

# **ASSESSMENT OF A FRAMEWORK FOR THE ALLOCATION OF PRIMARY DENTAL SERVICES**

by

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## **KEYWORDS**

Oral health

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Cost comparison



# ABSTRACT

## ASSESSMENT OF A FRAMEWORK FOR THE ALLOCATION OF PRIMARY DENTAL SERVICES

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**Background:** Standardized and evidence-based resource allocation frameworks for timely provision of primary dental services may support equitable distribution of comprehensive dental care. However, such frameworks, which can be applicable to primary care settings in Brazil, are not available. The purpose of this study was to explore the complex issue of equity allocation of dental staff for primary dental care services, by estimating time to dental disease progression in order to analyze costs when survival targets are set for patients waiting for primary dental care. The inclusion of wait time benchmarks for dental services in the design of the framework was an attempt to increase knowledge on the quality of access experienced by people living within catchment areas of the Family Health Strategy in Brazil. In view of ever scarce resources for public health services, ethical dilemmas arise in resource allocation when allocation choices require priority setting among individuals who face similar health needs. Since equity of access must be assured for all Brazilian citizens, the present study proposed a rational resource allocation model to help decision-makers in reconciling equity access and budgets.

**Aim:** This study aimed to compare equity of access to dental services and costs of dental staff of two models for primary care settings. Additionally, staffing requirements and staff costs were projected over a three-year time period. Both models comprised three inter-related components: (i) universal access to oral health care, (ii) comprehensiveness of primary dental care and (iii) equity of access to primary dental services.

**Method:** The present study was part empirical and part modeling in design. In the empirical phase, a set of maximum wait times for dental care determined by experts (Model 1) vs. wait times derived from survival analysis (Model 2) was compared. A one-year follow-up of a cohort of dental patients assigned to five primary health care clinics was conducted. The event of interest was clinical deterioration in the waiting time for dental visits.

At each consultation with a dentist either for routine or emergency reasons, the oral quadrants of the patient were assessed and classified according to their urgency for dental care (from 1, less urgent to 5, more urgent). In the modeling phase, costs of dental staff were estimated on the basis of survival probabilities found in Model 1 and on survival targets simulated in Model 2. The amount of staff required as calculated by combining data on: dental service needs, activity standards for dental services, workload components in dental care, cost per working hour of dental staff, and probabilities of clinical deterioration in the wait for dental visits.

**Main Findings:** In Model 1 (wait times determined by experts), survival probabilities were found to be unevenly distributed between diagnostic categories: category 4= 0.939 (SE 0.019); category 3= 0.829 (SE 0.035); category 2= 0.351 (SE 0.061) and category 1= 0.120 (SE 0.044). The cost of dental staff in Model 1 was estimated to be R\$104 110.88 (BRL). In cost simulations of Model 2, where wait times were derived from the survival analysis study, a similar 0.900 survival probability target for all sampled quadrants (n=7 376) was found regardless of their final classification in the study year. The resulting cost of Model 2 was R\$99 305.89 (BRL).

**Conclusions:** From an equity-access perspective, the survival analysis concluded that wait times for dental visits determined by the experts may engender inequitable survival probabilities for oral quadrants classified in different diagnostic categories. From a dental-staff costs perspective, one concluded that less resources were required by setting an equitable 90% survival target for all oral quadrants studied.



## DECLARATION

I declare that the thesis entitled “*Assessment of a framework for the allocation of primary dental services*” is my own work, that it has not been submitted before for any degree or examination at any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

*Denise Antunes*



UNIVERSITY of the  
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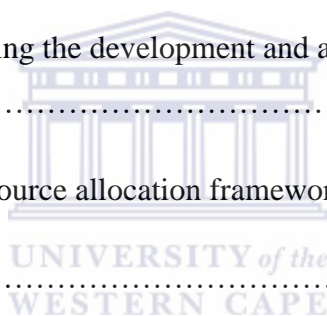
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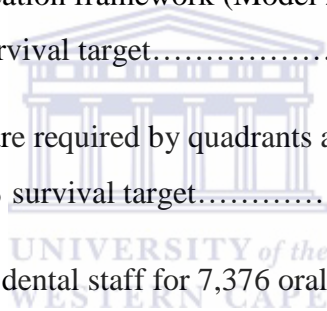
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## CHAPTER 1: INTRODUCTION

*“The technological advances, including internet connectivity, open-source technology and the emerging trends in the era of ‘big data’, are breaking new ground in improving the quality and use of data on human resources for health”.*

(World Health Organization, 2015)

Standardized frameworks that guide timely allocation of dental resources to primary care services may support equitable distribution of comprehensive dental care to individuals living in Family Health clinics catchment areas. However, such frameworks which are evidence-based and can be applicable to primary care settings in Brazil are not available as yet.

The present study sought to address the development of a dental resource allocation framework that was designed with the aim of supporting decision making for the allocation of public resources for timely provision of primary dental care, particularly within settings covered by the Brazilian Family Health Programme. That framework was submitted to a preliminary assessment in a previous study published as a Master's thesis at the University of Western Cape, South Africa in 2010 (Nascimento, 2010). The framework proposed an approach to managing wait times in a way as to provide dentists with full understanding on the dental care needs of the assigned populations, enabling professionals to make reliable decisions by using agreed diagnostic criteria, and equipping them to conduct a lifelong process of dental care. The framework suggested a series of theoretical wait time benchmarks for clinical and non-clinical primary dental care, delivered by different members of the family dental team. In the previous study, the set of wait time benchmarks obtained face validity.

The inclusion of wait time benchmarks for primary dental services in the design of the framework was an attempt to increase knowledge on the quality of access to primary dental care experienced by people living within catchment areas of the Family Health Programme. Since the public health system in Brazil is underpinned by the principle of equity of access to comprehensive health care (Brasil, 1990), the present research was motivated by the need to improve equity of access to non-urgent primary dental services. It intended to add to the existing evidence on equity allocation of dental resources raised in the above-mentioned earlier 2010 study.

When equity of access directs a waiting-time-for-healthcare policy, one expects that patient's health will not deteriorate due to the waiting for health services, regardless of their health status. Evidence-based wait time benchmarks are crucial to equity access to healthcare in general (Chan *et al.*, 2015) and to dental care in particular (Schroth and Morey, 2007), since those benchmarks enable oral health managers to plan and raise needed funds in advance so that health services are timely delivered according to individual needs. However, at present, there is no overarching national policy on timely access to dental care services in Brazil and no official waiting time figures have been routinely collected at local or national levels.

In the past few years, health managers and public officers have faced public pressure for timely access to public dental services. Wait times have been frequently related to inefficiencies in dental care delivery, prolonged patient suffering as well as dissatisfaction among the public (Vieira, 2008). The adoption of innovative strategies to improve equitable interventions at the primary health care level is a key focus of not only policy makers and planners, but also decision makers who are concerned about costs.

To help decision-makers reconcile equity and budgets, the present study aimed to create a rational model for resource allocation, based on the previously developed framework (Nascimento, 2010). The model was investigated by simulating the costs of two different population intervention scenarios. Equity of access analysis and cost analysis took into account the distribution of survival probabilities among individuals, based on two simulated provisions of primary dental services (Model 1 and Model 2). In Model 1, maximum wait times were set up for access to primary dental care based on the experts' judgement validated on the previous study. In Model 2, wait time benchmarks were set up based on the survival probability results obtained in the present study. "Survival to a certain time" refers to the length of time within which individual's oral health status does not deteriorate.

The present thesis consists of seven chapters. In the first chapter, an overview on the national context which motivated the development of the dental resource allocation framework is presented. The second chapter describes the review of the literature on survival analysis methods, wait times for health services in general and primary dental care in particular. The international experiences on waiting lists management and studies on wait time benchmarks for health services are explored. In the following chapters the research aim and objectives, methodology are reported on and the research results that aimed at:

- (i) describing probabilities of clinical deterioration among oral quadrants of patients waiting for a dental visit at five local clinics,
- (ii) analyzing Model 1 and simulation Model 2, according to survival probabilities, and
- (iii) comparing costs of dental staff of the resulting resource allocation models.

In the last chapters the study limitations are declared and the adoption of the two models discussed. Finally, concluding remarks are provided on study findings recommendations are made, indicating possible future areas of research and practice for health managers and public health professionals.

## **1.1. Background**

### ***1.1.1. Brazilian context underpinning the development of the resource allocation framework***

The right to healthcare has been recognized as a constitutional right of the Brazilian citizens since 1988 (Brasil, 1988). Because of the legislation currently in place in Brazil, the Brazilian Public Health System is tasked with providing equitable access to comprehensive public health services for all Brazilian citizens. Such duty has challenged public health planners and managers to implement the right-to-healthcare policy and to build accountability into the overall public health system. Despite the fact that constitutional rights are available to all Brazilian citizens, the country's healthcare system consists of both public and private care services. In the public sector, health care is a federal-provincial-municipal tax payment system, while in the private sector the patients pay out of their pocket.

Despite having the largest economy in South America and a productive industry and agriculture, Brazil has faced great disparities in the social-economic status of its population across its regions (Instituto Brasileiro de Geografia e Estatística, 2015). Regarding income, Brazil has one of the highest inequalities in the world as well as inequitable access to social welfare services (SustainAbility, 2006). The oral health status of the Brazilian population is a further expression of such inequity. This has been demonstrated by the findings of the latest epidemiological oral health survey, carried out in Brazil between 2010 and 2011 (Brasil, 2011).

The findings showed an uneven distribution of the burden of poor oral health where people from the low income Northern areas were considerably worse off than the Southern richer population.

Due to the large socio-economic disparities in Brazil, equity of access to public health care has been a particular challenge facing public health planners and managers. Poor health status of selected population groups associated with long waits for health care is a clear concern in relation to the quality of access to health care. For the last decade, countries such as Canada and Australia among others have made huge efforts to work towards evidence-based benchmarks for medically acceptable waiting times for their target population groups. They have compared acceptable waits to the real waits people have faced in several types of waiting lists for health services (Geddes, 2014; Lalloo, and Kroon, 2015; Viberg *et al.*, 2013).

In Brazil, the issue of wait times for public health services has been a newsworthy agenda, particularly in the last few years when the Supreme Justice Court of Brazil called for a nationwide debate among health professionals and health authorities towards consensus about the responsibility of the public health system in providing timely health treatments (Supremo Tribunal Federal, 2009). More recently, Brazilian judges have tended to base their decisions on scientific evidence to determine access within recommended maximum wait times for admissions to hospital and specialized medical care. However, several decisions have not yet taken scientific evidence into account (Almeida, 2013).

### ***1.1.2. Family health programme general features***

In Brazil, a key workforce strategy to tackle inequities of access to primary care services, including dental services, is the *Family Health Programme*. Financial incentives are provided from federal to municipal governments to the expansion of primary health service coverage in economically deprived areas, so that people assigned to family health clinics can access timely health care.

Despite significant achievements related to child survival (Pereira *et al.*, 2012; Macinko *et al.*, 2006), little is known about the balance of the workforce supply in relation to varying demand for primary care services and it is still uncertain how those programmes are affecting equity of access within and between target populations.

People living within areas covered by the Family Health clinics are registered users of Family Health services. Such registration is an official guarantee for access to comprehensive primary health services, which consequently generates a constant pressure on Family Health teams for provision of health care, particularly on the dental services.

The scope of Family Health clinic services encompass medical and dental consultations delivered in the health facilities as well as in the community centres, schools and at homes. Once a Family Health clinic is set up, the community health workers begins visiting people living in the catchment area and collects socio-demographic data. Community health workers enumerate each household, identify, and register every family member. They continue to visit the families systematically as well as performing non-routine home visits when any special need is found. Thus, vital events such as new pregnancies, occurrence of illness, disabilities, etc. can be routinely updated. This information is made available to Family Health teams who are then aware of the characteristics of people at greatest risk for health problems. Based on such knowledge, Family Health teams plan their activities, under a comprehensive approach to primary health care (Brasil, 2004).

Family dental teams are responsible for primary dental care, which comprises not only promotive, preventive, curative and rehabilitative activities to fulfill dental care needs of the population, but also includes a range of transformations in dental practice and beliefs. Each dental team generally consists of one dentist, one dental assistant, and one dental hygienist and four to six community health workers. According to the Ministry of Health (Brasil, 2006), dentists are responsible for dental care coordination of the assigned population and the supervision of dental hygienists and dental assistants. They also perform rehabilitative (restorative) procedures, diagnose and prescribe and administer medicines. Dental hygienists perform educational, preventive and therapeutic activities to help maintain oral health and to prevent and control oral diseases. They must practice within a structured professional relationship with the dentist. Family dental services have expanded to provide primary dental care to the entire country. In the last ten years, the percentage of population covered by Family Health clinics has increased from 44.88% to 63.85% (Brasil, 2016).

There are 40 196 family health teams currently working throughout the country, and but only 24 452 dental teams. This means that just 60% of the family clinics have an associated dental team. Yet, the great majority of the dental teams (91%) are composed of one dentist and one dental auxiliary and just 9% of them include a dental hygienist in the team. Dental hygienists

have to work under the supervision of the dentists, although the dentist might not always be present at the premises. Community health workers are also part of all family health teams and they can perform dental education activities and toothbrush training in order to maintain oral health. Both family health teams and dental teams are funded by federal and municipal governments. Municipal Health Departments are in charge of health resource management.

### ***1.1.3. Specific context motivating the development and assessment of dental resource allocation framework***

In recent years, especially since 2000, increased public awareness among Brazilian citizens regarding their right to healthcare has resulted in an increased demand for public health services generally and for dental services in particular. However, at the entry points of the public health system, the family dental teams are neither sufficiently prepared nor have appropriate methods to deal with the legal implications of such pressuring demand. For this reason, dental health managers have sought for suitable and easy-to-use methods so that Family Health teams improve their responsiveness.

In 2003, a working group consisted of public health dentists, among them the author of the present study, was set with the purpose of developing a theoretical model for dental resources allocation based on the requirements of health-related legislation.

The group consulted the Brazilian National Policy on Dental Health (Brasil, 2004a) which recommended a population health assessment before any intervention. The policy further highlighted the need to organize the entry and flow across different health services so as to ensure the most appropriate dental care for each patient. It recommended the adoption of appropriate indicators to measure the impact of oral health care, and the use of easy, reliable and continuous records. Furthermore, the group consulted the Primary Health Care Plan which was launched in 2001 and updated in 2012 (Brasil, 2012). This plan aimed to ensure gradual access to dental health care for all families living in the catchment areas and defined the specific duties of the primary care dentist among others as the: i) identification of the dental needs and of community perceptions regarding oral health care, ii) clinical examinations in order to measure oral health status of the community and iii) co-ordination of dental health promotion and prevention activities. The plan also recommended that epidemiological surveys should precede any health intervention.



The working group found that overall scheduling for dental visits at Family Health clinics had been managed by administrative staff and consequently dental treatment had been scheduled under subjective and inconsistent criteria. In addition, dentists working in primary dental clinics had not adopted uniform diagnostic measures to determine oral disease severity. Consequently, people seeking primary dental care might have been experiencing potentially unfair variations in waiting times for primary dental treatment; thereby inequities of access to primary dental care have been occurring.

