schools, which increases the number of children accessing early dental care in WA (Hallett & O'Rourke, 2003). In other situations, where SDS is difficult to be accessed, mobile dental clinics are provided to school children. School children are
examined by dentists to determine the state of their dental health. Dental therapists are also used in the provision of SDS (Bratthall, 2000). Therapists who provide these services are usually under the control of registered dentists in most Australian states (Government of Western Australia, 2008a). Though, dental therapists are used in areas where dentists are too expensive. Dental laboratory services in field clinics are provided by dental technicians (Government of Western Australia, 2008a). Dental health educators also participate in the SDS by carrying out dental health education lectures, such as brushing techniques, oral hygiene, plaque control, fluoridation and the importance of dental health (Rayner, Holt, Blinkhorn, & Duncan, 2003; Government of Western Australia, 2008b). Small groups of children in classrooms are taught the importance of fluoridation in preventing dental caries (Brennan et al., 2008). Young children attend demonstrations hosted by the dental service providers, which explain brushing techniques and application of fluoride. Older children attend lectures where dentists discuss signs of dental caries and prevention procedures (Nainar & Straffon, 2003). Dental therapists also aim at changing the children’s attitudes towards oral health care and other aspects of health behaviour.

The services provide access to free dental checkups at least once every year and children diagnosed with dental problems continue receiving free dental services from the SDS clinics. SDS staff provide oral health intervention treatment for controlling dental caries. Children undergo screening examination procedures such as bite-wing radiographs which aim at identifying dental diseases such as caries (Government of Western Australia, 2008a). Children with signs of dental caries undergo simple restorative treatment such as excavation of softened dentine and temporary restorations, and children with severe dental caries undergo restorations or extractions (Armfield, Slade, & Spencer, 2006). Those services
include preventive procedures such as topical fluoride application and prophylaxis. Oral prophylaxis of fluoride solutions is also provided to children especially those with limited access to fluoridated water as a preventive measure (Government of Western Australia, 2008a). The unit cost of the services is low and the health outcomes continue to improve, providing an excellent base on which the oral health of Australians can be built.

Although, treatments provided are cheap and considered to be an efficient way of combating dental caries among school children, the comprehensiveness of these programmes differs significantly among State and Territories in terms of the types of services covered, age restrictions and limits on the frequency of dental visits and enrolment levels. Some services, for instance, the SDS comprehensive dental care programmes in WA, were not extended through the secondary school population, and only limited to school children under the age of 15 years (Government of Western Australia, 2008a). Therefore, the Western Australian Government has introduced the Medicare Teen Dental Plan (MTDP) in 2008 (Australian Institute of Health and Welfare, 2012), where families, who are receiving Family Tax Benefit A, were provided with preventive dental check vouchers. These are worth $150 and are issued annually to children between the age of 12 and 17 years (Australian Institute of Health and Welfare, 2012). The preventive dental check covers oral examination, scale and cleaning, oral hygiene instruction, fluoride application, and fissure sealants, depending on the child’s requirements (Government of Western Australia, 2013). These vouchers can be used in both private and public dental clinics. However, they can only be redeemed for free at specific clinics. However, the (MTDP) closed on 31 December 2013, and was replaced by The Child Dental Benefits Schedule (CDBS) which was available only to eligible children since the beginning of 2014 (Australian Institute of Health and Welfare, 2013a). This $2.7 billion
measure will provide a Commonwealth funded capped benefit entitlement for basic dental services for children (Australian Institute of Health and Welfare, 2013a). Around 3.4 million children aged 2-17 in families who meet a means test will be eligible for benefits each year (Australian Institute of Health and Welfare, 2013a). The total benefit entitlement will be capped at $1,000 per child over a 2-year period (Australian Institute of Health and Welfare, 2013a).

The Western Australia Health Department assists the Metropolitan School Dental Services Key performance indicators. An annual report of the service's effectiveness indicators is released to assess and monitor the extent to which Government outcomes are being achieved through the resource used and the community service delivered. The key performance indicators in table 2.1 show the extent to which the Metropolitan School Dental Service is performing in Western Australia.
Table 2.1:
Key effectiveness indicators of disease prevention and health promotion of SDS in metropolitan areas of WA over time.

<table>
<thead>
<tr>
<th>Percentage of Eligible school children who are enrolled in the SDS program:</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-primary program</td>
<td>84.2</td>
<td>82.6</td>
<td>84.3</td>
<td>83.7</td>
<td>83.3</td>
<td>82.6</td>
<td>80.3</td>
<td>78.5</td>
<td>76.8</td>
</tr>
<tr>
<td>Primary program</td>
<td>85.9</td>
<td>85.2</td>
<td>85.2</td>
<td>84.7</td>
<td>84.5</td>
<td>84</td>
<td>83.5</td>
<td>82.7</td>
<td>80</td>
</tr>
<tr>
<td>Secondary program</td>
<td>77.2</td>
<td>82.2</td>
<td>82.2</td>
<td>84.4</td>
<td>80.7</td>
<td>81.2</td>
<td>82.9</td>
<td>82</td>
<td>79.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children under care:</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Pre-primary program</td>
<td>84.2</td>
<td>82.6</td>
<td>84.3</td>
<td>83.7</td>
<td>83</td>
<td>82.6</td>
<td>80.3</td>
<td>78.5</td>
<td>76.8</td>
</tr>
<tr>
<td>Primary program</td>
<td>85.9</td>
<td>85.2</td>
<td>85.2</td>
<td>84.7</td>
<td>84.5</td>
<td>84</td>
<td>83.5</td>
<td>82.7</td>
<td>80</td>
</tr>
<tr>
<td>Secondary program</td>
<td>58.9</td>
<td>58.9</td>
<td>58.5</td>
<td>70</td>
<td>58.3</td>
<td>58.7</td>
<td>60.4</td>
<td>59.7</td>
<td>57.9</td>
</tr>
</tbody>
</table>

| Children free of active dental caries on recall                | 67.1 | 67.2 | 67.6 | 67.6 | 66.7 | 66   | 66.0 | 65.9 | 65.4 |

Data source: WA Metropolitan Health Service Annual reports of 2005-06 and 2009-10

Although, over the past 20 years, the introduction of SDS has reduced the prevalence of caries among school children due to preventive measures and early treatment (Gussy, Waters, & Kilpatrick, 2006), dental caries is still a common disease among WA school children (Hallett & O’Rourke, 2002). Furthermore, decay is the fifth common cause of hospitalisation for school children in WA (Tennant et al., 2000). Thus, improving dental health of children is a major step towards improving their general health (Australasian Academy of Paediatric Dentistry, 2004).

Although, SDS is effective in reaching a high percentage of children, there are several limitations associated with the application of these standards. Difficulties include the
limitation that the service is restricted to registered school children. Children with no or limited access to SDS or mobile dental clinics who are living in very remote areas (Steele, 2000), aged under 5, and thus not registered in SDS (Kruger, Dyson, & Tennant, 2005), and children being home schooled, are not enrolled in the SDS, and this contributes to an underestimation the burden of dental and oral disease in the state. Home-educated children can only access SDS after booking appointments and showing evidence of registration. Lam et al. claimed that in Perth WA metropolitan areas, children had a median of 13 SDS visits until 12 years of age, with 10% having less than 5 visits, and 4% having more than 25 visits (Lam et al., 2012). On the other hand, Spencer (2012, p. 20) revealed that:

‘…..However, these services only reach a little less than 30 percent of primary and secondary school children. Services are somewhat loosely targeted toward lower and middle income families. While coverage has been declining rapidly since 2000, there is still a backbone of school or community dental services for children in Australia. What is desired is a system that captures those not visiting in any one year and which can re-orient dental services towards population and clinical prevention.’

Additionally, treatment outside the scope of the SDS is referred to hospitals or other specialist providers and any costs are the responsibility of the parent or guardian (Government of Western Australia, 2008a). Stewart et al. (2012) published a review of the reasons and sources of referral to hospital Paediatric dental service. The data showed that salaried public dental services are responsible for more than half (56%) of hospital consultations’ referrals; however, only 31.2% are from private dental practitioners (Stewart et al., 2012). Additionally, almost 8% and 5% were from emergency departments and
medical practitioners, respectively (Stewart et al., 2012). Researchers have also indicated that 51% of the total public dental service referrals to the hospitals were for children who had difficulty cooperating for dental treatment, and 22.7% were for treatment planning only (Stewart et al., 2012). Referrals from private dental practitioners were mainly for treatment planning only (Stewart et al., 2012). These findings reveal that public dental service professionals are facing more problems dealing with anxious children who had difficulty cooperating for dental treatment, than private dentists. At the same time, the proportion of referrals for trauma or for extensive dental disease from private dental practitioners was twice as high as from the public dental service (Stewart et al., 2012). However, almost all attendances for dental trauma were from an emergency hospital department. The majority of referrals from medical doctors were for medically at-risk children or oral disease induced by other illness (Stewart et al., 2012).

2.2.3. Hospital Admissions

2.2.3.1. Children Oral Health-related Hospital Admissions

Dental diseases are the third most common cause for having general anaesthetics in children (Sims, Stanley, & Milnes, 2005). Public hospitals are accountable for oral health-related child admissions, in WA only few numbers of them are responsible for those admissions. However, a significant number of potentially preventable hospitalisations occurred in private hospitals. Firstly, it is important to define the Potentially Preventable Hospitalisation (PPHs), which are ‘hospital separations’. This is a special term for hospitalisation data. In simple terms it means discharged from hospital but it takes into account some specific factors like being transferred to another hospital and also dying and being born in a hospital. In short is
means being discarded from hospitals. In the context of this thesis it refers to the case where the principal diagnosis of the hospitalisation is thought to be avoidable (Australian Institute of Health and Welfare, 2014b). Preventable oral health-related hospital admission rates can be considered as an indicator of inadequate access to dental care service. Furthermore, high PPHs rates indicating an increased in the prevalence of those conditions within the community, poor non-hospital care system performance or, alternatively, an appropriate use of the hospital system to respond to greater need (Australian Institute of Health and Welfare, 2013a). In Australia, the total number of preventable dental conditions hospital separations increased from 57,955 to 63,327, between 2007–08 and 2011–12 (Australian Institute of Health and Welfare, 2014b). Along with the population growth the separation rate remained steady at 2.8 per 1,000 population (Australian Institute of Health and Welfare, 2014b). Children aged less than 15 had a preponderance of those PPHs (Australian Institute of Health and Welfare, 2014a). Children aged 5–9 had the highest number of hospital admissions (13,503 separation), followed by children aged 4 and younger (7,791 separations). Across all States and Territories, Western Australia had by far the highest at 3.8 admissions per 1,000 population in 2010 (Australian Institute of Health and Welfare, 2014b). Tennant et al. (2000) conducted a study similar to Kruger et al. (2006) comprising oral related admissions of Western Australian children, aged 0 to 17 years. The results of those studies revealed increasing trends in oral related admission over time. Tennant et al. (2000) confirmed that a total of 3,754 episodes (4,395 bed days) were admitted for oral care. While Kruger et al’s study estimated that between 1999 and 2003, a total of 26,497 episodes of care (31,431 bed days). Of the latter admissions, 24% episodes were admitted in 1999-00, 23% in 2000-01, 25% in 2001-02 and 28% in 2002-03 (Kruger at al., 2006). Interestingly enough, although
the state of WA demonstrated average or low dmft/DMFT score among children across ages, high hospitalisations have been detected.

Hospitalisation rates of potentially preventable dental conditions thus provide an indicator of the potential inadequacy of dental care in the community (Chrisopoulos & Harford, 2013). Therefore, culturally-appropriate analysis for prevention and early intervention remains the backbone of targeting approaches and a number of prospective and retrospective studies’ findings give a valuable insight into the extent of such oral health problem within particular groups.

2.3. Determinants of Oral Health-related Hospital Admissions

Factors such as age, Indigenous status, socioeconomic status, private health insurance, accessibility and remoteness influence whether a child attends a dental professional (Kruger et al., 2005; Slack-Smith, 2003). There is, however, limited information regarding the factors associated with oral hospital admissions among children.

2.3.1. Age and Gender

Dental conditions in children are almost entirely preventable (Mouradian, Wehr, & Crall, 2000). However, of all hospital admissions requiring general anaesthetics in Western Australia in 2002–2003, 17% were for dental treatments, among children aged 1–4 years (Sims et al., 2005). Reports on oral related hospital admissions indicate that the problem of Early Childhood Caries (ECC) has been ongoing. For example, the rates all oral health-related hospital admissions are considered to be high (842 and 1635 per 100,000 population in < 12
months old and 1-4 years old children, respectively) (Kruger Dyson, & Tennant, 2006). The majority of those admissions might attributed to ECC, as it is the most prevalent oral condition in children aged 4 years or younger (American Academy of Pediatric Dentistry Clinical Affairs Committee, 2006).

On the other hand, dental hospitalisations requiring general anaesthetics are most common in school-age children. The rate in those aged 5–9 was 11 per 1,000 persons, with no differences between males and females (Australian Institute of Health and Welfare, 2014a). Another study revealed that children aged 13-17 had the highest rate of admissions (19.48 per 1,000 children aged 13-17), followed by those aged 5–12 (9.34 per 1,000 children aged 5-12) (Kruger Dyson, & Tennant, 2006). However, high school aged children admissions rates are more likely to be attributed to third molar removal than treatment of decayed teeth, in contrast, children aged 5-12 were more likely to be admitted for caries treatment.

2.3.2. Indigenous Status

In brief, the Australian bureau of Statistics (ABS) (2011) has estimated that the WA Indigenous population represents around 3.8% of the total WA population and 13.2% (669,736) of the total Australian Indigenous population (Australian Indigenous HealthInfoNet, 2015). Higher proportions of Indigenous population were accounted for children aged less than 15 years were observed compared to older age groups (Australian Indigenous HealthInfoNet, 2012; 2013).

Indigenous Australians are disadvantaged on almost every health and social indicator compared to non-Indigenous Australians (Australian Indigenous HealthInfoNet, 2015).
Marked oral health disparities exist between Indigenous and non-Indigenous children in Australia; with Indigenous children experiencing more caries in their deciduous teeth than non-Indigenous children (Jamieson, Armfield, & Roberts-Thomson, 2007). Australia-wide, dental hospitalisations that require general anaesthetics are most common in Indigenous children aged 5–9 years, followed by children aged 0–4 compared to other age groups (Australian Institute of Health and Welfare, 2014a). The rate of admissions in those aged 5–9 was 14.9 per 1,000 Indigenous children aged 5–9 and for those aged 0–4 the rate of admissions was 10.7 per 1000 years (Australian Institute of Health and Welfare, 2014a). No significant differences were observed between Indigenous males and females (Australian Institute of Health and Welfare, 2014a).

In Western Australia, a study investigated dental hospitalisations occurred between 1980-1995, for all children aged less than 5 years (Slack-Smith et al., 2009). The findings indicated that Indigenous children were 1.18 times more likely to be admitted than non-Indigenous children. Other authors reported similar findings elsewhere in Australia. Jamieson et al. (2006) found that Indigenous children aged less than 5 years had 1.4 times the admission rate of similarly aged non-Indigenous children (Jamieson & Roberts-Thomson, 2006). Furthermore, they claimed that Indigenous children living in remote areas had 1.5 times the admission rate of urban living Indigenous children (Jamieson & Roberts-Thomson, 2006). However, non-Indigenous children are more likely to be admitted than Indigenous counterparts. Kruger et al. (2006) estimated that Western Australian non-Indigenous children were 1.7 times more likely to be admitted than Indigenous children.
The previous findings suggest that although the Indigenous child population has a greater tendency to have more severe conditions than non-Indigenous counterparts, recent oral admission trends among Indigenous children, however, indicate limited access toward more invasive treatment. Therefore, there is an urgent need for the development of strategies targeting Indigenous children oral health, along with a multifactorial risk factor approach.

2.3.3. Socioeconomic Status

Oral health is strongly linked to the socioeconomic position of individuals, which is reflected in the patterns of oral disease in Australia (National Advisory Committee on Oral Health, 2004). Access to dental care in Western Australia also has a strong socioeconomic dimension with disadvantaged people having serious access problems and extensive waiting times (Kruger & Tennant, 2005; 2006). Several studies revealed different patterns of trends in demand for dental caries hospital care among different socioeconomic status (SES) groups. Evidence suggested that avoidable hospital admissions are substantially more common in low SES children (Blustein Hanson, & Shea, 1998), as those from the lowest SES areas were more likely to have more untreated decay than children from the highest SES areas (Australian Institute of Health and Welfare, 2011a). Similarly, a recent New-Zealand analysis indicated that higher rates of dental preventable hospitalisations in children were among the most deprived (Whyman, Mahoney, Morrison, & Stanley, 2014).

2.3.4. Accessibility and Remoteness

Remoteness and accessibility are significant factors determining the level of basic health; higher rates of poor oral health were observed in remote areas (Australian Institute of Health
and Welfare, 2008b). Increasing remoteness has a negative impact on oral health, where environmental or geographical factors such as long distances to access services exist. For example, in Victoria, avoidable dental hospitalisation rates are higher among rural dwellers, especially in children younger than 9 years (Department of Human Services, 2007). However, in Western Australia evidence indicate that hospital admissions do not reflect the actual burden of the oral conditions. Tennant et al. (2000) found that the hospitalisation rates for oral conditions (of children younger than 13 years) were higher among those living in rural areas than metropolitan living counterparts. The trend, however, has been reversed within the following decade. As in 2006, Kruger et al. (2006) published a 4-year period of study (from 1999-00 to 2002-03) on oral hospitalisation in WA children and showed a significant difference between the hospitalisation rates of Western Australian children living in rural areas (1284.6 per 100,000 population), compared to urban living counterparts (1391.1 per 100,000) (Kruger Dyson, & Tennant, 2006). Several studies, however, have examined the oral health status of people attending rural and remote dental clinics (Smith, Kruger, Dyson, & Tennant, 2007; Kruger et al., 2005; Dogar et al., 2011). The results indicate that rural living pre-school children are experiencing a higher dmft average.

As Indigenous Australians are more likely to live outside metropolitan areas than non-Indigenous Australians, the relationship of remoteness to oral health and oral health-related admissions is particularly important. Some studies examined the rate of oral hospital admission of Aboriginal children based on location, and found a higher rate of oral hospital admission among WA Indigenous children living in remote or very remote areas (796.2 per 100,000), compared with urban living children (755 per 100,000) (Kruger Dyson, & Tennant, 2006). In contrast, rural living non-Indigenous children have a high rate of admissions
compared with Indigenous children living in rural area. In rural/urban context, further analyses of other socioeconomic and demographic variables are essential to ameliorate the oral prevention approach.

2.3.5. Insurance Status

As previously discussed the percentages of privately-insured Australian children have declined over the past decade, with only half of the child population insured. It is important to note that in Australia, dental services are predominately provided in a private sector setting, and therefore prices and wealth influence access. However, further evidence on the insurance coverage among various conditions or socioeconomic subgroups does not exist.

2.4. Oral Health Expenditure

Over the last decades the health expenditure growth has largely been driven by increases in inflation (37%), population growth (14%) and actual increase in expenditure per individual (48.7%) (Australian Dental Association, 2006b). In the year 2001–02, nearly $3.7 billion was spent on dental services, representing 5.5% of total health expenditure (Australian Institute of Health and Welfare, 2003). Much of this was spent on repair and rehabilitation of tissue destroyed by dental caries and periodontal disease; conditions that are amenable to prevention through different levels of health measures (US Department of Health and Human Services, 2000). The expenditure on dental care has risen from $1.9 billion to over $4.7 billion in 1994–95 and 2004–05, respectively. Through the same period, dental expenditure’s portion of total health expenditure rises from 3.8% to 5.7% (Australian Dental Association, 2006b). Moreover, the following trends have been observed during the same
period: State, Territory and Local Governments increase their outlay on dental care to reach 13% of total expenditure in 1999-00, then drop to 8.1% in 2001–02 before growing to 9.9% in 2004–05 (Australian Dental Association, 2006b). Additionally, private health insurance rebates continue to decrease. In 1994–95, spending by private health insurance funds accounted for 28.1% of total dental expenditure. By 2004–05 this figure fell to 13.8% (Australian Dental Association, 2005; 2006a). Based on an Australian Dental Association (2006b) report, ‘expenditure by individuals continues to account for the majority share of total dental expenditure, rising from 58.8% in 1994–95 to 67.3% in 2004–05’ (Australian Dental Association, 2006b). In 2006, Australian total health expenditure on hospitals increased by 31%, whereas dental services expenditure only grew by 3.5% (Australian Dental Association, 2006b).

In 2004–05, the WA dental service total outlay was around $52 million (NRHA, 2005; Graham & Kucera, 2002). The total sector expenditure includes payment for public and SDSs that provides free dental services to school children. Of the total dental health expenditure, $7.8 million was granted to the Oral Health Centre of Western Australia (OHCWA) to provide some public dental service, as a governmental initiative to improve access to quality dental care (NRHA, 2005). With this agreement, ‘the OHCWA provides specialist oral health care to those eligible for state government subsidised dental care (Health Care Card holders) and general dental care to eligible patients within their local catchment area’ (Western Australia. Department of Health, 2007). According to the WA Department of Health annual report 2011–12, OHCWA has treated 8,262 cases in their general practice and more than 38,000 cases in different specialty areas during the period of 2007–2012 (Western Australia.
Chapter Two

Department of Health, 2012). Consequently, waiting times and shorter hospitalisation lists have been diminished which indicate more access to affordable services.

Table 2.2:
A summary of the total oral health Australian budget in ($ million) by source of fund, over time.

<table>
<thead>
<tr>
<th>Year</th>
<th>Federal government direct outlay</th>
<th>State &amp; local government</th>
<th>Federal government premium rebates</th>
<th>Health insurance funds</th>
<th>Individuals</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>110</td>
<td>600</td>
<td>398</td>
<td>907</td>
<td>4,107</td>
<td>11</td>
<td>6,133</td>
</tr>
<tr>
<td>2006-07</td>
<td>125</td>
<td>583</td>
<td>404</td>
<td>949</td>
<td>4,234</td>
<td>10</td>
<td>6,306</td>
</tr>
<tr>
<td>2007-08</td>
<td>235</td>
<td>614</td>
<td>448</td>
<td>983</td>
<td>4,182</td>
<td>10</td>
<td>6,473</td>
</tr>
<tr>
<td>2008-09</td>
<td>558</td>
<td>690</td>
<td>440</td>
<td>1,069</td>
<td>4,271</td>
<td>23</td>
<td>7,052</td>
</tr>
<tr>
<td>2009-10</td>
<td>768</td>
<td>652</td>
<td>509</td>
<td>1,076</td>
<td>4,737</td>
<td>32</td>
<td>7,775</td>
</tr>
</tbody>
</table>

*Source: Australian Institute of Health and Welfare (2014b) health expenditure data cubes*

The latest expenditure figures on dental health show a real growth in most areas, with an outlay of 7.5% for dental services ($8 million) (Australian Institute of Health and Welfare, 2011b) (Table 2.2). This is an increase of 13% from the total expenditure on dental services than the previous year. Individuals are considered the largest contributor (61%) to the total dental expenditure (Australian Institute of Health and Welfare, 2011b) (Table 2.2). The estimated national average level of regular spending on health was $5,251 per person, whereas in WA, the health budget has been experienced a 2.3% lower share ($5,128 per eligible person) than the national average (Australian Institute of Health and Welfare, 2011b) (Table 2.2). Twenty percent of the total expenditure was spent on school-based programmes (Leeder & Russell, 2007).

The State government is the primary financier of the SDS program to provide equipment, maintain clinics, and conduct training sessions for school children (Australian Institute of
Health and Welfare, 2006b). Although Australia’s health system is highly ranked on the medical scale worldwide, refinements are needed in regards to SDS to enable equitable and efficient care for all Australian children. According to Australian Institute of Health and Welfare (2006b), in order to improve the condition of the existing SDS clinics, the State government has to increase this funding (Australian Institute of Health and Welfare, 2006b). Unfortunately, the majority of those clinics experienced either the lack of essential equipment, such as computers, or fail to attract new staff due to low wages (Australian Institute of Health and Welfare, 2006b). Contrary to this, the Australian Dental Association has identified SDS as an area where more funds from the Federal government are required (Australian Institute of Health and Welfare, 2006b). The numbers of school aged children and adolescents have increased over time, and more funds are required for sustainable dental health provision services. These funds should enable a universal coverage of those children to access free or subsidised dental care services based on targeting approaches (Tennant et al., 2000). Targeting approaches work on the principle that some groups of the population are at greater risk compared with the whole population (Daly, Batchelor, Treasure, & Watt, 2013).

2.5. Oral Health Status of Australian Children

In this section, an overview of oral health of the most common oral conditions among Australian children is provided, with a particular focus on Western Australia.
2.5.1. Dental Caries

Dental caries, which also known as dental decay, is the most common oral disease worldwide. It is characterised by demineralisation (mineral ions loss) of the tooth surface (enamel). Caries is stimulated largely by the presence and interaction of acid-producing bacteria, fermentable carbohydrates and many host factors including teeth and saliva (HA et al., 2011). Normally, saliva induces the growth of dissolved crystals through re-depositing of lost minerals (remineralisation). However, under some circumstances, imbalance of the demineralisation/remineralisation process leads to destruction of the hard tissue of the tooth, which subsequently becomes a favorable place for bacterial growth. This may cause considerable pain and, if not treated, caries will progress causing pulp inflammation and pulp death then an abscess may occur and restorations or removal of the tooth may be required.

2.5.1.1. National Trends

In Australia, oral health measures suggest that significant improvements have occurred over the last 30 years. However, in Australia, tooth decay is considered the most prevalent dental problem and is over 5 times more prevalent than Asthma among children (Armfield Slade, & Spencer, 2007; Australian Bereau of Statisitics, 2009). In the last decade, approximately 8% of children aged 5–11 years who made a dental visit within the previous year received an extraction due to severe carious damage (Ellershaw & Spencer, 2009). Children who visited the dentist for a problem were more than twice as likely to have received an extraction compared to those who usually visited for a check-up (Ellershaw & Spencer, 2009). Subsequently, over the last generation, the trends have either plateaued or have begun to
decline. For example, the prevalence and incidence of deciduous caries among 5-year-old children has been growing by 20% between 1996 and 1999 (Australian Institute of Health and Welfare, 2014b). Similarly, a gradual increase of permanent teeth caries at age 12 has occurred since the late 1990s (Australian Institute of Health and Welfare, 2014b).

Table 2.3:
Percentages of children attending a School Dental Service with dmft + DMFT > 0 by age, over time.

<table>
<thead>
<tr>
<th>Years</th>
<th>Percentage of dmft + DMFT &gt; 0 by age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>2002</td>
<td>80.5</td>
</tr>
<tr>
<td>2006</td>
<td>42.0</td>
</tr>
<tr>
<td>2009</td>
<td>41.8</td>
</tr>
</tbody>
</table>

*Source: (Chrisopoulos & Harford, 2013; Chrisopoulos et al., 2011; Armfield et al., 2007)*

Table 2.3 shows the change in the proportion of children with caries (dmft + DMFT > 0), over time. For 5-year-olds children the trend has taken a positive direction toward prevention with less than half of them experiencing dental caries. This figure, however, might not be representative of the whole population, as the number of children included in the 2006 and 2009 surveys were far fewer than the number of children examined in the 2002 national survey. On the other hand, across all other ages, child caries experience has increased over time. Although the Australian children oral health survey method is widely accepted, there are several limitations associated with the application of these standards. Difficulties include their restriction to enrolled school aged children and excluded children younger than 5 years. Therefore, many pre-school children (aged 4 or less) develop very severe and extensive dental decay which is called ECC or also known as Nursing Bottle Caries. Diets rich in carbohydrates are the main contributing factors of ECC. Many children with ECC
frequently require hospitalisation for treatment under general anesthetic. Unfortunately, population-based data about caries experience among children within this age group does not exist.

Since the oral health care of children younger than 4 is not included in the SDS coverage scheme, their ECC prevalence is not routinely collected, and not part of the child national oral health survey. However, studies are replete with evidence suggesting that there has been an increase in ECC in Australia. Wyne (1999) examined the prevalence of nursing caries among 2 to 3-year-olds pre-school children in Adelaide, South Australia. The results revealed that the prevalence of ECC among those children was almost 17%, with some requiring hospitalisation and invasive treatment. In Australia, the mean dmft for 4 year-olds has gradually increased from 1.10 in 1997 to 1.44 in 1999, 1.64 in 2002 and 1.70 in 2003–2004 (Australian Institute of Health and Welfare, 2004; 2007a). The severe form of ECC affects a child’s general health, learning ability and future oral health (Horowitz, 1998; Peretz, Ram, Azo, & Efrat, 2003). Yet, ECC is largely preventable by targeting those in the high risk group.

Table 2.4:
Age-specific average caries experience (dmft) in children attending a School Dental Service, over time.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Deciduous dentition: average dmft per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
</tr>
<tr>
<td>5</td>
<td>1.83</td>
</tr>
<tr>
<td>6</td>
<td>1.96</td>
</tr>
<tr>
<td>7</td>
<td>2.22</td>
</tr>
<tr>
<td>8</td>
<td>2.32</td>
</tr>
<tr>
<td>9</td>
<td>1.98</td>
</tr>
<tr>
<td>10</td>
<td>1.60</td>
</tr>
</tbody>
</table>

*Source: (Chrisopoulos & Harford, 2013; Mejia et al., 2012; Chrisopoulos et al., 2011; Armfield et al., 2007)
Table 2.4 shows an increase in average dmft over time which displays a similar pattern across ages. Children aged 6–9 years had the highest dmft score across all ages. Similar to deciduous dentition, the average DMFT has increased for older age group (> 10 years) compared to younger age groups (Table 2.5).

**Table 2.5:**
Age-specific average caries experience (DMFT) in children attending a School Dental Service, over time.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Permanent dentition: average DMFT per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
</tr>
<tr>
<td>5</td>
<td>0.04</td>
</tr>
<tr>
<td>6</td>
<td>0.08</td>
</tr>
<tr>
<td>7</td>
<td>0.28</td>
</tr>
<tr>
<td>8</td>
<td>0.43</td>
</tr>
<tr>
<td>9</td>
<td>0.54</td>
</tr>
<tr>
<td>10</td>
<td>0.65</td>
</tr>
<tr>
<td>11</td>
<td>0.75</td>
</tr>
<tr>
<td>12</td>
<td>1.02</td>
</tr>
<tr>
<td>13</td>
<td>1.37</td>
</tr>
<tr>
<td>14</td>
<td>1.72</td>
</tr>
</tbody>
</table>

*Source: (Chrisopoulos & Harford, 2013; Chrisopoulos et al., 2011; Armfield et al., 2007)

Even the recent Australian national survey showed an increase in the percentages of children affected by caries. Australian Institute of Health and Welfare published the Child Dental Health Survey 2014 results. These data showed that the proportion of Australian children’s dmft, who attend a SDS, has varied from about 48% to 63% for those aged 5 and 9, respectively (Australian Institute of Health and Welfare, 2014b). Children aged 5 had an average of 2.32 dmft, those aged 8 had 2.63, and those aged 10 had 1.78 (Australian Institute of Health and Welfare, 2014b). This variation might be attributed to the fact that children aged 10 years old have fewer deciduous teeth than their younger counterparts. However, approximately 50% of children aged 12 had experienced caries in their permanent teeth.
(Australian Institute of Health and Welfare, 2014b). On average, 1 in every 10 children aged 12 to 15 years has an extensive history of permanent tooth decay (with between 5.2 and 8.6 permanent teeth affected). Those with very high levels of caries were more than 4 times the national average of DMFT children of those ages (Australian Institute of Health and Welfare, 2014b). When only permanent teeth DMFT scores are compared by age, it is evident that children aged 12 are more likely to have higher DMFT scores than their younger counterparts. Vice versa, when dmft scores for deciduous teeth are compared between the same age groups, higher rates are observed among those aged 6 or younger than those aged 12 or older. Unanimously, these differences in affected teeth with age are explained by the increased time that their teeth have been at risk of decay.

Caries experience varied between States and Territories and over time. This variation might be attributed to factors such as variation in service coverage policies, differences in targeting practices, and varying levels of access to services. Variations in the severity of caries experience between States and Territories are represented in the following table (Table 2.6).

Table 2.6:
Comparison of the average caries experience in children based on age and State and Territory, 2007.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>NSW</th>
<th>Qld</th>
<th>WA</th>
<th>SA</th>
<th>Tas</th>
<th>ACT</th>
<th>NT</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-6 (dmft)</td>
<td>1.53</td>
<td>2.47</td>
<td>1.51</td>
<td>2.01</td>
<td>2.21</td>
<td>1.37</td>
<td>3.75</td>
<td>1.88</td>
</tr>
<tr>
<td>12 (DMFT)</td>
<td>0.75</td>
<td>1.32</td>
<td>0.84</td>
<td>0.93</td>
<td>1.10</td>
<td>0.80</td>
<td>0.74</td>
<td>0.95</td>
</tr>
</tbody>
</table>

*Source: Child dental health survey Australia 2007. (Mejia et al., 2012)

---

1 New South Wales (NSW), Queensland (Qld), Western Australia (WA), South Australia (SA), Tasmania (Tas), Australian Capital Territory (ACT) and Northern Territory (NT).
Table 2.6 shows that dental caries in deciduous teeth were highest in the Northern Territory (NT), while the Australian Capital Territory (ACT) had the lowest level of dental caries in deciduous teeth. Moreover, WA children’s average dmft is lower than the national average. The table has also shown that DMFT of Queensland 12 year-old children is the highest, whereas WA reported a mean DMFT of (0.84).

### 2.5.1.2. Western Australia Trends

Several studies have investigated the Western Australian pre-school children caries experience. For example, Kruger et al. (2005) assessed caries among a sample of pre-school children in a rural community. Only 40% of the surveyed sample were caries free, which was much lower than average figures reported in ‘Child Dental Health Survey’ in Western Australian. The study also added that the prevalence of severe-ECC (s-ECC) was significantly higher among Aboriginal compared with non-Aboriginal children. Similar results were found when Dogar et al. (2011) examined the prevalence and severity of decay in pre-school children in rural and remote WA and considered some of the factors associated with these rates. The authors analysed the dental health of 253 children aged between 2 and 4 years within five rural and remote communities in WA. The findings showed that more than 40% of these children already had one or more decayed teeth. Of those, 19% had s-ECC and 15% had already suffered toothache, with Indigenous children experiencing higher burdens than non-Indigenous counterparts. Additionally, 69% of Indigenous children had decay; of those 34% experienced s-ECC. In contrast, of all non-Indigenous children who had dental decay, only 25% had s-ECC (Dogar et al., 2011). Another study also confirmed that in some
Indigenous communities, children aged older than 5 years are experiencing up to three times the prevalence of caries as non-Indigenous children (Christian & Blinkhorn, 2012).

Presented below is a table of trends over the last decade, of caries experience among Western Australian school aged children living in urban areas weighted by age. Across the period 2000-2009, caries experience slightly decreased for most age groups, with only 15 year-olds appearing to indicate an increase in caries across this period.

Table 2.7: Average numbers of decayed, missing or filled teeth (DMFT) for school children living in metropolitan areas, over time.

<table>
<thead>
<tr>
<th>Age</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 year-olds (dmft)</td>
<td>1.51</td>
<td>1.59</td>
<td>1.54</td>
<td>1.45</td>
<td>1.52</td>
<td>1.45</td>
<td>1.57</td>
<td>1.35</td>
<td>1.44</td>
<td>1.26</td>
</tr>
<tr>
<td>8-year-olds</td>
<td>0.37</td>
<td>0.34</td>
<td>0.35</td>
<td>0.30</td>
<td>0.31</td>
<td>0.28</td>
<td>0.30</td>
<td>0.30</td>
<td>0.22</td>
<td>0.27</td>
</tr>
<tr>
<td>12-year-olds</td>
<td>0.91</td>
<td>0.84</td>
<td>0.93</td>
<td>0.85</td>
<td>0.85</td>
<td>0.84</td>
<td>0.89</td>
<td>0.75</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>15-year-olds</td>
<td>1.68</td>
<td>1.51</td>
<td>1.57</td>
<td>1.61</td>
<td>1.69</td>
<td>1.49</td>
<td>1.67</td>
<td>1.68</td>
<td>1.69</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Data source: WA Metropolitan Health Service Annual reports of 2005-06 and 2009-10

The previous table indicates excellent status for dental health among school children in Western Australia through consistently low DMFT average scores over the past decade. However, those estimates do not represent the complete Western Australian child population, as they were only based on that portion of the population that is enrolled in and under the care of the metropolitan SDS clinic. Consequently, the results cannot be applied to children who are not enrolled in school and eligible for SDS. It is important to note that enrolment across Australia varies, but in all States and Territories, it is higher among primary school aged children than those in high school. Hence, estimates for primary school children might not differ substantially from those that would be obtained if all children were
surveyed; in contrast, estimates for high school children would differ from those obtained if all children were surveyed.