One of the key challenges identified by the group was the establishment of guidelines for timely access to dental services given the wide range of complexity of patient's dental problems at the primary care level. Hence, the group proposed a five-level categorization of clinical dental status, given that conditions assigned to each category shared similar deterioration rhythm.

In the context of a constantly increasing population nationally and varying dental disease burden, family dental teams have been challenged to provide adequate and timely dental care. However, they have faced the problem of lack of sound and timely information regarding waiting times for primary dental services. Wait time figures have not been reported by family programme teams. Apart from the complex nature of such information, a considerable amount of resources would be needed to achieve accurate standard information on what can be deemed acceptable waiting times for dental services within primary care settings.

## **1.2. Overview of the dental resource allocation framework**

As highlighted earlier, the dental resource allocation framework was designed for use of the Family Health Programme. The framework consisted of three inter-related components, tailored according to the legislation in place regarding the right to public funded healthcare for all Brazilian citizens. The three component parts of the framework are summarized as follows: The first component is a five-level categorization of the oral status, by which people living in the catchment area be systematically included in the dental care programming. This component represents the universal access to healthcare. The second component is the workload of the family dental team, which includes the performance of promotion, prevention curative, and rehabilitative activities. This component represents comprehensiveness of healthcare and the third component is a set of maximum waiting time for primary dental care. This component represents equity of access to health care.

### **1.3. Problem statement**

Increasing demands for public dental services and unacceptable inequalities in the oral health status in Brazil have required the development of innovative strategies to improve access to comprehensive primary dental care.

The issue of timely provision of health care has received much attention from public health policies internationally and this has stimulated a range of studies related to the management of waiting lists for access to health services in many countries. However, research on management of waiting lists has been devoted primarily to the scope of inpatient and outpatient specialist services, missing more attention in the literature regarding the management of waiting lists for timely access to primary health services.

In view of ever scarce resources for public health services, ethical dilemmas arise in resource allocation when allocation choices require priority setting among individuals who face similar needs of healthcare. That is a major underlying issue that has driven the investigation not only in the present study but since the previous one, when the dental resource allocation framework was initially assessed. As such, the rationale for this study was to advance in the assessment of that framework by investigating whether it is a valid option to guide equity distribution of comprehensive health care for all individuals. In the previous study, the criterion adopted as “distributive justice” for access to primary dental services was a set of maximum waiting times recommended by experts. Reliance on expert opinions was, at that moment, of great value when no other references regarding wait time benchmarks for primary dental services were available.

### **1.4. Purpose of the study**

The purpose of this study was to explore the complex issue of equity allocation of dental staff for primary dental care in Brazil, by estimating time to dental disease progression in order to analyse costs when survival targets are set for patients waiting for dental services.



## CHAPTER 2: LITERATURE REVIEW

In order to achieve the purpose of the present study, it was necessary to review a wide range of literature, including studies on waiting time benchmarks for health care and experiences reported by several countries on waiting lists management, besides diagnostic classification research in primary health care, health needs assessment, health workforce planning and concepts of equity of access to health care. However, it would have been unrealistic to conduct a comprehensive literature review of entirety of these fields and indeed would have been of little value, due to the numerous publications in each of them. Thus the boundaries of the literature review were set as follows:

- Equity of access to healthcare: as it was critical to identify definitions on equity of access to healthcare, since that is the key concept underpinning our investigation. Furthermore, it was important to explore different definitions on equity of access to healthcare and prioritization of access to healthcare, so that to distinguish between them;
- Wait time benchmarks in relation to access to health care: it was necessary to explore conceptual methodological issues associated with implementation of wait time benchmarks and its consequences for the access to health care and
- Waiting lists management and workforce planning: it was important to explore methods for workforce planning and their relation with health needs assessment in primary care settings and identify other countries experiences on waiting lists management, particularly those with an open data policy on waiting lists.

Scientific articles, official documents, and government websites were examined. The consulted literature is available at EBSCOhost, PubMed, Google and Google Scholar. One used these engines to perform an extensive on-line search in English and Portuguese on the terms: “recommended waiting times”, wait times benchmarks”, “waiting list”, “equity of access to health care”, “priority setting”, “health workforce planning”, “health needs assessment”, “diagnostic classification”.

The following sections describe the literature that was reviewed corresponding to each one of the above fields. The first section provides a brief overview of definitions on equity of access to healthcare and prioritization. The second section discusses health needs assessments and

diagnostic assessments in dental primary care. The third section covers the concepts of access to health services, waiting times benchmarks and waiting lists management. It briefly explores the strategies for managing waiting lists for selected health services. This section also reviews Canadian and Australian experiences on waiting lists management. The fourth section explores health workforce planning methods. A short summary on the implications of the literature review for this study is included at the end of this chapter.

## **2.1. Equity of Access to Healthcare**

The concept of equity of access to healthcare has been widely discussed in the literature for over decades, and defined in different ways. Nevertheless, discussions have not resulted in universally shared understandings by health policy makers and academics.

Although little consensus was found in the literature on how "equitable access" can be defined and measured, most definitions have agreed upon a common point, in which equity of access to health care is the fair distribution of health services among competing needs of individuals or groups of individuals (Zere *et al.*, 2007). The public health literature generally agrees that equity of access is the utilization of health services by all those who actually need those (Goddard and Smith, 2001).

For the purposes of this study one adopted the definition agreed during the International Forum on Common Access to Health Care Services, held in Stockholm, in 2003, in which it was decided that equity for the healthcare should be considered "equal access to health care for those in equal need" (Oliver and Mossialos, 2004).

As equity of access to health care may contribute to achieving equity in health, it is worth mentioning some definitions of equity in health. According to Whitehead (1992), equity in health "implies that ideally everyone should have a fair opportunity to attain their full health potential and, more pragmatically, that no-one should be disadvantaged from achieving this potential, if it can be avoided."

The International Society for Equity in Health provided a further definition during its first international conference, held in Cuba, in 2000, in which equity in health is "the absence of systematic and potentially remediable differences in one or more aspects of health across populations or population groups defined socially, economically, demographically, or geographically" (Starfield, 2002).

Access to health care is a multidimensional concept, which includes physical, communication, attitudinal, cultural and information aspects of both supply and demand sides (Ensor and Cooper, 2004). Regardless of the definition of health need, a number of factors may prevent people in need of healthcare from accessing health services. Ensor and Cooper (2004) argued that those factors must be analysed from both the supply side (factors derived from health care production) and the demand side (factors derived from barriers preventing patients from accessing health services). They mentioned that sometimes supply and demand factors might interact thereby influencing either positively or negatively the access to healthcare. They pointed out the issue of ‘quantity rationing’ as one example of barrier to healthcare access which is caused by the interaction between demand and supply. Ensor and Cooper (2004) further argued that quantity rationing may lead to inequities of access to healthcare due to excessive length of time people may have to wait for access to medical services (Ensor and Cooper, 2004).

The definitions of “priority” were also investigated in order to explore differences between concepts of priority of access to healthcare and equity of access to healthcare. According to The Free Dictionary (2016), priority, in its legal terms, refers to “the right to be first or ahead of the rights or claims of other” and in its medical terms, priority refers to actions established in order of importance or urgency to the welfare of the patient at a given time. The Reverso Dictionary (2016) says that if you give priority to someone, you treat them as more important than anyone else. In relation to health systems, Chalkidou *et al.* (2016) argue that priority-setting is to establish who ought to receive healthcare.

In view of these definitions, it is clear that equity of access to healthcare means that healthcare is to be accessed by everyone who needs it whereas priority of access implies that healthcare will be received by some and not by others. In the Brazilian legal context, where the government should guarantee universal access to comprehensive health care to all Brazilian citizens (Brasil, 1988), it sounds illegitimate, even illegal, to set priorities for access to public health care services within the Brazilian territory.

## **2.2. Health Needs and Diagnostic Assessments in Primary Dental Care**

It is important to differentiate between the concepts of health needs. Bradshaw (1972) proposed to describe health needs from three broad concepts: “normative needs” are determined by professionals evaluation and norms; “felt needs” are perceived by an

individual and determined by self-assessment; “expressed needs” are felt needs expressed by a request for assistance, that is: a demand.

Regarding oral health, Gherunpong, Tsakos and Sheiham (2006) argued that it would be unethical not to adopt normative assessments in the estimation of oral health needs, although recognizing that by conventional normative assessments alone, dental treatment needs are usually over-estimated. These authors recommend that, due to the contemporary concepts of health and well-being, health care needs should not be limited to clinical diagnostic assessments, but determined by a combination of methods using both clinical and subjective measures.

The Family Health Programme guidelines recommend that dental needs of people assigned to local clinics should justify the allocation of human and material resources for primary dental services according to demonstrable needs rather than based on socio-economic status (Brasil, 2004). From a policy perspective, the healthcare needed by people living in areas covered by the Family Health Programme should always be translated into a demand for primary health services. This is because family health teams are responsible for delivering either health promotion, prevention, curative or rehabilitative services and should work proactively.

Beltrán, Malvitz and Eklund (1997) recommend that diagnostic classification research should contribute to develop simpler and less costly tools in such a way as to match public health requirements for routinely measurements of disease severity. Gooch, Griffin and Malvitz (2006) argued that innovative methods for classifying oral disease severity must demonstrate credibility among the dental profession, and produce data easy to be understood by communities and non-dental decision makers. Brennan and Spencer (2005) have found that diagnostic criteria adopted by dentists can influence treatment choices and patterns of dental service delivered.

Summerton (2000) emphasized the need of research focusing on the development of diagnostic tools applicable within primary care settings, which are valid and reliable among general practitioners (GPs). He referred that diagnostics decisions made by GPs are different from those made by specialists due to the unselected nature of communities seeking primary health services. Hence, diagnostic research must be specifically designed to assist GPs in their decisions concerning the sort of patients they usually treat at primary health care facilities (Summerton, 2000). This implies that, at the primary health care level, early

decisions on the appropriate course of action are more important than those accurate diagnostic labels made by specialists (Summerton, 2000). This is because GPs' diagnostic primary objective is to identify cluster of clinical conditions with high discriminant ability among patients seen in general practice. For this reason, Summerton (2000) recommended that, in validation studies of primary health care-related diagnostic methods, gold standards should be more concerned to the course of actions than to specialized clinical diagnosis.

The National Oral Health Policy (Brasil, 2004a) recommended that oral health practices should be preceded by a diagnosis of the conditions of health and illness of populations. It stressed, in the chapter that dealt with access to health services, the need to organize the entry and flows of patients in order to ensure the most appropriate dental care to each person. It also pointed out that the impact of oral health actions should be accompanied by appropriate indicators, and highlighted the need of reliable, sound and easy to use health record systems.

Since the last decade, the Oral Health Department of the city of Sao Paulo has established a set of criteria for organizing the access to dental services by categorizing individual risk for dental caries, periodontal disease, and soft tissues lesions (Secretaria Municipal da Saúde de São Paulo, 2006). Such categorization allows that health professionals take appropriate course of action for treating different oral health care demands until each individual dental treatment is completed.

### **2.3. Waiting Times for Health Care and Access to Health Services**

The definition of 'waiting times' has not been consistent among researchers and policy makers in different countries. Generally, an evidence-based benchmark is a goal that expresses by clinical evidence the appropriate amount of wait for the provision of a particular health service. Jackson, Pederson and Boscoe (2006) refer to waiting times as "the length of time it takes people to access diagnostics and specialist treatment services. Polst (2006) defined a waiting time as commencing with the booking of a health service and ends with the commencement of the service.

Fogarty and Cronin (2008) defined the waiting time for health care as the gap between identification of a health condition and its diagnosis and treatment. The National Wait Times Strategy in Canada (Sanmartin, 2003) defined different kinds of waiting that may occur from initially noticing health problems to getting appointments to primary care providers, specialists or the needed rehabilitation or other hospital-level service. Hence, whether waiting

for health care is not adequate, such elapse time can result in poorer medical outcomes, transforming potentially reversible injuries or illnesses into irreversible, chronic conditions, if not into permanent disabilities.

Benchmarking can be defined as a mechanism for standardization of performance or comparative evaluation (Ettorchi-Tardy, Levif and Michel, 2012). In health care systems, it is a process of identification of the underlying causes leading to high levels of performance, in which organizations compare their outcomes learning from each other in order to improve their practices. In healthcare delivering, the Wait Time Alliance had defined benchmarks as “the maximum amounts of time that a patient should wait for specific treatments, tests, or procedures; beyond that, evidence shows that waiting will likely have adverse effects on a patient’s health” (Wait Time Alliance, 2014).

#### **2.4. Waiting lists Management and Workforce planning methods**

The issue of timely health care has received increased attention from public health policies and this has resulted in a number of studies related to the management of waiting lists for access to health services in various developed countries, such as Canada, Australia, United Kingdom and New Zealand. However, management of waiting lists for hospital or specialist outpatient services has received greater attention in the literature than that for primary care services. Regarding primary dental services, in a study addressing waiting times for general dental treatment in Australia, dentists’ judgements were considered the ‘gold standards’ for determining priority access to dental care, against receptionist’s judgment of urgency (Jones, 2013). However, consistency of dentists’ judgements was not tested. In the context of the present study, a waiting time benchmark refers to the maximum length of time for a clinical dental condition and does not deteriorate while waiting for dental care. In recent years, research on waiting lists management has been primarily devoted to the scope of hospital and specialist outpatient services and not the management of waiting lists for primary health care services.

Since the late 1990s, a project in Canada, the Western Canada Waiting List Project (2003), has involved various organizations in the development and validation of scoring diagnostic tools for prioritizing patients on hospital waiting lists (Noseworthy, McGurran, and Hadorn, 2003). Some diagnostic tools have been adapted for use by family doctors to determine priority of referral to specialist surgeons.



In its first stages, the Canadian project adopted consensus group activities in which health authorities, medical association members and researchers were brought together to develop and validate diagnostic classification tools (Noseworthy *et al.*, 2003). Because in the first stages of the Canadian project there was no gold standard for priority access, expert opinion was used as the evidence for the implementation of the newly developed diagnostic tools.

Development, validation and implementation of a prioritization tool for access to dental treatment under general anesthesia in a Canadian hospital were reported by Casas *et al.* (2007). In a six level scale of priority, medical and dental conditions were listed, paired and classified by three pediatric dentists according to the potential effect of children's dental diseases on their medical status. Since no evidence on maximum waiting times had been published, face validity was adopted as a first approach to investigate priority access for dental treatment in that hospital (Casas *et al.*, 2007). Reliability test was also used to evaluate the priority scale.

Australia has made huge efforts towards reducing the waiting beyond desirable periods for different types of healthcare, including dental care. Nonetheless, Australian dental health literature has pointed out that oral health inequalities have been generated by the lack of timely and comprehensive access to oral health service (Schwarz, 2006; Lalloo and Kroon, 2015a).

As part of its open data policy, information on public dental service waiting lists has been made available in Australia from the Queensland Government website (Queensland Health, 2016). In Queensland, a triage system has been in place for about five years, to reduce waiting times for dental care services in Australia. It was developed in consultation with a number of senior public sector dentists in the States of Queensland and New South Wales. A specialist in oral medicine was included in that process. Eligible patients are allocated in different types of waiting lists according to their oral health status, although in special situations, patients are allocated according to their socio-economic status (Queensland Health, 2015). Dentists from Queensland Health services undertake brief clinical examination for the purpose of determining dental clinical needs. Patients are then allocated to a waiting list for appointment within a clinically desirable timeframe. However, an increasing number of people are now seeking public dental care in Australia, thereby long dental waiting times persist across the public dental system (Fantin, 2016).

Health workforce planning is a crucial issue in public health, as it has the potential to impact on the length of time people will wait to access healthcare services (World Health Organization, 2010). In view of expected demographic changes and technological developments in dentistry, it is anticipated that the dental workforce profile will change radically different within a few decades and current dental health workforce planning has to take into account such upcoming challenges (Brailsford and De Silva, 2015). According to Al-Jundi (2006), the understanding on health needs is critical for health workforce planning and management.

In recent years, there has been a need for more rational methods of setting sufficient staffing levels in different health facilities that can match the variety of health needs of their assigned populations. There are various methods for health workforce planning including: trend analysis, regression analysis, meta-analysis and econometric analysis. The health needs approach is yet another method to predict and plan health personnel needs that focuses on disease prevalence and incidence among the general population (Brailsford and De Silva, 2015). The resulting information is then translated into treatment needs usually based on experts' opinions. By this approach, the total personnel hours required to meet the health needs of a defined population in a given elapsed time are calculated, by taking health staff productivity into account. This approach requires a well-maintained database and surveillance capacity, combined with planning expertise. Morbidity patterns in dental diseases vary due to factors, such as time to get a treatment, population characteristics and geographical location. Hence, up-to-date, accurate information is crucial for dental workforce planning (Brailsford and De Silva, 2015).

In recent years, the World Health Organization has proposed a health-needs approach method for calculating the number and type of health workers required to cope with the workload in a given health facility, namely: the Workload Indicator of Staffing Needs (WISN) (Shipp, 1998). The WISN methodology incorporates a combination of work activity measurement and professional judgement to improve health workforce planning. According to WISN method, the level of staff shortage or surplus is shown by the difference between calculated and actual number of personnel. Furthermore, the ratio of actual and required personnel can demonstrate workload pressure between health facilities.



A software application was developed by the WHO in 2010 and a revised Workload Indicators of Staffing Need (WISN) User's Manual was published in 2014 (World Health Organization, 2014). WISN has been currently applied in several countries (McQuide, Kolehmainen-Aitken and Forster, 2013; Namaganda, 2015; Mollahaliloğlu *et al.*, 2015). In Brazil, Bonfim *et al.* (2016) have highlighted the great potential applicability of WISM method for planning the workforce required in the Brazilian Family Health programme.

In the Brazilian public sector, workforce planning, including the health workforce, is of huge importance, insofar as staffing for public services account for nearly 60% of total government budget (Brasil, 2000). In the specific context of the Brazilian Family Health Programme, workforce planning for primary dental care services is a challenging and complex task due to lifelong changes in individual needs for dental care. Hence, decisions regarding the adequate number and type of dental staff for a particular local clinic must be dynamic in order to match the changing epidemiological scenario of the clinic catchment population. Furthermore, primary dental staff planning must be long term oriented and cover all dental staff, which includes not only dentists with their dental auxiliaries but also dental hygienists and community health workers. Dentists have been included in Family Health teams since 1990. However, it was only in the last decade that dental teams have included dental hygienists (Bonfim *et al.*, 2015).

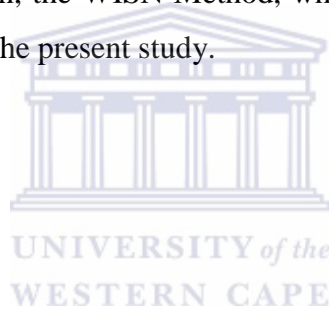
Despite the remarkable coverage expansion of Family Health services, inequities of access to dental care continue to occur since Family Health programme has adopted a standard dental staffing scheme for a given population size, with no distinction between the employment of dental health staff and the varying disease burden of target populations over time. Although the distribution of dental teams is intended to cover a well-defined and socio-economically deprived population, the application of fixed staff establishments for local clinics may have overtime not matched the changing dental staff requirements of the catchment areas. Historically, people seeking dental care at local clinics are allocated care on a first-come-first-served basis, taking the self-reported dental condition as the criteria for access to primary dental services. Historical data has shown the recorded levels of primary dental service utilization depends on the availability of such services, and therefore does not represent the true or hypothetical demand. This may have resulted in imbalance between demand for primary dental services and dental staff supply, contributing to prolonged waits in one hand and waste of resources in the other (Brandenburg *et al.*, 2015).

## **2.5. Implications of the Literature Review for this study**

By exploring the literature, one could distinguish between the definitions of equity and priority of access to healthcare and helped to understand that in a universal and comprehensive health care system, like in Brazil, the health budget cannot be prioritized for some population groups in detrimental to others nor prioritized for selected types of health care services over others. Such knowledge was the basis for the present policy-decision simulation exercise.

It was extremely helpful to learning from the experiences of other countries regarding waiting lists management, especially those with an open data policy, and their effort on the establishment of waiting times benchmarks for health services.

In the literature methods for workforce planning was explored among them the one proposed by the World Health Organization, the WISN Method, whose methodology was particularly useful for the modeling phase of the present study.



## CHAPTER 3: AIMS AND OBJECTIVES

### Study Aim

In order to address the problem of equity allocation of dental resources in primary care settings, the main aim was to compare equity of access to primary dental services and costs of dental staff of two theoretical models: Model 1, which set of wait times for dental care was recommended by experts versus Model 2, which set of wait times was derived from a survival target. Additionally, staffing requirements and costs were projected over a three-year time.

### The objectives of the study were:

1. To describe the demographic profile of the population sampled.
2. To conduct a survival analysis study in order to estimate time-to-oral health deterioration of patients waiting for dental visit.
3. To estimate oral deterioration probabilities at the maximum times for dental visit proposed by experts.
4. To identify workload components and timings for dental activities (activity standards) performed by family dental staff.
5. To estimate the cost of the working hour of dental staff working at Family Health clinics in the metropolitan region of Porto Alegre, Brazil.
6. To estimate cost of dental staff based on waiting times set by experts (Model 1).
7. To simulate costs of dental staff based on survival targets (Model 2)
8. To make recommendations on the study findings.

## CHAPTER 4: METHODOLOGY

### 4.1. Study design

This study utilized an equity-oriented research design, partly empirical and partly modeling. Firstly, a prospective follow-up study was conducted (Survival Analysis), from July 2014 to July 2015, to estimate time to clinical deterioration of oral health of patients waiting for a dental visit at five Family Health clinics located in the metropolitan area of Porto Alegre, Brazil.

Secondly, costs of the resource allocation framework were analysed by modelling it with two different sets (Model 1 and Model 2) of maximum waiting times for dental care. The sets of wait times fed a mathematical algorithm in Excel spread sheets, projecting the optimal dental staff working hours, allocating them according to the required type of dental services that should be delivered to classified patients within a certain length of time. Thereafter the results of the Model 1 were analysed and modelling of the Model 2 began, simulating a survival target for cost comparison purpose, under the assumption that any survival target is a policy decision. In the modelling phase, the methodology proposed in the WISN Method (Shipp, 1998) was adopted to collect the data related to timing to perform activities and expenses on dental personnel. The WISN method is a human resource management tool that helps to determine how many health workers of a particular type are required to cope with the workload of a given health facility. By combining the WISN method with our survival data, one predicted the costs of dental staff required to cope with a workload up to a given deadline.

### 4.2. Empirical phase: Time-to-event study (Survival Analysis Study)

In the survival analysis study, the oral clinical status of patients waiting for a dental visit was followed to estimate the deterioration rhythm of the clinical status in different diagnostic categories. Thus, clinical deterioration of oral health was the event of interest measured in the survival analysis study. The unit of observation was the oral quadrant, which was given a diagnostic classification code each time it was assessed by the dentist. When the quadrant was found clinically worsen in relation to the previous assessment, an event was observed. Then, the classification code changed in relation to the previous one.

When the quadrant was found clinically stable in relation to its previous assessment, the observation was censored. Then, the classification code did not change in relation to the previous one.

The clinical status of oral quadrants was categorized according the diagnostic criteria adopted in the previous study, although in the present study the participating dentists have revised some of the criteria. The categories are represented by codes ranging from 1 (which included the best clinical conditions) to 5 (which included the worst clinical conditions). The diagnostic criteria of the five categories are summarized in the Results Chapter.

#### **4.2.1. Variables:**

- Dependent variable: duration of clinical stability
- Independent variables: age group and gender

The deterioration rhythm in relation to age and gender was analysed. The analysis of other variables, such as behavioural and personal characteristics, that may influence time to clinical deterioration, was beyond the scope of the present study.

#### **4.2.2. Study population and sampling**

##### **4.2.2.1 Study population**

The study population consisted of the typical users of Family Health clinics, living in urban areas of Brazil. The target population encompassed nearly 17 500 people living in the catchment areas of five Family Health clinics, located in the metropolitan region of Porto Alegre. According to the Family Health Programme, 100% of residents in the catchment areas should be registered at the local clinics and they are all eligible for public health services. The study sample consisted of local clinic users who underwent dental treatment at the participating from July 1<sup>st</sup>, 2014 to July 31<sup>st</sup>, 2015.

##### **4.2.2.2. Sampling**

This survival analysis study was designed to capture all residents of the catchment areas who requested dental care and were treated at the participating clinics in the study year. As it is not a random sample, no sampling frame was required. Hence, a convenience sampling was adopted, with consecutive selection of patients. Since the unit of observation was the oral

quadrant, the actual sample was counted in terms of number of oral quadrants undergoing dental treatment.

The inclusion criterion in the survival analysis study was to be resident of the local clinic catchment area, which after the initial assessment underwent dental care at the participating clinics in the study year. Those patients who after the initial assessment, did not show up again at the local clinic to undergo dental treatment were excluded from the survival analysis study.

The primary criterion for the choice of sample size was to reach the total number of patients living in the catchment areas, assuming that all of them would see the dentist at least once in the study year. However, as the study was conducted in accordance to the working routine currently in place at the participating clinics, the sample size was limited to the number of patients who requested and actually underwent dental treatment. Furthermore, because of such staggered entries in the study, there was insufficient time in the later months of the study year, to schedule dental visits particularly for healthier quadrants and that too contributed to limiting the sample size.

#### **4.2.3. Measurements**

Dentists were given a Tablet and/or computer connected to the internet. Through a private link, they accessed an on-line form to register the diagnostic classification codes while examining the patients. When a classification code was typed in the on-line form, it automatically recorded the classification date. The on-line forms were piloted and access to the on-line database was adjusted prior to data collection.

To identify patients, dentists also registered the patient's health card number, which is the patient's official number in the National database of the Ministry of Health (CADSUS, 2016c). The classification codes were registered in each quadrant field, i.e., quadrant 1, 2, 3 and 4. On-line forms were used in order to facilitate data collection for the dentists and data capturing for the researchers. They captured the number of the national health card, name of the clinic, and the classifications performed in the quadrants. Other information such as gender and date of birth was collected by the researcher in the national database of the Ministry of Health. The use of on-line forms also made it possible to control the entire process of the field research. By supervising the on-line database, the researcher was able to make contact dentists as soon as any problems on the field had been identified.

#### ***4.2.4. Logistics for field research***

Firstly, a preliminary implementation plan that outlined the general logistics needs was drawn up and then one discussed it with the Municipal Health Department Board, since that municipality had committed to provide logistics support for the present study in terms of the human and material resources available in the participating clinics. The plan included all scheduled dates, personnel, office space, equipment and other operational logistics and described times for initiation and completion of all study phases regarding training, sample selection and data collection as well as team members required for the fieldwork.

Once the Health Department board approved the preliminary logistics plan, the coordinator of the primary care facilities was contacted and the participating dentists in order to explain how the present study would be conducted. As soon as each dentist agreed to participate in the study and signed the informed consent form, the coordinator's permission was sought for dentists to leave their workplaces in order to participate in the group meetings, trainings and field research.

The logistics plan was also discussed with the health personnel of working at the clinics, including the participating dentists. This allowed the researcher to have a clearer picture of the logistics issues involved in the daily working routine of those health facilities. The final logistics plan was outlined collectively with the staff and managers of the participating health facilities. It included setting up meetings with dentists, securing venue for the group discussions and choose the appropriate days for the calibration trainings.

In addition, the researcher also met with facility staff to anticipate and resolve any difficulty in obtaining collaboration from community members during the oral examinations. The objective of the meeting was to facilitate planning for the resources and arrangements needed to conduct the fieldwork. Staff who wished to be part of the field activities joined the meeting. The group discussed ideas on how to better arrange the logistics in a way as not to alter much the working routine at the health facilities. The researcher provided clarification regarding the purpose of the study and the group came to a consensus about the location and materials required for the oral examinations. Logistics were discussed with participating dentists, to oversee the field data collection process. A brief management plan was then agreed too as to who was responsible for field operations (welcoming community members and explaining the research and collecting the consent forms etc.).

#### *4.2.4.1. Selection of the field team*

The recruitment process started during the meetings with the health services' staff. The researcher selected staff members, including two more than needed for the fieldwork, and provided them with brief training for the preparation and distribution of tasks. A few additional selected staff allowed leeway to replace workers who could later quit participating or who become ill.

#### *4.2.4.2. Training of the field team*

The researcher conducted a brief training so that dental staff could become familiar with the background and general issues related to the study. They were brought together for an overview during which time materials were distributed, together with a description of the outline of the study, its objectives, format, schedule, and a reference document on oral health policy. The training session was highly participatory, during which the researcher covered topics related to the expectations of field staff regarding their attitudes and responsibilities as well as the supervision of the fieldwork. Trainees discussed all logistical arrangements and field conditions for a successful fieldwork.

The dental assistants took responsibility for welcoming groups of participants and collecting participant's informed consent forms, after the explanation of the study provided by the researcher. Due to their familiarity with local languages and cultures, participating dentists and dental assistants made suggestions on improving efficiency in the implementation of the fieldwork.

#### *4.2.4.3. Fieldwork*

The researcher coordinated all field logistics, including field access at health facilities, and conducted field supervision in order to ensure the conditions for the staff and dentists to approach and examine patients in an effective and friendly environment. During and after the fieldwork, the researcher carefully reviewed the on-line data base, as this was an important determinant of data quality. The researcher also supervised the fieldwork to avoid any problem regarding clarifications for patients about the exams being undertaken by dentists and to assure the collection of patients' consent form.