Australia-wide, children from less affluent areas still have poorer dental health than other Australian children. Across all ages, children residing in low socioeconomic areas have higher DMFT than children residing in the high socioeconomic areas. Additionally, when dental diseases were compared between children living in metropolitan areas and rural or remote regions of Australia, differences occur in relation to their social gradient. For example, in rural and remote areas, the average amount of dental decay was high in children who lived in the most disadvantaged areas. Children aged 4 years and younger who were living in rural and remote areas experienced between 25% and 30% more extreme caries than metropolitan children. Additionally, in urban areas there was a consistent trend of increasing levels of decay with increasing levels of disadvantage.

In Australia, dental caries was the 5th most common reason for hospital admission for 1 to 4-year-olds children in 1999–2000. Furthermore, dental conditions accounted for 7% of all procedures performed in hospital for children aged up to 14 years (Al-Yaman, Bryant, & Sargeant, 2002). A study by Slack-Smith et al. (2009) described the dental admissions occurred in WA during 1980-1995 among children aged 4 years or under. Oral hospital admissions of children less than 5 years accounted for 10,493 admitted cases. Of the total admissions, 78% were for dental caries, with 62% of those admissions occurred in children living in urban areas compared to 27% occurred in rural children. Further study using the same data set investigated the dental admissions among children under the age of 5 years found that 40% of admissions occurred in Indigenous children aged younger than 2 years
old compared with 10% among non-Indigenous children of the same age (Slack-Smith et al., 2011). When 3 years of data (1996–1998) were added to the previous analysis, Slack-Smith et al. (2013) revealed similar dental hospital admission trend on children up to the age of 2 years. The study found that 39% of children were most frequently admitted for dental caries (Slack-Smith et al., 2013).

More recently, Kruger et al.’s (2006) four year (1999–2003) analysis of oral admission in children under the age of 18 years found that 28.3% of all admission episodes were for dental caries. The highest rates of hospital admissions were in the pre-school age children, followed by primary age school children. Non-Aboriginal pre-school and school-aged children were 2 and 1.4 times, respectively, more likely to be admitted for dental caries than their Aboriginal counterparts. Although the prevalence of decay was somewhat higher in girls than in boys (Australian Institute of Health and Welfare, 2014a), no study has confirmed significant gender differences in children oral admissions.

On the other hand, children from the most deprived areas are experiencing higher decay levels, as previously discussed, and accordingly it would be assumed that they have higher service utilisation rates compared to children living in least deprived areas (who are experienced lower dmft). However, evidence indicated that higher dental caries related-hospitalisation rates were observed among children living in high SES. Madan et al. (2010) studied the trend of dental admissions in children aged 0–19 years in relation to their residential location, hospital service utilisation and their socioeconomic status. Children living in metropolitan, highly accessible and least deprived areas have higher caries related hospital admissions than children living in very remote and most deprived areas. Children
living in highly accessible areas were more likely to be admitted for dental decay in a private hospital than children living in very remote areas.

It is important to describe the current trend of dental decay admissions that occur in children and to determine their related risk indicators in order to inform population and risk-group based prevention strategies to minimise the burden of dental caries and other associated disorders.

2.5.2. Embedded and Impacted Teeth

In case of children aged 14 years and younger, impaction of maxillary permanent canines is the most frequently encountered clinical problem. Impacted canines are mostly asymptomatic and its precise cause is unknown. Although, impacted canines are a common dental anomaly among children as young as 9 years of age, it has the potential to damage the adjacent teeth. The treatment of such a condition usually requires an interdisciplinary approach such as surgical exposure of the impacted tooth and the complex orthodontic treatment, which may lead to various degrees of destruction of the tooth’s supporting structures (Manne, Gandikota, Juvvadi, Rama, & Anche, 2012); not to mention the long-term therapy and the financial burden to the patient. Hence, it seems valuable to focus on the means of early diagnosis and improving the outcome.

The fundamental aspect in the diagnosis and prevention of an impacted maxillary canine is the ability to recognise and predict its subsequent failure of eruption. Ericson & Kurol (1998) proposed that early diagnosis of canine displacement, in relation to the surrounding structures, is primarily based on the radiographic examination (Ericson & Kurol, 1988;
Ericson & Kurol, 1986a). However, it is vital to note that a radiographic examination in children younger than 9 does not provide a reliable means to determine the future unfavorable path of eruption of a maxillary canine (Lindauer, Rubenstein, Hang, Andersen, & Isaacson, 1992). The same authors also studied the outcome of extracting a retained deciduous canine in 10 to 13 year-old children in relation to the improvement of the angulation and eruption path of an ectopic canine. The results demonstrated that 78% of ectopic canines reverted to a normalised path of eruption after early extraction of their deciduous canine (Ericson & Kurol, 1986a; Ericson & Kurol, 1986b). Therefore, evidence suggested that early radiographic examination along with geometric measurements by the age of 9-10 years can provide substantial information on the eruption pattern of a maxillary canine, thus permitting early detection and proper intervention in order to minimise invasive and costly hospital treatment of an impaction.

The prevalence of canine impaction in Western Australian children is currently unknown. Unfortunately, as the SDS routine examination does not include impaction detection measures, a considerable number of children are hospitalised due to impacted or embedded teeth, and subsequent to this a massive cost is incurred. The only study to date conducted on the prevalence of impacted and embedded teeth related to hospital admissions among Western Australian children is by Kruger et al (2006). The results revealed that of all admissions between 1999 and 2003, approximately 33% was attributed to embedded and impacted teeth. About 10% of those admissions (8,797 episodes) occurred among high school-aged children, with non-Aboriginal children in this age group being 31 times more likely to be admitted for the removal of impacted teeth than their Aboriginal counterparts (Kruger et al., 2006). Based on these findings, it appears that the rate of hospital admissions
for impacted teeth removal may be considered as an indicator of service accessibility (George, Kruger, & Tennant, 2011a). It is important to note that those data were based on children aged 17 years or less, and a large number of these hospital admissions might be attributed to wisdom teeth removal. Another study investigated the socioeconomic divide on hospital based impacted tooth removal among young adults aged 10 years and older (George, Kruger, & Tennant, 2011b). The results found that a higher socioeconomic group is 4 times more likely to have an impacted tooth removed in a hospital than those individuals from a lower socioeconomic group. Similarly, individuals living in highly accessible urban areas were 3 times more likely to be hospitalised for this procedure than those from the rural areas. However, among children younger than 14 years, where the majority of hospital admissions for impacted teeth were related to canine removal; evidence on socio-demographics and economic disparities do not exist.

To overcome and improve this issue of early detection of potentially problematic erupting teeth, early assessment should be part of the routine examination protocol for the eruption status of permanent canines for all dental examinations for children in the School Dental Service. This would necessitate a routine examination via the palpation for the un-erupted tooth and visual assessment of the child’s dental development from the age of 8. Thus, when possible canine impaction is suspected further diagnostic tests and referral for a specialist’s opinion may be required.

### 2.5.3. Pulp and Periapical Conditions

Pulpal and periapical conditions are quite common, particularly in young children. Despite the decline in dental caries in past decades, many children are still at risk of dental decay
which allows bacteria to invade the pulp causing pulpal and periapical inflammation or infections (Robertson & Smith, 2009). In most children, these infections usually present as chronic inflammation which is localised to the offending tooth. Periapical abscesses are the most common pulpal and periapical condition. The majority of dental abscesses in paediatric patients occur secondary to dental caries, trauma, or unusual conditions which challenge diagnosis and management (Robertson & Smith, 2009). In the primary dentition management of localised pulpal infections includes root canal treatment, or extraction and space maintenance (Seow, 2003). In contrast, the treatment for children who show spread of the dental infection may require invasive hospital care for surgical drainage and removal of the source of infection and parenterally administered antibiotics (Seow, 2003). In some cases, extraction of the tooth may be required.

Acute dental abscesses are frequently underestimated in terms of morbidity and mortality. Several studies have shown that dental abscesses predominantly accounted for a significant number of oral related hospital admissions in children. In WA, despite a generally dentally motivated population, a large retrospective study reported that 1,881 of paediatric patients sought treatment for pulpal and periapical conditions over a 4-year period (Kruger Dyson, & Tennant, 2006). Furthermore, the majority of those hospital admissions occurred among pre-school aged children, with Indigenous children incurring the highest rates. The treatment cost of those admissions was $2.4 million AUD. Another study examined the rate of cellulitis-related hospital admissions in WA, as a measure of the extreme level of dental disease at a population level (Anjrini, Kruger, & Tennant, 2014). This critical condition, which develops as a result of caries-pulp necrosis, mainly occurs in pre-school age children (Anjrini et al., 2014). An earlier study also revealed similar findings, suggesting that the high
rates of hospital admissions among Aboriginal infants were mainly due to cellulitis, lymphadenitis and stomatitis conditions (Tennant et al., 2000). Those results provided an indicator of disease burden and the general dental service capability. Another study by Wang et al. (2005) analysed a 5-year retrospective data of odontogenic maxillofacial infections in children in a large urban public hospital. It was estimated that 1 per 2600 admissions was accounted for by acute dental infections (Wang et al., 2005). In the USA, 47% of all dental-related attendances at paediatric emergency rooms were for periapical abscesses (Graham, Webb, & Seale, 2000).

Pulpal and periapical infections have significant implications on patient morbidity and burdens on health care systems. Further detailed analyses are needed to mitigate the risk indicators that can lead to pulpal and periapical conditions among different Australian child population subgroups.

### 2.5.4. Other Conditions

Although oral conditions such as oral cancer, periodontal diseases, oral cysts, birth defect and dento-facial anomalies are rare in children, evidence suggests that an increasing number of cases have been reported over years.

#### 2.5.4.1. Oral Cancer

Cancer is a complex disease in terms of diagnosis and treatment, and represents a significant burden on both individual and community levels and the health system. Despite the fact that most studies of oral cancer in Australia have been restricted to the adult age group, childhood cancer is the leading disease-related cause of death among Australian children (Government
of Western Australia. Department of Health, 2011). However, the risk indicators, incidence and outcomes of oral cancer have not been systematically investigated. Therefore, the actual extent and impact of cancer among children is probably underestimated.

2.5.4.2. Periodontal Conditions

Children rarely develop severe forms of periodontal disease; however, gingivitis is relatively common among older children, especially in the Indigenous population. While gingivitis in itself does not cause destruction of periodontal structures, its inflammation may increases the likelihood of developing dental or root caries. In 2011, Williams et al. reviewed the oral health of the Indigenous population. The study revealed that the level of gingival bleeding was four times more likely to occur among 5 year-old Indigenous children than their non-Indigenous counterparts (Williams et al., 2011). Similarly, almost half (48%) of 12 year-old Indigenous children had gingival bleeding compared with 23% of non-Indigenous children (Williams et al., 2011). In a rural context, 3-in-5 (60%) of Indigenous children living in remote communities showed some evidence of gingivitis, and approximately one in every five (20%) of children were at moderate risk of developing gingivitis (Williams et al., 2011).

In Australia, many studies suggested that the number of children receiving periodontal preventive care has significantly declined over time. For instance, 47% of children aged 5–11 years had received a professional scale and clean within the previous 12 months (Ellershaw & Spencer, 2009). This figure has been decreased by 13% in 2005 (Ellershaw & Spencer, 2009). This decline was particularly evident among uninsured children, rural and remote living children (Ellershaw & Spencer, 2009). No up-to-date data have demonstrated the extent of periodontal-related hospital admissions in Australian children.
2.5.4.3. Oral Cysts

A cyst is a pathological cavity filled with fluid, semi-fluid or gas. Kalaskae et al. (2007) investigated the most common bony lesions of the jaws in children. They found that of all the epithelium-lined jaw cysts, Dentigerous cysts, which associated with the crown of an erupted or partially erupted tooth, accounted for approximately 20-24% of cases (Kalaskar, Tiku, & Damle, 2007). A preliminary study by Manor et al. (2012) showed that the most common cystic lesions of the jaws in children aged 11 and 4 years were Dentigerous cysts (44%) and Eruption cysts (21%), respectively. However, Traumatic bone cysts (18%), and Radicular cysts (17%) were more common in 14 and 8 year-old children, respectively (Manor et al., 2012). However, no statistically significant data have been reported among Australian children on the incidence of oral cysts.

2.5.4.4. Birth Defects and Dento-facial Anomalies

Of all congenital anomalies, Orofacial clefts (OFCs) are the most prevalent. Children born with OFCs have difficulty in feeding, with speech, hearing, and their often disfigured appearance may lead to chronic adverse health and developmental outcomes. The treatment of such conditions needs a multidisciplinary complex care from birth to adulthood. This includes hospital admission for surgery, speech therapy, general dentistry, and orthodontics. Mossey et al. (2009) observed a higher morbidity and mortality among children born with OFCs when compared with healthy populations.

In Western Australia, 1 in every 20 babies (approximately 6%) is born with a developmental anomaly (Abeywardana & Sullivan, 2008). This condition contributes to ongoing childhood
health problems, disability and mortality. A study by Bell et al (2013) aimed to describe the epidemiology of OFCs during the period of 1980 to 2009, among Western Australian children. The results revealed that high prevalence rates of OFCs; Cleft Lip ± Palate 12.05 per 10,000; Cleft Palate only 10.12 per 10,000, compared with most other parts of the world (Bell et al., 2013). The study has also identified some congenital deformities’ external variables other than those of genetic origin in order to determine the risk indicators in Western Australian children. For cleft lip and palate (CLP), rates were significantly 1.62 times higher in males than females, while the prevalence rate of cleft palate only (CPO) is 1.31 times higher in females than for males. The prevalence of CLP and CPO were 1.89, 1.30 times higher, respectively, in non-Aboriginal Australians than for Aboriginal Australians. Generally, the prevalence of OFC did not differ by geographic location or by socioeconomic status (Bell et al., 2013).

Kruger et al. (2006), reported that, of all hospital admissions between 1999–2003; 4.1% were attributed to congenital deformities among children, with an estimated cost of $3 million AUD. Both non-Aboriginal and Aboriginal infant groups had higher rates of admission (584.3 and 454.4 (p<0.05)), respectively. The same authors also examined the demographics of in-patient dento-facial anomalies among children. Over a 4-year period, 1,616 admissions were for dento-facial anomalies, with an estimated cost of $2.4 million AUD. The majority of those admissions occurred among high school aged children. Of this age group, non-Aboriginal children were 32 times more likely to be admitted than their Aboriginal counterparts.
It is necessary to monitor the prevalence of OFCs in order to provide valuable insight information regarding the potential causes, in order to prevent and quantify the burden of disease and the subsequent management via the most appropriate health service.

### 2.5.4.5. Dental Trauma and Dental Fractures

Dental trauma is an injury to the teeth and/or oral cavity caused by a sudden accident and often requires emergency attention. Dental trauma and dental fractures are more common among children and teenagers, and is not limited to people’s poor health. Costs to the injured individual and to the community can be substantial (Bastone, Freer, & McNamara, 2000). Stockwell (1988) conducted a prospective study that determined the annual incidence of trauma to the anterior permanent teeth. The study comprised of 66,500 children aged 6–12 years enrolled and treated in the Western Australian School Dental Service. Of the children suffering trauma in one year, the incidence per 100 erupted teeth was almost 12 (Stockwell, 1988). Approximately 81% of children traumatised one tooth only per incident, but 35% of all teeth that were traumatised involved trauma to two or more teeth (Stockwell, 1988). The majority of all traumatised teeth were central incisors, with females being more likely to receive trauma to their maxillary teeth than males (Stockwell, 1988).

In a rural context, Lam et al. (2008) analysed six years of retrospective data to investigate the prevalence, causes and presentation of dental trauma in a large rural centre in Western Australia. The majority of injuries (76%) occurred among children and adolescents, specifically the 0–4 year age group (30%) followed by the 5–9 year age (23%) and 10–14 year age groups (22%). Trauma mainly occurred due to falls, accidents while playing and participating in sports activities.
Kruger et al. (2006) attempted an analysis of all jaw fracture-related hospital admissions in Western Australia from 1999 to 2003. More than 90% of fractures occurred between the ages of 10 and 50 years with Indigenous people (especially the males) carrying the highest burden of disease associated with jaw fractures (Kruger, Smith, & Tennant, 2006). Indigenous people aged 0-19 years were 6.4 times more likely to be admitted for jaw fractures than their non-Indigenous counterparts (Kruger Smith, & Tennant, 2006). Regardless of the age, fractures rates were significantly (2.4 times) higher in rural areas than in metropolitan areas. Additionally, the hospitalisation rate of fractures was 3.6 times higher in very remote areas than in highly accessible areas. Over a 4-year period, the economic impact of fracture-related hospital admissions is evidenced by the cost of more than US$ 7.6 million (Kruger Smith, & Tennant, 2006). Currently there is a paucity of data on the analysis of dental trauma-related hospital admissions and associated variables among Australian children.

2.6. Oral Health Cost

While dental health has been eliminated from the Australian Government's health scheme, (Medicare), considerable suffering arises especially among most deprived families. Massive impacts were observed among low income and marginalised groups who identify the financial barriers as a leading cause of not seeking help with dental problems. Therefore, oral health becomes the second-most expensive disease burden group in Australia. In particular, dental caries is the second most costly diet-related disease, with an economic impact comparable with that of heart disease and diabetes (Australian Institute of Health and Welfare, 2004). Rogers (2011) noted that, in 2004, the treatment costs of over $6 billion annually, with additional care costs exceeding a further $1 billion. Additionally, when
outpatient and inpatient dental treatment costs are combined with pharmaceutical costs, a total of $500 million was spent in Australia, during 2004-05 (Richardson et al., 2011). Leeder et al. (2007) found that the dental treatment cost for GP services ranged from $245–$350 million (Leeder & Russell, 2007). In addition, a total of $2 billion was spent, when combining the total direct costs and lost productivity (Leeder & Russell, 2007). More specifically, the WA Department of Health (2010) estimated the actual cost spent per capita of metropolitan public health units over the last decade: the actual costs exceeded the target cost by 17-23% each year (WA Metropolitan Health Service, 2010).

In general, the cost of dental health includes:

1. **Direct costs** arising from:
   - Dental care by oral health professionals
   - Dental care by dental health workers such as therapists or hygienists.
   - Treatment of oral health-induced illnesses such as periodontitis induced by ischemic heart disease.

2. **Indirect costs (lost productivity)** arising from:
   - Time loss from the work and from school for dental treatment
   - Time loss attributable to oral conditions.

It is important to note that the Australian Government provides funds to support various public health programmes addressing children with poor oral health. For example, the Government has been actively funding various oral health screening programmes which particularly focus on children for oral diseases (Merrick et al., 2012). Yet, the Government is not entirely responsible for funding the hospital costs of children with oral health problems (Barraclough & Gardner, 2007). Besides that, the majority of dentists are in private practice;
consequently most hospitalisations concerning oral problems for children take place in private hospitals (Kruger Dyson, & Tennant, 2006; Australian Institute of Health and Welfare, 2010). Accordingly, parents are forced to pay the higher proportion of hospitalisation costs directly out of pocket or indirectly through private health insurance for the hospitalisation process. The Australian Government meets the operational costs of these hospitals, thus leaving parents to pay the admission and treatment fees.

Tennant et al. (2000) affirms how expensive oral health-care for Western Australian children is, by stating that in 1995, approximately AUD $111 million was used for the hospitalisation of children under 18 years of age. In WA during 1999-2000 and 2002-03, Kruger et al conducted a study on 26,497 children to estimate the cost of avoidable oral related hospital admissions (Kruger Dyson, & Tennant, 2006). Those admissions cost the State more than $40 million, with the majority of cases were for impacted teeth extractions or dental caries (Kruger Dyson, & Tennant, 2006). The analysis also showed that the State spent AUD $7.8 million on pulpal and periapical, dento-facial anomalies and birth trauma conditions combined. Based on a National Health and Hospital Reform Commission (2009) report in improving oral health and access to dental care, 50,000 persons were accounted for preventable dental hospital admissions, in 2004–05 (National Health and Hospitals Reform Commission, 2009). In 2010, the average annual oral health-related admissions direct cost was AUD $223 million, with an average cost of AUD $4,471 per admission (Commonwealth of Australia, 2010). Richardson et al. (2011) also noted that of those hospital admissions, surgical treatment of dental problems including dental extractions cost the nation approximately AUD $100 million. In contrast, for the same period, hospital treatment of dental caries conditions only cost the nation about AUD $9.5 million (Victorian Oral Health
Alliance, 2010). It has also noted that dental admissions are the largest category of acute preventable hospital admissions and that oral health problems are the second-most expensive disease group in Australia, with direct treatment costs of over AUD $6 billion annually, and additional care costs exceeding a further AUD $1 billion (Rogers, 2011).

The economic costs of poor oral health go well beyond the health care budget, in terms of lost productivity and absenteeism from school and work. In Australia, oral conditions cause an estimated loss of 1,000,000 days of work per year (Australian Institute of Health and Welfare, 2007). Additionally, Jackson, Vann, Kotch, Pahel & Lee (2011) determined the relationship between children's oral health status and school attendance. Children with poor oral health were almost 3 times more likely to miss school as a result of dental pain than their counterparts (Jackson et al., 2011).

There is a broad general consensus that indirect economic costs or loss of productivity costs due to dental health care are more likely to be higher than the treatment cost itself. The Commonwealth of Australia (2010) estimated the mean cost per hospital admission is $4,471 plus avoidable productivity losses of $660 million arising from work days lost (Gift Reisine, & Larach, 1992). A considerable portion of the cost of adult productivity loss is attributed to their children's hospitalisations. As in all circumstances, at least one parent or a guardian must accompany their child during his/her admission, which results in an additional time loss from both education and workforce. Other studies involving direct and indirect costs estimated that avoidable dental treatment expenses could be as high as $2 billion (Leeder & Russell, 2007). These indirect dental health economic expenses could be mainly avoided through better access to universal preventive dental services.
The distinctions are essential, as the dental health workers treatment cost is offset by the benefit of avoided illness. However, it is important to note that adequate dental care could reduce the dental professional’s higher treatment costs. Furthermore, increased access to SDS and preventive services would relieve pressure on hospitals and hospital waiting lists. Therefore, to enable the community to have timely access to preventively focused dental care that meets the minimum standard benchmarks for preventable oral health service provision, increased funding is needed to those services. To date, there are no good data to indicate the cost of oral health-related hospital admissions based on different variables in WA.

2.7. Recommendations and Conclusion

The impact of poor oral health is massive on both individuals and the community. In Australia, dental care is provided by a mix of private and public services, with the latter limited to provision of a safety net service for enrolled school age children. The majority of School Dental Services in Western Australia remain funded by the State. Any treatments outside the scope of SDS are referred to private practices or hospital clinics. Complex interventions such as that provided by hospitals are funded by private sources (health insurance funds and individuals).

Although the oral health of children has improved considerably over the past 30 years, consequently, over the last generation, the trends of most oral conditions have either plateaued or have begun to decline. Previous discussion indicated that hospital admissions for most caries and other avoidable oral conditions are concentrated on a minority of children. This has created an incentive to pursue risk identification and management strategies to improve the effectiveness and efficiency of preventive dental care. Data on
avoidable hospitalisations are increasingly used internationally as an indicator of access to primary care and its effectiveness, and as a measure of the potential health gains from primary care interventions. Thus, analyses of avoidable dental hospitalisations is necessary to identify groups within the population at higher risk for hospital admissions, as well as identifying time trends in hospitalisation rates against a background of rapidly changing demographics. Useful population sub-group risk predictors need to be correlated with a framework to target at-risk groups. Such predictors need to be based on relevant and reliable data such as population based studies. Interestingly, no published study has modelled children oral health-related hospital admission rates and their socioeconomic position in relation to oral health services at a community level.

This chapter has pointed out the importance of preventing costly in-patient treatment, by early detection, prevention, and implementing culturally-appropriate intervention. Though, at a time when public health resources are limited, strategies need to be developed to focus on high risk groups through best practice principles of care and demand management to better utilise limited health resources. It is also important to address the need for the redistribution of resources on the basis of regional need and the development of community-based preventive framework, which will have a significant impact on reducing the incidence of oral diseases among Australian children. This thesis will explore and attempt to resolve some of the issues highlighted above through extensive analysis of data from Western Australian child oral health-related hospital admissions. To this end, in the following chapter, the specific aims of this thesis are outlined.
3. Aims of the study and Hypotheses
Chapter Three

3.1. Aims and Hypotheses

Given the background and the questions raised in the previous chapter, there are five primary aims of this study, and the specific hypotheses are stated below. In the chapters that follow, chapters Five to Nine, each of these aims are addressed individually and relevant hypotheses restated.

1) **Aim**: To analyse a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with socio-demographic characteristics and with particular focus on dental decay and Indigenous children.

   **Hypothesis**: The hospital admissions for dental reasons (in children) are not associated with socio-demographic characteristics.

2) **Aim**: This study examines the disparities in dental insurance coverage among Western Australian children hospitalised due to oral health-related conditions and associated factors to address the inequalities that currently exist.

   **Hypothesis**: The children hospital admissions for dental conditions are not associated with the presence of private health insurance.

3) **Aim**: To analyse the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years, and to identify socio-demographic characteristics associated with these costs.
**Hypothesis:** The hospital admissions for dental reasons (in children) are not associated with an increased economic burden on Australian dental health expenditure.

4) **Aim:** To analyse projected oral-health related admission rates of Western Australian children, with a particular focus on dental caries, embedded and impacted teeth, and pulp and periapical conditions through to the year 2026, based on 10 years of past hospitalisation data for robustness.

**Hypothesis:** The trend of oral hospital admissions is expected to plateau or head into positive direction.

5) **Aim:** The aim of this study was to identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia. Central to the derivation of identified priority areas was oral health related hospitalisation data of all children over a ten year period.

**Hypothesis:** The trend in demand to primary oral health services would reflect differences in demand to oral hospital treatment in relation to socioeconomic perspective.
Chapter Four

4. Material and Methods
4.1. Material

The following chapters detail analyses of de-identified hospitalisation data obtained from the WA Hospital Morbidity Dataset (HMDS) for 10 financial years from 1999/2000 to 2008/09. This thesis has been conducted in full accordance with the World Medical Association Declaration of Helsinki, and ethics approval was granted by the Ethics Committee of The University of Western Australia (Ethics approval number RA/4/1/5502). Children were not directly involved in the study, as this was an analysis of de-identified hospitalisation data, as provided by the Health Department of Western Australia.

*Principal diagnosis:* Principal diagnosis, classified by the International Classification of Diseases Tenth-Australian Modification (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and accordingly admitted for an oral health condition from all private and public hospitals in Western Australia for the 10-year study period. The principal diagnosis was determined by a clinician for each admission based on the primary condition under treatment. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis which is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol’ (Commonwealth Department of Health and Aged Care, 1998).
4.2. Methods

4.2.1. Study Population

The total child population in Western Australia was 399,889 in 1999, 404,211 in 2005 and 438,576 in 2009. In 2009, 5.9% of the WA child population were of Indigenous descent, and 94% of non-Indigenous child population resided in Metropolitan Perth (Australian Bureau of Statistics, 2006).

4.2.2. The Data Source

Between 2000 and 2009, a total of 43,937 children (0–14 years) were hospitalised due to oral conditions. Of these, 94% (n=41,475) accounted for seven major categories of oral conditions with half (50%) of those hospitalisations for ‘dental caries’, followed by, ‘embedded and impacted teeth’ (14%), ‘pulp and periapical’ tissue conditions (11%), ‘developmental and birth defects’ (5%), ‘dental fractures’ (5%) and ‘dentofacial anomalies’ 4%. The remaining 6% were distributed across all other oral conditions.

Self-reported Indigenous status was used to compare Indigenous to non-Indigenous populations. Overall 5% (n = 2119) of admissions were for Indigenous children.

For each child, age, gender and Indigenous status, insurance status, residential area and hospital type were also included in the data set. The following table indicated the percentages of hospital admissions of those demographic variables in the data set.
Table 4.1. The percentages of hospital admissions of those demographic variables in the data set.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Raw Number of admissions (N)</th>
<th>Percentages of hospital admissions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All children</td>
<td>43,937</td>
<td>100</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>16367</td>
<td>37.3</td>
</tr>
<tr>
<td>5–9</td>
<td>15862</td>
<td>36.1</td>
</tr>
<tr>
<td>10–14</td>
<td>11708</td>
<td>26.6</td>
</tr>
<tr>
<td>Indigenous status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>2119</td>
<td>4.8</td>
</tr>
<tr>
<td>Non-Indigenous</td>
<td>21209</td>
<td>95.2</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22728</td>
<td>51.7</td>
</tr>
<tr>
<td>Female</td>
<td>21209</td>
<td>48.3</td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>23134</td>
<td>52.7</td>
</tr>
<tr>
<td>Uninsured</td>
<td>20803</td>
<td>47.3</td>
</tr>
<tr>
<td>Hospital type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>17303</td>
<td>39.4</td>
</tr>
<tr>
<td>Private</td>
<td>26591</td>
<td>60.5</td>
</tr>
<tr>
<td>Commonwealth</td>
<td>43</td>
<td>1</td>
</tr>
<tr>
<td>Residential area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>6525</td>
<td>14.9</td>
</tr>
<tr>
<td>Metropolitan</td>
<td>37412</td>
<td>85.1</td>
</tr>
</tbody>
</table>

Place of residency. Place of residency at the time of admission and the geographical classification was categorised according to the Accessibility/Remoteness Index of Australia (ARIA) which measures ‘remoteness in terms of access along the road network from populated localities to each of five categories of Service Centre. Localities that are more remote have less access to service centres; those that are less remote have greater access to service centres’ (Australian Population and Migration Research Centre, 2013). ARIA is grouped in to 5 categories: highly accessible; accessible; moderately accessible; remote; and very remote (Commonwealth Department of Health and Aged Care, 2001).

Socioeconomic status. The population Census provides data on the income, housing, education, employment, family structure, disability, transport, age, gender and ethnicity of people all over Australia. The ABS has combined these in a set of indicators called the Socio-
Economic Indexes for Areas (SEIFA) which give a summary measure of socioeconomic status for people living in specific geographic regions in Australia. Socioeconomic status was analysed using the (SEIFA) index which is developed by the ABS that ‘ranks areas in Australia according to relative socioeconomic advantage and disadvantage. The indexes are based on information from the five-yearly Census’ (Australian Bureau of Statistics, 2013a). Then the ranking are grouped into five categories: most disadvantaged, below average disadvantaged, average disadvantaged, above average disadvantage and least disadvantage (Australian Bureau of Statistics, 2013a).

**Determination of direct cost.** Across Australia, the Australian Refined Diagnosis Related Group (AR-DRG) is used to calculate the cost of each patient episode on the basis of actual data about the treatment process. AR-DRG ‘is an Australian admitted patient classification system which provides a clinically meaningful way of relating the number and type of patients treated in a hospital (that is, its casemix) to the resources required by the hospital’. Each AR-DRG represents ‘a class of patients with similar clinical conditions requiring similar hospital services’ (Australian Institute of Health and Welfare, 2013b). The categorisation classifies ‘acute admitted patient episodes of care into groups with similar conditions and similar usage of hospital resources, using information in the hospital morbidity record such as the diagnoses, procedures and demographic characteristics of the patient’ (Australian Institute of Health and Welfare, 2013b). It is considered that Australia is a model example of a mature costing system and has the most sophisticated approach according to cost guidelines which include the actual amount of resources used in the treatment of a particular patient (Raulinajtys-Grzybek, 2014). Therefore, AR-DRG version 5.1 was used to calculate the direct cost (the Australian dollar value used according to the year of admission).
Indirect Cost. Based on a previous study, indirect costs were predicted at approximately 1.5 times the direct cost (Drummond, Sculpher, O'Brain, Stoddart, & Torrance, 1997). Indirect costs include the following: patient and parents'/guardians' absence from school or work due to pain and discomfort or having to accompany the child; cost of transportation and accommodation and societal losses of productivity.

4.3. Projection Methods

Age and residential area for each child were analysed. Future predictions for dental caries embedded and impacted teeth, and pulp and periapical conditions, which accounted for 75% of all hospitalised conditions during the study period, were also analysed.

All projections used in (Chapter 8) were based on age specific and Age Adjusted Rates (AAR) which were calculated using the Health Statistics Calculator, a software package developed by the Health Department of Western Australia. In the context of projections, two separate methods were used to project future cases. Both methods accounted for the projected increase in both the population and the incidence of these conditions, with time using a ten years of data. The first method, the linear method, used the historical data to estimate a line of best fit for each 5-year age group, using the method of least squares. Based on the estimated AAR, the future number of cases was determined. The second method, the Exponentially Weighted Moving Average (EWMA) also uses historical trends to model future points equally, this method places greater weight on more recent data. Applying the two methods separately, resulted in very similar trends, therefore only the results of the linear method were presented. There is a general consensus among statisticians that a relatively simple linear model of age-specific rates provides a good fit to the data while giving
reasonably accurate predictions over a short to medium time span (Australian Bureau of Statistics, 2014a). The accepted approach among statisticians preparing projections of this nature is to assume a linear model for increasing rates to prevent projecting admission rates below zero. Further, there is a fundamental presumption in this approach that the factors that affect oral related admissions, such as, risk indicators, change in an approximately linear way with time for each age group (Australian Bureau of Statistics, 2014a). This presumption holds on condition that there are no major quantitative changes in any underlying factors, such as the introduction of an intervention program.

Cost Projections. The DRG cost were categorised into (Low cost ($0-$4000), Middle ($4001-$10,000), high ($10,001-$20,000) and extremely high ($20,001 and over)). The low cost category was most representative of the overall cost distribution which was normally distributed. Therefore, low cost was deemed appropriate to use in future cost projection.

4.4. Developing Framework Maps

To identify the possible gaps in primary dental service provision to children, data from Western Australia was used. WA occupies the western third of the Australian continent, comprising a land area of about 2.5 million square kilometers with a population of about half a million children aged younger than 15 years (Fig. 4.1; Australian Bureau of Statistics, 2014b). Of those, 19% live in the city of Perth, the capital of WA (Australian Bureau of Statistics, 2011). The Perth metropolitan area was used for this study as most (73%) of all hospital admissions for children under age 15 occurred in the metro area. The existing SDS in WA is a universal coverage model, providing free primary dental care to all school registered children who choose to enroll in the service. Despite being a universally applied
system however, it reaches a little less than 30 percent of all children (Government of Western Australia, 2008a). Some parents who choose to not enroll their children can access private dental services, but this is not an affordable or accessible option for many. Since 2000, SDS coverage has been declining rapidly, and more children are hospitalised for preventable oral related conditions (Spencer, 2012). Against this backdrop it is important that reliable methods are used to determine the distribution of demand for SDS clinics, in order to enable policy development and service planning. To date there has been no attempt to determine the distribution of demand for primary service (in this case SDS clinics), in order to enable policy development and service planning.

Primary places of residency at the time of hospitalisation were analysed using Statistical Local Area (SLA) which is ‘an Australian Standard Geographical Classification (ASGC) defined area’ developed by the Australian Bureau of Statistics (Australian Bureau of Statistics, 2011). SLAs cover the whole of Australia without gaps or overlaps, and there are a total of 37 SLA’s in WA (Australian Bureau of Statistics, 2011). Boundary files for each SLA were obtained from the Australian Bureau of Statistics (ABS) website (2012b). Age Adjusted Rates (AAR) of child hospital admissions per SLA were calculated using the Health Statistics Calculator of every child aged between 0–14 years old at the time of hospitalisation. In rate calculations, population data (denominators) was obtained from estimations by the Health Department of Western Australia, which is based on Australian Bureau of Statistics census data.