#### *4.2.4.4. Concluding remarks*

Logistics of the present study went well and in accordance with the researcher's plan. The Health Department supported the study's expenses, with relation to human resources and material supplies. The University supported the study in developing and storing the on-line data base.

The field research was developed in two phases:

#### *4.2.5. Calibration and standardization*

The calibration process was carried out in the preceding 15 months before the start of data collection. Dentists should ideally have been calibrated two or three months before data collection. However, there was a delay of several months in the implementation of internet connection at the local clinics. In the meantime, dentists tried to collect off-line data, but that procedure was not successful due to data transposition problems.

Theoretical and practical training had the objective of testing logistics for field research, reviewing the examiner manual, piloting the on-line data collection forms, and achieving acceptable levels of intra- and inter-examiners reliability. Calibration was on-going over the one-year data-collection period.

##### *4.2.5.1. Calibration method*

The training was conducted in seven parts from April 2013 to April 2014. An additional training was conducted during the field-research, in May 2015. An "Examiner's Manual" was developed by the researcher specifically for the calibration trainings conducted in the present study. During the training, the participating dentists reviewed several topics of the manual and enriched its content. The manual describes in detail the diagnostic classification method which was followed by the dentists in the field research, including a proposed timing of nearly 90 seconds for a brief clinical assessment of the four dental quadrants.

Firstly, dentists got familiar with the clinical assessment method, diagnostic categories as well as with the on-line forms for data-typing. They also had the opportunity to discuss to each other on the diagnostic thresholds, when conducting oral examinations. Whenever their observations differed, the oral examination was repeated until a consensus diagnostic decision had been achieved.

A summary description of what constituted the five different categories used to classify the oral quadrants is presented as follows:

- Category 1: filled teeth; sound teeth fully erupted; controlled dental plaque; normal skin and mucous;
- Category 2: partially erupted tooth; initial active cavities; dental plaque; active white spots;
- Category 3: active medium cavity; tartar; slight dental mobility; open bite in young children; lateral cross bite;
- Category 4: deep and extended cavity; fistula intra or extra oral; severe dental mobility; residual roots and factors retaining dental plaque; children/adolescents with face cross bite;
- Category 5: chronic dentally-related pain /discomfort Skin or mucous lesion needing further examination, relief of trauma, haemorrhage, swelling, medically compromised patients with a doctor's referral.

The next step was to measure inter- and intra-examiner consistency when dentists performed oral examinations without any discussion. The practical trainings sought to standardise dentist's judgement in accordance to the pre-defined diagnostic criteria. The calibration trainings aimed at reducing measurement and interpretation bias.

The diagnostic classification tool adopted in this study is summarized in the Results Chapter. Dental conditions that are possible to be seen by primary care dentists in a primary health care setting were categorized into one out five levels, from the best to the worst oral health condition. Within each category, clinical conditions were supposed to share similar deterioration rhythm. A classification code (1, 2, 3, 4 or 5) was determined to a quadrant, according to worst condition encountered within the quadrant.

#### *4.2.5.2. Calibration sampling*

The sample for the calibration exercises was consisted of users from different age groups who came to the local clinic in the training days. At each training day, users were randomly selected and consented to undergo oral examinations.

#### 4.2.6. Validity and Reliability

Gold standard measurements for clinical assessments in dentistry is a contentious issue among practitioners and researchers. According to Fyffe *et al.* (2000), there is no true gold standard in epidemiological caries diagnosis. Where gold standard references or objective criteria do not exist either for dental diagnosis or dental treatment, high level of discrepancy between dentists' opinion always remained (Bader and Shugars, 1997). Therefore, in the during the calibration trainings no gold standard examiner was adopted and the level of inter-rater reliability was used as a proxy measure of validity.

Although there is no validated calibration method for dental epidemiological surveys in the literature, some calibration methods have been widely accepted, such as that proposed by the (World Health Organization, 1979) to guide to oral health epidemiological investigations. Experts have discussed the need for the development of scientifically based protocols for calibrating examiners, who are going to participate in epidemiological dental surveys (Ismail, 2004). In view of the absence of a validated method, in the present study a proxy calibration method (based on our resource and time constraints) was used in order to test the standardization of dentists' clinical judgement.

By conducting previous calibration trainings, one intended to minimize the issue of verification/instrumentation bias. Memory bias was also addressed by blinding examiners for previous diagnostic classifications.

For caries surveillance in children, the British Association for the Study of Community Dentistry (Pine, Pitts and Nugent, 1997) recommends that during the calibration trainings dentists examine a minimum of 20 pre-selected children with and without caries experience. In the present study, the sample for the calibration exercise included more than 20 individuals from different age groups, aiming to anticipate the conditions examiners would encounter in the real working scenario, for the survival analysis study (Pine *et al.*, 1997).

In order to increase validity of the examiners calibration results, one had to minimize the impact of agreement by chance when evaluating the extent of diagnostic agreements among participating dentists. Kappa statistics has been largely used as a chance-corrected agreement coefficient, particularly in calibration trainings for dental epidemiological surveys in Brazil (Assaf *et al.*, 2006). However, by performing Kappa calculations there is a potential occurrence of unexpected and unduly low values when the ratings suggest high percentage of

agreement. That has been described in the literature as the “kappa paradoxes”. Further weaknesses of Kappa statistics is its dependency upon trait prevalence in the subject population and to marginal probabilities, i.e., raters' classification probabilities (Gwet, 2002). In the present study, one adopted the Gwet's AC1 statistics, which is a more stable (i.e. small variance) chance-corrected multiple-rater agreement coefficient and a more paradox-resistant alternative to Kappa statistics (Gwet, 2008). According to Quarfoot and Levine (2016), Gwet AC1 method has shown to have more robust statistical properties than Kappa-like coefficients. McCray (2013) argued that it is a better method to interpret, communicate and disseminate levels of inter-rater reliability.

#### ***4.2.7. Data collection process***

Following the calibration training, dentists began data collection. Dentists provided their patients with information on the research objectives and the oral assessment method and invited them to participate in the study and to sign the Informed Consent. There was no refusal to participate. Diagnostic classifications both initial and pre-post procedures classifications were performed over a 13 month period.

Diagnostic classifications were conducted in accordance to the method described in the Examiner Manual. After brief clinical assessments, diagnostic codes were registered by the dentists in the on-line forms. Forms were accessed on-line, via Tablets/computers connected to the internet. Data were captured in a database system stored in the university server, protected by password. Dentists were blinded for their previous classifications. The database was developed by one of the researchers and installed at the university's Informatics Laboratory.

When, for the first time in the study year, the patient sought an emergency appointment or a routine dental assessment or a general dental treatment at the local clinic, the dentist performed the first (initial) clinical assessment by classifying the patient's four quadrants.

When a previously classified patient showed up for a scheduled dental visit or for an emergency consultation, the dentist performed both the pre- and the post-procedure classifications in the treated quadrant. In this way, each time a patient showed up, his/her treated quadrant received two classifications: a first classification just before the dental procedure and a second one just after the dental procedure, i.e., two classifications per dental visit. That made it possible to count the time (in days) between dental consultations and

compare the quadrant status at the beginning and at the end of the patient's waiting time for a dental visit. This means that every time to an event (or to a censored observation) started either with an initial or a post-procedure classification and finished with a pre-procedure classification. Time to event or to censored observations were analysed by survival analysis techniques in order to estimate probabilities for classified quadrants to remain clinically stable, event-free, between dental visits. To accomplish this, the length of time each quadrant took to getting worse was measured in relation to its previous classification.

Since the event of interest was the natural course of clinical deterioration in the wait time for a dental visit, one excluded from the survival study sample the emergency observations of categories 1, 2 and 3. However, emergency observations of category 4, because the only possible event for category 4 is to become worse to category 5 was included.

It is important to highlight that the selected patients were scheduled for dental appointments according to the clinics current scheduling routine. Thus, quadrants were appointed for dental visits according to both dentists' judgement and availability of services at the clinics. When a patient cancelled the dental appointment or failed to show up, his/her wait continued until the following dental visit when the quadrant's clinical status was then re-classified.

#### ***4.2.8. Data management and statistical analysis***

##### ***4.2.8.1. Data-editing and data-coding***

The researcher performed a regular and routine check in the on-line database to ensure that it had neither duplicate entries nor missing data.

Classification codes were recorded by dentists directly in on-line forms via Tablets or computer connected to the internet. In this way, data were stored directly in the on-line database without transposition.

The database was hosted by the university server (UFRGS) whose access was exclusive to researchers and supervisors.

The on-line form was programmed to prevent various types of filling errors, as detailed below:

- The on-line form had a "JavaScript routine" to validate the user's' health card number against the official database of the Ministry of Health. If an invalid card number was filled in the on-line form, the system blocked the sending.
- The on-line form allowed the page to be reloaded by the dentist to erase any filling error.
- If the "Initial Classification" option was selected, the form automatically blocked filling the "Pre" column, allowing just to fulfil the "Post" column.
- If the "Initial Classification" was not selected, both "Pre" and "Post" columns remained available, but allowing sending just if the pre and post classifications referred to the same quadrant.
- During the one-year field research, the researcher remained available to dentists and health managers by email, by phone or in person to resolve questions and contribute to the proper data collection.
- For survival analysis procedures, data stored in the server database was exported to an Excel file, and then imported by the SPSS software.
- For cost analysis procedures, data in the Excel spread sheets were modelled by mathematical formula and algorithms.

#### 4.2.8.2. Data analysis procedures

To interpret the strength of agreement of examiners, the benchmark scale suggested by Landis and Koch (1977) was adopted due to its tradition in interpreting Kappa results. Such a scale is also recommended to categorize Gwet AC1 coefficient results (McCray, 2013). As such, according to Landis and Koch (1997), values from 0.0 to 0.20 represent poor or slight agreement level; from 0.21 to 0.40 reach fair agreement level; from 0.41 to 0.60, moderate level; from 0.61 to 0.80, a substantial level and from 0.81 to 1.00 an almost perfect level.

The gold standard examiner was not used in the calibration trainings, because according to Fyffe *et al.* (2000) no true "gold standard" is available in dental examinations conducted under epidemiological conditions. Hence, examiners agreement was used as a proxy for accuracy. Data processing and analysis of the calibration trainings were performed by the AgreeStat in MS Excel version 2015.5 for Windows and Mac).

The Survival Analysis was adopted mainly because of an interest in analysis of the duration of a given condition, and also because that is a unique method among other statistical techniques which, by adjusting for the occurrence of censored data, makes it possible to count on partial information thereby using all available data (Linden, Adams and Roberts, 2004; Prinja, Gupta and Verma, 2010). Because the method of collecting data, in which dentists re-classified quadrants in each dental visit, it was fundamental to consider all censored observations, so that one did not under estimate event-free (survival) probabilities. Thus, by using survival analysis method, it was possible to use all available follow-up time information.

Another reason for choosing Survival Analysis was because it is prospective in nature therefore appropriate for the prospective cohort of dental quadrants followed in their wait time journey for dental visits.

In the present study, survival (or event-free) means: to remain clinically stable (free of clinical deterioration) over the waiting time for a dental visit. Thus, the Survival Analysis offered insights into the progression of dental disease over the time people were waiting to see the dentist. Time to event was measured by counting the days between dental visits.

An event was observed when the quadrant was encountered clinically worse after it had waited for a dental visit since the previous one. Censored observations occurred when the event did not occur in the waiting time for a dental visit. However, censored data was used to develop the model for predicting time to event, because these data contributed to the survival probability for each next observation period, assuming that censored quadrants had the same likelihood of developing the event and the same survival prospects as those which were followed up until the occurrence of the event. That is called uninformative censoring (Murray, 2001).

Survival Analysis is also useful for comparison purposes. Other types of analysis such as risk and odds ratios or logistic regression, for example, can also be used to compare proportion of events in the groups being studied. However, these kinds of analysis cannot replace Survival Analysis as they ignore time. Time to event is actually the primary response in Survival Analysis. Thus, it would be a misconception of survival analysis to interpret the result as one group being more likely to experience the events (Clark *et al.*, 2003).



One can also compare mean time-to-event between studied groups by using t-test and linear regression. But again, these kinds of analysis cannot replace Survival Analysis because they ignore censored observations. However if confounders were incorporated into the analysis, Cox regression could have been used as it considers time and censoring.

For estimating survival probabilities the Kaplan-Meier estimator (Kaplan and Meier, 1958), was used because it is suitable for the purpose of (i) describing the general shape of survival function and (ii) using the descriptive probability results in the modelling phase. Furthermore, as Kaplan-Meier method is based on the assumption that the observations are censored no matter suitable for our data their likelihood of developing the event of interest it was suitable for our data. A further reason for adopting Kaplan-Meier estimator is because it is a nonparametric estimation of survival function, and there was no particular parametric function for the survival distribution of the events being studied.

#### *4.2.8.3. Discussion of the limitations in the data*

Due to the method of collecting data, in which classifications were carried out in the real working scenario of local clinics, one had a limitation regarding the level of agreement achieved in calibration training. In classical epidemiological studies, the recommendation is to exclude those examiners who do not achieve acceptable levels of agreement. However, in the present study no-one participating dentist was excluded from the examiner group, because under real employment circumstances no dentist is fired from the job due to diagnostic disagreements.

An additional limitation was a biased estimation of survival probabilities, caused by the large amount of censored observations. In Survival Analysis studies, a great number of censored observations may occur as a consequence of methodological problems. However, for ethical reasons, our study methodology was not designed to observe the natural progression of dental diseases. In this way, dental quadrants from categories 2, 3 and 4 were treated even without clinical deterioration. Furthermore, survival estimations may have been biased by potential patterns of censoring, since diagnostic classifications were performed according to the appointment routine in place at the participating clinics. Hence, one predicted that such scheduling routine would lead to a pattern of censoring, thereby censoring quadrants in specific times.



### **4.3. Modeling phase: Cost comparison analysis**

In this phase, the methodology for selecting the inputs for the modelling of the resource allocation framework into Model 1 and Model 2 is presented.

Firstly one selected the following inputs:

1. Dental care needs of the sample
2. Dental staff components of the family clinics
3. Workload components in family clinics
4. Activity standards in family clinics
5. Dental staff cost per working hour at family clinics

Secondly, one modelled the framework using the above inputs and two different sets of maximum wait time for dental care. That generated two models. For the first model (Model 1), the set of wait times was drawn from the results of the previous study (face validity study), when a group of expert dentists determined maximum wait times for dental care. For the second model (Model 2), one used the survival study results to set wait times, and one simulated the highest possible survival probability balanced between all diagnostic categories, considering the similar budget required by Model 1.

Thirdly one performed calculations for each model to obtain the following outputs:

1. Required dental staff working hours
2. Survival probabilities
3. Financial implications

The inputs were configured in the following way:

For configuring input 1 the following was collected:

- the last classification code of the sample quadrants captured in the on-line database
- the date of the quadrants' last classification

One exported the last classification code of all quadrants included in the sample during the study year and their respective classification dates from the on-line database to an Excel spread sheet. Each quadrant was identified by its number (1, 2, 3 or 4), and the number of patients' health card.

For configuring the inputs 2, 3 and 4, the methodology proposed in the Manual for Implementation of the Workload Indicators of Staffing Need (WISN) Method was adopted. The instructions and the approach suggested in that manual was used since it was appropriate for configuring these inputs and also because the manual was already field-tested by the World Health Organization in several countries (Shipp, 1998).

As suggested by WISN Implementation Manual, the "facility group method" was adopted, in which experienced and knowledgeable participants set standard workload and activity standards for all staff categories employed in a given type of facility. Hence, the five participating dentists were invited due to their large experience and knowledge in primary dental care practice. They accepted being part of the expert working group.

The workshop activities were conducted in two sections. Dentists' tasks consisted of defining: (i) dental staff components for family dental teams, (ii) components of daily work in primary dental care settings and (iii) activity standards for each component of daily work.

In the first workshop section, dentists were made familiar with the procedures and the scope of their task. The researcher used the instructions of the WISN Implementation Manual as an introductory presentation, providing dentists with the materials containing the following definitions:

- Dental staff components in primary dental care: staff categories which have been currently employed by the Family Health Programme and which have professional competencies to perform dental-related actions currently listed in the official Brazilian Occupational Code, published by the Ministry of Health (Brasil, 2016a).
- Daily work components: the procedures and activities which are part of the primary dental care practice and are listed in the official Brazilian Occupational Code, published by the Ministry of Health (Brasil, 2016a).
- Activity standard: it means the unit time for a dental health care activity. For a

particular dental activity, it is the average time it would take a trained and well-motivated member of the Family dental team to perform the action/procedures to an acceptable standard of dental practice, when required equipment/materials available.

By consulting the Ministry of Health website, the group of dentists listed all dental staff categories and related primary dental care activities and procedures in a way as do not overlap professional competencies. Each dental staff, activity/procedure was then assigned to a domain of the comprehensiveness of dental care, namely: dental health promotion, dental health prevention, dental cure/treatment, and dental rehabilitation. In this way, the domain represented a major component of workload for each dental staff category, according to their scope of practice and competencies (job descriptions) as follow:

- dental health promotion: a major component of daily workload for CHWs
- dental health prevention: a major component of daily workload for dental hygienists
- dental cure/treatment: a major component of daily workload for dental hygienists
- dental rehabilitation: a major component of daily workload for dentists

Having identified the four major components of workload in primary dental care, the next task was to set an activity standard for each component of daily workload. In this way, the group task was set an activity standard in terms of the average time taken by:

- dentists to perform actions in a quadrant eligible for rehabilitative procedures;
- dental hygienists to perform actions in a quadrant eligible for curative procedures;
- dental hygienists to perform activities for a group of patients eligible for preventive care;
- community health workers to perform activities for a community or a family group eligible for health promotion.

At the end of the second section, the activity standards produced by the expert group were reported for consideration and approved by consensus. When the expert group agreed on the activities standards for each component of workload, its task was completed and these data were due to be used in Model 1 and Model 2.

## **Configuring calculation algorithms in Excel spread sheets**

This phase was developed by the group of researchers. Computer calculations in Excel spread sheets were used to simulate staffing requirements and related costs for Model 1 and Model

2. The steps in this process were:

1) The volume of dental needs of the sample were entered into a spread sheet by transposing from the on-line database the latest classification code registered for quadrants;

2) Thereafter each classification code with a component of the workload was related, as follows:

- Code 1 was linked to group promotion activities

- Code 2 was linked to group preventive activities

- Code 3 was linked to curative procedures to be performed in a quadrant

- Code 4 was linked to rehabilitative procedures to be performed in a quadrant

3) Dental staff categories working at family clinics were listed in the spread sheet and one linked each category with the corresponding activity standards.

4) The average cost per working hour for each dental staff category of the family clinics was listed. Since the participating clinics were located in the metropolitan area of Porto Alegre, the average annual salaries which are currently paid to dental staff by the Municipal Health Departments located in that area was taken into account. To calculate the cost of working hour, one divided the salary by the number of working days in the study year.

5) Two algorithms inserting the maximum wait times for dental care were set: the first algorithm (Model 1) took the maximum wait times validated by the experts in the previous study, and the second algorithm (Model 2) took the maximum wait times for the highest possible probabilities for quadrants to remain clinically stable (event-free) up to the dental visit day. In this way, each time quadrants which had completed their wait time journey, they turned eligible for the required dental care.

6) A multiplying algorithm was set to obtain total cost of dental personnel per staff category which multiplied the resulting volume of working hours by the cost of a working hour.

It is important to mention that it was not in the scope of the present study to analyse the real staffing requirements at the participating clinics and not to make comparisons between clinics in terms of real workload pressure and costs.

#### **4.4. Ethical and legal considerations**

This study was conducted in accordance with the PAHO Ethical Guidelines for Research Involving Human Subjects (Pan American Health Organization and World Health Organization, 2007). This study was also conducted according to the terms of Resolution No. 196 of October 10, 1996, the National Council of Ethics in Research.

The study research proposal was submitted to the Ethics in Research of the School of Dentistry, Federal University of Rio Grande Committee of the South and the Senate Research Ethics Committee of the Faculty Dentistry, University of Western Cape, South Africa (Process No. 0033.0.216.203-09; ethical clearance no.13/10/71) (Appendix 1) getting approval from both committees in 2013.

In order to undertake this research, an information sheet was given to all participants. It is shown in detail in Appendix 2 and its items are summarized as follow:

1. The purpose of the study.
2. All information given by the participants during the research process is kept anonymous.
3. Participation is voluntary.
4. No individual is identified in the research report.
5. There are not consequences to those who refuse to participate in the study.
6. Any participant can withdraw from the study at any stage, and no reason is required.
7. Each participant may allow or not the use data collected from his/her mouth in the study.
8. The researcher protects the data from being uncovered, ensuring confidentiality.
9. The Family Health clinics managed by the Municipal Health Department are available to those participants who wish to undergo dental treatment.

All patients and health professionals who accepted to participate in this study were informed about the objectives, risks and benefits of the study and then were asked to sign an informed-consent form, shown in Appendix 3.



## CHAPTER 5: RESULTS

### 5.1. Survival Analysis

The results of the calibration training of examiners are shown in the Table 1 and Table 2. Table 1 shows the level of agreements between examiners (inter-examiner agreements) achieved during the calibration training carried out before the data collection in 2013 and 2014, and during data collection in 2015.

**Table 1: Inter-examiners agreement levels reached in the calibration training sessions carried out in 2013, 2014 and 2015**

Calibration session	Number of cases	Gwet's AC1 Agreement Coefficient	Inference		
			Std Error	95% C.I.	p-Value
April 2013	76	0.55188	0.04185	0.469 to 0.635	0.000
June 2013	60	0.56998	0.04386	0.482 to 0.658	0.000
October 2013	92	0.55366	0.03983	0.475 to 0.633	0.000
November 2013	72	0.46983	0.0383	0.393 to 0.546	0.000
December 2013	100	0.54607	0.03247	0.482 to 0.61	0.000
February 2014	72	0.52597	0.04608	0.434 to 0.618	0.000
April 2014	72	0.53863	0.04401	0.451 to 0.626	0.000
May 2015	42	0.61584	0.06255	0.49 to 0.742	0.000

According to the criteria proposed by Landis and Koch (1977), the overall inter-examiner agreement reached a minimum acceptable level, as the agreement coefficient results were not below 0.41. The decline in the agreement levels in November, 2013 (0.46983) may have occurred due minor changes made by the dentists in the diagnostic criteria. Taking into account the confidence interval margins (0.49 to 0.742) of the agreement result obtained in May 2015, one can considered that the level of agreement between examiners remained acceptable during the study year.

According to the British Association for the Study of Community Dentistry (Pine *et al.*, 1997), a minimum of 20 observations is indicated for calibration exercises in dental epidemiological surveys. As shown in Table 1, one reached that recommendation, since a mean of 74 quadrants including children, adolescents, adults and elderly were examined in each calibration section.

Table 2 shows intra-examiner agreements achieved in the calibration trainings carried out in before the data collection in 2013 and during data collection in 2014.

**Table 2: Intra-examiner agreement levels reached in the calibration sessions carried out in 2013 and 2014**

Calibration session	Number of cases	Examiner	Gwet's AC1 Agreement Coefficient	Inference		
				Std Error	95% C.I.	p-Value
November 2013	40	1	0.87983	0.058145	0.762 to 0.997	0.000
		2	0.70279	0.07949	0.543 to 0.863	0.000
		3	0.87728	0.058924	0.758 to 0.996	0.000
		4	0.83799	0.069392	0.698 to 0.978	0.000
		5	0.56617	0.098355	0.367 to 0.765	0.000
April 2014	72	1	0.61186	0.071936	0.468 to 0.755	0.000
		2	0.76058	0.060637	0.64 to 0.881	0.000
		3	0.72717	0.06081	0.606 to 0.848	0.000
		4	0.57372	0.069809	0.435 to 0.713	0.000
		5	0.77908	0.058774	0.662 to 0.896	0.000

Table 2 demonstrated that despite variations from the one session to the other, all examiners achieved at minimum satisfactory levels of intra-examiner agreement in both calibration sessions (November 2013 and April 2014). One can note that examiner 5 improved its agreement level in the second session, while examiner 4 reached lower agreement.

Since no examiner was excluded from the study because of its level of intra-examiner agreement or because of its contribution to inter-examiners disagreements, various additional theoretical trainings were provided in order to keep the level of agreement at minimum satisfactory during the study year.

The demographic characteristics of the 1 894 patients who were classified in the study year are summarized in Table 3. Age groups were categorized in four groups: children (from zero to 12 years old), adolescents (from 13 to 19 years old), adults (from 20 to 65 years old) and elderly (older than 65 years).

**Table 3: People classified in the study year, by gender and age group at the participating clinics (n=1,894)**

	Clinic 1	Clinic 2	Clinic 3	Clinic 4	Clinic 5	Total	Percent
<b>Female</b>	310	144	305	224	143	1126	59.50%
Adolescent	42	14	40	17	17	130	11.50%
Adult	178	99	192	141	84	694	61.60%
Children	79	19	47	46	34	225	20.00%
Elderly	11	12	26	20	8	77	6.80%
<b>Male</b>	177	124	204	169	94	768	40.50%
Adolescent	17	8	32	21	14	92	12.00%
Adult	93	65	110	85	43	396	51.60%
Children	61	41	46	45	24	217	28.30%
Elderly	6	10	16	18	13	63	8.20%
<b>Total</b>	487	268	509	393	237	1894	
<b>Percent</b>	25.70%	14.10%	26.90%	20.70%	12.50%	100.00%	



Table 3 shows that the majority of patients was female (59.5 %). Among age groups, the majority of patients was adult (61.6% female and 51.6% male), and the minority was elderly, 8.2% male and 6.8% female.

All patients described in Table 3, a total of 1 894 people, were included in the modeling phase for cost analysis purpose but only 677 of them were included in the survival analysis. That was because just 677 out of 1 894 persons received dental treatment at the participating clinics after their first clinical assessment. The other 1 217 individuals were classified but their classifications could not be used in the survival study, since for those patients there was no other classification code captured in the database, except the first one.

Patients, whose classifications were used in the survival study, underwent oral assessments every time a dental procedure or a dental review was performed. Patients' quadrants were then appointed for a following dental visit. When patients showed up either for the scheduled dental visit or for an urgent consultation, dentists classified the schedule quadrant or the urgent quadrant before the dental procedure was performed. As mentioned in the Methodology Chapter 3, although every urgent consultation was registered, only those transitions from category 4 to urgent (category 5) were included in the sample of the survival study.

Table 4 below shows the distribution of gender and age in both groups (included in and excluded from the survival study).

**Table 4: People included in and excluded from the survival study, by gender and age group**

	Age Group	Female	Perc	Male	Perc	Total	Perc
Included	Adolescent	33	2.9%	25	3.3%	58	3.1%
	Adult	285	25.3%	168	21.9%	453	23.9%
	Children	64	5.7%	54	7.0%	118	6.2%
	Elderly	19	1.7%	29	3.8%	48	2.5%
	Sub-total	401	35.6%	276	35.9%	<b>677</b>	35.7%
Excluded	Adolescent	97	8.6%	67	8.7%	164	8.7%
	Adult	409	36.3%	228	29.7%	637	33.6%
	Children	161	14.3%	163	21.2%	324	17.1%
	Elderly	58	5.2%	34	4.4%	92	4.9%
	Sub-total	725	64.4%	492	64.1%	<b>1217</b>	64.3%
Total		1126	100.0%	768	100.0%	<b>1894</b>	100.0%

Table 4 showed that in both groups female adults represented the highest percentages, while elderly and adolescents represented the minority in both groups.

From the excluded group of 1 217 individuals with just one classification per quadrant, the classifications codes captured in the database showed that 36.53% of the oral quadrants were classified in category 1(n=1 498); 30.48% were classified in classified in category 2(n=1 250), 19.85% in category 3(n=814) and 13.14% were classified in category 4(n=539).

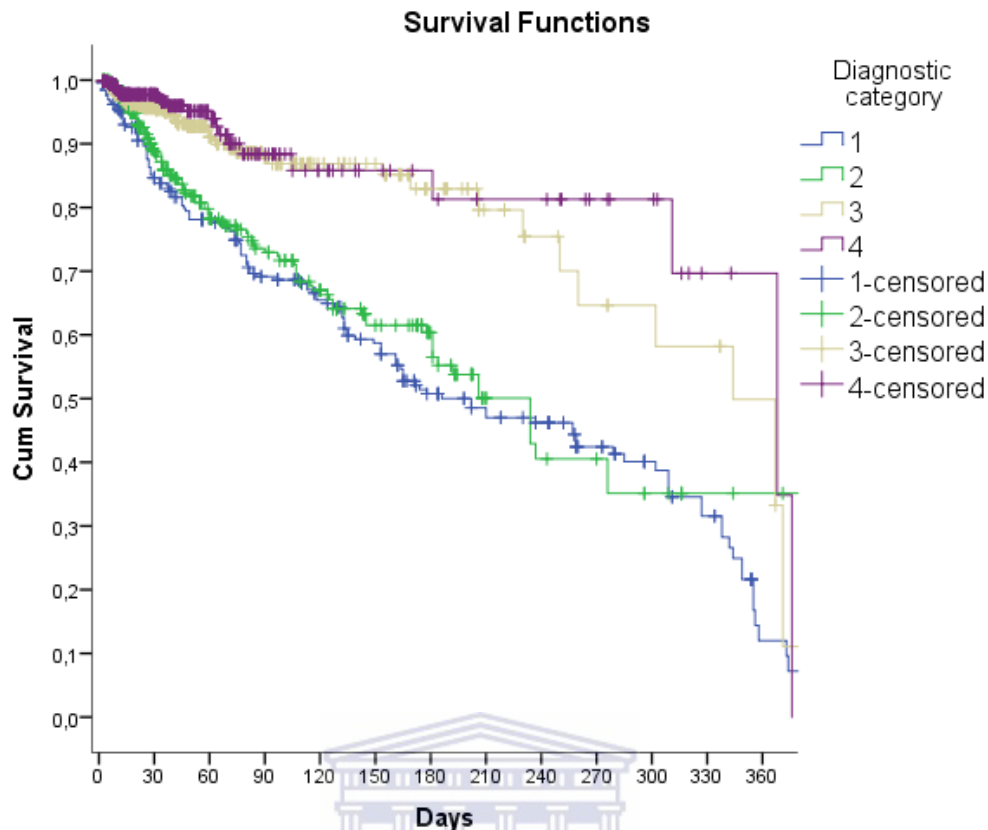
Table 5 shows the number of journeys made by quadrants from different diagnostic categories and the respective events (clinical deterioration) and censored observations (clinical stability) registered at the end of the journeys.