Based on these admission rates per SLA, the entire child population was categorised into five quintiles of even size, this was done separately for each age group.
Census Collection District (CD). Admission data for each child was available on SLA level, but for higher accuracy and precision analysis, smaller area-based analysis was needed, and therefore census Collection Districts (CD’s) were used. A CD is much smaller than an SLA, and is a quasi-measure of density of residents (based on an area that a single census officer can collect data from). Each SLA contains a number of CD’s. The Perth metropolitan area covers 2840 CDs, representing 65% of the Western Australia CDs, with a total child population aged 14 years and younger of more than 270,000 children. Census collection districts and the geographic boundaries of each CD were obtained from the ABS webpage
(2013). Each CD was linked geographically to its SLA. Hospitalisation data across each of the 37 SLAs was distributed by age groups (0–4 years, 5–9 years and 10–14 years), the rates of child hospitalisations was calculated for each SLA, and this rate was applied to each of the CD's within that specific SLA. This resulted in a hospitalisation rate for each age category, for each CD.

*Population data.* Number of children aged under 15 years for each CD were obtained from the ABS (2006) census data (Australian Bureau of Statistics, 2013b).

*Socioeconomic status.* Each CD in Australia has a SEIFA score [Socio-Economic Indexes of Area (SEIFA 2006)] score assigned to it by the ABS, based on certain socioeconomic indicators of the population within that CD (Australian Bureau of Statistics, 2013a). SEIFA is a nationally accepted coding system developed by the ABS which ‘ranks areas in Australia according to relative socioeconomic advantage and disadvantage based on information from the 5-yearly Census’ (Australian Bureau of Statistics, 2013a). These rankings were dichotomised into most disadvantaged areas (Poorest, SEIFA deciles 1 to 5) and least disadvantaged areas (Wealthiest, SEIFA deciles 6 to 10).

*School Dental Service locations.* The addresses of all fixed SDS clinics were obtained from the Department of Health website (Australian Bureau of Statistics, 2011) and geocoded, i.e. changed into map coordinates, and each located on a map. The SDS clinics were identified as points of provision of primary dental services and the populations of children who lived within 2km of a SDS clinic were identified.
Geographic information systems (GIS) in this study was used as a technique for integrating hospitalisation data related to dental disease with known risk indicators (e.g. socioeconomics), in order to identify and prioritise geographic areas of high need for a dental service. The approach using GIS was tested on one city but is designed to be universally applicable.

The numbers of child hospital admissions, numbers of children under age 15 years, and the SEIFA score of each CD were geocoded. Fixed service (School Dental Service) locations were geocoded. The resultant maps indicated where SDS clinics were located, as well as the following attributes of the child population both within and outside of a 2km zone around it: population density, age-specific hospital admission rates and an indication of area socioeconomic disadvantage.

4.5. Statistical Analysis

Age-adjusted rates (AAR) were calculated using the Health Statistics Calculator, a software package developed by the Health Department of Western Australia. It should be noted that the data for this study span the years 1999/00–2008/09. In rate calculations, population data (denominators) were obtained from estimations by the Health Department of Western Australia Bureau of Statistics. These estimations were based on population data as obtained by Australian Bureau of Statistics of 2006 Census Surveys. Age specific rates can only be calculated for age, gender, Indigenous status, rurality and SLA. Significant differences between rates were based on non-overlapping 95% confidence intervals ($P<0.05$).

All statistical analyses were conducted using the SPSS 21 for Windows (Statistical package for the Social Sciences; SPSS, Chicago, IL USA) software, unless stated otherwise.
Comparisons between variables were carried out using univariate, bivariate and multivariate analyses to determine which primary determinant had a significant impact on the outcome variable. Chi-square ($\chi^2$) tests were used to establish any statistical significant differences between nominal (categorical) variables. In all statistical tests, significance levels were set at 95% with $P < 0.05$ deemed to be significant. However, to determine significant differences between continuous variable and nominal (categorical) variables, Kruskal-Wallis tests were used when appropriate. Significant levels were set at 95% with a $p$ value less than 0.05 considered to be statistically significant.

All mapping and geocoding of data used QGIS v.2.6 (Boston, USA), analyses used SPSS 21 for Windows and data were tabulated in Excel 2007.
Chapter Five

5. Dental Hospitalisation Trends in Western Australian Children under the Age of 15 Years: A Decade of Population-based Study.

This chapter was published in the following article:

5.1. Abstract

Objective: This study analysed a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with sociodemographic characteristics and with particular focus on dental decay and Indigenous children.

Material and Methods: This retrospective study analysed the data obtained for 43,937 child patients under the age of 15 years hospitalised for an oral-health related condition, as determined by principal diagnosis (ICD-10AM). Primary place of residency, age, gender, insurance status and Indigenous status were also analysed.

Results: ‘Dental caries’ and ‘embedded and impacted teeth’ were the most common reasons for hospitalisation among children under the age of 15 years. ‘Dental caries’ were most common in non-Indigenous patients, with ‘pulp and periapical’ most prevalent in Indigenous patients. The age-adjusted rate (AAR) of hospitalisation for Indigenous children in the last decade increased to reach that of non-Indigenous children in 2009. Total DRG costs of hospitalisation, both public and private, were in excess of AUS $92 million over 10 years.

Recommendations and Conclusions: This study indicates the burden of oral-health-related conditions on Western Australian children and the hospital system, in terms of health and economical impact.
5.2. Introduction

In Australia, dental conditions are one of the highest causes of acute preventable hospital admissions (The Steering Committee for the Review of Government Service Provision, 2010). In 2003–2004, over 26,000 children under the age of 15 years old had to undergo general anesthesia in hospitals in Australia for dental extraction and/or restorations (Australian Institute of Health and Welfare, 2008a; 2011b). In 1995, Western Australia recorded 3,754 cases (4,395 bed days) of children under the age of 18 years-old admitted to hospital for oral conditions (Tennant et al., 2000). Unfortunately, subsequent studies indicated that the rate of hospitalisations for oral conditions has increased over time. Kruger et al. (2006) conducted a study and found that from 1999 to 2003, a total of 26,497 hospital admissions (31,432 bed-days) in WA were attributed to oral health conditions among children under the age of 18 (Kruger Dyson, & Tennant, 2006).

Some studies have found that the rates of hospitalisation due to oral conditions in children varied between the age groups, with the highest rates for high school aged children, followed by pre-primary, and the lowest rate is the primary school-aged group (Rogers, 2011). This is not unsurprising as the preschool children mostly do not, on the whole have access to the safety nets of School Dental Services (SA Dental Service, 2013), while the teenage levels are most likely related to the removal of impacted teeth (mostly third molars) (Australian Institute of Health and Welfare, 2011c).

In Australia, Aboriginal and Torres Strait Islander people are the first people of the land. They, like many Indigenous people have faced very significant marginalisation since European settlement and continue to this day to face extreme issues of poor health
According to recent studies, Indigenous children have, on average, twice the incidence of dental caries as their non-Indigenous counterparts (Government Northern Territory, 2011; Christian et al., 2012), but in all child age groups, except infants, the hospitalisation rates for all oral health conditions were significantly higher among non-Indigenous children (Rogers, 2011).

The aim of this study is to analyse a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with sociodemographic characteristics and with particular focus on dental decay and Indigenous children. The null hypothesis of this study is that the hospital admissions for dental reasons (in children) are not associated with sociodemographic characteristics.

5.3. Material and Methods

5.3.1. Data Source

This research involved a de-identified detailed analysis of the data obtained from the WA Hospital Morbidity Dataset for ten financial years from 1999/00 to 2008/09 under ethics approval from The University of Western Australia. Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and accordingly admitted for an oral health condition in Western Australia for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD–10-AM is the Australian Modification of the 10th revision of the International Classification of Diseases (ICD–10). It is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections,
including the National Minimum Data Set and the Hospital Casemix Protocol’ (Commonwealth Department of Health and Aged care, 1998). Age, gender and Indigenous status, insurance status, length of stay, hospital area and type of each child were analysed. Remoteness was determined using the Accessibility/Remoteness Index of Australia (ARIA) classification, which measures ‘remoteness in terms of access along the road network from populated localities to each of five categories of Service Centre. Localities that are more remote have less access to service centres; those that are less remote have greater access to service centres’ (Australian Population and Migration Research Centre, 2013). Socioeconomic status was analysed using Socio-Economic Indexes of Area (SEIFA) classification which is a ‘product developed by the Australian Bureau of Statistics that ranks areas in Australia according to relative socioeconomic advantage and disadvantage. The indexes were based on information from the five-yearly Census’ (Australian Bureau of Statistics, 2013a).

5.3.2. Statistical Analysis

Age-adjusted rates (AARs) were calculated using the Health Statistics Calculator, a software package developed by the Health Department of Western Australia. It should be noted that the data for this study span the years 1999/00-2008/09. In rate calculations, population data (denominators) were obtained from estimations by the Health Department of Western Australia Bureau of Statistics. These estimations were based on population data as obtained by Australian Bureau of Statistics Census Surveys. Significant differences between rates were based on non-overlapping 95% confidence intervals ($P < 0.05$).
To determine significant differences between nominal (categorical) variables, chi-square ($\chi^2$) tests were used. Significance levels were set at 95% with $\rho$ value < 0.05 deemed to be significant.

SPSS 21 for Windows (Statistical package for the social sciences; SPSS, Chicago, IL USA) software is used for analysis.

5.4. Results

5.4.1. Overall Data Summary

Between 2000 and 2009, a total of 43,937 children (0–14 years) were hospitalised due to oral conditions. Of these, 94% ($n=41,475$) accounted for seven major categories of oral conditions with half (50%) of those hospitalisations for ‘dental caries’, followed by, ‘embedded and impacted teeth’ (14%), ‘pulp and periapical’ tissue conditions (11%), ‘developmental and birth defects’ (5%), ‘dental fractures’ (5%) and ‘dentofacial anomalies’ 4%. Overall 5% ($n=2119$) of admissions were for Indigenous children.

5.4.2. All Children

*Time trends*. The AAR of hospitalisations for oral conditions increased from 926 in 2000 to 1085 cases per 100,000 person-years in 2009. Approximately 73% of the admissions were among children younger than 9 years old. In 2003, children aged < 5 years had 1.3 and 1.7 times the admission rate of 5- to 9- and 10- to 14-year-olds children, respectively. Since then,
the admission rates for 5- to 9-year-olds increased and in 2009 were 1.2 and 1.5 times the admission rates of 0- to 4-year-olds and 10- to 14-year-olds, respectively (Figure 5.1).

Sociodemographics association. Figure 5.2 represents the trends of the most common conditions over time. Overall, 546 per 100,000 children per annum were admitted for ‘dental caries’ and 144 per 100,000 had ‘embedded or impacted teeth’. A non-Indigenous child was 29 times more likely than an Indigenous child to be admitted for ‘embedded or impacted teeth’. Non-Indigenous children were more likely to be admitted than Indigenous children except for ‘pulp and periapical’ conditions. (Table 5.1) Children aged < 5 were more likely to be admitted due to ‘dental fracture’ or ‘birth defects’ conditions. In contrast, higher rates of children aged between 5 and 9 years were hospitalised due to ‘developmental defects’ or ‘dental caries’. ‘Dento-facial anomalies’ and ‘embedded and/or impacted teeth’, however, mainly accounted for the oldest age group admissions. Children younger than 9 years were more likely to be admitted due to ‘pulp and periapical’ conditions (Table 5.1).

Gender. Males were most likely to be hospitalised for ‘dental caries’ (AAR 560, 95% CI 550.1-570.4) than females (AAR 530, 95% CI 520.1-540.4) (Table 5.1).

Socioeconomic association. Across all common conditions, higher percentages of children hospitalised lived in the least and above average disadvantaged areas, except for children with ‘pulp and periapical’ conditions (25%), where most were living in the most disadvantaged areas, followed by 23% in below average disadvantaged areas (P <0.001) (Table 5.1).
Remoteness of residency. Across all conditions, children living in accessible areas are more likely to be admitted than children living in remote or very remote areas. Rural residence was significantly associated with less dental admissions, than metropolitan-living children across all conditions (\(P < 0.001\); Table 5.1).

Length of stay. The length of stay in hospital (LOS) was calculated and found 92% of separations from hospital happened on the same day (\(P < 0.001\); Table 5.1).

Conditions. Children admitted to public hospitals were more likely to have ‘dental fractures’, ‘birth defects’ or ‘pulp and periapical’ conditions. ‘Developmental defects’, ‘embedded and impacted teeth’, ‘dental caries’ or ‘dentofacial anomalies’ were more likely to be admitted in private hospitals (Table 5.1)

Most hospitalisations for ‘birth defects’ were for ankyloglossia, followed by cleft lip and palate, while the highest percentages of ‘developmental defects’ admissions were for supernumerary teeth and disturbances in tooth formation or eruption conditions.

Cost. The total DRG (diagnosis-related group) cost of this care was approximately AUS $92 million. Private insurance was the primary source of reimbursement for 55% of non-Indigenous children, while Indigenous child admissions were much more likely to be publicly funded (96%) (\(P < 0.001\); Table 5.1).
Figure 5.1
Hospitalisation rates by age, over time

Figure 5.2
Age-adjusted hospitalisation rates of WA children by condition, over time
### Table 5.1
Hospitalisation of WA children for most common oral conditions across different variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Dental fracture</th>
<th>Birth defect</th>
<th>Developmental defects</th>
<th>Embedded &amp; impaction</th>
<th>Dental caries</th>
<th>Pulp &amp; periapical</th>
<th>Dento-facial anomalies</th>
</tr>
</thead>
<tbody>
<tr>
<td>All children (AAR)</td>
<td>49.1</td>
<td>56.4</td>
<td>56.6</td>
<td>144.4</td>
<td>545.6</td>
<td>116.8</td>
<td>44.8</td>
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<td><strong>Age (AAR)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>111</td>
<td>136.7</td>
<td>29.7</td>
<td>1.9</td>
<td>746.3</td>
<td>165.3</td>
<td>2.6</td>
</tr>
<tr>
<td>5–9</td>
<td>28.2</td>
<td>22.3</td>
<td>83.6</td>
<td>35.4</td>
<td>754.4</td>
<td>165.7</td>
<td>25.8</td>
</tr>
<tr>
<td>10–14</td>
<td>11.1</td>
<td>14.4</td>
<td>55.2</td>
<td>388.8</td>
<td>146.8</td>
<td>22.1</td>
<td>103.9</td>
</tr>
<tr>
<td><strong>Indigenous status (AAR)</strong></td>
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<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>49.2</td>
<td>24.8</td>
<td>6.7</td>
<td>5.0</td>
<td>415.1</td>
<td>152.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Non-Indigenous</td>
<td>44.3</td>
<td>53.1</td>
<td>54.4</td>
<td>142.9</td>
<td>497.8</td>
<td>99.9</td>
<td>44.1</td>
</tr>
<tr>
<td><strong>Gender (AAR)</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>55.8</td>
<td>70.4</td>
<td>57.2</td>
<td>115.5</td>
<td>560.2</td>
<td>126.2</td>
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<tr>
<td>Female</td>
<td>42.0</td>
<td>41.7</td>
<td>56.0</td>
<td>175.2</td>
<td>530.2</td>
<td>106.9</td>
<td>52.8</td>
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<tr>
<td><em><em>SEIFA</em> (%)</em>*</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most disadvantage</td>
<td>19.4</td>
<td>17.8</td>
<td>10.8</td>
<td>9.0</td>
<td>17.2</td>
<td>25.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Below average disadvantage</td>
<td>20.7</td>
<td>19.6</td>
<td>14.4</td>
<td>14.9</td>
<td>19.3</td>
<td>23.2</td>
<td>14.0</td>
</tr>
<tr>
<td>Average disadvantage</td>
<td>18.4</td>
<td>20.0</td>
<td>18.5</td>
<td>20.3</td>
<td>18.4</td>
<td>17.1</td>
<td>17.9</td>
</tr>
<tr>
<td>Above average disadvantage</td>
<td>18.3</td>
<td>21.2</td>
<td>21.5</td>
<td>23.6</td>
<td>19.9</td>
<td>17.5</td>
<td>21.8</td>
</tr>
<tr>
<td>Least disadvantage</td>
<td>22.5</td>
<td>21.3</td>
<td>34.6</td>
<td>32.2</td>
<td>25.2</td>
<td>17.2</td>
<td>36.0</td>
</tr>
<tr>
<td><em><em>ARIA</em> (%)</em>*</td>
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<td></td>
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</tr>
<tr>
<td>Highly accessible</td>
<td>18.4</td>
<td>18.9</td>
<td>16.8</td>
<td>25.6</td>
<td>19.2</td>
<td>20.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Accessible</td>
<td>67.7</td>
<td>63.2</td>
<td>66.1</td>
<td>56.8</td>
<td>58.7</td>
<td>60.0</td>
<td>62.9</td>
</tr>
<tr>
<td>Moderately accessible</td>
<td>6.5</td>
<td>9.6</td>
<td>8.6</td>
<td>12.0</td>
<td>11.4</td>
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<td>11.6</td>
</tr>
<tr>
<td>Remote</td>
<td>2.6</td>
<td>3.9</td>
<td>4.5</td>
<td>4.1</td>
<td>5.1</td>
<td>4.0</td>
<td>3.9</td>
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<tr>
<td>Very remote</td>
<td>4.7</td>
<td>4.5</td>
<td>3.8</td>
<td>1.5</td>
<td>5.6</td>
<td>5.8</td>
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<td><em><em>Same day separation</em> (%)</em>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>78.5</td>
<td>70.1</td>
<td>97.5</td>
<td>94.4</td>
<td>97.6</td>
<td>87.0</td>
<td>92.8</td>
</tr>
<tr>
<td>No</td>
<td>21.5</td>
<td>29.9</td>
<td>2.5</td>
<td>5.6</td>
<td>2.4</td>
<td>13.0</td>
<td>7.2</td>
</tr>
<tr>
<td><em><em>Insurance status</em> (%)</em>*</td>
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<td></td>
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</tr>
<tr>
<td>Insured</td>
<td>34.3</td>
<td>42.9</td>
<td>69.9</td>
<td>71.5</td>
<td>52.5</td>
<td>25.7</td>
<td>74.8</td>
</tr>
<tr>
<td>Uninsured</td>
<td>65.7</td>
<td>57.1</td>
<td>30.1</td>
<td>28.5</td>
<td>47.5</td>
<td>74.3</td>
<td>25.2</td>
</tr>
<tr>
<td><em><em>Hospital type</em> (%)</em>*</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Public</td>
<td>88.2</td>
<td>56.8</td>
<td>18.2</td>
<td>9.0</td>
<td>35.5</td>
<td>79.3</td>
<td>21.0</td>
</tr>
<tr>
<td>Private</td>
<td>11.8</td>
<td>43.2</td>
<td>81.7</td>
<td>91.0</td>
<td>64.4</td>
<td>20.6</td>
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</tr>
<tr>
<td>Commonwealth</td>
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<td>0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
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<tr>
<td><strong>Hospital area(AAR)</strong></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>14.5</td>
<td>20</td>
<td>15.8</td>
<td>83.8</td>
<td>301</td>
<td>53.3</td>
<td>27.8</td>
</tr>
<tr>
<td>Metropolitan</td>
<td>55.1</td>
<td>62.4</td>
<td>64</td>
<td>152.1</td>
<td>560.3</td>
<td>123.8</td>
<td>46.3</td>
</tr>
</tbody>
</table>

AAR (Age adjusted rate per 100,000)
*P < 0.001, Pearson chi-square
5.4.3. Aboriginal and Torres Strait Islander Children

Rural-living non-Indigenous children had 1.2 times the admission rate of rural-living Indigenous children. In contrast, Indigenous children living in major cities or regional areas had 2.6 times the admission rate of their Indigenous counterparts in rural or remote areas. Sixty-three percent of all separations recorded for patients identified as non-Indigenous occurred in metropolitan private hospitals.

Time trends. Figure 5.3 shows that the AAR of hospitalisation for Indigenous children in the last decade increased to reach that of non-Indigenous children in 2009. From 2000 to 2008, the difference between Indigenous and non-Indigenous was statistically significant over this period. Admission AARs for non-Indigenous children were 1.3 times more than that of Indigenous children, with non-Indigenous females significantly, more likely to be admitted than Indigenous females. In contrast, there is no statistical difference in the admission rates between Indigenous males and females. Furthermore, the highest AAR of hospitalisation was observed among Indigenous children under the age of 5 years (1337) (Table 5.2).

Length of stay. Indigenous children were more likely to have longer admissions than non-Indigenous children ($P < 0.001$; Table 5.3).

Insurance. Nearly 97% of Indigenous hospitalised children were uninsured with public hospitals mostly the primary place of admission ($P < 0.001$).

Socioeconomic associations. It was more likely for non-Indigenous children, across all ages, from higher socioeconomic areas to be admitted compared to Indigenous children. Fifty-nine
percent of all Indigenous children hospitalised were in the lowest socioeconomic group ($P < 0.001$; Table 5.3).

*Remoteness of residency.* According to ARIA, 60% of non-Indigenous children hospitalised in WA lived in areas classified as accessible. Conversely, highest percentage (33%) of Indigenous children lived primarily in very remote areas ($p < 0.001$; Table 5.3).

**Figure 5.3**
Hospitalisation age-adjusted rates of WA children by Indigenous status, over time.
Table 5.2
Age-adjusted rates of hospitalisation for oral health conditions across age groups, gender and geographical location.

<table>
<thead>
<tr>
<th></th>
<th>Indigenous</th>
<th></th>
<th>Non-Indigenous</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AAR*</td>
<td>CI§</td>
<td>AAR*</td>
<td>CI§</td>
<td>AAR*</td>
<td>CI§</td>
</tr>
<tr>
<td>All ages</td>
<td>813.3</td>
<td>778.7-848.0</td>
<td>1,090.4</td>
<td>1,079.9-1,100.8</td>
<td>1,073.6</td>
<td>1,063.5-1,083.6</td>
</tr>
<tr>
<td>Age group</td>
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<td></td>
</tr>
<tr>
<td>0–4</td>
<td>1,328.7</td>
<td>1,251.2-1,406.2</td>
<td>1,244.7</td>
<td>1,224.9-1,264.4</td>
<td>1,250.2</td>
<td>1,231-1,269.3</td>
</tr>
<tr>
<td>5–9</td>
<td>901.3</td>
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<td>10–14</td>
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<td>197.3-261.5</td>
<td>853</td>
<td>837.4-868.6</td>
<td>816.8</td>
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<td>1,070.2-1,100.2</td>
<td>1,066</td>
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<td>476.6-546.0</td>
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<td>595.0-624.6</td>
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<td>1,238.1</td>
<td>1,225.6-1,250.7</td>
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</table>

*Age adjusted rate per 100,000 person-years.
§ CI represents the 95% confidence interval for AAR

Table 5.3
Percentages of child hospitalisations for oral health conditions across hospital type, SEIFA, ARIA and same day of separation.

<table>
<thead>
<tr>
<th>Percentage (%)*</th>
<th>Indigenous</th>
<th>Non-Indigenous</th>
</tr>
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<td><strong>Hospital type</strong></td>
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<tr>
<td>Public</td>
<td>96.0</td>
<td>36.5</td>
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<tr>
<td>Private</td>
<td>4.0</td>
<td>63.4</td>
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<td><strong>SEIFA</strong></td>
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<tr>
<td>Most disadvantage</td>
<td>58.9</td>
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</tr>
<tr>
<td>Below average disadvantage</td>
<td>20.9</td>
<td>18.5</td>
</tr>
<tr>
<td>Average disadvantage</td>
<td>9.4</td>
<td>19.0</td>
</tr>
<tr>
<td>Below average disadvantage</td>
<td>7.1</td>
<td>21.0</td>
</tr>
<tr>
<td>Least disadvantage</td>
<td>3.8</td>
<td>27.2</td>
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<tr>
<td><strong>ARIA</strong></td>
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<td></td>
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<td>Highly Accessible</td>
<td>12.2</td>
<td>20.3</td>
</tr>
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<td>Accessible</td>
<td>30.8</td>
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<td>Moderately Accessible</td>
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<td>10.6</td>
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<td>Remote</td>
<td>9.4</td>
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</tr>
<tr>
<td>Very remote</td>
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<td>3.3</td>
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<td><strong>Same day separation</strong></td>
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<td></td>
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<td>93</td>
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<td>7</td>
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<td>55.1</td>
</tr>
<tr>
<td>No</td>
<td>96.5</td>
<td>44.9</td>
</tr>
</tbody>
</table>

* P < 0.001, Pearson chi-square
Chapter Five

5.5. Discussion

In this study, the most common reasons for hospital admissions were ‘dental caries’ and ‘embedded and impacted teeth’. Over time, the hospitalisation rates of ‘dental caries’ increased. This is consistent with findings of a previous study (Kruger Dyson, & Tennant, 2006). Males exhibited a significantly higher rate of hospitalisation due to ‘dental caries’, than females. The reason for the higher caries experience in males is unclear, although it has been claimed that male children who have the same genotype of Streptococcus mutans as their mother have up to 13 times greater risk of caries development than female children that acquire the same strain of bacteria from their mother (Li & Caufield, 1995).

Hospitalisations for ‘embedded and impacted teeth’ were mainly among the oldest age group with very significant differences between non-Indigenous and Indigenous children. This confirm the finding of the previous surveys (Kruger Dyson, & Tennant, 2006; George et al., 2011a). Hospitalisation at this age group, however, is unlikely to be due to third molar impaction. Maxillary canine is one of the most frequently impacted teeth in children aged 11-14 years, with the prevalence ranging from 0.8 to 5.2% (Ranjit et al.; Litsas & Acar, 2011). ‘Embedded and impacted teeth’ are predominantly undertaken in the private sector, which is not managed through policy directives (George et al., 2011a). Non-Indigenous children are more likely to have private health cover, which plays an important role in dental health-care delivery in Australia. In 2010-11, 58% of dental expenditure in Australia was funded by out-of-pocket expenses and 14% by health insurance (Australian Institute of Health and Welfare, 2012).
Hospitalisations for ‘pulp and periapical’ conditions were mainly due to periapical abscess without sinus formation. It is not surprising that uninsured, Australian Indigenous male children aged < 9 years, and living in the most disadvantaged areas were more likely to be admitted for this condition. This can indicate that they only access dental care when conditions reached an advanced stage.

Although preschool children have difficulties accessing the existing dental health service, the rates of hospitalisation among this age group have been declining since 2003. In 2005–2009, however, the hospitalisation rates of 5- to 9-year-olds started to increase and exceeded the rates of 0- to 4-year-olds. The changing rates of procedures over time might be a result of changing trends in clinician beliefs, as well as changing health insurance levels in the community; no specific reason for change is evident. Currently, most publicly delivered children dental program in Australia is SDS, which includes only emergency or basic treatment, and covers only limited care for school children particularly those within low-income families (An Advocacy Kit for Community and Welfare, 2010). The comprehensiveness of these programmes differs significantly among state and territories in terms of the types of services covered, age restrictions, and limits on the frequency of dental visits. In Western Australia, the SDS is primarily a public dental health program, with emphasis on prevention and education, and it provides free limited general dental care to school children ranging from pre-primary through to year 11 and to year 12 in remote locations. This care is provided by dental therapists from fixed and mobile clinics located at schools throughout the state. Thus, treatment outside the scope of the SDS is referred to other providers, and any costs are the responsibility of the parent or guardian. Furthermore,
not all students are enrolled in SDS, and long intervals between visits might delay interventions and early prevention.

Although the health of Indigenous children in Australia is lower than that of non-Indigenous children for most indicators (Australian Institute of Health and Welfare, 2007b; 2012), admission rates were higher among non-Indigenous children, as reported previously for Western Australian children (Tennant et al., 2000; Kruger Dyson, & Tennant, 2006). The differences observed are thought to be attributed to a number of factors, such as variation in service access as a significant proportion of Indigenous children live in rural and remote locations (Steele et al., 2000), socioeconomic or environmental factors (Munoz, Powers, Nienhuys, & Mathews, 1992).

The Indigenous population in Western Australia constitutes just 3.2% of the total population of the state and predominantly lives in rural and remote areas and in areas of higher socioeconomic disadvantage (Australian Bureau of Statistics, 2006). The hospitalisation rates were higher among children living in metropolitan areas than in the rural children. This can be attributable to the fact that Western Australia is experiencing a dental workforce shortage in rural and remote areas, especially in terms of dental therapists and dental specialists (Steele et al., 2000). Furthermore, geographical access to health services was considered as the reason for this unequal distribution; it is evident by the fact that Indigenous children in metropolitan areas are also more likely to be admitted than Indigenous children in rural areas. They are also less likely to have private health cover, which plays an important role in the private-driven dental health-care delivery in Australia and hence fail to have adequate dental treatment. There is an obvious association between
insurance status, and hospital types (private or public), and the admission of Indigenous children, which might reflect the socioeconomic barriers to dental service utilisation. Moreover, the public sector largely services medical and surgical emergencies and other complex conditions and procedures. Indigenous children were more likely to have longer stays in hospital than non-Indigenous children, and might be attributed to the severity of the condition.

This study focused on the trends over a 10-year time period and to highlight those groups within the child population more likely to be admitted. The same dataset is also being used for further analysis to determine risk indicators and will involve more detailed statistical analysis.

5.6. Recommendations and Conclusion

Most oral conditions, and especially dental caries, are preventable. These findings of this study indicate rejection of the null hypothesis and it identified groups within the child population more likely to be admitted to hospital for treatment of oral health-related conditions, as well as associated characteristics. This information should be utilised and applied to prevent costly in-patient treatment by early detection, prevention, and intervention. At a time, when public health resources are limited, strategies need to be developed to focus on these high-risk groups and best practice principles of care and demand management to better utilise limited health resources. It is also important to address the need for the redistribution of resources on the basis of regional need and the development of community-based preventive programmes and treatment programmes, which will significantly reduce the incidence of dental diseases in Australian children.
Chapter Six

6. Disparities in Dental Insurance Coverage among Hospitalised Western Australian Children.

This chapter was published in the following article:

Alsharif, Alla, Kruger, Estie & Tennant, Marc. (2014). Disparities in dental insurance coverage among hospitalised Western Australian children. *International Dental Journal*. 64(5), 252-259. (Appendix C)
6.1. Abstract

Objective: We sought to understand disparities in dental insurance coverage among hospitalised Western Australian children and associated factors.

Material and Methods: This study analysed the data obtained for 43,937 child patients under the age of 15 years hospitalised for an oral-health related condition, as determined by principal diagnosis (ICD-10AM). Primary place of residency, age, gender, Indigenous status and socioeconomic status were also analysed.

Results: Of our sample, 47.3% reported lack of dental insurance coverage. Non-Indigenous children were more likely to have dental insurance than Indigenous children. When insurance status was considered, Indigenous children were less likely to be hospitalised for dental treatment. Rural children were more likely to be uninsured than urban children. Lack of health insurance coverage was strongly associated with children living in very remote areas. These disparities were exacerbated among rural indigenous children. Disparities in dental insurance coverage and dental care are also evident by socioeconomic status.

Recommendations and Conclusions: Better understanding of disparities in access to care among children, socioeconomic divide in oral health insurance coverage and subsequent development of intervention programmes, will be critical to improving Australian children's oral health.

Key words: Disparities, hospitalisation, dental, Australia.
Chapter Six

6.2. Introduction

One of the fundamental objectives of health-care systems across the globe is to ensure that individuals have access to care on the basis of need, rather than ability to pay. However, this objective in a free-market economy is often warped by the economic goals of society. In Australia, dental services are predominately provided in the private sector setting and therefore prices and wealth wraps around access. Historically, because dental care has not been considered integral to health care, it is not subject to the tenets of the Australian Health Act (AHA): that is, publicly administered, universal, portable, accessible and comprehensive (Haas & Anderson, 2005). In contrast to physician- and hospital-based services that are mainly publicly funded, Australians are largely responsible for financing their own dental care. Australians pay for dental care in four different ways: through third-party insurance (employment-related health insurance coverage); through private dental insurance; by paying directly out-of-pocket; or through government-subsidised programmes (e.g. School Dental Services for children or community and public hospital clinics for adults) (Haas & Anderson, 2005).

At present, most publicly delivered child dental programmes in Australia are via School Dental Services, which includes only emergency and basic treatment, and cover only limited care for school children, particularly those with in low-income families (An Advocacy Kit for Community & Welfare, 2010). However, most major in-hospital dental services are provided by the private sector offering non-subsidised care. In addition, private health insurance covers a proportion of costs but consumers have always faced relatively high out-of-pocket costs for these services. In 2005, 43.8% of Australian children aged from 5–11 years had private dental insurance (predominately personal) and 22.3% had cardholder status.
(eligible for publicly provided services) (Ellershaw & Spencer, 2009). The groups most marginalised by the current dental care system are the lowest income families, Indigenous people and children living in remote areas; this has a great impact on these suffering high disease burdens such as the children of Australia’s first people the Aboriginal and Torres Strait Islander people (An Advocacy Kit for Community & Welfare, 2010). These population groups have the least access to dental care and carry the greatest burden of untreated disease (An Advocacy Kit for Community & Welfare, 2010). People from wealthier groups have better oral health and make use of more complex and expensive services, while waiting lists for public dental care have grown by 20% per year (Haas & Anderson, 2005). Over time, this has resulted in increased inequity in access to care.

This study examines the disparities in dental insurance coverage among Western Australian children hospitalised because of oral health-related conditions and associated factors to address the inequalities that currently exist. The null hypothesis of this study is that childrens’ hospital admissions for dental conditions are not associated with the presence of private health insurance.

6.3. Material and Methods

6.3.1. Data Source

This primary research data set was de-identified detailed data obtained from the Western Australia Hospital Morbidity Dataset for 10 financial years from 1999–2000 to 2008–2009.
Ethics. This research was conducted in full accordance with the World Medical Association Declaration of Helsinki and ethical approval was granted by the Ethics Committee of The University of Western Australia. Children were not directly involved in the study, as this was only an analysis of de-identified hospitalisation data, as provided by the Health Department of Western Australia.

Principal diagnosis. Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and admitted for an oral health condition in Western Australia for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD–10–AM 'is the Australian Modification of the 10th revision of the International Classification of Diseases (ICD–10). It is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol' (Commonwealth Department of Health and Aged Care, 1998). For each child, age, gender and Indigenous status, insurance status, hospital area and hospital type were also analysed.

Residential location. Remoteness was classified using the Accessibility/Remoteness Index of Australia (ARIA) which measures ‘remoteness in terms of access along the road network from populated localities to each of five categories of Service Centre. Localities that are more remote have less access to service centres; those that are less remote have greater access to service centres’ (Australian Population and Migration Research Centre, 2013).
Socioeconomic status. Socioeconomic status was analysed using the Socio-Economic Indexes of Area (SEIFA) classification which is a ‘product developed by the Australian Bureau of Statistics that ranks areas in Australia according to relative socioeconomic advantage and disadvantage. The indexes are based on information from the five-yearly Census’ (Australian Bureau of Statistics, 2013a).

6.3.2. Statistical Analysis

All data were analysed using SPSS 21 (Statistical package for the social sciences; SPSS, Chicago, IL USA) for Windows software. Statistical significance was set at 95% ($P < 0.05$) and was calculated using Pearson chi-square tests ($\chi^2$), to determine significant differences between nominal (categorical) variables.

6.4. Results

From 2000 to 2009, a total of 43,937 children (0–14 years) were hospitalised because of oral health-related conditions. Overall 5% ($n = 2119$) of admissions were for Indigenous children.

6.4.1. Dental Insurance (All children)

Almost one in every two children hospitalised was uninsured (47.3%; Table 6.1).

Age in years on admission. Children aged between 10 years and 14 years reported a significantly higher level of dental insurance coverage than children younger than 9 years old ($P < 0.01$; Table 6.1).
Gender. More females (54%) were insured than males (51.4%) (Table 6.1).

Hospital type. Children with private health insurance were more likely to be admitted to private hospitals than uninsured children ($P < 0.01$; Table 6.1).

Location. Children admitted to metropolitan hospitals were 1.6 times more likely to be insured than children admitted to rural hospitals. Children from the oldest age group were more likely to be insured than younger age groups. The observed variations were statistically significant ($P < 0.01$; Table 6.1).

Socioeconomic status. Children with the lowest socioeconomic status (SES) were significantly less likely to have dental insurance. In contrast, 76% of children hospitalised from least disadvantaged areas were insured. Hospitalised children from high SES backgrounds were three times more likely to be insured than children from most disadvantaged areas. ($P < 0.01$; Table 6.1)

Remoteness/ accessibility. Statistically significant variations were observed across ARIA classification ($P < 0.01$). Lack of health insurance coverage was strongly associated with children living in very remote areas. Children living in accessible areas were twice as likely to be insured as children living in very remote areas (Table 6.1).