**Table 5: Quadrants' wait time journeys by diagnostic category and the respective events and censored observations in the study time**

Diagnostic category	Wait time journeys		Number of Events	Censored	
	Number	Percent		N	Percent
1	265	15.51%	137	128	48.30%
2	408	23.87%	98	310	76.00%
3	539	31.54%	49	490	90.90%
4	497	29.08%	23	474	95.40%
Overall	1709	100.00%	307	1402	82.00%

Table 5 demonstrates that during the study time it was possible to observe 1 709 journeys made by quadrants from a dental visit to another and that the majority of journeys (60.62%) were made by quadrants of category 3 and 4. Moreover, Table 5 shows a high percentage of censored observations in all category, which indicates that the majority of quadrants scheduled for a dental visit had not getting worse in the waiting for dental care, particularly those of category 4.

Figure 1 below shows Kaplan-Meier (KM) curves for the cumulative probability of clinical deterioration among 1,709 wait time journeys of quadrants classified in different categories.



**Figure 1: Survival function of oral quadrants of four diagnostic categories**

Figure 1 shows a survival plot which is extended right through to the longest follow-up time of the present study. However, as the KM curves are drawn to the right, i.e., nearly 360 days, there is least information and greatest uncertainty about survival estimates. That is because much of the right-hand part of the survival plot depicts just a few remaining quadrants' journeys. It will often be reasonable to curtail the plot when only around 10–20% were still in follow-up. In general terms, one can observe in Figure 1 that quadrants of categories 3 and 4 had a slower deterioration rhythm than that of quadrants of categories 1 and 2. Moreover, one can note that within the first 60 days, nearly 20% of quadrants from categories 1 and 2 had already experienced clinical deterioration while just nearly 5% of quadrants from categories 3 and 4 got clinically worse. The observations in Figure 1 included quadrants of patients from all age groups and gender.

Table 6 shows comparisons between survival experiences of quadrants from different categories. By performing the log rank test, one found that KM curves of categories 1 and 2 were significantly different from KM curves of categories 3 and 4.

**Table 6: Pairwise comparisons of survival experience between diagnostic categories, using Log Rank (Mantel-Cox) test**

Diagnostic category	1		2		3		4	
	Chi-Square	p-value.	Chi-Square	P-value.	Chi-Square	p-value	Chi-Square	p-value
1			1.802	0.179	<u>34.461</u>	<u>0</u>	<u>31.01</u>	<u>0</u>
2	1.802	0.179			<u>20.077</u>	<u>0</u>	<u>20.596</u>	<u>0</u>
3	<u>34.461</u>	<u>0</u>	<u>20.077</u>	<u>0</u>			1.369	0.242
4	<u>31.01</u>	<u>0</u>	<u>20.596</u>	<u>0</u>	1.369	0.242		

The log rank test took the whole follow up period into account, to test if there was no difference in the probability of event occurrence (clinical deterioration) at any time point over the study year. For each such time point, long rank calculated the observed number and the expected number in each category. Since the log rank test is purely a test of significance it could not provide an estimate of the size of the difference between the diagnostic categories or a confidence interval (Macinko *et al.*, 2006).

The next analysis was to verify the equality of survival distributions between male and female and among age groups from different diagnostic categories. These results are shown in Table 7 and Table 8.

**Table 7: Case processing summary of the survival sample by gender and comparisons of equality of survival distribution performed by log rank test**

Diagnostic category		Total	Number of Events	Censored		Chi Square	df	P-value
				N	Percent			
1	Female	159	82	77	48.40%	0.816	1	0.366
	Male	106	55	51	48.10%			
	Overall	265	137	128	48.30%			
2	Female	233	51	182	78.10%	1.394	1	0.238
	Male	175	47	128	73.10%			
	Overall	408	98	310	76.00%			
3	Female	320	30	290	90.60%	0.054	1	0.816
	Male	219	19	200	91.30%			
	Overall	539	49	490	90.90%			
4	Female	262	13	249	95.00%	0.001	1	0.975
	Male	235	10	225	95.70%			
	Overall	497	23	474	95.40%			
Overall		1709	307	1402	82.00%			

The log rank test found no difference statistically significant in the survival experience between male and female in each diagnostic category (0.05 level of significance). For this reason, survival curves were drawn with no gender distinction.

**Table 8: Case processing summary of the survival sample by age groups and comparisons of equality of survival distribution performed by log rank test**

Diagnostic category	Total	Number of Events	Censored		Chi Square	df	P-value
			N	Percent			
1	Adolesc	20	10	10	8.056	3	0.045
	Adult	146	65	81			
	Children	68	45	23			
	Elderly	31	17	14			
	Overall	265	137	128			
2	Adolesc	34	7	27	27.75	3	0.000
	Adult	250	70	180			
	Children	100	14	86			
	Elderly	24	7	17			
	Overall	408	98	310			
3	Adolesc	22	2	20	6.57	3	0.087
	Adult	426	27	399			
	Children	54	13	41			
	Elderly	37	7	30			
	Overall	539	49	490			
4	Adolesc	40	3	37	6.465	3	0.091
	Adult	349	17	332			
	Children	74	0	74			
	Elderly	34	3	31			
	Overall	497	23	474			
Overall	1709	307	1402	82.00%			

The log rank test found a statistically significant difference in survival experience among age groups from categories 1 and 2 (0.05 level of significance). In categories 3 and 4 it was found a not significant equality of survival distribution among age groups. In this way, survival curves were drawn for different age groups in both categories 1 and 2. For categories 3 and 4, survival curves included all age groups.

Figures 2 and 3 depict the survival curves of age groups from category 1 and 2, where the differences in the deterioration rhythm among age groups found by the log rank test are seen.

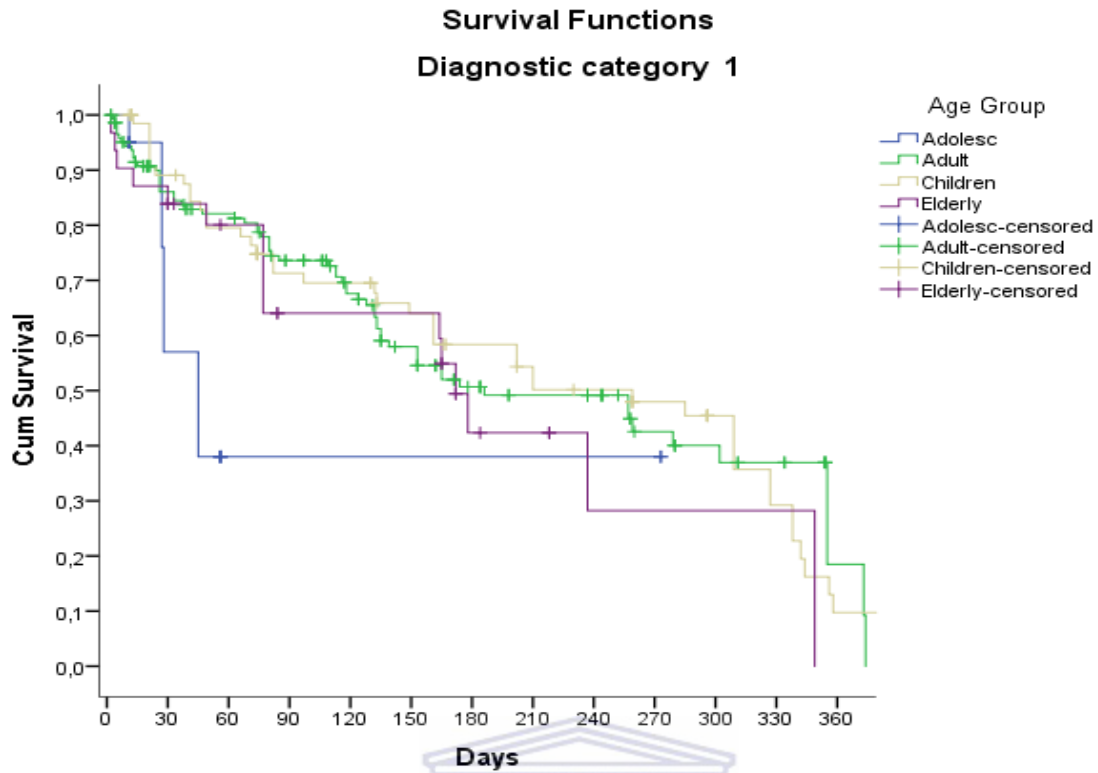


Figure 2: KM curves by age group of category 1

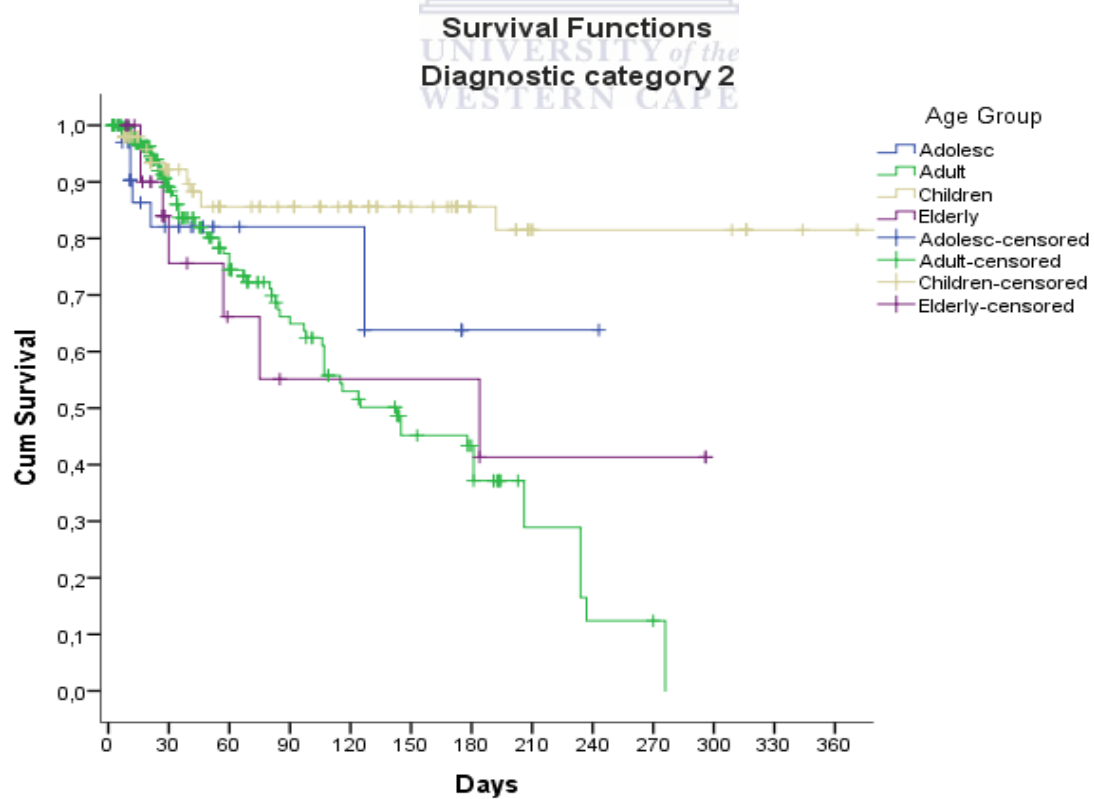


Figure 3: KM curves by age groups of category 2

Figure 2 shows that, within the first month, the dental quadrants in the elderly in category 1 had the fastest deterioration rhythm. In the second month, adolescents' dental quadrants showed a faster deterioration rhythm. In Figure 3 one can note that while more than 80% of children's quadrants of category 2 tend to remain stable after the second month waiting for a dental visit, adults' quadrants of category 2 continue to deteriorate up to the ninth month waiting for a dental visit.

## 5.2. Modelling phase

In a previous study, Nascimento (2010) together with expert dentists validated, by face validity technique, a set of maximum waiting times for primary dental care, within which dental care should be delivered. Dental clinical conditions were collapsed into five categories according to their urgency for dental care. In the 2010 study, the sustained hypothesis for quadrants that did not deteriorate were:

- quadrants classified in category 4 should see the dentist within 60 days, and in the waiting time should start preventive activities with the dental hygienist in 2 days;
- quadrants classified in category 3 should see the dentist within 180 days, and in the waiting time should start promotion activities with the community health worker in 2 days; start prevention activities with the dental hygienist in 60 days, and start curative procedures with the dental hygienist in 120 days;
- quadrants classified in category 2 should see the dentist within 365 days, and in the waiting time should start promotion activities with the community health worker in 30 days; prevention activities with the dental hygienist in 90 days, curative procedures with the dental hygienist in 180 days;
- quadrants classified in category 1 should see the dentist within 365 days, and in the waiting time should start promotion activities with the community health worker in 60 days.

Table 9 below shows the complete framework validated by the earlier study. It depicts the set of maximum wait times, summarizes the criteria for the diagnostic categories. These criteria were now used in the survival study, for classification purposes.

**Table 9: Dental resource allocation framework (Model 1) with maximum wait times set by the experts in the previous study (Nascimento, 2010)**

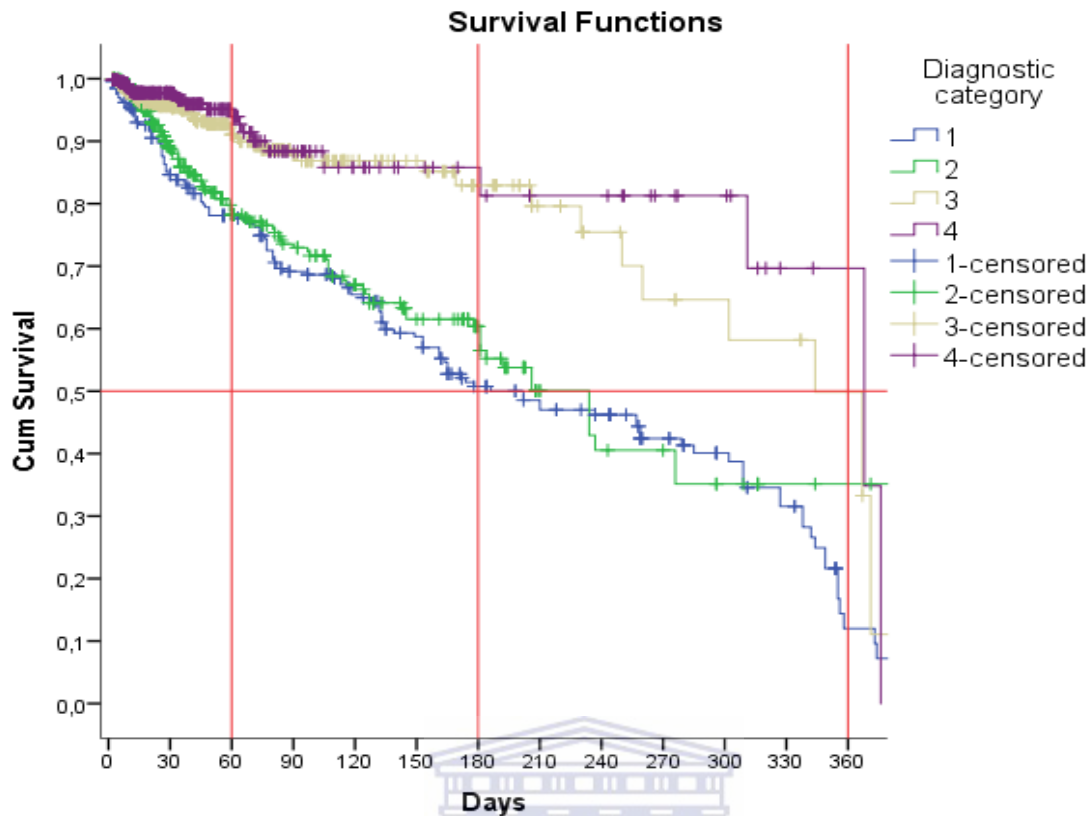
Summary description of the oral clinical status	Diagnostic category	Waiting times (in days)			
		CHW* Health	Dental Hygienist	Dental Hygienist	Dentist Rehabilitative
Chronic dentally-related pain /discomfort Skin or mucous lesion needing further examination, relief of trauma, hemorrhage, swelling, medically compromised patients with a doctor's referral	5				2
Deep and extended cavity; fistula intra or extra oral; severe dental mobility; residual roots and factors retaining dental plaque; children/ adolescents with face cross bite	4		2		60
Active medium cavity; tartar; slight dental mobility; open bite in young children; lateral cross bite	3	2	60	120	180
Partially erupted tooth; initial active cavities; dental plaque; active white spots	2	30	90	180	365
Filled teeth; sound teeth fully erupted; controlled dental plaque; normal skin and mucous	1	60			365

\* CHW Community Health Worker

In order to start modelling, the results of the survival study were taken to analyse the probability of clinical deterioration up to the wait times for a dental visit proposed by the experts in the previous study.

Figure 4 below provides an overview of the survival probabilities of categories 1, 2, 3 and 4 up to 60, 180 and 365 days respectively.





**Figure 4: KM curves crossing the deadline determined by the experts for a dental visit**

One can note in Figure 4 that, when the KM curve of category 4 crosses the line of the 60<sup>o</sup> day, the survival probability was above 90.0%. Moreover, the survival probability was above 80.0%, when the KM curve of category 3 crosses the line of the 180<sup>o</sup> day. One also found that, when the KM curves of categories 1 and 2 encountered the line of the 360<sup>o</sup> day, the survival probabilities were below 40.0%.

Table 10 shows in numbers what is depicted by Figure 4. It shows the cumulative proportion of quadrants remaining clinically stable at the maximum times for dental visits proposed by the experts, with the respective percentage of observations remaining at these times. Table 10 also includes the times when at least 10% of observations remained, which represent the percentage of remaining cases until which survival estimates are more accurate (Pocock, Clayton and Altman, 2002).

**Table 10: Survival probabilities at the times proposed by the experts, and at the times with 10% remaining observations**

Diagnostic category	Maximum time (in days) proposed by experts	Maximum time (in days) when 10% of cases still remained	Cumulative Proportion Surviving at the Time		Percentage of remaining cases
			Estimate	Std. Error	
1	365		0.12	0.044	1.89%
		309	0.387	0.041	10.19%
2	365		0.351	0.061	1.23%
		184	0.552	0.042	10.07%
3	180		0.829	0.035	5.95%
		139	0.868	0.023	10.04%
4	60		0.939	0.019	16.30%
		81	0.884	0.032	10.06%

Table 10 reveals great disparities in survival probabilities among diagnostic categories considering the waiting times, proposed by the experts, for quadrants to get a consultation with the dentist. One can note that considering the proposed maximum wait times, one found quadrants of category 4 with higher probability of survival (93.9%) than quadrants of category 1 and 2 (12.0% and 35.1% respectively). However, in view of the low percentage of remaining cases at the times proposed by experts in categories 1, 2 and 3, survival estimates are accurate just at the maximum time proposed by expert for category 4. Even if one takes into account the maximum times when 10% of cases still remain, and survival estimates are more accurate, there is a marked imbalance in survival probabilities between diagnostic categories.

Table 11 below shows the estimated percentiles for survival time in days for quadrants in different categories.

**Table 11: Percentiles for survival time (in days) for quadrants classified in different categories (n=1 709 observations)**

Diagnostic category	25.00%		50.00%		75.00%	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
1	344	8.661	202	32.395	74	9.779
2	390	-	234	22.829	83	11.968
3	371	1.792	344	29.993	250	38.026
4	376	-	368	41.456	311	132.766

Taking into account the standard errors of the estimates, the percentile 50 estimated the median waiting time, and found that 50% of quadrants were clinically stable. The percentile 75 estimated the duration of clinical stability for 75% (the great majority) of quadrants in each category.

One can note in Table 11 that, in all percentiles, quadrants classified in categories 3 and 4 had a larger duration of clinical stability (event-free) than quadrants of categories 1 and 2.

Table 12 below shows the scheduling pattern for dental visits at the participating clinics, for quadrants sampled in the survival study.

**Table 12: Wait times to dental visits, by diagnostic category (n=1 709)**

Diagnostic category	Type of transition observed in the wait time for the dental visit	Number of routine dental visits	Mean				Median				Percentile	
			Estimate	Std. Error	95% CI		Estimate	Std. Error	95% CI		Estimate	Std. Error
					Lower Bound	Upper Bound			Lower Bound	Upper Bound		
1	1 - 1	128	136	9.09	117.91	153.6	117	13.4	90.67	143.3	39	11.55
	1 - 2	56	143	16.19	111.05	174.5	113	22.4	69.03	157	33	7.29
	1 - 3	52	128	17.06	94.93	161.8	80	23.4	34.07	125.9	21	5.86
	1 - 4	29	93	15.86	61.67	123.9	49	26.9	0	101.7	27	10.23
	Overall	265	131	6.74	117.86	144.3	108	12.5	83.5	132.5	33	4.43
2	2 - 2	310	73	3.98	65.14	80.72	35	3.29	28.55	41.45	15	1.12
	2 - 3	83	71	4.64	62.15	80.34	30	3.09	23.94	36.06	27	3.08
	2 - 4	15	84	8.52	67.25	100.7	57	7.08	43.12	70.88	12	2.85
	Overall	408	47	14.81	17.78	75.82	21	3.42	14.31	27.69	17	1.17
3	3 - 3	490	59	2.86	53.27	64.5	40	1.69	36.7	43.3	17	1.22
	3 - 4	49	55	2.62	50.31	60.59	39	1.91	35.26	42.74	13	2.65
	Overall	539	93	16.85	60.21	126.3	42	4.89	32.41	51.59	15	1.16
4	4 - 4	474	39	2.57	33.88	43.95	18	1.35	15.36	20.64	9	0.52
	4 - 5	23	37	2.4	32.08	41.49	18	1.31	15.43	20.57	10	1.58
	Overall	497	83	23.9	36.08	129.8	38	12	14.52	61.48	9	0.49
Overall	1709	68	1.97	63.76	71.49	35	1.44	32.18	37.82	14	0.54	

One can note in Table 12 that the overall time to dental visits for 75 % of quadrants with heavier burden of dental disease (diagnostic category 4) was estimated to be 9 days, while 75% of the healthier quadrants (category 1) got a dental visit within 33 days. The percentile 75 also shows that 75% of quadrants classified in categories 2 and 3 had to wait for a dental visit 17 (standard error 1.17) and 15 days (standard error 1.16) respectively. The median time, within which 50 % quadrants in all categories got a dental visit, was estimated at 35 days (with a 95% confidence interval from 32.18 to 37.82), while the mean time for all quadrants sampled in the survival study to get a dental visit was estimated to be 68 days (standard error 1.97). Table 12 reveals a scheduling pattern at the participating dental clinics, in which the great majority (percentile 75%) of dental quadrants undergoing dental treatment are given appointments for follow-up dental visits within one month, including healthier quadrants.

Table 13 presents the results of the workload components of the dental staff categories (dentists, dental hygienists and community health workers), whose daily work is mainly related to assisting patients. Although dental auxiliaries are also a staff category of the dental team, they were not listed because their main daily work is related to assisting dentists and dental hygienists as well as taking action on the dental office logistics.

**Table 13: Main workload components of family dental staff, published at the Ministry of Health website (Brasil, 2016a)**

Community Health Worker	Dental Hygienist	Dental Hygienist	Dentist
Group promotion activities	Group prevention activities	Curative procedures	Rehabilitative and emergency procedures
Home visit Education activity in the community or at homes Toothbrush training groups	Fluoride treatment groups	Home assistance Application of cariostatic agents Teeth scaling, cleanings and polishing (prophylaxis) Application of dental sealants	Home visit for rehabilitation; Tooth fillings; Periodontal scaling and root planning; Tooth extractions; Restoration; Pulpotomy; Frenectomy; Abscess drainage; Pulpotomy; Installation of dental prosthesis; Shaping for dental prosthesis

The workload components were obtained from the so-called “Table of Procedures” available online at the Ministry of Health website (Brasil, 2016a). All items that had job descriptions for each staff category were listed without overlapping professional competencies. For example, dentists can perform health promotion, prevention and curative activities, but only dental hygienists can perform rehabilitative procedures. Thus, for dentists’ procedures, one did not list those workload components that can be performed by dental hygienists or by community health workers.

Table 14 depicts the results derived from the facility group methodology, conducted with the participating dentists, in which participants set activity standards for primary dental services delivered by family health clinics.

**Table 14: Activity standards for primary dental services at family health clinics**

Type of staff required	Timings for procedures / activities
Dentist	1 hour per quadrant
Dental Hygienist	45 minutes per quadrant
Dental Hygienist	2 hours per group of 8 people whose the worst quadrant is of category 4
Dental Hygienist	3 hours per group of 10 people whose the worst quadrant is of category 3
Dental Hygienist	4 hours per group of 12 people whose the worst quadrant is of category 2
Community Health Worker	2 hours per group of 4 people whose all quadrants are of category 1

In setting the activity standards, the proposed timings took into account the ideal consultation timing within which dentists could lower the urgency level of a quadrant. Furthermore, the timings set for community health workers and dental hygienists took into account the ideal group activities timing within which they could perform activities and procedures aimed at keeping quadrants clinically stable in the wait for a dental visit.

The cost calculation of the working hour per staff category at the family health clinics is shown in Table 15. From the Health Department official web site (Secretaria Municipal da Saúde de Sapucaia do Sul, 2016) the salary currently paid to each dental staff category was collected. In the official calendar one found in the study year a total 1 832 working hours available at the participating clinics. This volume of hours was the result of the 229 working days at the Health Department multiplied by the eight contractual working hours per day at the participating clinics. The resulting cost of the working hour per dental staff category is show in Table 15.

**Table 15: Cost calculation of the working hour per staff category at the family health clinics**

Type of dental staff at Family Health clinics	Annual salary in the study year	Working days in the study year	Contractual working hours per day	Working hours available in the study year	Cost of the working hour
Dentist	R\$ 124 041.58	229	8	1832	R\$ 67.71
Dental Hygienist	R\$ 32 395.35	229	8	1832	R\$ 17.68
Community Health Worker	R\$ 16 588.00	229	8	1832	R\$ 9.05

With the results of the workload components (Table 13), the activity standards (Table 14) and the cost of the working hour, by dental staff category (Table 15), the next step was to simulate how much it would cost to provide comprehensive primary dental services within the times proposed by the experts (Table 9) for all the 1 894 patients classified during the study year (Table 3).

As mentioned earlier, among the 1 894 patients are those 1 217 patients who did not have any dental consultation in the study year after the first classification and also those 677 patients who had one or more dental visits after the first classification. To perform calculations, one computed in Excel spread sheets the number of days elapsed from the last classification day up to the end of the study year for each one of the 1 894 patients' quadrants. Then, an algorithm was developed to determine which stream of dental care (promotion, prevention, treatment or rehabilitation) each quadrant should be scheduled in, according to their last classification code and according to the time they were waiting for care.

Because there was no difference in the maximum times among age groups in the framework validated by the experts, the cost simulation took into account the last diagnostic code of the quadrant, regardless of date of birth of the patient.

Table 16 shows the distribution of non-urgent primary dental services among all the 7 376 patients' quadrants waiting for care at the end of the study time, by applying the wait times proposed by the experts.

**Table 16: Non-urgent dental care required by 7 376 oral quadrants according to the maximum wait times proposed by the experts**

Diagnostic category	Number of quadrants	Quadrants waiting to start dental care	Quadrants due for promotion activities	Quadrants due for prevention activities	Quadrants due for curative procedures	Quadrants due for rehabilitative procedures / dental review
1	3047	654	2130	0	0	263
2	2068	318	476	491	632	151
3	1444	21	264	265	220	674
4	817	19	0	210	0	588
Total	7376	1012	2870	966	852	1676

The resulting cost of the dental staff for delivering the required activities/procedures, based on the activity standards and on the cost per hour of each dental staff category was then calculated.

Table 17 shows the amount of resources, R\$ 104 110.88 in Brazilian currency, that the Health Department would be expected to spend on dental staff to deliver comprehensive dental care for all quadrants assessed in the study, within the wait times proposed by the experts.

**Table 17: Cost of the required dental staff for 7376 oral quadrants, taking into account maximum wait times proposed by the experts**

Dental Staff	Cost
Dentists	R\$ 89 197.60
CHWs and Dental Hygienists	R\$ 14 913.28
Total	R\$ 104 110.88

By computing calculations with algorithm adjusted for the times proposed by the experts, one found the resulting costs of Model 1.

At this stage, the second simulation round was started. Based on the great disparity found between survival experiences of quadrants from different diagnostic categories, shown earlier in Table 10, which was the projected survival at the times proposed by the experts, and taking

the resulting cost this model (Model 1), the researchers began a policy-decision simulation exercise, changing and adjusting maximum waiting times to balance the survival probabilities between diagnostic categories, for the highest possible survival rate with the Model 1 budget.

In doing so, it was important to keep in mind that the amount of resources shown in Table 17 included the payment of dentists' working hours to treat quadrants of category 4, given that in that category there was a 93.9% probability of the quadrants remaining clinically stable up to the dental visit day.