Length of stay. Sixty-six percent of children admitted for more than a day were uninsured. Of those admitted for more than a day, 78% of the 5-9 year olds and 74% of the < 5 year olds were uninsured ($P < 0.01$; Table 6.1).
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Insurance status over time. In 2000, children admitted to hospital for oral health-related conditions were more likely to be uninsured. Since then, insurance levels have increased to reach 63% of all children younger than 15 years old hospitalised because of oral conditions in 2009 ($P < 0.01$, Figure 6.1a). Statistically significant higher levels of dental insurance coverage were observed among children aged between 10 and 14 years over time, followed by the 5- to 9-year-old group ($P < 0.01$; Figure 6.1b). However, over last decade, the percentage of uninsured children younger than 4 years old has decreased by 22% ($P < 0.01$; Figure 6.1c).

Table 6.1
The percentages of hospitalisation of Western Australia children based on insurance status compared with different variables

<table>
<thead>
<tr>
<th>Age (years)</th>
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<th></th>
<th>Uninsured</th>
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<th></th>
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<tbody>
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<td></td>
<td>0–4</td>
<td>5–9</td>
<td>10–14</td>
<td>Total</td>
<td>0–4</td>
<td>5–9</td>
<td>10–14</td>
</tr>
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<td>68.0</td>
<td>52.7</td>
<td>57.9</td>
<td>47.8</td>
<td>32.0</td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>52.4</td>
<td>66.5</td>
<td>51.4</td>
<td>57.9</td>
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<td>48.0</td>
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<td>Most disadvantage</td>
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<td>82.7</td>
<td>76.8</td>
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<td>69</td>
<td>61.8</td>
<td>44.9</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average disadvantage</td>
<td>42.2</td>
<td>49.3</td>
<td>64.8</td>
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<td>57.8</td>
<td>50.7</td>
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<td>60.4</td>
<td>71.1</td>
<td>61.4</td>
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<tr>
<td>Least disadvantage</td>
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<td>Highly Accessible</td>
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<td>67.3</td>
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<td>60.5</td>
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<td>42.2</td>
<td>26.9</td>
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<tr>
<td>Modestly Accessible</td>
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<td>63.1</td>
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<td>40.7</td>
<td>28.3</td>
<td>72.8</td>
<td>74.5</td>
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<td>69</td>
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<td>34.2</td>
<td>73.5</td>
<td>77.8</td>
<td>42.6</td>
</tr>
</tbody>
</table>

SEIFA, Socio-Economic Indexes of Area; ARIA, Accessibility/Remoteness Index of Australia.

*P < 0.001, Pearson chi-square, and refer to differences between variable categories, not between insured and uninsured.
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**Figure 6.1a**
The percentages of hospitalisation among WA children based on insurance status.

**Figure 6.1b**
The percentages of insured hospitalised WA children over time based on age.
6.4.2. Dental Insurance (Indigenous Status)

The disparities were exacerbated among Indigenous children. Non-Indigenous Western Australian children aged less than 15 years and hospitalised because of oral conditions over the last decade were 16 times more likely to be insured compared with their Indigenous counterparts.

Age. Across all ages, the majority of Indigenous children were uninsured. The percentage of insured Indigenous children aged 5–9 years were higher (1.2%) than the percentages in other Indigenous age groups ($P < 0.01$; Table 6.2).
Gender. Slightly more (3.9%) male Indigenous children were insured compared with female Indigenous children (3.1%). In contrast, 57% of non-Indigenous females were insured compared with their male counterparts (54%) ($P < 0.01$; Table 6.2).

Location. Indigenous children living in urban areas were five times more likely to be insured compared with their rural counterparts. Interestingly, non-Indigenous children living in rural areas were 37 times more likely to be insured than Indigenous children living in rural areas ($P < 0.01$; Table 6.2).

Hospital type. Both insured Indigenous and non-Indigenous children were significantly more likely to be admitted in private hospitals ($P < 0.01$; Table 6.2).

Length of stay. Only (0.9%) of Indigenous children hospitalised for more than a day were insured ($P < 0.01$).

Common oral conditions. There was a distinct contrast in the percentages of children with health insurance among Indigenous and non-Indigenous group ($P < 0.01$; Table 6.2).

Socioeconomic status. Ninety-eight percent of Indigenous children hospitalised and living in the most disadvantaged areas were uninsured. Significant differences in insurance status between Indigenous and non-Indigenous children were observed based on socioeconomic status, using the SEIFA scale (Table 6.2). Non-Indigenous children living in the most disadvantaged areas were 19 times more likely to be insured than Indigenous children living in the same areas. Statistically significant variations were observed across socioeconomic distribution ($P < 0.01$).
Remoteness/accessibility. For both Indigenous and non-Indigenous children the proportion with health insurance decreased with increasing geographic remoteness, with insurance levels of only 4% and 1.3% of the Indigenous child population residing in remote or very remote areas, respectively. However, non-Indigenous children living in very remote areas were 32 times more likely to be insured than their Indigenous counterparts \( (P < 0.01; \text{ Table 6.2}) \).

Changes over time. Constant and high percentages of hospitalised Indigenous children have been uninsured over the last decade \( (P < 0.01) \). The percentages of those with health insurance among Indigenous hospitalised children were very low and constant over the study period, with a slight increase (13%) in 2009 (Figure 6.2). In contrast, since 2005, insurance among hospitalised non-Indigenous children has increased \( (P < 0.01; \text{ Figure 6.3}) \).
Table 6.2
The percentages of insurance coverage among hospitalised WA children based on Indigenous status and different variables.

<table>
<thead>
<tr>
<th></th>
<th>Indigenous</th>
<th></th>
<th>Non-Indigenous</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insured</td>
<td>Uninsured</td>
<td>Insured</td>
<td>uninsured</td>
</tr>
<tr>
<td>All children*</td>
<td>3.5</td>
<td>96.5</td>
<td>55.1</td>
<td>44.9</td>
</tr>
<tr>
<td><strong>Age</strong>&lt;br&gt;(years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>3.1</td>
<td>96.9</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>5–9</td>
<td>4.3</td>
<td>95.7</td>
<td>54.7</td>
<td>45.3</td>
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<td>10–14</td>
<td>3.1</td>
<td>96.9</td>
<td>69.1</td>
<td>30.9</td>
</tr>
<tr>
<td><strong>Gender</strong>&lt;br&gt;Male</td>
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<td>96.1</td>
<td>53.9</td>
<td>46.1</td>
</tr>
<tr>
<td>Female</td>
<td>3.1</td>
<td>96.9</td>
<td>56.5</td>
<td>43.5</td>
</tr>
<tr>
<td><strong>Location</strong>&lt;br&gt;Urban</td>
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<td>57.5</td>
<td>42.5</td>
</tr>
<tr>
<td>Rural</td>
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<td>98.9</td>
<td>40.2</td>
<td>59.8</td>
</tr>
<tr>
<td><strong>Hospital type</strong>&lt;br&gt;Public</td>
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<td>98.9</td>
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<td>38.1</td>
<td>78.2</td>
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<tr>
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<td>95.5</td>
<td>56.2</td>
<td>43.8</td>
</tr>
<tr>
<td>No</td>
<td>0.9</td>
<td>99.1</td>
<td>40.7</td>
<td>59.3</td>
</tr>
<tr>
<td><strong>Conditions</strong>&lt;br&gt;Dental fracture</td>
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<td>97.8</td>
<td>36.6</td>
<td>63.4</td>
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<tr>
<td>Birth defects</td>
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<td>97.1</td>
<td>44.2</td>
<td>55.8</td>
</tr>
<tr>
<td>Developmental Defects</td>
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<td>78.9</td>
<td>70.4</td>
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<tr>
<td>Embedded &amp; Impacted teeth</td>
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<td>92.9</td>
<td>71.6</td>
<td>28.4</td>
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<tr>
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<td>55.1</td>
<td>44.9</td>
</tr>
<tr>
<td>Pulp &amp; periapical</td>
<td>1.3</td>
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<td>28.8</td>
<td>71.2</td>
</tr>
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<td>Dento-facial anomalies</td>
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<td>100</td>
<td>75.1</td>
<td>24.9</td>
</tr>
<tr>
<td><strong>SEIFA</strong>&lt;br&gt;Most disadvantage</td>
<td>1.5</td>
<td>98.5</td>
<td>28</td>
<td>72.0</td>
</tr>
<tr>
<td>Below average disadvantage</td>
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<td>96.6</td>
<td>40.9</td>
<td>59.1</td>
</tr>
<tr>
<td>Average disadvantage</td>
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<td>94.9</td>
<td>51.9</td>
<td>48.1</td>
</tr>
<tr>
<td>Above average disadvantage</td>
<td>11.3</td>
<td>88.7</td>
<td>62.3</td>
<td>37.7</td>
</tr>
<tr>
<td>Least disadvantage</td>
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<td>85</td>
<td>76.1</td>
<td>23.9</td>
</tr>
<tr>
<td><strong>ARIA</strong>&lt;br&gt;Highly Accessible</td>
<td>6.6</td>
<td>93.4</td>
<td>53</td>
<td>47.0</td>
</tr>
<tr>
<td>Accessible</td>
<td>5.4</td>
<td>94.4</td>
<td>59.5</td>
<td>40.5</td>
</tr>
<tr>
<td>Moderately Accessible</td>
<td>2</td>
<td>98</td>
<td>41</td>
<td>59.0</td>
</tr>
<tr>
<td>Remote</td>
<td>4</td>
<td>96</td>
<td>47.6</td>
<td>52.4</td>
</tr>
<tr>
<td>Very remote</td>
<td>1.3</td>
<td>98.7</td>
<td>41.8</td>
<td>58.2</td>
</tr>
</tbody>
</table>

* $P < 0.001$, Pearson chi-Square
Figure 6.2
The percentages of hospitalisation among WA Indigenous children based on insurance status.

Figure 6.3
The percentages of hospitalisation among WA non-Indigenous children based on insurance status.
6.5. Discussion

Health insurance coverage has previously been found to be a good predictor of preventive care service use (Kenney, McFeeters, & Yee, 2005; Harford & Luzzi, 2010). Health insurance in Australia does not automatically include dental insurance, but Australians can obtain dental insurance by purchasing either private patient hospital cover combined with an ‘extras’ option that includes dental services, or the ‘extras only’ option. There are two levels of dental services provided by this insurance: general dental coverage and major dental coverage. General dental coverage typically includes services such as cleaning, removal of plaque, radiographs and small restorations. Major dental coverage includes these services plus additional services such as orthodontics, third molar removal, crowns, bridges and dentures.

Dental health-care coverage is an indicator that reflects the extent to which people in need actually receive essential dental health interventions (Kenney et al., 2005; Harford & Luzzi, 2010). The primary explanation cited in the literature for delayed dental health care seeking is financial barriers (Harford & Luzzi, 2010). In this study, we found statistically significant disparities in dental insurance coverage among hospitalised children associated with Indigenous status, socioeconomic status and remoteness and accessibility of residential area. The impacts of this disparity go beyond just the greater prevalence of the dental and oral disease, and include greater morbidity and mortality.

In this study, those children who did have dental health insurance were more likely to come from urban, accessible and least disadvantaged areas. This confirms findings of previous surveys and may be an indication that insurance enabled access to dental care and led to
greater demand for care once access had been obtained (Bagramian, Garcia-Godoy, & Volp, 2009). Although private dental insurance does not necessarily increase receipt of preventive service or decrease perceived unmet need in all cases, it is evident that insured children are more likely to be hospitalised for less invasive treatment than their uninsured counterparts (who were probably more likely to receive extractions in dental clinics as outpatients and would have difficulty paying a $100 dental bill). Kaspe et al. (2000) found that the uninsured individuals were more likely to have difficulty obtaining health care once they lost coverage (Kasper, Giovanni, & Hoffman, 2000). However, those uninsured individuals that did gain private health cover had increased access to health services compared with those that remained uninsured (Kasper et al., 2000). In terms of health status, it is suggested that individuals losing coverage might experience adverse health outcomes compared with those that remained insured. The previous article elucidates that having private health insurance increases access to care and possibly improves health status. It is evident that Australian children who were covered by private dental health insurance were less likely to report fair or poor oral health than uninsured children (Harford & Luzzi, 2010).

A much smaller percentage of Indigenous children with health insurance compared with non-Indigenous children could contribute to the poorer oral health status of Indigenous children and inequality in access to oral health-care (Australian Institute of Health and Welfare, 2007). As a result of inadequate health insurance coverage, with nearly 97% of hospitalised Indigenous children being uninsured, numerous concerns about dental service utilisation are raised. In dental markets where well-insured or private-pay patients are common, public dental care coverage in children alone will be insufficient to remove disparities in dental utilisation. The lack of affordable dental care and insurance coverage
leads to postponing dental treatment, often for years. These untreated symptoms inevitably get more severe, resulting in children requiring admission for more invasive treatment at a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

Furthermore, over the past 20 years, health care has become more expensive and more individuals are unable to afford health insurance. It is important to note that the vast majority of dental specialists are in private practice; consequently, most hospitalisations for oral problems in children, and requiring general anaesthesia, take place in specialised private hospitals (Kruger Dyson, & Tennant, 2006; Australian Institute of Health and Welfare, 2010). Accordingly, parents are forced to pay directly out of pocket or indirectly through private health insurance for the hospitalisation process. In 2013, in Australia, Harford et al.’s reported that almost 30% of children avoided or delayed seeking oral health care, did not have recommended treatment, or their parents experienced a large financial burden because of the cost of dental care (Harford & Luzzi, 2010). Children from low SES were seven times more likely to avoid or delay visits because of cost compared with high SES counterparts, and six times more likely to not have had recommended treatment because of costs (Harford & Luzzi, 2010). Therefore, private dental insurance is an important factor modifying access to dental care. These affordability and accessibility inequalities between groups might indicate a substantial variation within Australian children, as seen in previous studies (Kruger Dyson, & Tennant, 2006; Williams et al., 2011).

The literature is replete with evidence that remote Indigenous children experience worse oral health than their urban counterparts (Australian Institute of Health and Welfare, 2007;
Smith et al., 2007), but this is not reflected in the higher rates of hospitalisation among metropolitan Indigenous children (Williams et al., 2011; Tennant et al., 2000; Australian Indigenous HealthInfoNet, 2013; Australian Institute of Health and Welfare, 2012 & MacRae et al., 2012). This can be partly explained by the greater availability of service (even SDS) and the higher proportion of insured urban-living Indigenous children than insured rural and remote dwellers. In the rural environment, dental health-care services may be sparse and located at great distances from the patient. In an urban environment, health-care services may be located closer but, in addition to financial issues, transportation (such as buses, trains) may be a barrier to getting to the needed care on time.

The Indigenous population is disadvantaged across a range of socioeconomic conditions, and these affect child health outcomes. Research over the past decade has continued to show that Indigenous children suffer disproportionately from many diseases, including dental diseases, and a delayed access to the health-care system will increase their risk for other complications and mortality from these illnesses. Most dental diseases are preventable and unnecessary suffering and disability can be avoided by decreasing delays in diagnosis and treatment. In addition, lack of access to ambulatory health care can lead to unnecessary hospitalisations and more expensive forms and utilisation of health care. Therefore, having dental insurance is seen, at least partly, as a way of overcoming financial barriers when in need of dental care.

Over time the level of health insurance for Indigenous and non-Indigenous children can thus be seen to reflect the inequality in health systems (including dental health) among the Australian child population. Throughout Western Australia the SDS primarily focuses on
prevention and education, and it provides free limited basic dental care by dental therapists to school children ranging from pre-primary up to Year 12 in remote locations. The Australian government provided a ‘safety-net’ system (SDS) as a way to provide free or reduced fee dental care to uninsured children. However, these sources of care are not always accessed and, as the numbers of poor and uninsured increase, the ‘safety-net’ health system will be unable to bear the burden of providing dental health care to all of the uninsured. In addition, any further invasive treatment is referred to other providers and any costs are the responsibility of the parent.

The public health community needs to know more about the restrictions to seeking dental health care within the Australian child population to enable better resource allocation, policy and planning. Therefore, understanding and developing a plan to combat the disparities in dental health among these groups should be a national priority.

**6.6. Recommendations and Conclusion**

Dental health insurance is a major component of obtaining and accessing child dental health care. Our study adds new information regarding the demand for dental care among children aged between 0 and 14 years, who account for 18.9% of the Australian population, leading to an increasing awareness of the substantial heterogeneity within the populations. Therefore, better understanding of disparities in access to care among children and the socioeconomic divide in oral health insurance coverage, and subsequent development of intervention programmes, will be critical to improving Australian children’s oral health. Eliminating socioeconomic and geographical disparities in dental insurance and dental care requires additional efforts in removing both financial and non-financial barriers to dental
utilisation. Furthermore, improving dental insurance coverage for Indigenous and rural-living children will ultimately help save health costs and improve overall health for the next generation.
Chapter Seven


This chapter was published in the following article:


7.1. Abstract

**Objective:** We sought to analyse the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years and to identify socio-demographic characteristics associated with these costs.

**Material and Methods:** This study analysed the cost of 43,937 child patients under the age of 15 years hospitalised for an oral health-related condition, as determined by principal diagnosis International Classification of Diseases (ICD-10AM). The Australian Refine Diagnosis Related Group version 5.1 was used to calculate the direct cost. An analysis of costs was broken down by socioeconomic status, primary place of residency, age, gender, insurance status, and Indigenous status.

**Results:** The total DRG cost of these admissions was approximately AUS$92 million over 10 years. Most of these funds went toward treating “Dental caries” and “Embedded and impaction” conditions of children under the age of 15 years. Approximately 95 percent of the total cost of hospitalisation for oral conditions, over the last decade, accounted for non-Indigenous children. Since 2000, the direct cost of child hospitalisation for oral health-related conditions has increased to reach $13 million AUD in 2009.

**Recommendations and Conclusions:** This study identified the substantial economic burden of child oral health-related hospitalisations that emphasises the importance of preventing costly inpatient treatments.

**Key words:** cost, children, dental hospitalisation, Western Australian.
7.2. Introduction

Dental conditions, specifically caries, are affecting the majority of children who live in Western Australia (WA). It is important to note that the Australian Government provides funds for running various public health programmes, such as School Dental Services (SDS), addressing children with poor oral health (Merrick et al., 2012). Yet, many children still end up in hospitals for dental treatment. The public health burden of hospital admissions due to oral conditions is quite substantial. Recent research indicates that the rate of hospitalisation due to oral conditions among WA children is 1,074 per 100,000 populations annually (Alsharif, Kruger, & Tennant, 2014a). Yet, little is known about the economic effects of in-hospital treatment of such conditions in Australia. It has also been noted that dental admissions are the largest category of acute preventable hospital admissions and that oral health problems are the second-most expensive disease group in Australia, with direct treatment costs of over $6 billion annually and additional care costs exceeding a further $1 billion (Rogers, 2011).

The provision of health-care services to children affected by oral health issues in WA has been a very costly obligation. Tennant et.al affirms how expensive oral health-care for Western Australian children is, by stating that in 1995 approximately $111 million were spent on the hospitalisation of children under 18 years of age (Tennant et al., 2000). Existing data suggest that in the period between 1999 and 2003, the cost of hospitalisation for children under the age of 18 years was $40 million (Kruger Dyson, & Tennant, 2006). However, current estimates of treatment costs are unknown, and prior estimates are likely to be obsolete in light of newer therapeutic modalities, inflation and changing patterns of hospitalisation and surgery. The precise estimation of the costs of oral health services is
Chapter Seven

critical to prevent undesired consequences affecting the quality of oral health-care. Therefore, an updated estimate of the treatment costs of oral diseases in WA is necessary, as this is an expensive service of providing treatments for (mostly) preventable conditions, and our objective was to document all costs associated with the treatment of dental conditions in the child population.

The aim of this study is to analyse the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years and to identify sociodemographic characteristics associated with these costs. The null hypothesis of this study is that hospital admissions for dental reasons (in children) are not associated with an increased economic burden on Australian dental health expenditure.

7.3. Material and Methods

7.3.1. Data Source

This research involved a de-identified detailed analysis of the data obtained from the WA Hospital Morbidity Data System for ten fiscal years from 1999/00 to 2008/09. This research has been conducted in full accordance with the World Medical Association Declaration of Helsinki, and ethics approval was granted by the Ethics Committee of the University of Western Australia. Children were not directly involved in the study, as this was only an analysis of de-identified hospitalisation data, as provided by the Health Department of Western Australia. These admissions included all children hospitalised for oral treatment at WA including the day surgery for the study period. Demographics including age-adjusted rates and percentages of variables were previously published (Alsharif et al., 2014a).
7.3.2. Principle Diagnosis

Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and accordingly admitted for an oral health condition in Western Australia for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD–10–AM is the Australian Modification of the revision 10 of the International Classification of Diseases (ICD–10). It is the ‘standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol’ (Commonwealth Department of Health and Aged Care, 2000).

7.3.3. Determination of Direct Cost

Across Australia, the Australian Refine Diagnosis Related Group (AR-DRG) is used to calculate the cost of each patient episode on the basis of actual data about the treatment process. It is considered that Australia is a model example of a mature costing system and has the most sophisticated approach according to cost guidelines that include the actual amount of resources used in the treatment of a particular patient (Raulinajtys-Grzybek, 2014). Therefore, AR-DRG version 5.1 was used to calculate the direct cost (the Australian dollar value used according to the year of admission). AR-DRG ‘is an Australian admitted patient classification system which provides a clinically meaningful way of relating the number and type of patients treated in a hospital (that is, it’s casemix) to the resources required by the hospital’. Each AR-DRG represents ‘a class of patients with similar clinical conditions requiring similar hospital services’ (Australian Institute of Health and Welfare, 2013b). The categorisation classifies ‘acute admitted patient episodes of care into groups with similar..."
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conditions and similar usage of hospital resources, using information in the hospital morbidity record such as the diagnoses, procedures and demographic characteristics of the patient' (Australian Institute of Health and Welfare, 2013b). AR-DRG cost based on age, gender and Indigenous status, insurance status, hospital area and hospital type of each child were analysed.

Remoteness/accessibility. Direct cost based on remoteness was determined using the Accessibility/Remoteness Index of Australia (ARIA) classification, which measures ‘remoteness in terms of access along the road network from populated localities to each of five categories of Service Centre. Localities that are more remote have less access to service centres; those that are less remote have greater access to service centres’ (Australian Population and Migration Research Centre, 2013).

Socioeconomic status. DRG based on socioeconomic status was analysed using Socio-Economic Indexes of Area (SEIFA) classification. SEIFA is a nationally accepted coding developed by the Australian Bureau of Statatistics, which ‘ranks areas in Australia according to relative socioeconomic advantage and disadvantage based on information from the five-yearly Census’ (Australian Bureau of Statistics, 2013a).

7.3.4. Indirect Cost

Based on previous study, indirect costs were predicted at approximately 1.5 times the direct cost (Drummond et al., 1997), and because DRG is a direct cost, this method has been used to calculate the indirect costs. Indirect costs include the following: patient and parents/guardians’ absence from school or work due to pain and discomfort or having to
accompany the child; cost of transportation and accommodation and societal losses of productivity.

7.3.5. Statistical Analysis

To determine significant differences between continuous variables and nominal (categorical) variables, Kruskal-Wallis test was used when appropriate. Significant levels were set at 95% with $P$ value less than 0.05 deemed to be significant.

SPSS 21 for Windows (Statistical Package for the Social Sciences; SPSS, Chicago, IL USA) software and Excel 2007 (Microsoft, Redmond, WA, USA) are used for analysis.

7.4. Results

From 2000 to 2009, a total of 43,937 children (0–14 years) were admitted to hospital for oral health-related conditions. Of these, 5% ($n=2119$) were Indigenous children.

7.4.1. Direct cost (All children)

The total DRG cost of these admissions was approximately AUD $92 million with an estimation of additional AUD $138 million indirect cost (Table 7.1).

Age in years on admission. Costs were higher for children younger than 9 years (DRG 68 million) compared with 10- to 14-year-old children (DRG 25 million) ($P < 0.01$; Table 7.1).

Gender. The cost did not vary substantially by gender (Table 7.1).
**Indigenous status.** Approximately 95% of the total cost of hospitalisation for oral conditions, over the last decade, was accounted for non-Indigenous children. The difference between the DRG cost of hospitalisation among Indigenous children and non-Indigenous children was statistically significant, \( \chi^2(1) = 68.3 \ (P < 0.01) \), with a mean rank DRG cost of 24,185 for Indigenous and 21,857 for non-Indigenous (Table 7.1).

**Hospital type.** Fifty-nine and 41% of the hospitalisation costs were incurred in private and public hospitals, respectively. The difference between the DRG cost of hospitalisation among private and public hospital was statistically significant, \( \chi^2(1) = 43 \ (P < 0.01) \), with a mean rank DRG cost of 21,457 for private hospitals and 22,267 for public hospitals (Table 7.1).

**Location.** Children living in metropolitan areas accounted for the highest proportion (86 percent) of oral hospitalisation costs. The DRG cost among children living in urban areas was significantly higher than rural living children, \( \chi^2(1) = 172.5 \ (P < 0.01) \), with a mean rank DRG cost of 22,300 for urban areas and 20,072 for rural areas (Table 7.1).

**Socioeconomic status.** The oral condition-associated costs of hospitalisation were much less for the most disadvantaged children (17 percent of the total cost) when compared with the other socioeconomic groups (Table 7.1).

**Remoteness/accessibility.** The proportion of admissions decreased with increasing geographic remoteness. Therefore, total disease-attributable costs of oral hospitalisation varied significantly by ARIA, \( \chi^2(1) = 67 \ (P < 0.01) \), with a mean rank DRG cost represented
in table 7.1. The direct DRG cost of hospitalisation of children living in accessible areas was 12 times higher than children living in very remote areas.

*Insurance status.* The cost of hospitalisation of insured children was higher than their uninsured counterparts by approximately $5 million AUD. (Table 7.1)

*Cost per condition over time.* In 2000, the direct cost of child (younger than 14 years old) hospitalisation for oral related conditions reached about $6 million AUD. Since then the cost had more than doubled to $13 million AUD in 2009 (Figure 7.1). The variations over time were statistically significant ($P < 0.01$).
Table 7.1
The Australian Refine Diagnosis Related Group cost of hospitalisation of Western Australian children based on different variables

<table>
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<tr>
<th>Variable</th>
<th>Subcategory</th>
<th>Mean Rank</th>
<th>N</th>
<th>Cost (DRG) in million**</th>
<th>Indirect Cost in million**</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>All children</td>
<td></td>
<td>19,975</td>
<td>43,937</td>
<td>92</td>
<td>138</td>
<td>230</td>
</tr>
<tr>
<td>Age (years)</td>
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<td>20,631</td>
<td>16,367</td>
<td>34</td>
<td>52</td>
<td>86</td>
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<tr>
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<td>5–9</td>
<td>23,183</td>
<td>15,862</td>
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<td>82</td>
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<td></td>
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<td>22,195</td>
<td>11,708</td>
<td>25</td>
<td>37</td>
<td>62</td>
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<tr>
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<td>44</td>
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<td>5</td>
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<td>12</td>
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<td>135</td>
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<td>0.133</td>
<td>0.222</td>
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<td>37,412</td>
<td>79</td>
<td>119</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>20,072</td>
<td>6,525</td>
<td>13</td>
<td>19</td>
<td>32</td>
</tr>
<tr>
<td>SEIFA</td>
<td>Most disadvantage</td>
<td>21,525</td>
<td>7202</td>
<td>15</td>
<td>23</td>
<td>38</td>
</tr>
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<td>Below average disadvantage</td>
<td>21,130</td>
<td>8133</td>
<td>17</td>
<td>25</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Average disadvantage</td>
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<td>8128</td>
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<td>43</td>
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<tr>
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<td>Above average disadvantage</td>
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<td>8918</td>
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<td>22,560</td>
<td>11422</td>
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<td>8690</td>
<td>19</td>
<td>28</td>
<td>47</td>
</tr>
<tr>
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<td>21,786</td>
<td>26162</td>
<td>55</td>
<td>82</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>Moderately Accessible</td>
<td>20,923</td>
<td>4720</td>
<td>10</td>
<td>15</td>
<td>24</td>
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<tr>
<td></td>
<td>Remote</td>
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<td>2043</td>
<td>4</td>
<td>6</td>
<td>11</td>
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<tr>
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<td>Very remote</td>
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<td>2092</td>
<td>4</td>
<td>7</td>
<td>11</td>
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<tr>
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<td>22,569</td>
<td>23134</td>
<td>48</td>
<td>73</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Un-insured</td>
<td>21,302</td>
<td>20803</td>
<td>44</td>
<td>65</td>
<td>109</td>
</tr>
</tbody>
</table>

* P < 0.001, Kruskal-Wallis test
** AUD $ = Australian Dollar
**7.4.2. Direct cost** (based on the most common oral conditions)

Of all admitted cases 94% \( (n=41,475) \) accounted for seven major categories of oral conditions with half (50%) of those hospitalisations for ‘dental caries’, which cost approximately $45 million AUD. This was followed by, ‘embedded and impacted teeth’ (14% = $12 million AUD), ‘pulp and periapical’ tissue conditions (11% = $10 million AUD), ‘developmental and birth defects’ (5% = $4.5 million AUD), and ‘dental fractures’ (5%) and ‘dentofacial anomalies’ 4%, which costs around $4 million AUD each (Table 7.2).

*Age in years on admission.* Oral health-related hospitalisation costs did differ by age group. The highest costs were significantly accounted for 5- to 9-year-old children who were
hospitalised for ‘dental caries’, pulp and periapical’ or ‘developmental defects’ ($P < 0.01$). ‘Embedded and impacted teeth’ significantly incurred the highest costs among 10- to 14-year-old ($P < 0.01$). However, in the younger than 5-year-old group, the highest hospitalisation costs were incurred by the conditions classified as ‘dental fracture’ or ‘birth defects’ (Table 7.2).

**Indigenous status.** Non-Indigenous child hospitalisation costs were significantly higher than those of Indigenous children across the condition categories of ‘birth defect’, ‘developmental defects’, ‘dental caries’ and ‘pulp and periapical conditions’ ($P < 0.01$; Table 7.2).

**Gender.** It has been observed that hospitalisation costs for ‘embedded and impacted teeth’ conditions were significantly higher among females than males ($P < 0.01$; Table 7.2).

**Socioeconomic status.** Significantly higher costs were observed among children living in least disadvantage areas admitted for ‘dental caries’ conditions ($P < 0.01$). However, of children admitted with ‘pulp and periapical’ conditions, the admissions costs of children living in the most disadvantaged areas were 1.5 times higher than the admission cost of those living in the least disadvantaged areas ($P < 0.01$; Table 7.2).

**Remoteness/ accessibility.** Across all conditions, the majority of hospitalisation costs were driven by children living in accessible areas (Table 7.2). These variations were significantly higher among children hospitalised for ‘developmental defects’, ‘dental caries’ or ‘pulp and periapical’ conditions ($P < 0.01$).
Insurance status. The cost of insured children admitted due to ‘dental caries’, ‘embedded and impacted teeth’ or ‘developmental defects’ conditions were more likely to be higher than those without insurance admitted with the similar conditions. However, the cost of insured children hospitalised as a result of ‘pulp and periapical’, ‘birth defects’ or ‘dental fracture’ conditions were lower than those without dental insurance hospitalised with parallel conditions (Table 7.2).

Hospital type. The highest admission costs of ‘dental caries’, ‘embedded and impacted teeth’ or ‘developmental defects’ were significantly incurred in the private sector ($P < 0.01$). For ‘dental fracture’, ‘birth defects’ and ‘pulp & periapical’ conditions, the greatest children hospitalisation costs, were incurred in public hospitals ($P < 0.01$; Table 7.2).

Location. The admission costs for all common conditions (except ‘dental caries’ and ‘embedded and impacted teeth’) were significantly higher among children living in rural areas, when compared with their urban living counterparts ($P < 0.01$). Conversely, the cost of hospitalisation of children with ‘dental caries’ or ‘embedded and impacted teeth’ conditions living in metropolitan areas were 5.5, and 5.2 times higher than their rural living counterparts, respectively (Table 7.2). However, the admissions cost of rural living children (admitted for birth defects, pulp and periapical or dentofacial anomalies condition) were significantly higher among urban living counterparts ($P < 0.01$).

Cost per condition over time. Figure 7.2 shows that the costs of hospitalisation for common oral conditions except ‘dental caries’ were nearly doubled in 2009 ($P < 0.01$). However, the
admission cost of ‘dental caries’ in 2009 was almost threefold higher than the admission cost of children in 2000 ($P < 0.01$).

**Table 7.2**
The Australian Refine Diagnosis Related Group cost (in $ millions) of hospitalisation of Western Australian children based most common oral conditions and different variables

<table>
<thead>
<tr>
<th>AR-DRG cost based on Variables (AUD)*</th>
<th>Dental fracture</th>
<th>Birth defects</th>
<th>Developmental defects</th>
<th>Embedded &amp; impaction</th>
<th>Dental caries</th>
<th>Pulp &amp; periapical</th>
<th>Dentofacial anomalies</th>
</tr>
</thead>
<tbody>
<tr>
<td>All children</td>
<td>4.1</td>
<td>6.5</td>
<td>4.5</td>
<td>11.9</td>
<td>44.8</td>
<td>9.5</td>
<td>3.8</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>3</td>
<td>5.1</td>
<td>0.7</td>
<td>0.04</td>
<td>19.7</td>
<td>4.2</td>
<td>0.08</td>
</tr>
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<td>5–9</td>
<td>0.7</td>
<td>0.8</td>
<td>2.2</td>
<td>0.9</td>
<td>21</td>
<td>4.6</td>
<td>0.7</td>
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<tr>
<td>10–14</td>
<td>0.3</td>
<td>0.6</td>
<td>1.6</td>
<td>10.9</td>
<td>4.1</td>
<td>0.7</td>
<td>3</td>
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<td></td>
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<tr>
<td>Indigenous</td>
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<td>0.3</td>
<td>0.04</td>
<td>0.03</td>
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<td>1.1</td>
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<td>6.2</td>
<td>4.46</td>
<td>11.86</td>
<td>42.4</td>
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<td>7</td>
<td>21.2</td>
<td>4.2</td>
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<td></td>
</tr>
<tr>
<td>Most disadvantage</td>
<td>0.8</td>
<td>1.2</td>
<td>0.5</td>
<td>1</td>
<td>7.7</td>
<td>2.4</td>
<td>0.4</td>
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<td>Below average disadvantage</td>
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<td>1.8</td>
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<td>0.5</td>
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<tr>
<td>Average disadvantage</td>
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<td>8.1</td>
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<td>Above average disadvantage</td>
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<td>3.9</td>
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<td>1.4</td>
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<tr>
<td>Highly accessible</td>
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<td>0.7</td>
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<td>5</td>
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<td>10.8</td>
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<td>1.9</td>
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<td>0.4</td>
<td>10</td>
<td>37.9</td>
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*AUD $ = Australian Dollar
7.5. Discussion

This study indicates that, over time, the hospital admissions for dental reasons (in children) were associated with an increasing economic burden on Australian dental health expenditure. A steady but significant rise can be seen in the oral health-related admission rates of children over the period (Alsharif et al., 2014a). As the average cost per admission has increased, this inevitably led to an increase in total costs. Most of these funds went towards treating ‘dental caries’ and ‘embedded and impacted teeth’ conditions. This is consistent with previous studies (Tennant et al., 2000; Kruger Dyson, & Tennant, 2006).
Significant cost differences were found based on age, with children younger than 5 years old, incurred the highest admission costs as a result of traumatic dental fracture or birth defects (mainly cleft lip and palate). On the other hand, among children aged between 5- and 9-years-old, the highest admission costs of dental caries or pulp and periapical conditions might be attributed to the fact that children at this age generally have deciduous teeth that were exposed to cariogenic factors for a longer time. This explanation is supported by finding low costs of dental caries admissions for children in the oldest age group, as new healthy permanent dentition is present. In addition, older children are able to cope better with dental treatment under local anesthesia than younger children (Nsour & Almoherat, 2013). However, the greater cost related to treatment for embedded and impacted teeth at this age group was mainly attributable to the impaction of maxillary permanent canine that is common oral pathological finding reported after 12 years of age, especially among those seeking orthodontic treatment. Moreover, it has been evident that an impacted canine is twice more likely to be common in females than males (Litsas & Acar, 2011).

The Indigenous population is disadvantaged across a range of socioeconomic conditions that sequentially affect child health outcomes. The literature is replete with evidence that Indigenous children experience worse oral health than their non-Indigenous counterparts (Australian Institute of Health and Welfare, 2007; Smith et al., 2007), but this is not reflected in the costs of hospitalisation among Indigenous children. These challenges in accessing dental care are fundamentally linked to issues of affordability, lack of health-care service (even SDS), and the proportion of insured Indigenous children. In addition, most Indigenous children live in rural areas where dental health-care services may be sparse and located at great distances from the patient.
The structure of the dental system in Australia is largely private, consequently most hospitalisations concerning oral problems for children take place in private hospitals with both providers and services concentrated in major cities (Kruger Dyson, & Tennant, 2006; Australian Institute of Health and Welfare, 2010). In an urban environment, health-care services may be located closer in distance; therefore the availability of the service increases the utilisation and consequently increases the cost. On the other hand, it might be obvious that the greater costs of admissions in public hospitals were incurred by emergency oral conditions, whereas the highest costs of admissions in private hospitals were incurred by dental caries treatment and impacted teeth removals. Dental health insurance coverage is known to be the dominant predictors of the private sectors utilisation of and access to dental care. This is because of their ability to mitigate the costs of care (Alsharif, Kruger, & Tennant, 2014b).

Researches over the past decade have continued to show that low socioeconomic status children suffer disproportionately from many dental diseases and a delayed access to the health-care system that will increase their risk for other complications (Marshall & Spencer, 2006). However, our study indicates that hospitalisation costs of the most disadvantaged group are low, except for ‘pulp and periapical’ conditions. This may be attributed to the fact that children only access dental health care when conditions reached an advanced stage that requires admission for more invasive treatment, and accordingly a much greater public expense, than if they had been provided dental treatment or prevention in early stages.

Furthermore, for children living in remote regions of the state where access to dental care is difficult, resulting in long delays in the provision of treatment and, most likely, significant
morbidity associated with dental pain and oral infection. Additionally, travelling to distant centres for treatment under general anesthesia by specialist pediatric dentists has become the usual method by that treatment is provided to the majority of affected children. In this context, the costs which accounted primarily for this significant difference were travel and treatment costs associated with hospitalisation and the administration of general anesthesia (Milnes, Rubin, Karpa, & Tate, 1993). Many parents, especially rural-based or Indigenous, cannot afford such high hospitalisation and treatment costs. Accordingly, a procedure such as extraction of decayed teeth, which is relatively cheaper, is more preferable option. However, when affordability and accessibility issues are overcome, the remote band groups had significantly higher costs than groups that were located closer to treatment centres.

Over the last decade, there has been a substantial growth in hospitalisation costs for all conditions particularly dental caries. This might be explained by the increase in child population over the study period; however, hospitalisation rates also shows increases (Alsharif et al., 2014a). It has also been anecdotally reported that in light of the recent global economic crisis, overall dental treatment prices in Australia have increased well beyond inflation, and the shift toward demanding more expensive private services has occurred. Furthermore, it can be argued that a decline in the robustness of the current school dental service approach has an impact on child dental hospitalisations, resulting in elevated costs in WA. Figures of increasing cost over time would have implications for the future, indicating a significant burden on the Australian health-care system.

In Australia dental care is not subjected to the tenets of the Australian Health Act, hence the funding structure in the dental system is different to the rest of the health system in that
individuals pay for the majority of their care. Although government funding is significant, the subsidies available are far less than those provided in the general health system. The amount of funding available to the public system is dwarfed by consumer expenditure in the private system. However, historically, the United Kingdom included dental care in their National Health Service system. Therefore, economic analyses in the United Kingdom and other European nations are not generally applicable to Australia, given that different patterns of dental care utilisation and payment systems between countries result in marked variations in dental health-care expenditures.

### 7.6. Recommendations and Conclusion

In brief, our study concludes that it is important to prevent costly inpatient treatment by early detection, prevention, and intervention as findings indicate a substantial economic burden of child hospitalisation (for dental reasons) (Donly & Brown, 2005; Pienihakkinen, Jokela, & Alanen, 2005; Splieth, Nourallah, & Konig, 2004; Davies, 2003). Therefore, with limited public health resources, strategies are needed to focus on best practice principles of care and demand management for better utilisation of available health resources. In our view, tremendous monetary benefits are expected when primary prevention of dental caries, especially in children, through SDS is implemented. The high economic burden of children dental hospitalisation implies the need for health resources redistribution based on a regional need in conjugation with the development of community-based preventive programmes and treatment programmes.
Chapter Eight

8. Future Projections of Child Oral Health-related Hospital Admission Rates in Western Australia.

This chapter was published in the following article:

8.1. Abstract

Objective: This study aimed to project the hospital admission rates of Western Australian children for oral conditions, with a particular focus on dental caries, embedded and impacted teeth, and pulp and periapical conditions through to the year 2026.

Material and Methods: Two methods (the linear method and the exponentially weighted moving average) were used to generate projection data through to the year 2026, using the Western Australian Hospital Morbidity Dataset for the period 1999–2000 to 2008–2009.

Results: The projected admission rate increase in those children aged 14 years and younger from 2000 to 2026 was 43%. The admission rates are expected to more than double over time (7317 cases in 2026 compared to only 3008 cases in 2000) for those children living in metropolitan areas. Dental caries, embedded and impacted teeth, and pulp and periapical conditions will remain the top (mostly) preventable causes of admission throughout this time.

Recommendations and Conclusion: Anticipating the future burden of oral health-related hospital admissions in children, in terms of expected numbers of cases, is vital for optimising the resource allocation for early diagnosis, prevention and treatment. A concerted effort will be required by policymakers and oral health-care communities to effect substantial change for the future.

Key words: dental care for children, hospitalised child, oral health.
8.2. Introduction

Over the past 30 years, there have been significant improvements in the oral health of Western Australian children, partly associated with the development of a comprehensive school dental service (SDS) and public health measures, such as widely accessible fluoridated water supplies (Kruger Dyson, & Tennant, 2006). As a result, the prevalence of dental disease in children has diminished (Blinkhorn & Davies, 1996). However, dental caries are still a major public health concern in most developed countries, affecting 60–90% of school-age children, and their incidence is expected to increase significantly over time in many developing countries (World Health Organisation, 2015). Oral health conditions are responsible for the highest number of acute preventable hospital admissions and significant cost to Australia (The Steering Committee for the Review of Government Service Provision, 2010), and cause considerable social concern within the community.

In Western Australia (WA) during 1999–2000 and 2008-09, dental conditions accounted for 933 and 1081 hospital admissions per 100 000 person-year (PY), respectively; these numbers could be reduced by providing early access to appropriate services (Alsharif et al., 2014a). The majority of cases were for dental caries and extractions. Dental conditions cost the state more than $92 million over the last decade (Alsharif, Kruger, & Tennant, 2014c). Overall, 546 cases per 100 000 children per annum were admitted for ‘dental caries’ and 144 admissions per 100 000 had ‘embedded or impacted teeth’ (Alsharif et al., 2014c). In addition, a previous study has shown a clear urban–rural divide in child hospital admissions; the estimated age-adjusted hospitalisation rates (AARs) of urban-dwelling children were twice that of their rural-dwelling counterparts (Alsharif et al., 2014a).
By 2040, the WA population is projected to double, with metropolitan areas remaining the dominant population centres in the state (Australian Bureau of Statistics, 2014a). Hence, an increase in oral health-related conditions in children is expected to have a significant impact on the demands for oral health services over the next 20 years. This is likely to be exacerbated by limited resources and workforce shortages. Projections of oral health-related admission rates and their associated costs need to be performed to inform policy, planning and resource allocation. Previously, projections have led to better planning and resource allocation (Madge, 2000; Goss, 2008; Australian Government Department of Health, 2009; Australian Institute of Health and Welfare, 2014c; Health Workforce Australia 2014).

To date, there are no data available on future child oral-health hospitalisation demands in Western Australia. An understanding of the projected incidence of children’s oral conditions is a fundamental obligation to enable rational planning for monitoring and treatment of oral conditions. Against this backdrop, the aim of this study was to analyse projected oral-health-related admission rates of Western Australian children, with a particular focus on dental caries, embedded and impacted teeth, and pulp and periapical conditions through to 2026, based on 10 years of past hospitalisation data for robustness.

8.3. Material and Methods

8.3.1. Data Source

This study involved a de-identified detailed analysis of the data obtained from the Western Australian Hospital Morbidity Dataset for the period 1999–2000 to 2008–2009 under ethics approval from The University of Western Australia. A principal diagnosis was obtained for
every child under the age of 15 years admitted for an oral health condition (in both private and public hospitals) in WA for the study period, using the International Classification of Diseases Tenth Revision Australian Modification (ICD-10-AM) system. All principal diagnoses of oral health conditions (ICD-10-AM) were included in the analysis. The ICD-10-AM ‘is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol’ (Commonwealth Department of Health and Aged Care, 1998). Age and residential area for each child were analysed. Future predictions for dental caries, embedded and impacted teeth, and pulp and periapical conditions, which accounted for 75% of all hospitalised conditions during the study period, were also analysed.

8.3.2. Data Analysis

All projections were based on Age-Adjusted hospitalisation rates (AARs), which were calculated using the Health Statistics Calculator, a software package developed by the Health Department of WA. Population data (denominators) for hospital admission rates were obtained from estimations by the Health Department of WA. These estimations were based on population data obtained by Australian Bureau of Statistics census surveys. Two separate methods were used to project future cases (Gill, Codde, & Vasudaven, 1997). Both methods accounted for the projected increase in both the population and the incidence of these conditions, using ten years of data. The first method, the linear method, used historical data to estimate a line of best fit for each 5-year age group, using the method of least squares. Based on the estimated AARs, the future number of cases was determined. The second method, the exponentially weighted moving average (EWMA), used historical trends to
model future points equally. This method places greater weight on more recent data. Applying the two methods separately resulted in very similar trends; therefore, only the results of the linear method are presented. There is a general consensus among statisticians that a relatively simple linear model of age-specific rates provides a good fit to the data while giving reasonably accurate predictions over a short to medium time span (Australian Bureau of Statistics, 2014a). The accepted approach among statisticians preparing projections of this nature is to assume a linear model for increasing rates to prevent projecting admission rates below zero. Further, there is a fundamental presumption in this approach that the factors that affect oral health-related admissions, such as risk indicators, change in an approximately linear way with time for each age group (Australian Bureau of Statistics, 2014a). This presumption holds on condition that there are no major quantitative changes in any underlying factors, such as the introduction of an intervention program.

8.3.3. Cost Projections

Based on a previous study, Australian refined diagnosis-related groups (AR-DRGs) were used to calculate the direct cost of each patient episode on the basis of actual data about the treatment process (Alsharif, Kruger, & Tennant, 2015). Each AR-DRG represents ‘a class of patients with similar clinical conditions requiring similar hospital services’ (Australian Institute of Health and Welfare, 2013b). The DRG cost was divided into categories: low (0–4000); middle (4001–10 000); high (10 001–20 000); and extremely high (20 001 and over). The low-cost category was most representative of the overall cost distribution, which was normally distributed. Therefore, low-cost was deemed appropriate to use in future cost projections.
Other data analyses were performed using SPSS 21 for Windows (IBM Statistical Package for the Social Sciences, Chicago, IL, USA) and Excel 2007 (Microsoft, Redmont, WA USA).

8.4. Results

A total of 43,937 children (0–14 years) were admitted to hospital for oral-health-related conditions over the study period. Of these, 15% \((n = 6,525)\) were rural-dwelling children.

8.4.1. Projections of all Oral Health-related Hospitalisations

Rates

Population projections through 2026 for WA indicated a significant increase (66%) in the total population. The actual projected oral health-related admission rates increase in those aged 14 years and younger from 2000 to 2026 is 43% (Figure 8.1). Of the total projected oral health-related admissions, a 171% increase in hospitalisation rates of children aged 5–9 years is projected to occur in 2026. However, in 2026, a 23% decrease in hospitalisation rates among children younger than 5 years is projected (Figure 8.1).
**Figure 8.1**
Projection of children’s Age Adjusted hospitalisation Rates due to oral conditions over time and based on age.

It is anticipated that the AARs will more than double (7317 cases in 2026 compared to only 3008 cases in 2000) for those children living in metropolitan areas (Figure 8.2). In contrast, a slight reduction is projected in the AARs among rural-dwelling children (Figure 8.2).
**Figure 8.2**
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children based on location.

The overall direct costs of all oral health-related child hospitalisations are estimated to increase from $10 million in 2009 to $16 million in 2026, an increase of 61% (Figure 8.3). From 2016 to 2026, oral hospital admissions will cost the state a minimum of AU$147 million (Figure 8.3).
Figure 8.3
The projected diagnosis-related group cost of dental hospitalisation of Western Australian children through to 2026 in millions of dollars.

8.4.2. Projections of Dental Caries Hospitalisation Rates

Hospitalisation due to oral conditions among children is highly influenced by dental caries, as this condition accounts for ~50% of all cases. Assuming hospitalisation rates will follow a similar trend in future, it is projected that the overall AARs of dental caries will more than double from 406 to ~937 cases per 100,000 PY between 2000 and 2026. With the anticipated increases in the population, this equates to ~3742 new cases expected to be hospitalised in 2026 (Figure 8.4). In addition, the overall AARs of hospitalisation in children living in metropolitan areas is projected to rise from 417 to ~1190 cases per 100,000 PY between 2000 and 2026, which equates to ~3982 new cases expected to be admitted in 2026 (Figure 8.5). A significant gap is predicted to occur in the future between the hospitalisation rates of children living in rural areas compared to those living in metropolitan areas (Figure 8.5).
Figure 8.4
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to caries conditions based on age.

Figure 8.5
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to dental caries based on location.
8.4.3. Projections of Hospitalisation Rates for Embedded and Impacted Teeth

The admission rates of children with embedded and impacted teeth are projected to stabilise over the next decade, with children aged 10–14 years still accounting for the highest admission rates (Figure 8.6). Although hospitalisation rates of children living in metropolitan areas will decrease slightly over time, remarkable variations in admission rates will continue to occur between rural- and urban-dwelling children (Figure 8.7).

**Figure 8.6**
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to impacted or embedded tooth removal based on age.
Figure 8.7  
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to impacted or embedded dental removal based on location.

8.4.4. Projections of Hospitalisation Rates for Pulp and Periapical Treatment

The admission rates of children for pulp and periapical treatment are projected to stabilise over the next decade and are expected to reach ~244 cases per 100,000 PY in 2026, an increase of almost 66% from 2000 (Figure 8.8). The significant split in admission rates between rural- and urban-dwelling children will continue through the next 10 years, with children living in urban areas 2.4 times more likely to be admitted to hospital as a result of pulpal and periapical conditions than their rural-dwelling counterparts (Figure 8.9).
**Figure 8.8**
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to pulp and periapical conditions based on age.

**Figure 8.9**
Age-adjusted hospitalisation rates projection to 2026 of hospitalised children due to pulp and periapical dental conditions based on location.
8.5. Discussion

Although there has been a significant reduction in dental caries in children over the last generations in Australia (as in other developed countries), the rates of oral health-related hospital admissions among children have increased substantially over the past decade. The annual rates of admissions in WA are predicted to increase significantly over the next 20 years. It is important to note that projections are not intended to function as exact forecasts, but to indicate what might be expected if the stated assumptions were to apply over the projected time frame. More recently, our team has revealed that the AARs of hospitalisations for oral conditions increased from 926 in 2000 to 1085 cases per 100 000 PY in 2009 (Alsharif et al., 2014c). By 2026, the rates of avoidable hospitalisation and associated costs are projected to increase. It is reasonable to predict that the number of children with oral conditions will increase by an even greater percentage, as only school-registered children are clinically diagnosed and treated within the limited SDS scope. An increase in age-adjusted dental caries admission rates has been observed over the past 10 years and this trend is likely to continue, resulting in an estimated 52% increase in the annual number of admissions due to dental caries by 2020. If these trends continue, an estimated 83% increase in dental caries admissions can be expected by 2026. The dramatic increase in the anticipated number of dental caries in school-age children should be alarming to all those concerned with planning and providing dental services to children in WA.

The projected rates of hospitalisation for embedded and impacted teeth removal/treatment are expected to remain stable or decrease slightly. This might be attributed to the changing rates of procedures as a result of changing trends in clinician beliefs, as well as changing health insurance levels in the community. However, the authors believe that this trend is not
expected to continue indefinitely and there will be an increase in the projected number of cases admitted to hospital for the removal of embedded and impacted teeth among disadvantaged children once they have access to appropriate services. This assumption is based on the fact that disadvantaged children are at higher risk of systemic and metabolic disorders, genetic disorders and deciduous teeth injuries, which are all causes of delay in tooth eruption or impaction (Almonailiene, Balciuniene, & Tutkuviene, 2010).

It is predicted that there will be an increase in admission rates for pulpal and periapical conditions in children aged 5–9 years old over the next 20 years as a result of population growth and poor dental health service access. Long intervals between SDS visits might delay interventions and early prevention; consequently, children only access care when dental conditions have reached advanced stages. In addition, the lack of affordable dental care and insurance coverage lead to the postponement of dental treatment, often for years. These untreated symptoms inevitably become more severe, resulting in children requiring admission for more invasive treatment at a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

The health of rural- and remote-dwelling children in Australia is poorer than that of urban-dwelling children for most indicators, including marked inequalities in oral health and oral health services (Australian Institute of Health and Welfare, 2008b). Geographical access to health services is clearly the reason for these inequalities in health. In metropolitan areas, clinics are located mainly in community health centres, or on school or hospital grounds. However, in some rural communities, mobile dental clinics provide limited oral health services for children. This inequality is evident in the fact that children living in metropolitan
areas are more likely to be admitted to a hospital for dental procedures than children living in rural areas (Alsharif et al., 2014c). Children in rural and remote regions are also less likely to have private health cover (Alsharif et al., 2014b), which plays an important role in the private-driven oral health-care delivery system in Australia. Further contributing to inequalities is the fact that WA is experiencing a dental workforce shortage in rural and remote areas, especially in dental therapists and specialists (Steele et al., 2000).

Over the last decade, there has been substantial growth in hospitalisation costs for all oral conditions, particularly dental caries (Alsharif et al., 2015). This cost-pressure scenario is only expected to increase in the near future. As a result of the recent global economic crisis, dental treatment prices in Australia are expected to increase well beyond inflation rates and a demand for more expensive private services has occurred. In addition, a decline in the robustness of the current SDS approach has had an impact on child dental admissions, resulting in elevated costs in WA. The projected increasing costs will have implications for the future, indicating a significant burden on the Australian health-care system.

Increases in the AARs of children admitted for oral conditions may be explained by several factors. For example, demographic shifts in the Australian population will have a major influence on the projected number of oral-condition cases in the future. Although evidence indicates that some minority populations have higher oral-condition rates that are not reflected by lower admission rates, additional increases in the projected admission rates are expected once these groups gain access to the service. In addition to an actual increase in the incidence of oral diseases, population growth (primarily in urban areas), workforce shortages and misdistribution, changes in diagnostic and treatment practices, and limited
resources for specific conditions, are likely to affect the future burden of these diseases. These shifts will create a significant socioeconomic burden on the Australian dental health system, since dental services are not covered by the principle of universal access. Clearly, opportunities to target early intervention towards those at higher risk of the need for admission, and to target primary and preventive services towards areas of need, are key research and policy directions that come from this research.

8.6. Recommendations and Conclusion

Projections indicate increasing rates of oral health-related admissions among Western Australian children, especially for dental caries, and pulp and periapical conditions. Oral diseases among children have a considerable impact on the Western Australian community. The rates of oral health-related admissions occurring in Western Australian hospitals each year is an important measure of the burden of oral conditions in Australia and has implications for resource allocation and planning. Investment decisions on the prevention of oral conditions and treatment facilities, workforce planning and evaluation of oral health policy rely not only on knowing how many cases were hospitalised in a given year, but on how many can be expected to be admitted in the future. Therefore, a universal strategy is needed to set the platform for oral health actions in WA into the next decade. Anticipating the future burden of oral health-related admissions in children in terms of expected numbers of cases is vital in optimising the allocation of resources to enable children to have timely access to preventively focused dental care that meets the minimum standard benchmarks for oral health service provision.
Chapter Nine


This chapter was published in the following article:


9.1. Abstract

Objective: To identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia.

Material and Methods: All children hospitalised due to an oral-condition from 2000 to 2009, at metropolitan areas of Perth were included in the analysis of a 10-year data set. QGIS tools mapped the residential location of each child and socioeconomic data in relation to existing services (School Dental Service clinics).

Results: The tables and maps provide a clear indication of specific geographical areas, where no services are located, but where high hospital-admission rates are occurring, especially among school-age children. The least-disadvantaged areas and areas of high rates of school-age child hospital-admissions were more likely to be within 2km of the clinics than not. More of high risk-areas (socio-economically deprived areas combined with high oral health-related hospital admissions rates), were found within 2km of the clinics than elsewhere.

Recommendation and Conclusion: The application of GIS methodology has identified a community’s current service access needs, and assisted evidence based decision making for planning and implementing changes to increase access based on risk.

Key words: Geographic Information System, hospital admissions, child oral health, Australia.
9.2. Introduction

With the substantial reduction in dental decay prevalence in child populations there is an ongoing need for the systems that underpin care for this group to evolve in order to meet changing oral health profiles. Consistent with the greater exposure of many societies to fluoride, dental decay in children has diminished dramatically. In most developed countries caries prevalence hovers around 50% of the population, and severity as measured by the DMFT at age 12 years, is below two (Petersen, 2003). Caries experience in Australia is consistent with these global measures (Mejia et al., 2012). Several countries have, for many years, operated School Dental Services (SDS), which is (in various forms) a universal service model to provide primary dental care to the child population. These services started their existence in environments of high burdens of dental disease, and have adapted to falling burden of dental disease by, for example, means testing, integration with adult services and, in rare cases, cessation or outsourcing to private dental providers. With the majority of the disease burden now resting with a small minority of children, the concept of targeting of dental services to those in greatest need becomes a key to effective services. Results of our previous studies indicated that Indigenous status, absence of private insurance, low socioeconomic status and rural living are the most common risk indicators of decreased receipt of preventive service or increased perceived unmet need (Alsharif et al., 2014a;b; 2015). In addition, it is well known that previous history of dental caries is the best indicator of higher future risk. In this study, we used geographic information systems (GIS) method to identify areas of need for primary dental services for children. GIS is a computational approach to health planning is not new (Aronoff, 1989), and GIS technology has a distinct component of geography or location that captures and represents features known as georeferenced or spatial data (Fun-Mun, Poh-Chin, & Ka-Win, 2008). Within the framework of
health information management, GIS are able to answer health questions regarding ‘where is what’ (Graves, 2008), and has come into use in health to describe and understand the changing spatial organisation of the health care system, examining its relation to health outcomes and access, and exploring how to improve health care delivery (McLafferty, 2003).

The aim of this study was to identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia using the oral health related hospitalisation data of all children over a ten year period.

9.3. Materials and Methods

Ethics approval to conduct the study was granted by the Ethics Committee of The University of Western Australia RA/4/1/5502.

To identify the possible gaps in primary dental service provision to children, data from metropolitan Western Australia (WA) were used. WA occupies the Western third of the Australian continent; comprising an area of about 2.5 million sq.km with a population of about half a million aged under 15 years (Australian Bureau of Statistics, 2014b). Of those, 19% live in the capital city of Perth region (Australian Bureau of Statistics, 2015). Perth was used for this study as 73% of all hospital admissions for children under age 15 occurred in the metropolitan area, and existing SDS clinics are located predominantly in that area. The existing SDS in WA is a universal coverage model, providing free primary dental care to all school registered children who choose to enrol in the service. Despite being a universally applied system however, it reaches a under 30% of children (GWA DHS, 2008c). Some parents who choose to not enrol their children can access private dental services, but this is
not an affordable or accessible option for many. Since 2000, SDS coverage has been declining rapidly, and more children are hospitalised for preventable oral related conditions (Spencer, 2012). Against this backdrop it is important that reliable methods are used to determine the distribution of demand for SDS clinics, to inform policy development and service planning.

9.3.1. Hospitalisation Data:

Hospitalisation data were analysed for every 0- to 14-year-olds, diagnosed and accordingly admitted to hospital in WA for an oral health condition, as classified by the International Classification of Disease – Tenth Australian Modification (ICD-10AM) (CDHAC, 1998). These data were obtained from the WA Hospital Morbidity Dataset (HMDS) for 10 financial years, from 1999/00 to 2008/09. Primary place of residence at the time of hospitalisation were also analysed, using Statistical Local Areas (SLAs). A total of 37 SLAs cover WA without gaps or overlaps, and their boundary files were obtained from the (ABS) website (Australian Bureau of Statistics, 2012a; b). Age adjusted Rates (AAR) of child hospital admissions per SLA were calculated using the Health Statistics Calculator developed by the Health Department of Western Australia and population data based on ABS census data. Based on these admission rates per SLA, the entire child population was categorised into five quintiles, separately for each age group.

9.3.2. Census Collection District (CD):

Admission data for each child was available at SLA level, but for higher accuracy and precision analysis, a smaller area-based analysis was needed, and therefore census Collection Districts (CDs) were used. A CD is much smaller than an SLA, and is a quas-
measure of density of residents (based on an area that a single census officer can collect data from). Census collection districts and the geographic boundaries of each CD were obtained from the ABS webpage (2011). The Perth metropolitan area covers 2,840 CDs, 65% of the WA’s CDs, with more than 270,000 under 14-year-olds. Hospitalisation data across each of the 37 WA SLAs were distributed by age groups (0–4, 5–9 and 10–14 years). For each age group, the rates of child hospitalisations was calculated for each SLA then this SLA rate was applied to each of the SLA’s CDs.

9.3.3. Population Data

The numbers of under 15-year-olds for each CD were obtained from the ABS (2006) census data (Australian Bureau of Statistics, 2013b).

9.3.4. Socioeconomic Status Data

Each CD has a Socio-Economic Indexes of Area score (SEIFA 2006) assigned by the ABS, based on socioeconomic indicators of the CD’s population (Australian Bureau of Statistics, 2013a). SEIFA is a nationally accepted coding system ranking areas in Australia according to relative socioeconomic advantage based on five-yearly census data (Australian Bureau of Statistics, 2013a). These rankings were dichotomised into most disadvantaged areas (Poorest, SEIFA deciles 1 to 5) and least disadvantaged areas (Wealthiest, SEIFA deciles 6 to 10).
9.3.5. School Dental Service Locations:

The addresses of all fixed SDS clinics were obtained from the Department of Health (Australian Bureau of Statistics, 2011) and geocoded, i.e. changed into map coordinates and located on a map. The populations of children who lived within 2km of each SDS clinic were identified.

9.3.6. Geographic Information Systems (GIS)

GIS in this study were used as a technique for integrating hospitalisation data related to dental disease with known risk indicators (e.g. socioeconomics), to identify and prioritise geographic areas of high need for a dental service. The approach while tested on this one city was designed to be universally applicable. The resultant maps indicated where SDS clinics were located, as well as the following attributes of the child population both within and outside of a 2km zone around it: population density, age-specific hospital admission rates and an indication of area socioeconomic disadvantage.

All mapping and geocoding of data used QGIS v.2.6 (Boston, USA), analyses used SPSS 21 for Windows and data were tabulated in Excel 2007.

9.4. Results

From 2000 to 2009, 31,910 metropolitan Perth children aged from 0–14 years were hospital admissions for oral health-related conditions. All (77 fixed SDS clinics were included, with a ratio of 2,414 school aged child population per clinic.
The distributions of hospital admissions rates by both socioeconomic status and location inside or outside 2km of a clinic are presented in Tables 9.1, 9.2 and 9.3. More children (68%) lived within 2km of existing SDS clinics than further away. Of all children living within 2km of a clinic, 18% of 0–4 year olds come from areas with higher (i.e. high or very high) admission rates and low socioeconomic scores (poorest urban areas) (Table 9.1). In addition, 11% and 5% of 5–9 and 10–14 year-olds, respectively, were living in the poorest areas with higher admission rates (Table 9.2 and 9.3).

**Table 9.1**
Zero to four years old child population distribution by hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics.

<table>
<thead>
<tr>
<th>Admission rates</th>
<th>Very low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorest areas</td>
<td>Wealthiest areas</td>
<td>Total</td>
<td>Poorest areas</td>
<td>Wealthiest areas</td>
</tr>
<tr>
<td>Very low</td>
<td>3,964 (7%)</td>
<td>7,791 (13%)</td>
<td>11,758 (20%)</td>
<td>1,153 (4%)</td>
<td>5,349 (20%)</td>
</tr>
<tr>
<td>Low</td>
<td>4,656 (8%)</td>
<td>6,181 (10%)</td>
<td>10,837 (18%)</td>
<td>1,340 (5%)</td>
<td>4,525 (17%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>6,355 (11%)</td>
<td>6,947 (12%)</td>
<td>13,302 (23%)</td>
<td>967 (4%)</td>
<td>3,525 (13%)</td>
</tr>
<tr>
<td>High</td>
<td>5,000 (8%)</td>
<td>7,170 (12%)</td>
<td>12,170 (20%)</td>
<td>1,077 (4%)</td>
<td>3,073 (11%)</td>
</tr>
<tr>
<td>Very High</td>
<td>5,431 (9%)</td>
<td>5,528 (9%)</td>
<td>10,962 (18%)</td>
<td>1,950 (7%)</td>
<td>4,103 (15%)</td>
</tr>
<tr>
<td>Total</td>
<td>25,406 (43%)</td>
<td>33,617 (57%)</td>
<td>59,029 (100%)</td>
<td>6,487 (24%)</td>
<td>20,575 (76%)</td>
</tr>
</tbody>
</table>

1All admission rates per 100,000 population. (Very Low = 0-1141, Low = 1142-1183, Moderate = 1184-1209, High = 1210-1299, Very High ≥ 1300)
Table 9.2:
Five to nine years old child population distribution by hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics.

<table>
<thead>
<tr>
<th>Admission rates</th>
<th>Inside the 2km zones</th>
<th>Outside the 2km zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorest areas</td>
<td>Wealthiest areas</td>
</tr>
<tr>
<td>Very low</td>
<td>8,046 (13%)</td>
<td>5,606 (9%)</td>
</tr>
<tr>
<td>Low</td>
<td>5,356 (9%)</td>
<td>7,161 (12%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>5,287 (9%)</td>
<td>7,255 (12%)</td>
</tr>
<tr>
<td>High</td>
<td>4,567 (7%)</td>
<td>6,499 (11%)</td>
</tr>
<tr>
<td>Very High</td>
<td>1,884 (3%)</td>
<td>9,256 (15%)</td>
</tr>
<tr>
<td>Total</td>
<td>25,140 (41%)</td>
<td>35,777 (59%)</td>
</tr>
</tbody>
</table>

1All admission rates per 100 000 population. (Very Low = 0-1041, Low = 1042-1139, Moderate=1140-1209, High=1210-1391, Very High≥1392)

Table 9.3
Ten to fourteen years old child population distribution based on hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics.

<table>
<thead>
<tr>
<th>Admission rates</th>
<th>Inside the 2km zones</th>
<th>Outside the 2km zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorest areas</td>
<td>Wealthiest areas</td>
</tr>
<tr>
<td>Very low</td>
<td>8,691 (13%)</td>
<td>5,356 (8%)</td>
</tr>
<tr>
<td>Low</td>
<td>6,362 (10%)</td>
<td>9,564 (14%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>7,964 (12%)</td>
<td>9,103 (14%)</td>
</tr>
<tr>
<td>High</td>
<td>2,346 (4%)</td>
<td>7,263 (11%)</td>
</tr>
<tr>
<td>Very High</td>
<td>580 (1%)</td>
<td>8,042 (12%)</td>
</tr>
<tr>
<td>Total</td>
<td>25,943 (40%)</td>
<td>39,328 (60%)</td>
</tr>
</tbody>
</table>

1All admission rates per 100 000 population. (Very Low = 0-652, Low = 653-773, Moderate=774-817, High=818-980, Very High≥981)

About a third of children live outside the 2km zones, 6% of them come from the poorest and higher admission rates urban areas. Meanwhile, 41% of all the children are from the wealthiest areas with higher hospitalisation rates and lived predominantly more than 2km from a clinic (Tables 9.1–9.3).

In this analysis, the term ‘highest risk areas’ refers to CDs with the poorest areas and having high oral related hospital admissions rates; ‘lowest risk areas’ being the wealthiest with the
lowest admission rates. Note that admissions were based on children’s addresses at the time of admission. The locations of clinics were considered as a potential barrier to children’s hospital admissions through access to early diagnosis and treatment.

Large geographical variations of high risk areas in relation to age, either outside of, or inside the 2km zone of existing SDS clinics, were observed (Figures 9.1 and 9.2). More high risk areas were observed among preschool aged children, regardless of their location in relation to the clinics. High risk areas for children aged under 5 years were more likely to be within, rather than outside of a 2km radius of a clinic. There were also more high risk areas within, rather than outside 2km of clinics (Figures 9.1 and 9.2) for children older than 5 years. Most high risk areas were in the peripheral areas of this particular metropolitan region.

Figures 9.3 and 9.4 compared the high oral related admission rates of children living in the wealthiest areas, outside and inside the 2km zone of existing SDS clinics and reveal large geographical variation. For the wealthiest areas, those with high admission rates of school-age children were more likely to be within a 2 km of a clinic than further away. However, many areas at risk of high (school-age children) hospitalisation rates were found more than 2km from a clinic, where no SDS service is available. Most wealthier areas with high preschool child hospital admission rates, were concentrated in peripheral areas of this metropolitan region.
Figure 9.1
High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) inside 2km zones of existing School Dental Service clinics in Perth.
Figure 9.2
High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) outside 2km zones of existing School Dental Service clinics in Perth.
Figure 9.3
High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) inside 2km zones of existing School Dental Service clinics in Perth.
Figure 9.4
High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) outside 2km zones of existing School Dental Service clinics in Perth.
When comparing children of different age groups, from poorest/wealthiest areas, where high risk of hospitalisations occur, differences were observed (Figures 9.1–9.4). Most areas with high risk preschool admission rates, were from the poorest areas. In contract, most of high risk school-age hospital admissions areas, were from the wealthiest areas, with a significant number being in areas with worse SDS coverage.

9.5. Discussion

While there has been a significant reduction in tooth decay levels in children over the last generation in Australia as in other developed economies, marked inequalities in oral health still exist. Results of our earlier work on the incidence of oral related hospitalisations among the child population of Western Australia were previously published (Alsharif et al., 2014a). It has been determined that the total Diagnosis Related group (DRG) cost of these admissions was AUD$92 million, with an estimated additional $138 million as indirect cost (Alsharif et al., 2015). While hospitals are a vital component of any health system, the Australian dental health care system is searching for ways to increase SDS coverage and reduce costs of hospitalisations. One clear strategy is to increase the access to and utilisation of those universal primary care and preventive services.

In the present study, integrated data from hospital admissions, socioeconomic population-based indicators, and service locations, were used to form a cohesive risk-based geographic output to support the spatial configuration of future service planning. The study demonstrates an application of GIS to population-based oral health planning.
The findings reflect the oral health profile disparities of a metropolitan population. Preventable oral hospitalisations have been proposed as a key marker of poor health plan performance (Australian Institute of Health and Welfare, 2014b). Currently, SDSs are the main public child dental program in Australia, providing dental check-ups, emergency and basic treatment, but cover only limited care for enrolled school children, particularly those within disadvantaged families (NSW Oral Health Alliance, 2010). Treatment outside the scope of the SDS is referred to other providers and any costs are the responsibility of the parent or guardian (Government of Western Australian. Department of Health, 2008a). Many studies confirmed that lower use of preventive health services, delay seeking primary care and higher levels of oral diseases are observed among children living in low socioeconomic areas, these untreated symptoms get more severe and admission for complex treatment may be inevitable (Australian Bureau of Statistics, 2010). However, admission rates do not reflect the actual burden of the disease among disadvantaged groups possibly due to economic constraints and reduced mobility.

On the other hand, a different admission pattern was evident among children from high SES areas. These children were more likely to be admitted for oral conditions than those living in more deprived areas. Based on our previous study using the same data set, 76% of children in wealthy areas have private dental health insurance (compared to only 24% of those in poor areas) which might indicate that insurance enabled improved access to dental care and led to greater demand for hospital-based care once access had been obtained (Alsharif et al., 2014b; Bagramian et al., 2009).
This can be confirmed by the findings in Figures 9.3 and 9.4, where children from wealthy areas are more likely to be admitted for oral related conditions than children living in poor areas. Nevertheless, it is obvious from our previous analysis that insured, wealthy children are more likely to be admitted for less invasive treatment than their most deprived counterparts (who were probably more likely to receive invasive treatment), (Alsharif et al., 2014a;b) despite individuals from poor backgrounds carrying a higher burden of oral disease (Australian Institute of Health and Welfare, 2011a). In general, it is evident that people from the most deprived areas were less likely to have taken preventive health actions such as dental screening, or having their teeth cleaned (Australian Bureau of Statistics, 1999). Our study findings suggested that variations in SES may lead to variations in utilising complex health service based on need. This may contribute to widening oral health inequalities among Australians, with more low-SES children requiring admission for more invasive treatment which has a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

The results and maps provide a clear indication of specific geographical areas (in this city) where no local service is provided, but where high hospital admission rates occur especially among school-age children.

Therefore, our findings provide valuable insights to the extent of child oral health admissions in relation to access to existing services and deprivation mapped in detail across the city. These findings provide a methodological approach that can be applied, not just locally, but elsewhere to assist in planning resource allocation, prioritising services and targeting of interventions.
9.6. Recommendations and Conclusion

This study has applied GIS methodology to identify a community’s current service access needs, and informed evidence based decision making for planning and implementing changes to increase access based on risk. The methods developed in this framework can be adopted by other communities to identify a set of target areas with vulnerable populations and subsequently to monitor the effectiveness of remedial interventions. This model may be particularly well suited for planning and prioritising future health services in other urban communities, based on population projections and disease models of the current population.
Chapter Ten

10. Discussion and Conclusion
10.1. Introduction

The Australian health care system’s fundamental goal is to ensure individual accessibility to care based on need rather than ability to pay. Since the Australian Health Act does not consider dental care as part of general health care, this goal has not been entirely met in relation to oral or dental services. This compartmentalisation needs to be reconsidered as oral health affects general health by causing considerable pain and suffering and by changing their diet, speech and quality of life.

Australian child national surveys have found that there is an overall decrease in the average number of decayed teeth over the past 30 years, however, since the late 1990s a gradual increase has been noticed (Australian Institute of Health and Welfare, 2015). Australians’ oral health care is delivered through private practice or government-subsidised programmes such as SDS, or through public hospital clinics for adults (Haas & Anderson, 2005). The existing SDS remains the only universal coverage model which is limited to school registered children. In general, since 2000, SDS coverage has been declining, and at the same time we have seen more children hospitalised for preventable oral related conditions (Spencer, 2012). We now find that dental diseases has become the third most common cause for having general anaesthetics in pre-school age Western Australian children (Sims et al., 2005).

Previous research has reported a gradual increase in oral hospital admissions trend among Western Australian children since the late 1990s (Tennant et al., 2000; Kruger Dyson, & Tennant, 2006; Slack-Smith et al., 2009; Slack-Smith et al., 2013). Reports on those
admissions indicated that higher rates of hospitalisation were observed among children living in rural areas, those of low SES and of Indigenous origin, and the highest admissions were amongst pre-school aged children. Other study suggest that even adult hospitalisations for oral-health-related conditions remain considerable, even though a large proportion might be preventable (Kruger & Tennent, 2016). High hospital admission rates indicate an increase in the prevalence of those conditions within the community, poor non-hospital care system performance or, alternatively, an increasing use of the general anesthesia in the hospital system for dental needs (Australian Institute of Health and Welfare, 2013a).

In terms of funding and access, the oral health care system does not operate in the same way as the general health care system in Australia, and strategies to identify and address access issues should be based on relevant and reliable information such as population based studies. Little is known about the current trends in potentially preventable hospitalisations over time in Western Australian children, as well as those groups in the population most at risk, and the specific dental conditions leading to admissions. Against this backdrop it is important to identify the recent trends of oral hospital admissions in children, as well as identifying groups at higher risk for admission, in order to develop a reliable method to determine the distribution of demand for SDS clinics which will enable precise policy development and service planning.

10.2. Trend of Children Oral Health-related Hospitalisation

The study (Chapter 5) aims to analyse a decade of potentially avoidable children oral related hospital admissions in Western Australian children under the age of 15 years, examining associations with socio-demographic characteristics and with particular focus on dental
decay and Indigenous children. In contrast to the null hypothesis, the results identified groups within the child population more likely to be admitted to hospital for treatment of oral conditions. The results of Chapter Five showed that Kruger et al.’s (2006) population had similar trends of school aged child dental hospital admission rates to our population. However, differences were observed between the two studies when pre-school child admission rates were compared; suggesting that there is somehow an increase access to oral preventive services among this particular group or a changing rates of procedures over time might be a result of changing trends in clinician beliefs, as well as changing health insurance levels in the community; no specific reason for change is evident.

Although Indigenous status, poverty and rural/remote dwelling are all risk indicators for admission to hospital for dental conditions, WA children admission rates were higher among non-Indigenous children, and those living in least disadvantaged metropolitan areas. The differences observed are thought to be attributed to several factors. One of those factors is the fact that Western Australia is experiencing a dental workforce shortage in rural and remote areas, especially in terms of dental therapist and dental specialists (Steele et al., 2000). This unequal distribution can also be attributable to the variation in geographical access to health services (Steele et al., 2000).

As health insurance coverage has previously been found to be a good predictor of preventive care service use (Kenney et al., 2005; Harford & Luzzi, 2010), this thesis (Chapter 6) has examine the disparities in dental insurance coverage among WA children admitted for oral related conditions and associated factors to address the equalities that currently exist. It is apparent that there are statistically significant disparities in dental insurance coverage
among hospitalised children associated with Indigenous status, socioeconomic status and remoteness and accessibility of residential area, which might reflect the socio-demographic and economic barriers to dental service utilisation. The results of this thesis confirm that as a result of inadequate health insurance coverage in privately driven market, numerous concerns about dental service utilisation are raised. Those children who did have dental health insurance were more likely to come from urban, accessible and least disadvantaged areas. This result is of a particular significance because it indicates that insurance enabled access to dental care and led to greater demand for care once access had been obtained. Although private dental insurance does not necessarily increase receipt of preventive service or decrease perceived unmet need in all cases, it is evident that insured children are more likely to be hospitalised for less invasive treatment than their uninsured counterparts (Chapter Six). Kasper et al. (2000) found that the uninsured individuals were more likely to have difficulty obtaining health care once they lost coverage. However, those uninsured individuals that did gain private health cover had increased access to health services compared with those that remained uninsured (Kasper et al., 2000). In terms of health status, it is suggested that individuals losing coverage might experience adverse health outcomes compared with those that remained insured (Kasper et al., 2000).

Therefore, there is now evidence (Chapter Six) that having private health insurance increases access to dental care and possibly improves oral health status, and the disparities observed in regards of dental insurance could attributed to subtle variations between the different subsets of the population. The Australian government provided a ‘safety-net’ system (SDS) as a way to provide free or reduced fee dental care to uninsured children. However, these sources of care are not always accessed and, as the numbers of poor and
uninsured increase, the ‘safety-net’ health system will be unable to bear the burden of providing dental health care to all of the uninsured. In addition, any further invasive treatment is referred to other providers and any costs are the responsibility of the parent.

As the United Kingdom included dental care in their National Health Service system, economic analyses in the UK and other European nations are not generally applicable to Australia, given that different patterns of dental care utilisation and payment systems between countries result in marked variations in dental health care expenditures. Therefore, (Chapter Seven) aims to analyse the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years, and to identify socio-demographic characteristics associated with these costs. When costs were estimated using DRG, a substantial growth in hospitalisation costs for all conditions particularly dental caries were observed. Admittedly, the child population increased over the study period, but not just did this result in increasing absolute numbers of hospitalisations, but there was an increase in rates of hospital admissions (Chapter Five). It has also been anecdotally reported that in light of the recent global economic crisis, overall dental treatment prices in Australia have increased well beyond inflation, and the shift toward demanding more expensive private services has occurred. Furthermore, it can be argued that a decline in the robustness of the current school dental service approach has an impact on child dental hospitalisations, resulting in elevated costs in WA. Figures of increasing cost over time would have implications for the future, indicating a significant burden on the Australian health care system.

The literature is replete with evidence that the socioeconomic disadvantage experienced by rural living Indigenous people places them at greater risk of exposure to behavioural and
environmental health risk indicators (Australian Institute of Health and Welfare, 2007a; Smith et al., 2007), however, this is not reflected in the hospital admission rates and associated costs (Chapter Five & Seven). Although the Government funding is significant, the subsidies available are far less than those provided in the general health system. The amount of funding available to the public system is dwarfed by consumer expenditure in the private system. Therefore, these challenges in accessing dental care are fundamentally linked to issues of affordability, lack of health care service (including SDS) and the proportion of uninsured children. Therefore, an understanding of the projected incidence of children’s oral conditions is a fundamental obligation to enable rational planning for monitoring and treatment of oral conditions.

By 2040, the WA population is projected to double; with metropolitan areas remaining the dominant population centre in WA (Australian Bureau of Statistics, 2013b). Hence, an increase in oral health-related conditions in children is expected to have an enormous impact on the demands for oral health services over the next 20 years, particularly with limited resources and workforce shortages. Unfortunately, there were no data available on future child oral health hospitalisation demands in Western Australia. Against this backdrop (Chapter Eight) aims to project future oral-health related admission rates of Western Australian children through to the year 2026, based on 10 years of past hospitalisation data for robustness. The rates of oral related hospital admissions among children have substantially increased over the past decade (Chapter Five). Subsequent to this, the annual rates of admissions in Western Australia are predicted to increase significantly over the next 20 years. It is also reasonable to predict that the number of children with oral conditions will increase by an even greater percentage, as only school registered children are clinically
diagnosed and treated within the limited SDS scope. Increases in the AAR of children admitted for oral conditions over time may be explained by a number of possible factors. For example, the demographic shifts in the Australian population have a major influence on the projected number of oral condition cases for the future. Although, evidence indicates that some minority populations have higher oral condition rates which is not reflected by lower admission rates, additional increases in the projected admission rates are expected once they get access to the service. In addition to a true increase in the incidence of oral diseases, population growth primarily in urban areas, workforce shortages and maldistribution, changes in diagnostic and treatment practices, along with limited resources for specific conditions impact the future burden of these diseases. Those increases will create a significant socioeconomic burden on the Australian dental health system, since dental services are not covered by the principle of universal access. This was in general agreement with Kruger & Tennant (2015a,b) preliminary study which reported that projections indicate that if current trends are set to continue, hospitalisations for oral health-related conditions among Western Australians older than 65 years will place a considerable burden on the health system.

### 10.3. Trends of Children Oral Health-related Hospitalisation for Most Prevalent Conditions

An analysis of oral related hospital admissions indicated that most hospitalisation were for ‘dental caries’, ‘embedded and impacted teeth’ and ‘pulp and Periapical’ conditions. The outcome is similar to other studies which have obtain reliable results indicating an increase
in the hospital admission rate of ‘dental caries’ over time. When establishing differences at
the population level, males, non-Indigenous, insured, living in least deprived urban areas
exhibited significantly higher rates of hospitalisation due to ‘dental caries’. Across all ages,
primary school age, followed by pre-school age groups experienced higher admission rates
due to ‘dental caries’. The admission cost of ‘dental caries’ in 2009, was almost three-folds
higher than the admission cost of children in 2000. Higher hospital admission costs were
observed among children aged younger than 9 years, non-Indigenous, living in accessible
metropolitan areas. Approximately, 95% Indigenous children, who were admitted for dental
caries treatment, were uninsured, in contrast to 45% of non-Indigenous children. Another
point of interest is that the projected overall AAR of dental caries is expected to more than
double by 2026. The dramatic increase in the anticipated number of dental caries in school
age children should be alarming to all those concerned with planning and providing dental
services to children in Western Australia. Additional analysis revealed a massive gap is
observed to occur in the future between the caries related hospital admission rates in
children living in rural areas when compared to their metropolitan counterparts.

The data obtained for Chapter Five, demonstrated there are significant differences in
hospitalisations for ‘embedded and impacted teeth’ between non-Indigenous and
Indigenous children. Non-Indigenous children were 29 times more likely to be admitted for
impacted teeth removal than Indigenous counterparts. This result is of a particular
significance because it demonstrates how private health cover plays an important role in
dental health-care delivery in Australia, as non-Indigenous children were more likely to be
covered than Indigenous children. However, hospitalisation among the older group is
unlikely to be due to third molar impaction, as maxillary canine is common oral pathological
finding reported in children aged 11-14 years, especially those seeking orthodontic treatment (Manne et al., 2012; Litsas & Acar, 2011). Embedded and impacted teeth removal was predominantly undertaken in the private sector which is not managed through policy directives. ‘Embedded and impacted teeth’ significantly incurred the highest costs of admissions among 10–14 year-olds, children living in least disadvantage and metropolitan areas. The projected rates of hospitalisation for embedded and impacted teeth removal are expected to remain stable or decrease slightly. This might be attributed to early detection of permanent canine displacement, and early intervention by removal of the retained deciduous canine which has been proven to improve the angulation and eruption of an ectopic permanent canine (Ericson & Kurol, 1986a). However, the authors believe that this constant trend is not expected to continue indefinitely and there will be an increase in the projected number of cases admitted to hospital for embedded and impacted teeth removal among disadvantaged children once they have access to appropriate services. Unless SDS providers in WA incorporate canine’s eruption assessment into their routine examination of the child’s dental development from the age of 8. Thus, when possible canine impaction is suspected further diagnostic tests and extraction of the retained deciduous canine may be required. Previous international comparison revealed significant differences in rates of admission for impacted teeth, with England having rates approximately five times less than France, and seven times less than Australia. Those results could be explained by the implementation of guidelines in the United Kingdom, and the absence of similar guidelines in France and Australia (Anjrini et al., 2014). On the other hand, although hospitalisation rates of children living in metropolitan areas will slightly decrease over time, remarkable variations in the admission rates will continue to be observed between rural and urban living children.
Hospitalisations for ‘pulp and periapical’ conditions were mainly due to periapical abscess without sinus formation. It is not surprising that uninsured, Australian Indigenous male children aged less than 9 years, and living in the most disadvantaged areas were more likely to be admitted for this condition. When determining the insurance status of children admitted for pulp and periapical conditions, both Indigenous and non-Indigenous children revealed inadequate health coverage. The highest costs of admission for pulp and periapical were significantly accounted for 5–9 year old children. Additional analysis revealed that hospitalisation costs of the most disadvantaged group are low for all oral conditions, except for ‘Pulpal and periapical’ conditions. This may be attributed to the fact that children only access dental health care when conditions reached an advanced stage which requires admission for more invasive treatment, and accordingly a much greater public expense, than if they had been provided dental treatment or prevention in early stages. Even assuming the current hospitalisation rates, it is been projected that the admission rates of children for pulp and periapical treatment will stabilise over the next decade, except for children aged 5–9 years old. This might be due to long intervals between SDS’s visits which might delay interventions and early prevention, and children thus access care when conditions reached advanced stages. In addition, lack of affordable dental care and insurance coverage lead to postponing dental treatment, often for years. These untreated symptoms inevitably get more severe, resulting in children requiring admission. The significant split of admission rates between rural/urban living children will continue to exist through the next 10 years.

Most hospitalisations for ‘birth defects’ were for ankyloglossia, followed by cleft lip and palate. Admissions for birth defect treatment were common among pre-school age children,
non-Indigenous, children living in least disadvantaged urban areas. Children admitted for birth defect conditions were more likely to be uninsured, with a higher rate of admissions encountered for public hospitals. On the other hand, the highest percentages of ‘Developmental defects’ admissions were for supernumerary teeth and disturbances in tooth formation or eruption conditions, with children aged 5–9 years more likely to be admitted for treatment of dental developmental defect conditions. Children living in least disadvantaged urban areas and being insured were more likely to be admitted in private hospitals for ‘Developmental defect’ conditions.

10.4. Framework Model

Without a doubt, potentially preventable oral hospitalisations have been proposed as a key marker of poor health system performance (Australian Institute of Health and Welfare, 2014a). Therefore, the Australian dental health care system is searching for ways to increase universal primary care and preventative services coverage. One clear strategy is to increase the access to and utilisation of those primary oral health services (in this case SDS) and reduce costs of hospitalisations.

Previously, no studies have been conducted which integrated data from hospital admissions, socioeconomics and service locations to form a cohesive risk based geographic output. In this preliminary study (Chapter Nine), the hospitalisation data set has been merged with the population distribution data using a geographic modelling technique which support the spatial configuration of future service planning. The study (Chapter Nine) demonstrates an application of GIS to population-based oral health planning. In the agreement with the null hypothesis, the findings reflect the oral health profile disparities of a population living in the
same area, indicating that variations in SES and primary service access (e.g. SDS), may lead to variations in utilising complex health service based on need. These discrepancies may contribute to stark inequalities in oral health among Australian children.

The models have provided a clear indication of specific geographical areas (in this particular metropolitan region) where no services (SDS clinics) are located, but where high hospital admission rates are occurring, especially among school-age children. Therefore, our population-based framework method has with the example data provided valuable insight to the extent of child oral health admissions in relation to access to existing services, within a precise socioeconomic characteristic of a geographical area. These findings provide a methodological approach that can be applied, not just locally, but elsewhere to assist in planning resource allocation, service prioritising and implementing of targeting-appropriate intervention.

10.5. Future Studies

Since it was revealed in this thesis that children oral health diseases are not evenly distributed anymore and one universal approach (e.g. SDS) that fits all Australian children dental health has to be modified to address WA’s sprawling geographic and demographic spread. Therefore, additional in-depth analysis should include those areas which were identified as high risk areas of oral hospitalisation, to guide the design and selection of SDS interventions in those specific areas. An increase in efforts is necessary to curb escalating government health expenditure by reducing avoidable and preventable oral health related hospitalisations, and focusing efforts on an improved, accessible and equitable primary oral health care system.
10.6. Recommendations and Conclusion

Most oral conditions, and especially dental caries, are preventable. Thus, this thesis investigated the avoidable dental hospitalisations to identify groups within the population at higher risk for hospitalisation, as well as identifying time trends in hospitalisation rates against a background of rapidly changing demographics (Chapter Five). This information should be utilised and applied to prevent costly in-patient treatment by early detection, prevention, and intervention. At a time when public health resources are limited, strategies need to be developed to focus on these high-risk groups and best practice principles of care and demand management to better utilise limited health resources.

Dental health insurance is a major component of obtaining and accessing child dental health care. Most recently, this study has determined the disparities in access to care among children in relation to socioeconomic divide in oral health insurance coverage (Chapter Six). New information has been added regarding the demand for dental care based on insurance coverage among children aged between 0 and 14 years, leading to an increasing awareness of the substantial heterogeneity within the populations. Eliminating socioeconomic and geographical disparities in dental care requires additional efforts in removing both financial and non-financial barriers to dental utilisation.

The high economic burden of children dental hospitalisation over the last decade implies the need for health resources redistribution based on a regional need in conjugation with the development of community-based preventive programmes and treatment programmes (Chapter Seven). In our view, tremendous monetary benefits are expected when primary prevention of dental caries, especially in children, through SDS is implemented. Investment
decisions in oral conditions prevention and treatment facilities, workforce planning and evaluation of oral health policy rely not only on knowing how many cases of oral conditions were hospitalised in a given year, but on how many can be expected to be admitted in the future. Thus, anticipating the future burden of oral related admissions in children in terms of expected numbers of cases is vital in optimising the resources allocation to enable children to have timely access to preventively focused dental care that meets the minimum standard benchmarks for oral health service provision (Chapter Eight).

This thesis was the first of its kind to model children oral health-related hospital admissions rates and their socioeconomic position in relation to oral health service at a community level (Chapter Nine), and to illustrate and predict a community’s current service access needs and assist in evidence-based decision making for planning and implementing changes to increase access to basic risk. This new geographical model may be particularly well suited for planning and prioritising future health service in other urban communities, based on population projections and disease models of the current population. This thesis developed a framework that can be adopted by other communities to identify a set of target areas, vulnerable populations and monitor the effectiveness of interventions designed to improve their access to care. It also provides an understanding of the distribution of demand for oral health services, to enable policy development and service planning.

Significant reduction on the incidence of dental diseases in Australian children can be attained through development of community-based preventive programmes and treatment programmes on the basis of regional need. In this thesis a number of new finding were made, paving the way for a universal strategy reform in order to set the platform for oral health actions in WA into the next decades.
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References


Appendices
Appendix A
Our Ref: RA/4/1/5502

16 August 2012

Winthrop Professor Marc Tennant
Primary, Aboriginal & Rural Health Care (School of)
MBDP: M309

Dear Professor Tennant

HUMAN RESEARCH ETHICS OFFICE – AMENDMENT REQUEST APPROVED

Hospitalisations for oral-health related reasons in Western Australia: A ten-year analysis of trends and future projections

Student(s): Alla Talal Y Alsharif

I confirm receipt of your correspondence requesting an amendment to the protocol for the above project.

Approval has been granted for the amendment as outlined in your correspondence and attachments (if any) subject to any conditions listed below.

Any conditions of ethics approval that have been imposed are listed hereunder:

1. Addition of graduate student Ala Alsharif (student number 20446892)

If you have any queries, please do not hesitate to contact Kate Kirk on (08) 6488 3703.

Please ensure that you quote the file reference RA/4/1/5502 and the associated project title in all future correspondence.

Yours sincerely

[Signature]

Peter Johnstone
Manager
Appendix B
Dental hospitalization trends in Western Australian children under the age of 15 years: a decade of population-based study

ALLA T. ALSHARIF, ESTIE KRUGER & MARC TENNANT
International Research Collaborative-Oral Health and Equity, The University of Western Australia, Nedlands, WA, Australia

Background and Aim. This study analyzed a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with sociodemographic characteristics and with particular focus on dental decay and Indigenous children.

Methods. This retrospective study analyzed the data obtained for 43,937 child patients under the age of 15 years hospitalized for an oral-health-related condition, as determined by principal diagnosis (ICD-10AM). Primary place of residency, age, gender, insurance status and Indigenous status were also analyzed.

Results. ‘Dental caries’ and ‘embedded and impacted teeth’ were the most common reasons for hospitalization among children under the age of 15 years. ‘Dental caries’ were most common in non-Indigenous patients, with ‘pulp and periapical’ most prevalent in Indigenous patients. The age-standardized rate (ASR) of hospitalization for Indigenous children in the last decade increased to reach that of non-Indigenous children in 2009. Total DRG costs of hospitalization, both public and private, were in excess of AUS $92 million over 10 years.

Conclusions. This study indicates the burden of oral-health-related conditions on Western Australian children and the hospital system, in terms of health and economical impact.

Introduction
In Australia, dental conditions are one of the highest causes of acute preventable hospital admissions. In 2003–2004, over 26,000 children under the age of 15 years old had to undergo general anesthesia in hospitals in Australia for dental extraction and/or restorations. In 1995, Western Australia (WA) recorded 3754 cases (4395 bed-days) of children under the age of 18 years old admitted to hospital for oral conditions. Unfortunately, subsequent studies indicated that the rate of hospitalizations for oral conditions has increased over time. Kruger et al. conducted a study and found that from 1999 to 2003, a total of 26,497 hospital admissions (31,432 bed-days) in WA were attributed to oral health conditions among children under the age of 18.

Some studies have found that the rates of hospitalization due to oral conditions in children varied between the age groups, with the highest rates for high school-aged children, followed by pre-primary, and the lowest rate is the primary school-aged group. This is not unsurprising as the preschool children mostly do not, on the whole have access to the safety nets of School Dental Services, while the teenage levels are most likely related to the removal of impacted teeth (mostly third molars).

In Australia, Aboriginal and Torres Strait Islander people are the first people of the land. They, like many indigenous people, have faced very significant marginalization since European settlement and continue to this day to face extreme issues of poor health. According to recent studies, Indigenous children have, on average, twice the incidence of dental caries as their non-Indigenous counterparts, but in all child age groups, except infants, the hospitalization
rates for all oral health conditions were significantly higher among non-Indigenous children.

The aim of this study is to analyze a decade of dental admission patterns in Western Australian children under the age of 15 years, examining associations with sociodemographic characteristics and with particular focus on dental decay and Indigenous children. The null hypothesis of this study is that the hospital admissions for dental reasons (in children) are not associated with sociodemographic characteristics.

Materials and methods

Data source

This research involved a de-identified detailed analysis of the data obtained from the WA Hospital Morbidity Dataset for ten financial years from 1999/00 to 2008/09 under ethics approval from The University of Western Australia. Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and accordingly admitted for an oral health condition in Western Australia for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD–10–AM is the Australian Modification of the 10th revision of the International Classification of Diseases (ICD–10). It is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol. Age, gender and Indigenous status, insurance status, length of stay, hospital area, and type of each child were analyzed. Remoteness was determined using the Accessibility/Remoteness Index of Australia (ARIA) classification, which measures remoteness in terms of access along the road network from populated localities to each of five categories of service center. Localities that are more remote have less access to service centers; those that are less remote have greater access to service centers.

Socioeconomic status was analyzed using Socio-Economic Indexes of Area (SEIFA) classification, which is a ‘product developed by the ABS that ranks areas in Australia according to relative socio-economic advantage and disadvantage. The indexes were based on information from the 5-yearly census.

Age-specific and age-standardized rates (ASRs) were calculated using the Health Statistics Calculator, a software package developed by the Health Department of Western Australia. It should be noted that the data for this study span the years 1999/00-2008/09. In rate calculations, population data (denominators) were obtained from estimations by the Health Department of Western Australia Bureau of Statistics. These estimations were based on population data as obtained by Australian Bureau of Statistics Census Surveys. Significant differences between rates were based on non-overlapping 95% confidence intervals (P < 0.05).

To determine significant differences between nominal (categorical) variables, chi-square (χ²) tests were used. Significance levels were set at 95% with P value < 0.05 deemed to be significant. SPSS 21 for Windows (Statistical package for the social sciences; SPSS, Chicago, IL, USA) software is used for analysis.

Results

Overall data summary

Between 2000 and 2009, a total of 43,937 children (0–14 years) were hospitalized due to oral conditions. Of these, 94% (n = 41,475) accounted for seven major categories of oral conditions with half (50%) of those hospitalizations for ‘dental caries’, followed by, ‘embedded and impacted teeth’ (14%), ‘pulp and periapical’ tissue conditions (11%), ‘developmental and birth defects’ (5%), ‘dental fractures’ (5%), and ‘dentofacial anomalies’ 4%. Overall, 5% (n = 2119) of admissions were for Indigenous children.

All children

Time trends. The ASR of hospitalizations for oral conditions increased from 926 in 2000 to
1085 cases per 100,000 person-years in 2009. Approximately 73% of the admissions were among children younger than 9 years old. In 2003, children aged <5 years had 1.3 and 1.7 times the admission rate of 5- to 9- and 10- to 14-year-old children, respectively. Since then, the admission rates for 5- to 9-year-olds increased and in 2009 were 1.2 and 1.5 times the admission rates of 0- to 4-year-olds and 10- to 14-year-olds, respectively (Fig. 1).

**Sociodemographic association.** Figure 2 represents the trends of the most common conditions overtime. Overall, 546 per 100,000 children per annum were admitted for ‘dental caries’ and 144 per 100,000 had ‘embedded or impacted teeth’. A non-Indigenous child was 29 times more likely than an Indigenous child to be admitted for ‘embedded or impacted teeth’. Non-Indigenous children were more likely to be admitted than Indigenous children except for ‘pulp and periapical’ conditions. (Table 1) Children aged <5 were more likely to be admitted due to ‘dental fracture’ or ‘birth defects’ conditions. In contrast, higher rates of children aged between 5 and 9 years were hospitalized due to ‘developmental defects’ or ‘dental caries’. ‘Dentofacial anomalies’ and ‘embedded and/or impacted teeth’, however, mainly accounted for the oldest age group admissions. Children younger than 9 years were more likely to be admitted due to ‘pulp and periapical’ conditions.

**Gender.** Males are most likely to be hospitalized for ‘dental caries’ (ASR 560, 95% CI 550.1–570.4) than females (ASR 530, 95% CI 520.1–540.4).

**Socioeconomic association.** Across all common conditions, higher percentages of children hospitalized lived in the least and above average disadvantaged areas, except for children with ‘pulp and periapical’ conditions (25%), where most were living in the most disadvantaged areas, followed by 23% in below average disadvantaged areas ($P < 0.001$).

**Remoteness of residency.** Across all conditions, children living in accessible areas are more likely to be admitted than children living in remote or very remote areas. Rural residence was significantly associated with less dental admissions, than metropolitan-living children across all conditions ($P < 0.001$; Table 1).

**Length of stay.** The length of stay in hospital (LOS) was calculated and found 92% of
separations from hospital happened on the same day ($P < 0.001$; Table 1).

**Conditions.** Children admitted to public hospitals were more likely to have ‘dental fractures’, ‘birth defects’ or ‘pulp and periapical’ conditions. ‘Developmental defects’, ‘embedded and impacted teeth’, ‘dental caries’ or ‘dentofacial anomalies’ were more likely to be admitted in private hospitals.

**Cost.** The total DRG (diagnosis-related group) cost of this care was approximately AUS $92 million. Private insurance was the primary source of reimbursement for 55% of non-Indigenous children, while Indigenous child admissions were much more likely to be publicly funded (96%) ($P < 0.001$).

**Aboriginal and Torres Strait Islander children**

Rural-living non-Indigenous children had 1.2 times the admission rate of rural-living Indigenous children. In contrast, Indigenous children living in major cities or regional areas had 2.6 times the admission rate of their Indigenous counterparts in rural or remote areas. Sixty-three percent of all separations recorded for

### Table 1. Hospitalization of WA children for most common oral conditions across different variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Dental fracture</th>
<th>Birth defect</th>
<th>Developmental defects</th>
<th>Embedded and impaction</th>
<th>Dental caries</th>
<th>Pulp and periapical</th>
<th>Dentofacial anomalies</th>
</tr>
</thead>
<tbody>
<tr>
<td>All children (ASR)</td>
<td>49.1</td>
<td>56.4</td>
<td>56.6</td>
<td>144.4</td>
<td>545.6</td>
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<td>Age (ASR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
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<td>0–4</td>
<td>111</td>
<td>136.7</td>
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<td>1.9</td>
<td>746.3</td>
<td>165.3</td>
<td>2.6</td>
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<tr>
<td>5–9</td>
<td>28.2</td>
<td>22.3</td>
<td>83.6</td>
<td>35.4</td>
<td>754.4</td>
<td>165.7</td>
<td>25.8</td>
</tr>
<tr>
<td>10–14</td>
<td>11.1</td>
<td>14.4</td>
<td>55.2</td>
<td>388.8</td>
<td>146.8</td>
<td>22.1</td>
<td>103.9</td>
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<td>Indigenous status (ASR)</td>
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<td>Indigenous</td>
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<td>5.0</td>
<td>415.1</td>
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<td>Non-Indigenous</td>
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<td>54.4</td>
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<td>497.8</td>
<td>99.9</td>
<td>44.1</td>
</tr>
<tr>
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<td></td>
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</tr>
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<td>Male</td>
<td>55.8</td>
<td>70.4</td>
<td>57.2</td>
<td>115.5</td>
<td>560.2</td>
<td>126.2</td>
<td>37.3</td>
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<td>42.0</td>
<td>41.7</td>
<td>56.0</td>
<td>175.2</td>
<td>530.2</td>
<td>106.9</td>
<td>52.8</td>
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<tr>
<td>SEIFA* (%)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Most disadvantage</td>
<td>19.4</td>
<td>17.8</td>
<td>10.8</td>
<td>9.0</td>
<td>17.2</td>
<td>25.0</td>
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<tr>
<td>Below average disadvantage</td>
<td>20.7</td>
<td>19.6</td>
<td>14.4</td>
<td>14.9</td>
<td>19.3</td>
<td>23.2</td>
<td>14.0</td>
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<tr>
<td>Average disadvantage</td>
<td>18.4</td>
<td>20.0</td>
<td>18.5</td>
<td>20.3</td>
<td>18.4</td>
<td>17.1</td>
<td>17.9</td>
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<tr>
<td>Above average disadvantage</td>
<td>18.3</td>
<td>21.2</td>
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<td>23.6</td>
<td>19.9</td>
<td>17.5</td>
<td>21.8</td>
</tr>
<tr>
<td>Least disadvantage</td>
<td>22.5</td>
<td>21.3</td>
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<td>32.2</td>
<td>25.2</td>
<td>17.2</td>
<td>36.0</td>
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<td>ARIA* (%)</td>
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</tr>
<tr>
<td>Highly accessible</td>
<td>18.4</td>
<td>18.9</td>
<td>16.8</td>
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<td>20.5</td>
<td>18.9</td>
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<td>58.7</td>
<td>60.0</td>
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<td>Moderately accessible</td>
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<td>12.0</td>
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<td>9.6</td>
<td>11.6</td>
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<td>Remote</td>
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<td>4.5</td>
<td>4.1</td>
<td>5.1</td>
<td>4.0</td>
<td>3.9</td>
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<tr>
<td>Very remote</td>
<td>4.7</td>
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<td>1.5</td>
<td>5.6</td>
<td>5.8</td>
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<tr>
<td>Same day separation* (%)</td>
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</tr>
<tr>
<td>Yes</td>
<td>78.5</td>
<td>70.1</td>
<td>97.5</td>
<td>94.4</td>
<td>97.6</td>
<td>87.0</td>
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<td>21.5</td>
<td>29.9</td>
<td>2.5</td>
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<td>2.4</td>
<td>13.0</td>
<td>7.2</td>
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<td>Insurance status* (%)</td>
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<td>Insured</td>
<td>34.3</td>
<td>42.9</td>
<td>69.9</td>
<td>71.5</td>
<td>52.5</td>
<td>25.7</td>
<td>74.8</td>
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<tr>
<td>Uninsured</td>
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<td>57.1</td>
<td>30.1</td>
<td>28.5</td>
<td>47.5</td>
<td>74.3</td>
<td>25.2</td>
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<td>Hospital type* (%)</td>
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<td>Public</td>
<td>88.2</td>
<td>56.8</td>
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<td>35.5</td>
<td>79.3</td>
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<td>Private</td>
<td>11.8</td>
<td>43.2</td>
<td>81.7</td>
<td>91.0</td>
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<td>79.0</td>
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<td>0.1</td>
<td>0.1</td>
<td>0</td>
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<tr>
<td>Hospital area (ASR)</td>
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<td></td>
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</tr>
<tr>
<td>Rural</td>
<td>14.5</td>
<td>20</td>
<td>15.8</td>
<td>83.8</td>
<td>301</td>
<td>53.3</td>
<td>27.8</td>
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<tr>
<td>Metropolitan</td>
<td>55.1</td>
<td>62.4</td>
<td>64</td>
<td>152.1</td>
<td>560.3</td>
<td>123.8</td>
<td>46.3</td>
</tr>
</tbody>
</table>

ASR (age-standardized rate per 100,000).

* $P < 0.001$, Pearson chi-square.
patients identified as non-Indigenous occurred in metropolitan private hospitals.

**Time trends.** Figure 3 shows that the ASR of hospitalization for Indigenous children in the last decade increased to reach that of non-Indigenous children in 2009. From 2000 to 2008, the difference between Indigenous and non-Indigenous was statistically significant over this period. Admission ASRs for non-Indigenous children were 1.3 times more than that of Indigenous children, with non-Indigenous females significantly more likely to be admitted than Indigenous females. In contrast, there is no statistical difference in the admission rates between Indigenous males and females. Furthermore, the highest ASR of hospitalization was observed among Indigenous children under the age of 5 years (1337) (Table 2).

**Length of stay.** Indigenous children were more likely to have longer admissions than non-Indigenous children ($P < 0.001$) (Table 3).

**Insurance.** Nearly 97% of Indigenous hospitalized children were uninsured with public hospitals mostly the primary place of admission ($P < 0.001$).

**Socioeconomic associations.** It was more likely for non-Indigenous children, across all ages, from higher socioeconomic areas to be admitted compared with Indigenous children. Fifty-nine percent of all Indigenous children hospitalized were in the lowest socioeconomic group ($P < 0.001$; Table 3).

**Remoteness of residency.** According to ARIA, 60% of non-Indigenous children hospitalized in WA lived in areas classified as accessible. Conversely, highest percentage (33%) of Indigenous children lived primarily in very remote areas ($P < 0.001$; Table 3).

**Discussion**

In this study, the most common reasons for hospital admissions were ‘dental caries’ and ‘embedded and impacted teeth’. Over time,

---

**Table 2. Age-specific and age-standardized rates of hospitalization for oral health conditions across age groups, gender, and geographical location.**

<table>
<thead>
<tr>
<th></th>
<th>Indigenous</th>
<th>Non-Indigenous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASR* Cl†</td>
<td>ASR* Cl†</td>
<td>ASR* Cl†</td>
</tr>
<tr>
<td>All ages</td>
<td>813.3 777.7–848.0</td>
<td>1090.4 1079.9–1100.8</td>
<td>1073.6 1063.5–1083.6</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>1328.7 1251.2–1406.2</td>
<td>1244.7 1224.9–1264.4</td>
<td>1250.2 1231–1269.3</td>
</tr>
<tr>
<td>5–9</td>
<td>901.3 838.6–964.0</td>
<td>1182.4 1163.6–1201.3</td>
<td>1164.3 1146.1–1182.4</td>
</tr>
<tr>
<td>10–14</td>
<td>229.4 197.3–261.5</td>
<td>853 837.4–868.6</td>
<td>816.8 802.1–831.6</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>853.1 803.5–902.6</td>
<td>1095.6 1080.9–1110.2</td>
<td>1080.6 1066.6–1094.7</td>
</tr>
<tr>
<td>Female</td>
<td>771.9 723.6–820.3</td>
<td>1085.2 1070.2–1100.2</td>
<td>1066 1052.2–1080.9</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>511.3 476.6–546.0</td>
<td>626.4 610.1–642.6</td>
<td>609.8 595.0–624.6</td>
</tr>
<tr>
<td>Urban</td>
<td>1312.6 1240–1384.3</td>
<td>1235.0 1222.2–1247.7</td>
<td>1238.1 1225.6–1250.7</td>
</tr>
</tbody>
</table>

*Age-standardized rate per 100,000 person-years.
†Cl represents the 95% confidence interval for ASR.
the hospitalization rates of ‘dental caries’ increased. This is consistent with findings of a previous study\(^5\). Males exhibited a significantly higher rate of hospitalization due to ‘dental caries’, than females. The reason for the higher caries experience in males is unclear, although it has been claimed that male children who have the same genotype of mutans streptococci as their mother have up to 13 times greater risk of caries development than female children that acquire the same strain of bacteria from their mother\(^14\).

Hospitalizations for ‘embedded and impacted teeth’ were mainly among the oldest age group with very significant differences between non-Indigenous and Indigenous children. This confirms the finding of the previous surveys\(^5,15\). Hospitalization at this age group, however, is unlikely to be due to third molar impaction.

Maxillary canine is one of the most frequently impacted teeth in children aged 11–14 years, with the prevalence ranging from 0.8 to 5.2%\(^16,17\). ‘Embedded and impacted teeth’ are predominantly undertaken in the private sector, which is not managed through policy directives\(^17\). Non-Indigenous children are more likely to have private health cover, which plays an important role in dental healthcare delivery in Australia. In 2010–2011, 58% of dental expenditure in Australia was funded by out-of-pocket expenses and 14% by health insurance\(^18\).

Hospitalizations for ‘pulp and periapical’ conditions were mainly due to periapical abscess without sinus formation. It is not surprising that uninsured, Australian Indigenous male children aged < 9 years, and living in the most disadvantaged areas were more likely to be admitted for this condition. This can indicate that they only access dental care when conditions reached an advanced stage.

Most hospitalizations for ‘birth defects’ were for ankyloglossia, followed by cleft lip and palate, while the highest percentages of ‘developmental defects’ admissions were for supernumerary teeth and disturbances in tooth formation or eruption conditions.

Although preschool children have difficulties accessing the existing dental health service, the rates of hospitalization among this age group have been declining since 2003. In 2005–2009, however, the hospitalization rates of 5- to 9-year-olds started to increase and exceeded the rates of 0- to 4-year-olds. The changing rates of procedures over time might be a result of changing trends in clinician beliefs, as well as changing health insurance levels in the community; no specific reason for change is evident. Currently, most publicly delivered children dental program in Australia is SDS, which includes only emergency or basic treatment and covers only limited care for school children particularly those within low-income families\(^19\). The comprehensiveness of these programs differs significantly among state and territories in terms of the types of services covered, age restrictions, and limits on the frequency of dental visits. In Western Australia, the SDS is primarily a public dental health program, with emphasis on prevention and education, and it provides free limited general dental care to school children ranging from pre-primary through to year 11 and to year 12 in remote locations. This care is provided by dental therapists from fixed and mobile clinics located at schools throughout the state. Thus, treatment outside the scope of the SDS is referred to

### Table 3. Percentages of child hospitalizations for oral health conditions across hospital type, SEIFA, ARIA, and same day of separation.

<table>
<thead>
<tr>
<th>Percentage (%)*</th>
<th>Indigenous</th>
<th>Non-Indigenous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hospital type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>96.0</td>
<td>36.5</td>
</tr>
<tr>
<td>Private</td>
<td>4.0</td>
<td>63.4</td>
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<tr>
<td><strong>SEIFA</strong></td>
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<tr>
<td>Most disadvantage</td>
<td>58.9</td>
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</tr>
<tr>
<td>Below average disadvantage</td>
<td>20.9</td>
<td>18.5</td>
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<tr>
<td>Average disadvantage</td>
<td>9.4</td>
<td>19.0</td>
</tr>
<tr>
<td>Below average disadvantage</td>
<td>7.1</td>
<td>21.0</td>
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<tr>
<td>Least disadvantage</td>
<td>3.8</td>
<td>27.2</td>
</tr>
<tr>
<td><strong>ARIA</strong></td>
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<td>Highly accessible</td>
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<tr>
<td>Accessible</td>
<td>30.8</td>
<td>61.3</td>
</tr>
<tr>
<td>Moderately accessible</td>
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<td>10.6</td>
</tr>
<tr>
<td>Remote</td>
<td>9.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Very remote</td>
<td>33.2</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Same day separation</strong></td>
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<td>93</td>
</tr>
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<td>No</td>
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<td>No</td>
<td>96.5</td>
<td>44.9</td>
</tr>
</tbody>
</table>

*\(P < 0.001\), Pearson chi-square.
other providers, and any costs are the responsibility of the parent or guardian. Furthermore, not all students are enrolled in SDS, and long intervals between visits might delay interventions and early prevention.

Although the health of Indigenous children in Australia is lower than that of non-Indigenous children for most indicators, admission rates were higher among non-Indigenous children, as reported previously for Western Australian children. The differences observed are thought to be attributed to a number of factors, such as variation in service access as a significant proportion of Indigenous children live in rural and remote locations, socioeconomic or environmental factors. The Indigenous population in Western Australia constitutes just 3.2% of the total population of the state and predominantly lives in rural and remote areas and in areas of higher socioeconomic disadvantage. The hospitalization rates were higher among children living in metropolitan areas than in the rural children. This can be attributable to the fact that Western Australia is experiencing a dental workforce shortage in rural and remote areas, especially in terms of dental therapist and dental specialists. Furthermore, geographical access to health services was considered as the reason for this unequal distribution; it is evident by the fact that Indigenous children in metropolitan areas are also more likely to be admitted than Indigenous children in rural areas. They are also less likely to have private health cover, which plays an important role in the private-driven dental healthcare delivery in Australia and hence fail to have adequate dental treatment. There is an obvious association between insurance status and hospital types (private or public), and the admission of Indigenous children, which might reflect the socioeconomic barriers to dental service utilization. Moreover, the public sector largely services medical and surgical emergencies and other complex conditions and procedures. Indigenous children were more likely to have longer stays in hospital than non-Indigenous children and might be attributed to the severity of the condition.

This study focused on the trends over a 10-year time period and to highlight those groups within the child population more likely to be admitted. The same dataset is also being used for further analysis to determine risk indicators and will involve more detailed statistical analysis.

Conclusion

Most oral conditions, and especially dental carries, are preventable. These findings of this study indicate rejection of the null hypothesis, and it identified groups within the child population more likely to be admitted to hospital for treatment of oral-related conditions, as well as associated characteristics. This information should be utilized and applied to prevent costly in-patient treatment by early detection, prevention, and intervention. At a time, when public health resources are limited, strategies need to be developed to focus on these high-risk groups and best practice principles of care and demand management to better utilize limited health resources. It is also important to address the need for the redistribution of resources on the basis of regional need and the development of community-based preventive programs and treatment programs, which will significantly reduce the incidence of dental diseases in Australian children.

Bullet points to describe the importance of this paper to paediatric dentists

- This paper identify groups in the child population at risk for dental condition-related hospitalizations.
- Early intervention aimed at these high-risk groups could prevent costly hospital-based procedures, as most are preventable.
- Indigenous status, poverty and rural/remote dwelling are all risk indicators for admission to hospital for dental conditions.

Acknowledgement

The authors would like to thank Professor John McGeachie OAM for his continuous ongoing support of the whole team.

Conflict of interest

The authors declare no potential conflict of interest.
References


Disparities in dental insurance coverage among hospitalised Western Australian children

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International Research Collaborative – Oral Health and Equity, Department of Anatomy, Physiology and Human Biology, The University of Western Australia, Nedlands, WA, Australia.

Objectives: We sought to understand disparities in dental insurance coverage among hospitalised Western Australian children and associated factors. Methods: This study analysed the data obtained for 43,937 child patients under the age of 15 years hospitalised for an oral-health related condition, as determined by principal diagnosis (ICD-10AM). Primary place of residency, age, gender, Indigenous status and socioeconomic status were also analysed. Results: Of our sample, 47.3% reported lack of dental insurance coverage. Non-Indigenous children were more likely to have dental insurance than Indigenous children. When insurance status was considered, Indigenous children were less likely to be hospitalised for dental treatment. Rural children were more likely to be uninsured than urban children. Lack of health insurance coverage was strongly associated with children living in very remote areas. These disparities were exacerbated among rural Indigenous children. Disparities in dental insurance coverage and dental care are also evident by socioeconomic status. Conclusions: Better understanding of disparities in access to care among children, socioeconomic divide in oral health insurance coverage and subsequent development of intervention programmes, will be critical to improving Australian children's oral health.

Key words: Disparities, hospitalisation, dental, Australia

INTRODUCTION

One of the fundamental objectives of health-care systems across the globe is to ensure that individuals have access to care on the basis of need, rather than ability to pay. However, this objective in a free-market economy is often warped by the economic goals of society. In Australia, dental services are predominately provided in a private sector setting and therefore prices and wealth wraps around access. Historically, because dental care has not been considered integral to health care, it is not subject to the tenets of the Australian Health Act (AHA): that is, publicly administered, universal, portable, accessible and comprehensive. In contrast to physician- and hospital-based services that are mainly publicly funded, Australians are largely responsible for financing their own dental care. Australians pay for dental care in four different ways: through third-party insurance (employment-related health insurance coverage); through private dental insurance; by paying directly out-of-pocket; or through government-subsidised programmes (e.g. School Dental Services for children or community and public hospital clinics for adults).

At present, most publicly delivered child dental programmes in Australia are via School Dental Services (SDS), which includes only emergency and basic treatment, and cover only limited care for school children, particularly those with in low-income families. However, most major in-hospital dental services are provided by the private sector offering non-subsidised care. In addition, private health insurance covers a proportion of costs but consumers have always faced relatively high out-of-pocket costs for these services. In 2005, 43.8% of Australian children aged from 5–11 years had private dental insurance (predominately personal) and 22.3% had cardholder status (eligible for publicly provided services). The groups most marginalised by the current dental care system are the lowest income families, Indigenous people and children living in remote areas; this has a great impact on these suffering high disease burdens such as the children of Australia’s first people the Aboriginal and Torres Strait Islander people. These population groups have the least access to dental care and carry
the greatest burden of untreated disease. People from wealthier groups have better oral health and make use of more complex and expensive services, while waiting lists for public dental care have grown by 20% per year. Over time, this has resulted in increased inequity in access to care.

This study examines the disparities in dental insurance coverage among Western Australian children hospitalised because of oral-related conditions and associated factors to address the inequalities that currently exist. The null hypothesis of this study is that children’s hospital admissions for dental conditions are not associated with the presence of private health insurance.

MATERIALS AND METHODS

Data source

This primary research data set was de-identified detailed data obtained from the Western Australia Hospital Morbidity Dataset for 10 financial years from 1999–2000 to 2008–2009.

Ethics

This research was conducted in full accordance with the World Medical Association Declaration of Helsinki and ethical approval was granted by the Ethics Committee of the University of Western Australia. Children were not directly involved in the study, as this was only an analysis of de-identified hospitalisation data, as provided by the Health Department of Western Australia.

Principal diagnosis

Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and admitted for an oral health condition in Western Australia for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD-10-AM is the Australian Modification of the 10th revision of the International Classification of Diseases (ICD-10). It is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol. For each child, age, gender and Indigenous status, insurance status, hospital area and hospital type were also analysed.

Residential location

Remoteness was classified using the Accessibility/Remoteness Index of Australia (ARIA) which measures ‘remoteness’ in terms of access along the road network from populated localities to each of five categories of service centre. Localities that are more remote have less access to service centres, whereas those that are less remote have greater access to service centres.

Socioeconomic status

Socioeconomic status was analysed using the Socio-Economic Indexes of Area (SEIFA) classification which is a product developed by the Australian Bureau of Statistics that ranks areas in Australia according to relative socioeconomic advantage and disadvantage. The indexes are based on information from the five-yearly Census.

All data were analysed using SPSS 21 (SPSS, Chicago, IL USA) for Windows software. Statistical significance was set at 95% (P < 0.05) and was calculated using Pearson chi-square (χ²) tests, to determine significant differences between nominal (categorical) variables.

RESULTS

From 2000 to 2009, a total of 43,937 children (0–14 years) were hospitalised because of oral-related conditions. Overall 5% (n = 2,119) of admissions were for Indigenous children.

Dental insurance (All children)

Almost one in every two children hospitalised was uninsured (47.3%; Table 1).

Age in years on admission

Children aged between 10 years and 14 years reported a significantly higher level of dental insurance coverage than children younger than 9 years old, (P < 0.01) (Table 1).

Gender

More females (54%) were insured than males (51.4%) (Table 1).

Hospital type

Children with private health insurance were more likely to be admitted to private hospitals than uninsured children (P < 0.01; Table 1).

Location

Children admitted to metropolitan hospitals were 1.6 times more likely to be insured than children admitted to rural hospitals. Children from the oldest age group...
were more likely to be insured than younger age groups. The observed variations were statistically significant ($P < 0.01$; Table 1).

### Socioeconomic status

Children with the lowest socioeconomic status (SES) were significantly less likely to have dental insurance. In contrast, $76\%$ of children hospitalised from least disadvantaged areas were insured. Hospitalised children from high SES backgrounds were three times more likely to be insured than children from most disadvantaged areas ($P < 0.01$; Table 1).

### Remoteness/accessibility

Statistically significant variations were observed across the ARIA classification ($P < 0.01$). Lack of health insurance coverage was strongly associated with children living in very remote areas. Children living in accessible areas were twice as likely to be insured as children living in very remote areas (Table 1).

### Length of stay

Sixty-six per cent of children admitted for more than a day were uninsured, from those $78\%$ were children aged between 5–9 years, followed by $74\%$ of children younger than 5 years old ($P < 0.01$; Table 1).

### Insurance status over time

In 2000, children admitted to hospital for oral-related conditions were more likely to be uninsured. Since then, insurance levels have increased to reach $63\%$ of all children younger than 15 years old hospitalised because of oral conditions in 2009 ($P < 0.01$; Figure 1a). Statistically significant higher levels of dental insurance coverage were observed among children aged between 10 and 14 years over time, followed by the 5–9-year-old group ($P < 0.01$; Figure 1b). However, over the last decade, the percentage of uninsured children younger than 4 years old has decreased by $22\%$ ($P < 0.01$; Figure 1c).

### Dental insurance

The disparities were exacerbated among Indigenous children. Non-Indigenous Western Australian children aged less than 15 years and hospitalised because of oral conditions over the last decade were 16 times more likely to be insured compared with their Indigenous counterparts.

### Age

Across all ages, the majority of Indigenous children were uninsured. The percentage of insured Indigenous children aged 5–9 years were higher ($1.2\%$) than the
percentages in other Indigenous age groups ($P < 0.01$; Table 2).

**Gender**

Slightly more (3.9%) male Indigenous children were insured compared with female Indigenous children (3.1%). In contrast, 57% of non-Indigenous females were insured compared with their male counterparts (54%) ($P < 0.01$; Table 2).

**Location**

Indigenous children living in urban areas were five times more likely to be insured compared with their rural counterparts. Interestingly, non-Indigenous children living in rural areas were 37 times more likely to be insured than Indigenous children living in rural areas ($P < 0.01$; Table 2).

**Hospital type**

Both insured Indigenous and non-Indigenous children were significantly more likely to be admitted in private hospitals ($P < 0.01$; Table 2).

**Length of stay**

Only (0.9%) of Indigenous children hospitalised for more than a day were insured ($P < 0.01$).

**Common oral conditions**

There was a distinct contrast in the percentages of children with health insurance among Indigenous and non-Indigenous group ($P < 0.01$; Table 2).

**Socioeconomic status**

Ninety-eight per cent of Indigenous children hospitalised and living in the most disadvantaged areas were uninsured. Significant differences in insurance status between Indigenous and non-Indigenous children were observed based on socioeconomic status, using the SEIFA scale (Table 2). Non-Indigenous children living in the most disadvantaged areas were 19 times more likely to be insured than Indigenous children living in the same areas. Statistically significant variations were observed across socioeconomic distribution ($P < 0.01$).

**Remoteness/accessibility**

For both Indigenous and non-Indigenous children the proportion with health insurance decreased with increasing geographic remoteness, with insurance levels of only 4% and 1.3% of the Indigenous child population residing in remote or very remote areas, respectively. However, Non-Indigenous children living in very remote areas were 32 times more likely to be insured than their Indigenous counterparts ($P < 0.01$; Table 2).

**Changes overtime**

Constant and high percentages of hospitalised Indigenous children have been uninsured over the last decade ($P < 0.01$). The percentages of those with health insurance among Indigenous hospitalised children were very low and constant over the study period, with a slight increase (13%) in 2009 (Figure 2), In contrast, since 2005, insurance among hospitalised non-Indigenous children has increased ($P < 0.01$; Figure 3).
DISCUSSION

Health insurance coverage has previously been found to be a good predictor of preventive care service use\(^7,8\). Health insurance in Australia does not automatically include dental insurance, but Australians can obtain dental insurance by purchasing either private patient hospital cover combined with an ‘extras’ option that includes dental services, or the ‘extras only’ option. There are two levels of dental services provided by this insurance: general dental coverage and major dental coverage. General dental coverage typically includes services such as cleaning, removal of plaque, radiographs and small restorations. Major dental coverage includes these services plus additional services such as orthodontics, third molar removal, crowns, bridges and dentures.

Dental health-care coverage is an indicator that reflects the extent to which people in need actually receive essential dental health interventions\(^7,8\). The primary explanation cited in the literature for delayed dental health care seeking is financial barriers\(^8\). In this study, we found statistically significant disparities in dental insurance coverage among hospitalised children associated with Indigenous status, socioeconomic status and remoteness and accessibility of residential area. The impacts of this disparity go beyond just the greater prevalence of the dental and oral disease, and include greater morbidity and mortality.

In this study, those children who did have dental health insurance were more likely to come from urban, accessible and least disadvantaged areas. This confirms findings of previous surveys and may be an indication that insurance enabled access to dental care and led to greater demand for care once access had been obtained\(^7\). Although private dental insurance does not necessarily increase receipt of preventive service or decrease perceived unmet need in all cases, it...
is evident that insured children are more likely to be hospitalised for less invasive treatment than their uninsured counterparts (who were probably more likely to receive extractions in dental clinics as outpatients and would have difficulty paying a $100 dental bill). Kasper et al.\textsuperscript{10} found that the uninsured individuals were more likely to have difficulty obtaining health care once they lost coverage. However, those uninsured individuals that did gain private health cover had increased access to health services compared with those that remained uninsured\textsuperscript{10}. In terms of health status, it is suggested that individuals losing coverage might experience adverse health outcomes compared with those that remained insured. The previous article elucidates that having private health insurance increases access to care and possibly improves health status\textsuperscript{10}. It is evident that Australian children who were covered by private dental health insurance were less likely to report fair or poor oral health than uninsured children\textsuperscript{8}.

A much smaller percentage of Indigenous children with health insurance compared with non-Indigenous children could contribute to the poorer oral health status of Indigenous children and inequality in access to oral health-care\textsuperscript{14}. As a result of inadequate health insurance coverage, with nearly 97% of hospitalised Indigenous children being uninsured, numerous concerns about dental service utilisation are raised. In dental markets where well-insured or private-pay patients are common, public dental care coverage in children alone will be insufficient to remove disparities in dental utilisation. The lack of affordable dental care and insurance coverage leads to postponing dental treatment, often for years. These untreated symptoms inevitably get more severe, resulting in children requiring admission for more invasive treatment at a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

Furthermore, over the past 20 years, health care has become more expensive and more individuals are unable to afford health insurance. It is important to note that the vast majority of dental specialists are in private practice; consequently, most hospitalisations for oral problems in children, and requiring general anaesthesia, take place in specialised private hospitals\textsuperscript{12,13}. Accordingly, parents are forced to pay directly out of pocket or indirectly through private health insurance for the hospitalisation process. In 2013, in Australia, Harford et al.\textsuperscript{8} reported that almost 30% of children avoided or delayed seeking oral health care, did not have recommended treatment, or their parents experienced a large financial burden because of the cost of dental care. Children from low SES were seven times more likely to avoid or delay visits because of cost compared with high SES counterparts, and six times more likely to not have had recommended treatment because of cost\textsuperscript{8}. Therefore, private dental insurance is an important factor modifying access to dental care. These affordability and accessibility inequalities between groups might indicate a substantial variation within Australian children, as seen in previous studies\textsuperscript{12,14}.

The literature is replete with evidence that remote Indigenous children experience worse oral health than their urban counterparts\textsuperscript{11,15}, but this is not reflected in the higher rates of hospitalisation among metropolitan Indigenous children\textsuperscript{14,16–20}. This can be partly explained by the greater availability of service (even SDS) and the higher proportion of insured urban-living Indigenous children than insured rural and remote dwellers. In the rural environment, dental health-care services may be sparse and located great distances from the patient. In an urban environment, health-care services may be located closer but, in addition to financial issues, transportation (such as buses, trains) may be a barrier to getting to the needed care on time.

The Indigenous population is disadvantaged across a range of socioeconomic conditions and these affect child health outcomes. Research over the past decade has continued to show that Indigenous children suffer disproportionately from many diseases, including dental diseases, and a delayed access to the health-care system will increase their risk for other complications and mortality from these illnesses. Most dental dis-
cases are preventable and unnecessary suffering and disability can be avoided by decreasing delays in diagnosis and treatment. In addition, lack of access to ambulatory health care can lead to unnecessary hospitalisations and more expensive forms and utilisation of health care. Therefore, having dental insurance is seen, at least partly, as a way of overcoming financial barriers when in need of dental care.

Over time the level of health insurance for Indigenous and non-Indigenous children can thus be seen to reflect the inequality in health systems (including dental health) among the Australian child population. Throughout Western Australia the SDS primarily focuses on prevention and education, and it provides free limited basic dental care by dental therapists to school children ranging from pre-primary up to Year 11 and to Year 12 in remote locations. The Australian government provided a ‘safety-net’ system (SDS) as a way to provide free or reduced fee dental care to uninsured children. However, these sources of care are not always accessed and, as the numbers of poor and uninsured increase, the ‘safety-net’ health system will be unable to bear the burden of providing dental health care to all of the uninsured. In addition, any further invasive treatment is referred to other providers and any costs are the responsibility of the parent.

The public health community needs to know more about the restrictions to seeking dental health care within the Australian child population to enable better resource allocation, policy and planning. Therefore, understanding and developing a plan to combat the disparities in dental health among these groups should be a national priority.

CONCLUSION

Dental health insurance is a major component of obtaining and accessing child dental health care. Our study adds new information regarding the demand for dental care among children aged between 0 and 14 years, who account for 18.9% of the Australian population, leading to an increasing awareness of the substantial heterogeneity within the populations. Therefore, better understanding of disparities in access to care among children and the socioeconomic divide in oral health insurance coverage, and subsequent development of intervention programmes, will be critical to improving Australian children’s oral health. Eliminating socioeconomic and geographical disparities in dental insurance and dental care requires additional efforts in removing both financial and non-financial barriers to dental utilisation. Furthermore, improving dental insurance coverage for Indigenous and rural-living children will ultimately help save health costs and improve overall health for the next generation.

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Conflict of interest

None declared

REFERENCES


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Appendix D
A population-based cost description study of oral treatment of hospitalized Western Australian children aged younger than 15 years

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Keywords
cost; children; dental hospitalization; Western Australian.

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Abstract

Objectives: We sought to analyze the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years and to identify socio-demographic characteristics associated with these costs.

Methods: This study analyzed the cost of 43,937 child patients under the age of 15 years hospitalized for an oral health–related condition, as determined by principal diagnosis International Classification of Diseases (ICD-10AM). The Australian Refine Diagnosis Related Group version 5.1 was used to calculate the direct cost. An analysis of costs was broken down by socioeconomic status, primary place of residence, age, gender, insurance status, and Indigenous status.

Results: The total DRG cost of these admissions was approximately AUS$92 million over 10 years. Most of these funds went toward treating “Dental caries” and “Embedded and impaction” conditions of children under the age of 15 years. Approximately 95 percent of the total cost of hospitalization for oral conditions, over the last decade, accounted for non-Indigenous children. Since 2000, the direct cost of child hospitalization for oral-related conditions has increased to reach $13 million AUD in 2009.

Conclusions: This study identified the substantial economic burden of child oral-related hospitalizations that emphasizes the importance of preventing costly inpatient treatments.

Introduction

Dental conditions, specifically caries, are affecting the majority of children who live in Western Australia (WA). It is important to note that the Australian Government provides funds for running various public health programs, such as School Dental Services (SDS), addressing children with poor oral health (1). Yet, many children still end up in hospitals for dental treatment. The public health burden of hospital admissions due to oral conditions is quite substantial. Recent research indicates that the rate of hospitalization due to oral conditions among WA children is 1,074 per 100,000 populations annually (2). Yet, little is known about the economic effects of in-hospital treatment of such conditions in Australia. It has also been noted that dental admissions are the largest category of acute preventable hospital admissions and that oral health problems are the second-most expensive disease group in Australia, with direct treatment costs of over $6 billion annually and additional care costs exceeding a further $1 billion (3).

The provision of healthcare services to children affected by oral health issues in WA has been a very costly obligation. Tennant et al. affirms how expensive oral healthcare for Western Australian children is, by stating that in 1995 approximately $111 million were spent on the hospitalization of children under 18 years of age (4). Existing data suggest that in the period between 1999 and 2003, the cost of hospitalization for children under the age of 18 years was $40 million (5). However, current estimates of treatment costs are unknown, and prior estimates are likely to be obsolete in light of newer therapeutic modalities, inflation, and changing patterns of hospitalization and surgery. The precise estimation of the costs of oral health services is critical to prevent undesired consequences affecting the quality of oral health care. Therefore, an updated estimate of the treatment costs of oral diseases in WA is necessary, as this is an expensive service of
providing treatments for (mostly) preventable conditions, and our objective was to document all costs associated with the treatment of dental conditions in the child population.

The aim of this study is to analyze the economic cost of a decade of dental hospital admissions in Western Australian children under the age of 15 years and to identify socio-demographic characteristics associated with these costs. The null hypothesis of this study is that hospital admissions for dental reasons (in children) are not associated with an increased economic burden on Australian dental health expenditure.

**Materials and methods**

**Data source**

This research involved a de-identified detailed analysis of the data obtained from the WA Hospital Morbidity Data System for ten fiscal years from 1999/00 to 2008/09. This research has been conducted in full accordance with the World Medical Association Declaration of Helsinki, and ethics approval was granted by the Ethics Committee of the University of Western Australia. Children were not directly involved in the study, as this was only an analysis of de-identified hospitalization data, as provided by the Health Department of Western Australia. These admissions included all children hospitalized for oral treatment at WA including the day surgery for the study period. Demographics including age-adjusted rates and percentages of variables were previously published (2).

**Principal diagnosis**

Principal diagnosis, classified by the International Classification of Diseases (ICD-10AM) system, was obtained for every child under the age of 15 years diagnosed and accordingly admitted for an oral health condition in WA for the study period. All principal diagnoses of oral health conditions (ICD-10AM) were included in the analysis. The ICD–10–AM “is the Australian Modification of the revision 10 of the International Classification of Diseases (ICD–10)” (6). It is the “standard classification scheme now used for reporting diagnoses in all Hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol” (6).

**Determination of direct cost**

Across Australia, the Australian Refine Diagnosis Related Group (AR-DRG) is used to calculate the cost of each patient episode on the basis of actual data about the treatment process. It is considered that Australia is a model example of a mature costing system and has the most sophisticated approach according to cost guidelines that include the actual amount of resources used in the treatment of a particular patient (7). Therefore, AR-DRG version 5.1 was used to calculate the direct cost (the Australian dollar value used according to the year of admission). AR-DRG “is an Australian admitted patient classification system which provides a clinically meaningful way of relating the number and type of patients treated in a hospital (that is, it’s casemix) to the resources required by the hospital”. Each AR-DRG represents “a class of patients with similar clinical conditions requiring similar hospital services” (8). The categorization classifies “acute admitted patient episodes of care into groups with similar conditions and similar usage of hospital resources, using information in the hospital morbidity record such as the diagnoses, procedures and demographic characteristics of the patient” (8). AR-DRG cost based on age, gender and Indigenous status, insurance status, hospital area, and type of each child were analyzed.

**Remoteness/accessibility**

Direct cost based on remoteness was determined using the Accessibility/Remoteness Index of Australia (ARIA) classification, which measures “remoteness in terms of access along the road network from populated localities to each of five categories of Service Centre. Localities that are more remote have less access to Service Centers; those that are less remote have greater access to Service Centers” (9).

**Socioeconomic status**

DRG based on socioeconomic status was analyzed using Socio-Economic Indexes of Area (SEIFA) classification. SEIFA is a nationally accepted coding developed by the Australian Bureau of Statistics (ABS), which ranks areas in Australia according to relative socioeconomic advantage and disadvantage based on information from the five-yearly census (10).

**Indirect cost**

Based on previous study, indirect costs were predicted at approximately 1.5 times the direct cost (11), and because DRG is a direct cost, this method has been used to calculate the indirect costs. Indirect costs include the following: patient and parents/guardians’ absence from school or work due to pain and discomfort or having to accompany the child; cost of transportation and accommodation; and societal losses of productivity.

**Statistical analysis**

To determine significant differences between continuous variables and nominal (categorical) variables, Kruskal–Wallis
test was used when appropriate. Significant levels were set at 95 percent with P value less than 0.05 deemed to be significant.

SPSS 21 for Windows (Statistical Package for the Social Sciences; SPSS, Chicago, IL, USA) software and Excel 2007 (Microsoft, Redmond, WA, USA) are used for analysis.

**Results**

From 2000 to 2009, a total of 43,937 children (0-14 years) were admitted to hospital for oral health–related conditions. Of these, 5 percent \( n = 2,119 \) were Indigenous children.

**Dental cost (all children)**

The total DRG cost of these admissions was approximately AUS $92 million with a mean DRG cost of $19,975, with an estimation of additional AUD $138 million indirect cost (Table 1).

**Age in years on admission**

Costs were higher for children younger than 9 years (DRG 68 million) compared with 10- to 14-year-old children (DRG 25 million) \( P < 0.01 \) (Table 1).

**Gender**

The cost did not vary substantially by gender (Table 1).

**Indigenous status**

Approximately 95 percent of the total cost of hospitalization for oral conditions, over the last decade, was accounted for non-Indigenous children. However, the mean DRG cost among Indigenous children \( $24,185 \) actually was higher than the non-Indigenous children \( $21,857 \) \( P < 0.01 \) (Table 1).

**Hospital type**

Fifty-nine and 41 percent of the hospitalization costs were incurred in private and public hospitals, respectively. However, the mean DRG cost among children admitted to private hospitals \( $22,283 \) was significantly higher than children admitted in public hospitals \( $21,473 \) \( P < 0.01 \) (Table 1).

**Location**

Children living in metropolitan areas accounted for the highest proportion (86 percent) of oral hospitalization costs.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The Australian Refine Diagnosis Related Group Cost of Hospitalization of Western Australian Children Based on Different Variables</th>
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* P < 0.001, Kruskal–Wallis test.
† AUD $ = Australian dollar.
The mean DRG cost among children living in urban areas ($22,300) actually was higher than rural living children ($20,072) \((P < 0.01)\) (Table 1).

**Socioeconomic status**

The oral condition-associated costs of hospitalization were much less for the most disadvantaged children (17 percent of the total cost) when compared with the other socioeconomic groups (Table 1).

**Remoteness/accessibility**

The proportion of admissions decreased with increasing geographic remoteness. Therefore, total disease-attributable costs of oral hospitalization varied significantly by ARIA \((P < 0.01)\). The direct cost of hospitalization of children living in Accessible areas was 12 times higher than children living in Very Remote areas. However, the mean DRG cost of admission among children living in very remote areas actually was the highest ($22,808) among other ARIA groups \((P < 0.01)\) (Table 1).

**Insurance status**

The cost of hospitalization of insured children was higher than their uninsured counterparts by approximately $5 million AUD (Table 1).

**Cost per condition overtime**

In 2000, the direct cost of child (younger than 14 years old) hospitalization for oral related conditions reached about $6 million AUD. Since then the cost had more than doubled to $13 million AUD in 2009 (Figure 1). The variations overtime were statistically significant \((P < 0.01)\).

**Direct cost (based on the most common oral conditions)**

Of all admitted cases 94 percent \((n = 41,475)\) accounted for seven major categories of oral conditions with half (50 percent) of those hospitalizations for “Dental caries,” which cost approximately $45 million AUD. This was followed by, “Embedded and impacted teeth” (14 percent = $12 million AUD), “Pulp and periapical” tissue conditions (11 percent = $10 million AUD), “Developmental and Birth defects” (5 percent = $11.5 million AUD), and “Dental fractures” (5 percent) and “Dentofacial anomalies” 4 percent, which costs around $4 million AUD each (Table 2).

**Age in years on admission**

Oral-related hospitalization costs did differ by age group. The highest costs were significantly accounted for 5- to 9-year-old children who were hospitalized for “Dental caries,” “Pulp and periapical,” or “Developmental defects” \((P < 0.01)\). “Embedded and impacted teeth” significantly incurred the highest costs among 10- to 14-year-olds \((P < 0.01)\). However, in the younger than 5-year-old group, the highest hospitalization costs were incurred by the conditions classified as “Dental fracture” or “birth defects” (Table 2).

**Indigenous status**

Non-Indigenous child hospitalization costs were significantly higher than those of Indigenous children across the condition categories of “Birth defect,” “Developmental defects,” “Dental caries,” and “Pulp and periapical conditions” \((P < 0.01)\) (Table 2).

**Gender**

It has been observed that hospitalization costs for “Embedded and impacted teeth” conditions were significantly higher among females than males \((P < 0.01)\) (Table 2).

**Socioeconomic status**

Significantly higher costs were observed among children living in least disadvantage areas admitted for “Dental caries” conditions \((P < 0.01)\). However, of children admitted with “Pulp and periapical” conditions, the admissions costs of children living in the most disadvantaged areas were 1.5 times higher than the admission cost of those living in the least disadvantaged areas \((P < 0.01)\) (Table 2).
Remoteness/accessibility

Across all conditions, the majority of hospitalization costs were driven by children living in Accessible areas. (Table 2) These variations were significantly higher among children hospitalized for “Developmental defects,” “Dental caries,” or “Pulp and periapical” conditions ($P < 0.01$).

Insurance status

The cost of insured children admitted due to “Dental caries,” “Embedded and impacted teeth,” or “Developmental defects” conditions were more likely to be higher than those without insurance admitted with the similar conditions. However, the cost of insured children hospitalized as a result of “Pulp and periapical,” “Birth defects,” or “Dental fracture” conditions were lower than those without dental insurance hospitalized with parallel conditions (Table 2).

Hospital type

The highest admission costs of “Dental caries,” “Embedded and impaction,” or “Developmental defects” were significantly incurred in the private sector, ($P < 0.01$). For “Dental fracture,” “Birth defects,” and “Pulp and periapical” conditions, the greatest children hospitalization costs were incurred in public hospitals ($P < 0.01$) (Table 2).

Location

The admission costs for all common conditions (except “Dental caries” and “Embedded and impacted teeth”) were significantly higher among children living in rural areas, when compared with their urban living counterparts ($P < 0.01$). Conversely, the cost of hospitalization of children with “Dental caries” or “Embedded and impacted teeth” conditions living in metropolitan areas were 5.5, and 5.2 times higher than their rural living counterparts, respectively (Table 2). However, the admissions cost of rural living children (admitted for birth defects, pulp, and periapical or dentofacial anomalies condition) were significantly higher among urban living counterparts ($P < 0.01$).

Cost per condition over time

Figure 2 shows that the costs of hospitalization for common oral conditions except “Dental caries” were nearly doubled in
after 12 years of age, especially among those seeking ortho-
canine that is common oral pathological finding reported
mainly attributable to the impaction of maxillary permanent
tooth. In addition, older children are able to cope better
in the oldest age group, as new healthy permanent dentition is
usually have deciduous teeth that were exposed to cario-
tic factors for a longer time. This explanation is supported
as the average cost per admission has increased, this inevita-
ably led to an increase in total costs. Most of these funds went
towards treating “Dental caries” and “Embedded and impac-
tion” conditions. This is consistent with previous studies
Baseline admission costs of oral treatment of Western Australian children by condition, overtime.
*AUD $ = Australian dollar. Amount expressed in constant dollars to account for inflation.
2009 (P < 0.01). However, the admission cost of “Dental caries” in 2009 was almost threefolds higher than the admission cost of children in 2000 (P < 0.01).

Discussion
This study indicates that, overtime, the hospital admissions for dental reasons (in children) were associated with an increasing economic burden on Australian dental health expenditure. A steady but significant rise can be seen in the oral-related admission rates of children over the period (2).

As the average cost per admission has increased, this inevitably led to an increase in total costs. Most of these funds went towards treating “Dental caries” and “Embedded and impaction” conditions. This is consistent with previous studies (4,5).

Significant cost differences were found based on age, with children younger than 5 years old, incurred the highest admission costs as a result of traumatic dental fracture or birth defects (mainly cleft lip and palate). On the other hand, among children aged between 5 and 9 years old, the highest admission costs of dental caries or pulp and periapical conditions might be attributed to the fact that children at this age generally have deciduous teeth that were exposed to cariogenic factors for a longer time. This explanation is supported by finding low costs of dental caries admissions for children in the oldest age group, as new healthy permanent dentition is present. In addition, older children are able to cope better with dental treatment under local anesthesia than younger children (12). However, the greater cost related to treatment for embedded and impacted teeth at this age group was mainly attributable to the impaction of maxillary permanent canine that is common oral pathological finding reported after 12 years of age, especially among those seeking ortho-

dodontic treatment. Moreover, it has been evident that an impacted canine is twice more likely to be common in females than males (13).

The Indigenous population is disadvantaged across a range of socioeconomic conditions that sequentially affect child health outcomes. The literature is replete with evidence that Indigenous children experience worse oral health than their non-Indigenous counterparts (14,15), but this is not reflected in the costs of hospitalization among Indigenous children. These challenges in accessing dental care are fundamentally linked to issues of affordability, lack of healthcare service (even SDS), and the proportion of insured Indigenous children. In addition, most Indigenous children live in rural areas where dental healthcare services may be sparse and located at great distances from the patient.

The structure of the dental system in Australia is largely private, consequently most hospitalizations concerning oral problems for children take place in private hospitals with both providers and services concentrated in major cities (5,16). In an urban environment, healthcare services may be located closer in distance; therefore, the availability of the service increases the utilization and consequently increases the cost. On the other hand, it might be obvious that the greater costs of admissions in public hospitals were incurred by emergency oral conditions, whereas the highest costs of admissions in private hospitals were incurred by dental caries treatment and impacted teeth removals. Dental health insurance coverage is known to be the dominant predictors of the private sectors utilization of and access to dental care. This is because of their ability to mitigate the costs of care (17).

Researches over the past decade have continued to show that low socioeconomic status children suffer disproportionately from many dental diseases and a delayed access to the healthcare system that will increase their risk for other complications (18). However, our study indicates that hospitalization costs of the most disadvantaged group are low, except for “Pulp and periapical” conditions. This may be attributed to the fact that children only access dental health care when conditions reached an advanced stage that requires admission for more invasive treatment, and accordingly a much greater public expense, than if they had been provided dental treatment or prevention in early stages.

Furthermore, for children living in remote regions of the state where access to dental care is difficult, resulting in long delays in the provision of treatment and, most likely, significant morbidity associated with dental pain and oral infection. Additionally, traveling to distant centers for treatment under general anesthesia by specialist pediatric dentists has become the usual method by which treatment is provided to the majority of affected children. In this context, the costs that accounted primarily for this significant difference were travel and treatment costs associated with hospitalization and the administration of general anesthesia (19). Many parents,
especially rural-based or Indigenous, cannot afford such high hospitalization and treatment costs. Accordingly, a procedure such as extraction of decayed teeth, which is relatively cheaper, is more preferable option. However, when affordability and accessibility issues are overcome, the remote band groups had significantly higher costs than groups that were located closer to treatment centers.

Over the last decade, there has been a substantial growth in hospitalization costs for all conditions particularly dental caries. This might be explained by the increase in child population over the study period; however, hospitalization rates also shows increases (2). It has also been anecdotally reported that in light of the recent global economic crisis, overall dental treatment prices in Australia have increased well beyond inflation, and the shift toward demanding more expensive private services has occurred. Furthermore, it can be argued that a decline in the robustness of the current school dental service approach has an impact on child dental hospitalizations, resulting in elevated costs in WA. Figures of increasing cost overtime would have implications for the future, indicating a significant burden on the Australian healthcare system.

In Australia, dental care is not subjected to the tenets of the Australian Health Act, hence the funding structure in the dental system is different to the rest of the health system in that individuals pay for the majority of their care. Although government funding is significant, the subsidies available are far less than those provided in the general health system. The amount of funding available to the public system is dwarfed by consumer expenditure in the private system. However, historically, the UK included dental care in their National Health Service system. Therefore, economic analyses in the UK and other European nations are not generally applicable to Australia, given that different patterns of dental care utilization and payment systems between countries result in marked variations in dental healthcare expenditures.

**Conclusion**

In brief, our study concludes that it is important to prevent costly inpatient treatment by early detection, prevention, and intervention as findings indicate a substantial economic burden of child hospitalization (for dental reasons) (20-23). Therefore, with limited public health resources, strategies are needed to focus on best practice principles of care and demand management for better utilization of available health resources. In our view, tremendous monetary benefits are expected when primary prevention of dental caries, especially in children, through SDS is implemented. The high economic burden of children dental hospitalization implies the need for health resources redistribution based on a regional need in conjunction with the development of community-based preventive programs and treatment programs.

**Acknowledgment**

The authors would like to thank Professor John McGeachie OAM for his continuous ongoing support of the whole team.

**Conflict of interest**

None declared.

**References**

Cost description study of oral treatment of Western Australian children

A. Talal Alsharif et al.
Appendix E
Future projections of child oral-related hospital admission rates in Western Australia

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Abstract. This study aimed to project the hospital admission rates of Western Australian children for oral conditions, with a particular focus on dental caries, embedded and impacted teeth, and pulp and periapical conditions through to the year 2026. Two methods were used to generate projection data through to the year 2026, using the Western Australian Hospital Morbidity Dataset for the period 1999–2000 to 2008–2009. The projected admission rate increase in those children aged 14 years and younger from 2000 to 2026 was 43%. The admission rates are expected to more than double over time (7317 cases in 2026 compared to only 3008 cases in 2000) for those children living in metropolitan areas. Dental caries, embedded and impacted teeth, and pulp and periapical conditions will remain the top (mostly) preventable causes of admission throughout this time. Anticipating the future burden of oral-related hospital admissions in children, in terms of expected numbers of cases, is vital for optimising the resource allocation for early diagnosis, prevention and treatment. A concerted effort will be required by policymakers and oral healthcare communities to effect substantial change for the future.


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Introduction

Over the past 30 years, there have been significant improvements in the oral health of Western Australian children, partly associated with the development of a comprehensive school dental service (SDS) and public health measures, such as widely accessible fluoridated water supplies (Kruger et al. 2006). As a result, the prevalence of dental disease in children has diminished (Blinkhorn and Davies 1996). However, dental caries are still a major public health concern in most developed countries, affecting 60–90% of school-age children, and their incidence is expected to increase significantly over time in many developing countries (WHO 2015). Oral health conditions are responsible for the highest number of acute preventable hospital admissions and significant cost to Australia (SCRGSP 2010), and cause considerable social concern within the community.

In Western Australia (WA) during 1999–2000 and 2008–09, dental conditions accounted for 933 and 1081 hospital admissions per 100 000 person-year (PY), respectively; these numbers could be reduced by providing early access to appropriate services (Alsharif et al. 2014a). The majority of cases were for dental caries and extractions. Dental conditions cost the state more than $92 million over the last decade (Alsharif et al. 2015a). Overall, 546 cases per 100 000 children per annum were admitted for ‘dental caries’ and 144 admissions per 100 000 had ‘embedded or impacted teeth’ (Alsharif et al. 2015a). In addition, a previous study has shown a clear urban–rural divide in child hospital admissions; the estimated age-adjusted hospitalisation rates (AARs) of urban-dwelling children were twice that of their rural-dwelling counterparts (Alsharif et al. 2014a).

By 2040, the WA population is projected to double, with metropolitan areas remaining the dominant population centres in the state (ABS 2013). Hence, an increase in oral-related conditions in children is expected to have a significant impact on the demands for oral health services over the next 20 years. This is likely to be exacerbated by limited resources and workforce shortages. Projections of oral-related admission rates and their associated costs need to be performed to inform policy, planning and resource allocation. Previously, projections have led to better planning and resource allocation (Madge 2000; Goss 2008; Commonwealth Department of Health 2009; Australian Institute of Health and Welfare 2014; Health Workforce Australia 2014).

To date, there are no data available on future child oral-health hospitalisation demands in Western Australia. An understanding of the projected incidence of children’s oral conditions is a fundamental obligation to enable rational planning for monitoring and treatment of oral conditions. Against this backdrop, the aim of this study was to analyse projected oral-health-related admission rates of Western Australian children, with a particular focus on dental caries, embedded and impacted teeth, and pulp
What is known about the topic?

- To date, there are no data available on future child oral-health hospitalisation demands in Western Australia.

What does this paper add?

- Future oral-related hospital admission rates among children are an important measure of the burden of oral health care in Australia and have implications for future resource allocation and planning.

and periapical conditions through to 2026, based on 10 years of past hospitalisation data for robustness.

Materials and methods

Data source

This study involved a de-identified detailed analysis of the data obtained from the Western Australian Hospital Morbidity Dataset for the period 1999–2000 to 2008–2009 under ethics approval from the University of Western Australia. A principal diagnosis was obtained for every child under the age of 15 years admitted for an oral health condition (in both private and public hospitals) in WA for the study period, using the International Classification of Diseases Tenth Revision-Australian Modification (ICD-10-AM) system. All principal diagnoses of oral health conditions (ICD-10-AM) were included in the analysis. The ICD-10-AM ‘is the standard classification scheme now used for reporting diagnoses in all hospital statistical collections, including the National Minimum Data Set and the Hospital Casemix Protocol’ (Commonwealth Department of Health and Aged Care 1998). Age and residential area for each child were analysed. Future predictions for dental caries, embedded and impacted teeth, and pulp and periapical conditions, which accounted for 75% of all hospitalised conditions during the study period, were also analysed.

Data analysis

All projections were based on age-specific hospitalisation rates and AARs, which were calculated using the Health Statistics Calculator, a software package developed by the Health Department of WA. Population data (denominators) for hospital admission rates were obtained from estimations by the Health Department of WA. These estimations were based on population data obtained by Australian Bureau of Statistics census surveys. Two separate methods were used to project future cases (Gill et al., 1997). Both methods accounted for the projected increase in both the population and the incidence of these conditions, using 10 years of data. The first method, the linear method, used historical data to estimate a line of best fit for each 5-year age group, using the method of least squares. Based on the estimated AARs, the future number of cases was determined. The second method, the exponentially weighted moving average (EWMA), used historical trends to model future points equally. This method places greater weight on more recent data. Applying the two methods separately resulted in very similar trends; therefore, only the results of the linear method are presented. There is a general consensus among statisticians that a relatively simple linear model of age-specific rates provides a good fit to the data while giving reasonably accurate predictions over a short to medium time span (Australian Bureau of Statistics 2013). The accepted approach among statisticians preparing projections of this nature is to assume a linear model for increasing rates to prevent projecting admission rates below zero. Further, there is a fundamental presumption in this approach that the factors that affect oral-related admissions, such as risk factors, change in an approximately linear way with time for each age group (Australian Bureau of Statistics 2013). This presumption holds on condition that there are no major quantitative changes in any underlying factors, such as the introduction of an intervention program.

Cost projections

Based on a previous study, Australian refined diagnosis-related groups (AR-DRGs) were used to calculate the direct cost of each patient episode on the basis of actual data about the treatment process (Alsharif et al. 2015b). Each AR-DRG represents ‘a class of patients with similar clinical conditions requiring similar hospital services’ (AIHW 2013). The DRG cost was divided into categories: low (0–4000); middle (4001–10 000); high (10 001–20 000); and extremely high (20 001 and over). The low-cost category was most representative of the overall cost distribution, which was normally distributed. Therefore, low-cost was deemed appropriate to use in future cost projections.

Other data analyses were performed using SPSS 21 for Windows (IBM, Chicago, IL, USA) and Excel 2007 (Microsoft, Redmont, WA USA).

Results

A total of 43 937 children (0–14 years) were admitted to hospital for oral-health-related conditions over the study period. Of these, 15% (n = 6525) were rural-dwelling children.

Projections of all oral-related hospitalisations rates

Population projections through 2026 for WA indicated a significant increase (66%) in the total population. The actual projected oral-related admission rates increase in those aged 14 years and younger from 2000 to 2026 is 43% (Fig. 1). Of the total projected oral-related admissions, a 171% increase in hospitalisation rates of children aged 5–9 years is projected to occur in 2026. However, in 2026, a 23% decrease in hospitalisation rates among children younger than 5 years is projected. (Fig. 1)

It is anticipated that the AARs will more than double (7317 cases in 2026 compared to only 3008 cases in 2000) for those children living in metropolitan areas (Fig. 2). In contrast, a slight reduction is projected in the AARs among rural-dwelling children (Fig. 2).

The overall direct costs of all oral-related child hospitalisations are estimated to increase from $10 million in 2009 to $16 million in 2026, an increase of 61% (Fig. 3). From 2016 to 2026, oral hospital admissions will cost the state a minimum of AU $147 million (Fig. 3).
Projections of dental caries hospitalisation rates

Hospitalisation due to oral conditions among children is highly influenced by dental caries, as this condition accounts for ~50% of all cases. Assuming hospitalisation rates will follow a similar trend in future, it is projected that the overall AARs of dental caries will more than double from 406 to ~937 cases per 100 000 PY between 2000 and 2026. With the anticipated increases in the population, this equates to ~3742 new cases expected to be hospitalised in 2026 (Fig. 4). In addition, the overall AARs of hospitalisation in children living in metropolitan areas is projected to rise from 417 to ~1190 cases per 100 000 PY between 2000 and 2026, which equates to ~3982 new cases expected to be admitted in 2026 (Fig. 5). A significant gap is predicted to occur in the future between the hospitalisation rates of children living in rural areas compared to those living in metropolitan areas. (Fig. 5)
Projections of hospitalisation rates for embedded and impacted teeth

The admission rates of children with embedded and impacted teeth is projected to stabilise over the next decade, with children aged 10–14 years still accounting for the highest admission rates (Fig. 6). Although hospitalisation rates of children living in metropolitan areas will decrease slightly over time, remarkable variations in admission rates will continue to occur between rural- and urban-dwelling children. (Fig. 7)

Projections of hospitalisation rates for pulp and periapical treatment

The admission rates of children for pulp and periapical treatment are projected to stabilise over the next decade and are expected to reach ~244 cases per 100 000 PY in 2026, an increase of almost 66% from 2000 (Fig. 8). The significant split in admission rates between rural- and urban-dwelling children will continue through the next 10 years, with children living in urban areas 2.4 times more likely to be admitted to hospital as a result of pulpal and periapical conditions than their rural-dwelling counterparts. (Fig. 9)

Discussion

Although there has been a significant reduction in dental caries in children over the last generations in Australia (as in other developed countries), the rates of oral-related hospital admissions among children have increased substantially over the past decade. The annual rates of admissions in WA are predicted to increase significantly over the next 20 years. It is important to note that projections are not intended to function as exact forecasts, but to indicate what might be expected if the...
stated assumptions were to apply over the projected time frame. More recently, our team has revealed that the AAR of hospitalisations for oral conditions increased from 926 in 2000 to 1085 cases per 100,000 PY in 2009 (Alsharif et al. 2015a). By 2026, the rates of avoidable hospitalisation and associated costs are projected to increase. It is reasonable to predict that the number of children with oral conditions will increase by an even greater percentage, as only school-registered children are clinically diagnosed and treated within the limited SDS scope. An increase in age-adjusted dental caries admission rates has been observed over the past 10 years and this trend is likely to continue, resulting in an estimated 52% increase in the annual number of admissions due to dental caries by 2020. If these trends continue, an estimated 83% increase in dental caries admissions can be expected by 2026. The dramatic increase in the anticipated number of dental caries in school-age children should be alarming to all those concerned with planning and providing dental services to children in WA.

The projected rates of hospitalisation for embedded and impacted teeth removal/treatment are expected to remain stable or decrease slightly. This might be attributed to the changing rates of procedures as a result of changing trends in clinician beliefs, as well as changing health insurance levels in the community. However, the authors believe that this trend is not expected to continue indefinitely and there will be an increase in the projected number of cases admitted to hospital for the removal of embedded and impacted teeth among disadvantaged children once they have access to appropriate services. This assumption is based on the fact that disadvantaged children are at higher risk of systemic and metabolic disorders, genetic disorders and deciduous teeth injuries, which are all causes of delay in tooth eruption or impaction (Almonailiene et al. 2010).

It is predicted that there will be an increase in admission rates for pulpal and periapical conditions in children aged 5–9 years old over the next 20 years as a result of population growth and poor dental health service access. Long intervals between SDS visits might delay interventions and early prevention; consequently, children only access care when dental conditions have reached advanced stages. In addition, the lack of affordable dental care and insurance coverage lead to the postponement of dental treatment, often for years. These untreated symptoms inevitably become more severe, resulting in children requiring admission for more invasive treatment at a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

The health of rural- and remote-dwelling children in Australia is poorer than that of urban-dwelling children for most indicators, including marked inequalities in oral health and oral health services (AIHW 2008). Geographical access to health services is clearly the reason for these inequalities in health. In metropolitan areas, clinics are located mainly in community health centres, or on school or hospital grounds. However, in some rural communities, mobile dental clinics provide limited oral health services for children. This inequality is evident in the fact that children living in metropolitan areas are more likely to be admitted to a hospital for dental procedures than children living in rural areas (Alsharif et al. 2015a). Children in rural and remote regions are also less likely to have private health cover (Alsharif et al. 2014b), which plays an important role in the private-driven oral healthcare delivery system in Australia. Further contributing to inequalities is the fact that WA is experiencing a dental workforce shortage in rural and remote areas, especially in dental therapists and specialists (Steele et al. 2000).

Over the last decade, there has been substantial growth in hospitalisation costs for all oral conditions, particularly dental caries (Alsharif et al. 2015b). This cost-pressure scenario is only expected to increase in the near future. As a result of the recent global economic crisis, dental treatment prices in Australia are expected to increase well beyond inflation rates and a demand for more expensive private services has occurred. In addition, a decline in the robustness of the current SDS approach has had an impact on child dental admissions, resulting in elevated costs in WA. The projected increasing costs will have implications for the future, indicating a significant burden on the Australian healthcare system.

Increases in the AARs of children admitted for oral conditions may be explained by several factors. For example, demographic shifts in the Australian population will have a major influence on the projected number of oral-condition cases in the future. Although evidence indicates that some minority populations have higher oral-condition rates that are not reflected by lower admission rates, additional increases in the projected admission rates are expected once these groups gain access to the service. In addition to an actual increase in the incidence of oral diseases, population growth (primarily in urban areas), workforce shortages and misdistribution, changes in diagnostic and treatment practices, and limited resources for specific conditions, are likely to affect the future burden of these diseases. These shifts will create a significant socioeconomic burden on the Australian dental health system, since dental services are not covered by the principle of universal access. Clearly, opportunities to target early intervention towards those at higher risk of the need for admission, and to target primary and preventive services towards areas of need, are key research and policy directions that come from this research.

**Conclusion**

Projections indicate increasing rates of oral-related admissions among Western Australian children, especially for dental caries, and pulpal and periapical conditions. Oral diseases among children have a considerable impact on the Western Australian community. The rates of oral-related admissions occurring in Western Australian hospitals each year is an important measure of the burden of oral conditions in Australia and has implications for resource allocation and planning. Investment decisions on the prevention of oral conditions and treatment facilities, workforce planning and evaluation of oral health policy rely not only on knowing how many cases were hospitalised in a given year, but on how many can be expected to be admitted in the future. Therefore, a universal strategy is needed to set the platform for oral health actions in WA into the next decade. Anticipating the future burden of oral-related admissions in children in terms of expected numbers of cases is vital in optimising the allocation of resources to enable children to have timely access to preventively focused dental care that meets
References


Appendix F
Identifying and prioritising areas of child dental service need: a GIS-based approach

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**Aim:** To identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia. **Design:** All children hospitalised due to an oral-condition from 2000 to 2009, at metropolitan areas of Perth were included in the analysis of a 10-year data set. QGIS tools mapped the residential location of each child and socioeconomic data in relation to existing services (School Dental Service clinics). **Results:** The tables and maps provide a clear indication of specific geographical areas, where no services are located, but where high hospital-admission rates are occurring, especially among school-age children. The least-disadvantaged areas and areas of high rates of school-age child hospital-adoptions were more likely to be within 2km of the clinics than not. More of high-risk-areas (socio-economically deprived areas combined with high oral-related hospital admissions rates), were found within 2km of the clinics than elsewhere. **Conclusion:** The application of GIS methodology has identified a community’s current service access needs, and assisted evidence based decision making for planning and implementing changes to increase access based on risk.

**Key words:** Geographic Information System, hospital admissions, child oral health, Australia

**Introduction**

With the substantial reduction in dental decay prevalence in child populations there is an ongoing need for the systems that underpin care for this group to evolve to meet changing oral health profiles. Consistent with the greater exposure of many societies to fluoride, dental decay in children has diminished dramatically. In most developed countries caries prevalence hovers around 50% of the population, and severity as measured by the DMFT index at age 12 years, is below two (Petersen, 2003). Caries experience in Australia is consistent with these global measures (Mejia et al., 2012). Several countries have, for many years, operated School Dental Services (SDS), as a universal service model to provide primary dental care to the child population. These services have adapted to falling burdens of dental disease by, for example, means testing, integration with adult services and, in rare cases, cessation or outsourcing to private dental providers. With most of the disease burden now resting with a small minority of children, targeting of dental services to those in greatest need becomes important for effective services. Results of our previous studies indicated that Indigenous status, absence of private insurance, low socioeconomic status and rural living are the most common risk indicators of decreased receipt of preventive service or increased perceived unmet need (Alsharif et al., 2014a;b; 2015). In addition, it is well known that previous history of dental caries is the best indicator of higher future risk. In this study, we used geographic information systems (GIS) methods to identify areas of need for primary dental services for children. GIS is a computational approach to health planning using geo-referenced data (Aronoff, 1993).

The aim of this study was to identify and prioritise areas of high need for dental services among the child population in metropolitan Western Australia using the oral health related hospitalisation data of all children over a ten year period.

**Material and Methods**

Ethics approval to conduct the study was granted by the Ethics Committee of the University of Western Australia RA/4/1/5502.

To identify any possible gaps in primary dental service provision to children, data from metropolitan Western Australia (WA) were used. WA occupies the western third of the Australian continent; comprising an area of about 2.5 million sq.km with a population of about half a million aged under 15 years (ABS, 2014). Of those, 19% live in the capital city of Perth region (ABS, 2011a). Perth was used for this study as 73% of all hospital admissions for children under age 15 occurred in the metropolitan area, and existing SDS clinics are located predominantly in that area. The existing SDS in WA is a universal coverage model, providing free primary dental care to all school registered children who choose to enrol in the service. Despite being a universally applied system however, it reaches a under 30% of children (GWA DHS, 2008a). Some parents who choose to not enrol their children can access private dental services, but this is not an affordable or accessible option for many. Since 2000, SDS coverage has been declining rapidly, and more children are hospitalised for preventable oral related conditions (Spencer, 2012). Against this backdrop it is important that reliable methods are used to determine the distribution of demand for SDS clinics, to inform policy development and service planning.
Hospitalisation data were analysed for every 0-14-year-old, diagnosed and accordingly admitted to hospital in WA for an oral health condition, as classified by the International Classification of Disease – Tenth Australian Modification (ICD-10AM) (CDHAC, 1998). These data were obtained from the WA Hospital Morbidity Dataset (HMDS) for 10 financial years, from 1999/00 to 2008/09. Primary place of residence at the time of hospitalisation were also analysed, using Statistical Local Areas (SLAs) - 37 SLAs cover WA without gaps or overlaps (ABS, 2012a), and their boundary files were obtained from the (ABS) website (ABS, 2011b). Age Standardised Rates (ASR) of child hospital admissions per SLA were calculated using the Health Statistics Calculator developed by the Health Department of Western Australia and population data based on ABS census data. Based on these admission rates per SLA, the entire child population was categorised into five quintiles, separately for each age group.

Admission data for each child was available at SLA level, but for higher accuracy and precision analysis, a smaller area-based analysis was needed, and therefore census Collection Districts (CDs) were used. A CD is much smaller than an SLA, and is a quasi-measure of density of residents (based on an area that a single census officer can collect data from). Census collection districts and the geographic boundaries of each CD were obtained from the ABS webpage (2011b). The Perth metropolitan area covers 2,840 CDs, 65% of the WA’s CDs, with more than 270,000 under 14-year-olds. Hospitalisation data across each of the 37 WA SLAs were distributed by age groups (0-4, 5-9 and 10-14 years). For each age group, the rates of child hospitalisations was calculated for each SLA then this SLA rate was applied to each of the SLA’s CDs.

The number of under-15-year-olds for each CD were obtained from the ABS (2006) census data (ABS, 2013b).

For socioeconomic data, each CD has a Socio-Economic Indexes of Area score (SEIFA 2006) assigned by the ABS, based on socio-economic indicators of the CD’s population (ABS, 2013a). SEIFA is a nationally accepted coding system ranking areas in Australia according to relative socio-economic advantage based on five-yearly census data (ABS, 2013b). These rankings were dichotomised into most disadvantaged areas (Poorest, SEIFA deciles 1 to 5) and least disadvantaged areas (Wealthiest, SEIFA deciles 6 to 10).

The addresses of all fixed SDS clinics were obtained from the Department of Health (ABS, 2011b) and geocoded, i.e. changed into map coordinates and located on a map. The populations of children who lived within 2km of each SDS clinic were identified.

Geographic information systems (GIS) in this study were used as a technique for integrating hospitalisation data related to dental disease with known risk indicators (e.g. socioeconomics), to identify and prioritise geographic areas of high need for a dental service. The approach while tested on this one city was designed to be universally applicable. The resultant maps indicated where SDS clinics were located, as well as the following attributes of the child population both within and outside of a 2km zone around it: population density, age-specific hospital admission rates and an indication of area socio-economic disadvantage.

All mapping and geocoding of data used QGIS v.2.6 (Boston, USA), analyses used SPSS 21 for Windows and data were tabulated in Excel 2007.

Results

From 2000 to 2009, 31,910 metropolitan Perth children aged from 0-14 years were hospital admissions for oral-related conditions. All 77 fixed SDS clinics were included, with a ratio of 2,414 school aged child population per clinic.

The distributions of hospital admissions rates by both socio-economic status and location inside or outside 2km of a clinic are presented in Tables 1, 2 and 3. More children (68%) lived within 2km of existing SDS clinics than further away. Of all children living within 2km of a clinic, 18% of 0-4 year old children come from areas with higher (i.e. high or very high) admission rates and low socio-economic scores (poorest urban areas) (Table 1). In addition, 11% and 5% of 5-9 and 10-14 year-olds, respectively, were living in the poorest areas with higher admission rates (Table 2 and 3).

A third of children live outside the 2km zones, 6% of them come from the poorest and higher admission rates urban areas. Meanwhile, 41% of all the children are from the wealthiest areas with higher hospitalisation rates and lived predominantly more than 2km from a clinic (Tables 1-3).

Table 1. Zero to four years old child population distribution by hospital admission rates and socioeconomic status inside/outside the 2km Zone of existing SDS clinics

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<th>Admission rates1</th>
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<th>Outside the 2km zones</th>
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<tbody>
<tr>
<td></td>
<td>Poorest areas</td>
<td>Wealthiest areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low</td>
<td>3,964 (7%)</td>
<td>7,791 (13%)</td>
</tr>
<tr>
<td>Low</td>
<td>4,656 (8%)</td>
<td>6,181 (10%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>6,355 (11%)</td>
<td>6,947 (12%)</td>
</tr>
<tr>
<td>High</td>
<td>5,000 (8%)</td>
<td>7,170 (12%)</td>
</tr>
<tr>
<td>Very high</td>
<td>5,431 (9%)</td>
<td>5,528 (9%)</td>
</tr>
<tr>
<td>All rates</td>
<td>25,406 (43%)</td>
<td>33,617 (57%)</td>
</tr>
</tbody>
</table>

|                  | Poorest areas        | Wealthiest areas     | Overall |
|                  |                      |                      |         |
| Very low         | 1,153 (4%)           | 5,349 (20%)          | 6,502 (24%) |
| Low              | 1,340 (5%)           | 4,525 (17%)          | 5,871 (22%) |
| Moderate         | 967 (4%)             | 3,525 (13%)          | 4,492 (17%) |
| High             | 1,077 (4%)           | 3,073 (11%)          | 4,150 (15%) |
| Very high        | 1,950 (7%)           | 4,103 (15%)          | 6,080 (22%) |
| All rates        | 6,487 (24%)          | 20,575 (76%)         | 27,097 (100%) |

1All admission rates per 100,000 population: Very low=0-1141, Low=1142-1183, Moderate=1184-1209, High=1210-1299, Very high≥1300)
In this analysis, the term ‘highest risk areas’ refers to CDs with the poorest areas and having high oral related hospital admissions rates; ‘lowest risk areas’ being the wealthiest with the lowest admission rates. Note that admissions were based on children’s addresses at the time of admission. The location of clinics were considered as a potential barrier to children’s hospital admissions through access to early diagnosis and treatment.

Large geographical variations of high risk areas in relation to age, either outside of, or inside the 2km zone of existing SDS clinics, were observed (Figures 1 and 2). More high risk areas were observed among pre-school aged children, regardless of their location in relation to the clinics. High risk areas for children aged under 5 years were more likely to be within, rather than outside of a 2km radius of a clinic. There were also more high risk areas within, rather than outside 2km of clinics (Figures 1 and 2) for children older than 5 years. Most high risk areas were in the peripheral areas of this particular metropolitan region.

Figures 3 and 4 compared the high oral related admission rates of children living in the wealthiest areas, outside and inside the 2km zone of existing SDS clinics and reveal large geographical variation. For the wealthiest areas, those with high admission rates of school-age children were more likely to be within a 2 km of a clinic than further away. However, many areas at risk of high (school-age children) hospitalisation rates were found more than 2km from a clinic, where no SDS service is available. Most wealthier areas with high pre-school child hospital admission rates, were concentrated in peripheral areas of this metropolitan region.

When comparing children of different age groups, from poorest/wealthiest areas, where high risk of hospitalisations occur, differences were observed (Figures 1-4). Most areas with high risk pre-school admission areas, were from the poorest areas. In contrast, most of high risk school-age hospital admissions areas, were from the wealthiest areas, with a significant number being in areas with worse SDS coverage.

**Discussion**

While there has been a significant reduction in tooth decay levels in children over the last generation in Australia as in other developed economies, marked inequalities in oral health still exist. Results of our earlier work on the incidence of oral related hospitalisations among the child population of Western Australia were previously published (Alsharif et al., 2014a). It has been determined that the total Diagnosis Related group (DRG) cost of these admissions was $92 million, with an estimated additional $138 million as indirect cost (Alsharif et al., 2015). While hospitals are a vital component of any health system, the Australian dental health care system is searching for ways to increase SDS coverage and reduce costs of hospitalisations. One clear strategy is to increase the access to and utilisation of those universal primary care and preventive services.
1. The following are not a continuation of the typescript but the full sized images for use as mocked-up above.

**Figure 1.** High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) inside 2km zones of existing School Dental Service clinics in Perth.

**Figure 2.** High age-adjusted oral related admission rates of children living in low socioeconomic areas (SEIFA<6) outside 2km zones of existing School Dental Service clinics in Perth.

**Figure 3.** High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) inside 2km zones of existing School Dental Service clinics in Perth.

**Figure 4.** High age-adjusted oral related admission rates of children living in high socioeconomic areas (SEIFA>5) outside 2km zones of existing School Dental Service clinics in Perth.
In the present study, integrated data from hospital admissions, socio-economic population-based indicators, and service locations, were used to form a cohesive risk-based geographic output to support the spatial configuration of future service planning. The study demonstrates an application of GIS to population-based oral health planning.

The findings reflect the oral health profile disparities of a metropolitan population. Preventable oral hospitalisations have been proposed as a key marker of poor health plan performance (AIHW, 2014). Currently, SDSs are the main public child dental program in Australia, providing dental checkups, emergency and basic treatment, but cover only limited care for enrolled school children, particularly those within disadvantaged families (NSW OHA, 2010). Treatment outside the scope of the SDS is referred to other providers and any costs are the responsibility of the parent or guardian (GWA DHS, 2008b). Many studies confirmed that lower use of preventive health services, delay seeking primary care and higher levels of oral diseases are observed among children living in low socioeconomic areas, these untreated symptoms get more severe and admission for complex treatment may be inevitable (ABS, 2010). However, admission rates do not reflect the actual burden of the disease among disadvantaged groups possibly due to economic constraints and reduced mobility.

On the other hand, a different admission pattern was evident among children from high SES areas. These children were more likely to be admitted for oral conditions than those living in more deprived areas. Based on our previous study using the same data set, 76% of children in wealthy areas have private dental health insurance (compared to only 24% of those in poor areas) which might indicate that insurance enabled improved access to dental care and led to greater demand for hospital-based care once access had been obtained (Alsharif et al., 2014b; Bagramian et al., 2009).

This can be confirmed by the findings in Figures 3 and 4, where children from wealthy areas are more likely to be admitted for oral related conditions than children living in poor areas. Nevertheless, it is obvious from our previous analysis that insured, wealthy children are more likely to be admitted for less invasive treatment than their most deprived counterparts (who were probably more likely to receive invasive treatment), (Alsharif et al., 2014a;b) despite individuals from poor backgrounds carrying a higher burden of oral disease (AIHW, 2011). In general, it is evident that people from the most deprived areas were less likely to have taken preventive health actions such as dental screening, or having their teeth cleaned (ABS, 1999). Our study findings suggested that variations in SES may lead to variations in utilising complex health service based on need. This may contribute to widening oral health inequalities among Australians, with more low-SES children requiring admission for more invasive treatment which has a much greater public expense than if they had been provided dental treatment when the symptoms first occurred.

The results and maps provide a clear indication of specific geographical areas (in this city) where no local service is provided, but where high hospital admission rates occur especially among school-age children.

Therefore, our findings provide valuable insights to the extent of child oral health admissions in relation to access to existing services and deprivation mapped in detail across the city. These findings provide a methodological approach that can be applied, not just locally, but elsewhere to assist in planning resource allocation, prioritising services and targeting of interventions.

Conclusion

This study has applied GIS methodology to identify a community’s current service access needs, and informed evidence based decision making for planning and implementing changes to increase access based on risk. The methods developed in this framework can be adopted by other communities to identify a set of target areas with vulnerable populations and subsequently to monitor the effectiveness of remedial interventions. This model may be particularly well suited for planning and prioritising future health services in other urban communities, based on population projections and disease models of the current population.

Acknowledgments

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References


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