In the second simulation round, one adopted an arbitrary level of 90% survival probability for quadrants of category 4, lowering in 3.9 % the survival probability for quadrants category 4 in relation to their probability in Model 1. In doing so, the KM curve of diagnostic category 4 was analysed and it was found that with 90.0% survival probability, quadrants of category 4 could wait up to the 76 days without experiencing clinical deterioration. Therefore, the algorithm was modified, changing the maximum wait time for quadrants of category 4 from 60 days to 76 days. The resulting cost of this simulation is shown in Table 18.

**Table 18: Cost of dental staff by setting a survival target for quadrants classified in category 4**

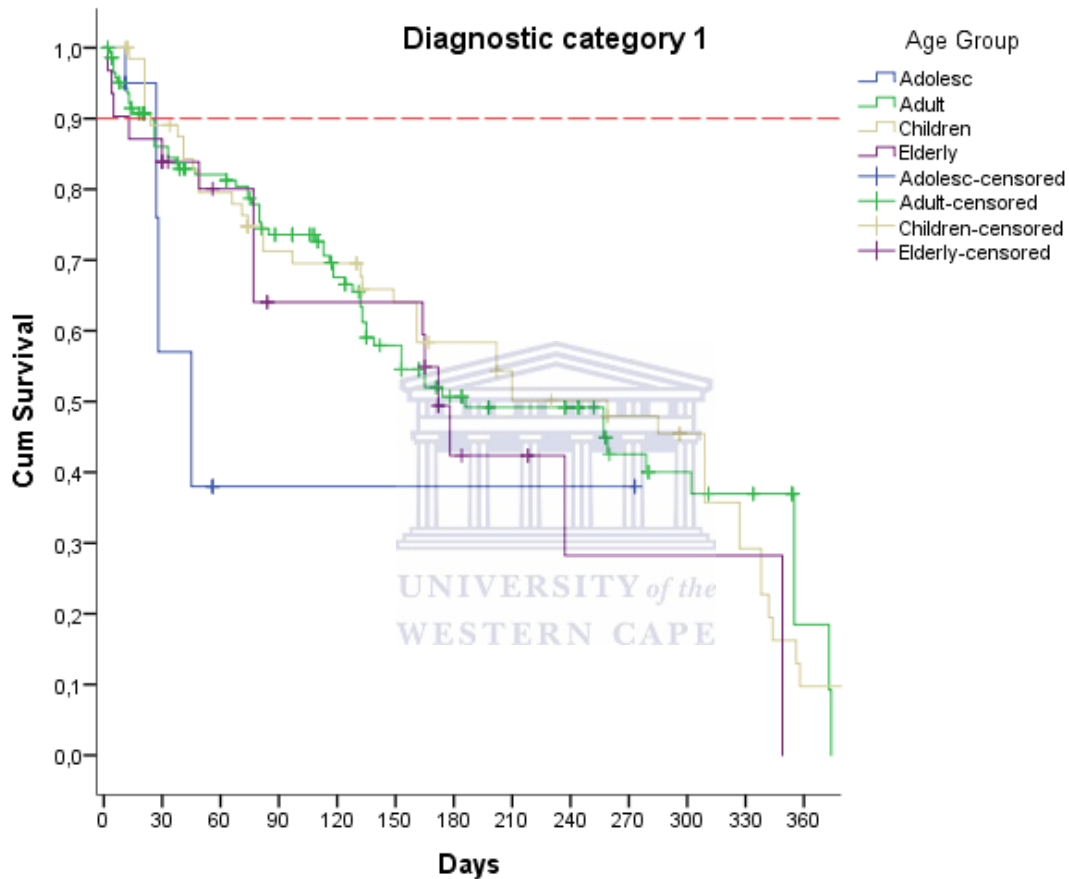
	Waiting time in days	Survival probabilities for category 4 to remain event-free	Dental Staff	Cost
Proposed by the experts	60	93.9%	Dentists	R\$ 89,197.60
			CHWs and Dental Hygienists	R\$ 14,913.28
			Total	R\$ 104 110.88
Survival target	76	90.0%	Dentists	R\$ 86 802.67
			CHWs and Dental Hygienists	R\$ 15 55.20
			Total	R\$ 101 857.87
			Difference	R\$ 2 253.01

It was determined that an amount of R\$ 2 253.01 would be saved, by lowering from 93.9% to 90.0% the probability for quadrants of category 4 that do not deteriorate in the waiting time for a dental visit.

The next simulation step was to apply that amount of saved resources by increasing as much as possible the probability for quadrants of category 1, 2 and 3 that do not deteriorate in the waiting time for a dental visit. The analysis of KM curves of categories 1, 2 and 3 found that 90.0% of 1 125 quadrants classified in category 1, 90.0% of 1 478 quadrants classified in category 2, and 90.0% of 2 324 quadrants classified in category 3 remained clinically stable. Since age groups of categories 1 and 2 had a difference statistically significant in their

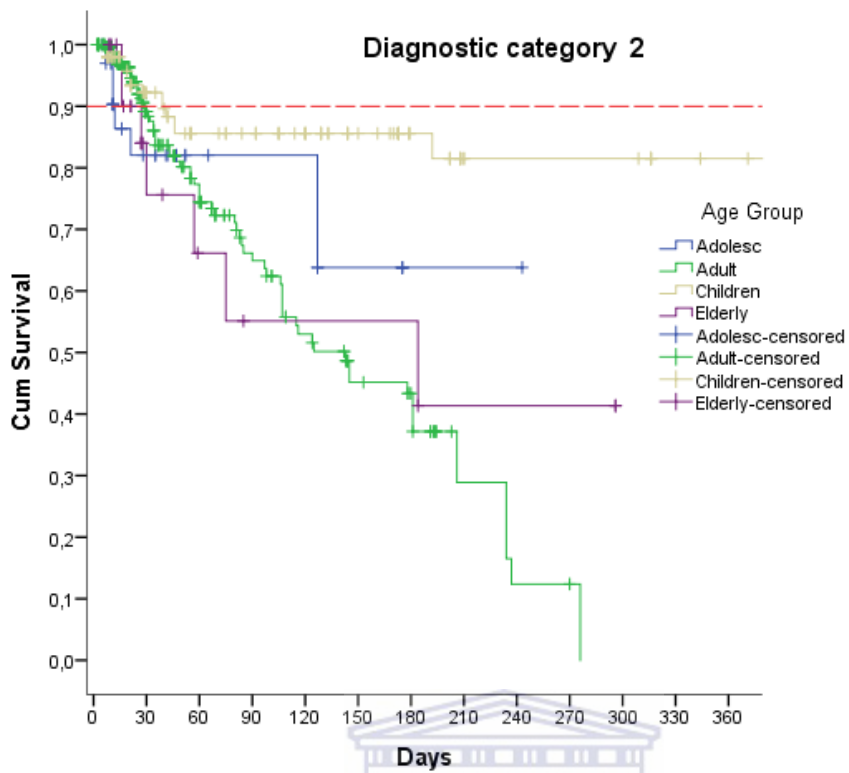
survival experience, as shown in Table 8, KM curves were created for each age group in categories 1 and 2. As there was no difference statistically significant among age groups of categories 3 and 4, there was only one KM curve for category 3 and one for category 4.

The following four Figures 5 to 8 show the maximum length of time for 90.0% probability of all quadrants to remain event-free (no clinical deterioration).

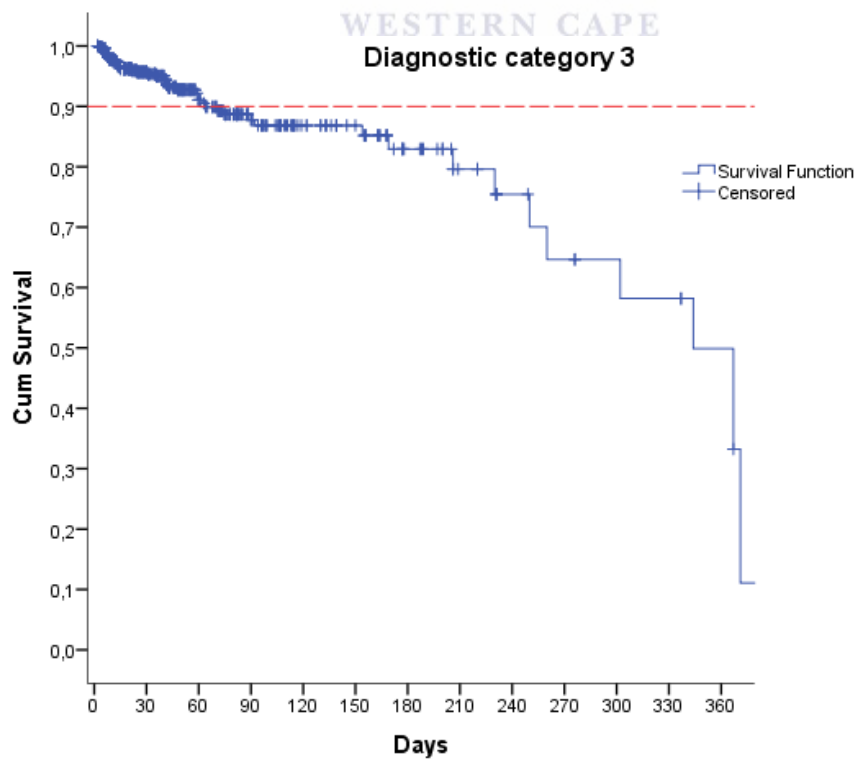


**Figure 5: KM curves by age group of category 1**

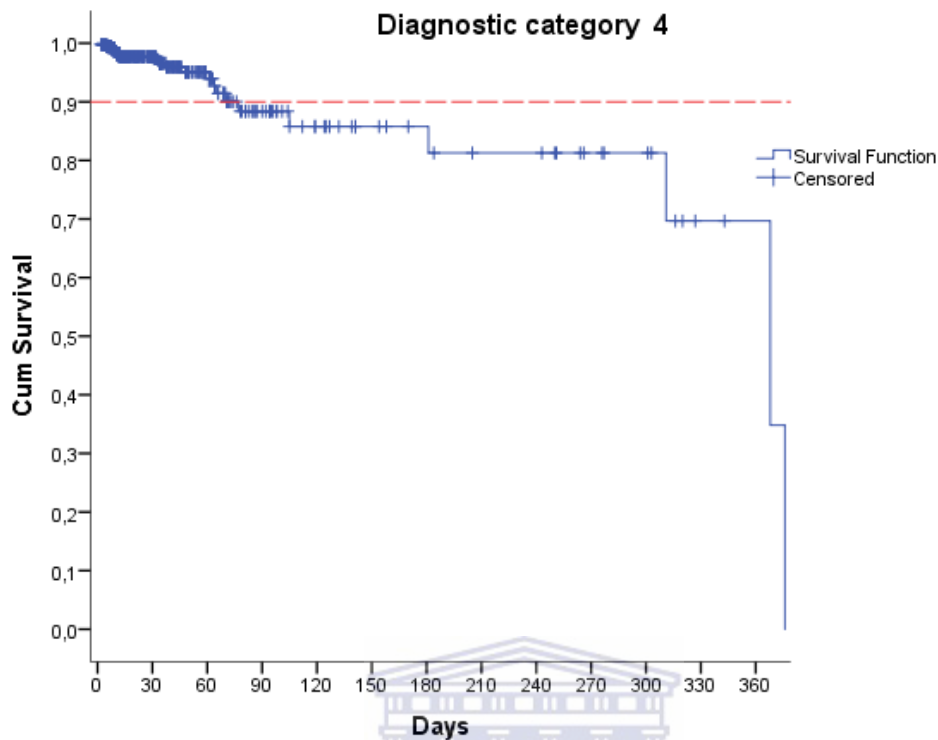




**Figure 6: KM curves by age group of category 2**



**Figure 7: KM curves by age group of category 3**



**Figure 8: KM curves by age group of category 4**



Based on the assumption that, as soon as quadrants start undergoing dental care with the dental team staff, regardless of their clinical status, they have a probability of remain free of clinical deterioration within a certain length of time, one set a 90.0% survival target and thus the respective maximum wait times were determined.

Table 19 below depicts in red, the set of maximum waiting times of Model 2. These wait times were found after various simulations trying to reach the highest possible survival probability (clinical stability) balanced for all diagnostic categories and age groups by using similar budget of by Model. The highest possible survival level was found around 90% survival probability level.

**Table 19: Dental resource allocation framework (Model 2) with maximum wait times (in red) derived from a 90% survival target**

Diagnostic category	Age Group	Promotion activities CHW				Prevention activities Dental Hygienist				Curative procedures Dental Hygienist				Rehabilitative procedures Dentist			
		Cumulative Proportion				Cumulative Proportion				Cumulative Proportion				Cumulative Proportion			
		Wait times (in days)	Surviving at the Times	Std. Error	Percent of remaining cases	Wait times (in days)	Surviving at the Times	Std. Error	Percent of remaining cases	Wait times (in days)	Surviving at the Times	Std. Error	Percent of remaining cases	Wait times (in days)	Surviving at the Times	Std. Error	Percent of remaining cases
4	All ages					2								76	0,900	0,029	11,07%
3						2				63	0,905	0,017	29,18%	180			
2	Elderly					16	0,900	0,067	78,26%	180				365			
	Adolesc					11	0,903	0,053	69,70%	180				365			
	Adult					29	0,906	0,022	49,80%	180				365			
	Children					39	0,922	0,028	70,00%	180				365			
1	Elderly	5	0,903	0,053	90,32%									365			
	Adolesc	27	0,950	0,049	65,00%									365			
	Adult	21	0,907	0,024	80,00%									365			
	Children	21	0,906	0,036	86,57%									365			

CHW\* Community Health Worker

Since quadrants from category 1 demand oral health promotion activities, the start of dental care for those quadrants must start within 5 and 27 days according to each age group, assuming that from that time until the consultation with the dentist, 90% of them will remain clinically stable. The same occurred with quadrants of category 2, which had to start prevention activities within 11 and 39, according to the age groups, in order 90.0% of them to remain free of clinical deterioration up to the dental visit. Furthermore, the maximum length of time for 90% of quadrants from category 3 to remain clinically stable was found in the 63<sup>rd</sup> day. For this reason, one arbitrarily anticipated the start of prevention activities from the 60<sup>th</sup> day (Model 1) to the second day after classification. Thus, 90.0% probability of clinical stability was also set for quadrants of category 4. The maximum wait time was set in 76 days for quadrants of category 4, in order for 90.0% of them remain clinically stable until the dental visit.

The wait times for categories 1, 2 and 3 to see the dentist were not changed. The curative procedures performed by dental hygienists for quadrants of category 2, based on the classification criteria in which quadrants of category 2 demand just preventive not curative activities in the wait for dental visit were also eliminated.

The next simulation step was to apply these waiting times, and adjust the algorithm with the respective day required by each category and age group.

The resulting number and type of dental services required after simulating 90.0% survival probability for all the 7 376 dental quadrants is shown in Table 20.

**Table 20: Non-urgent dental care required by quadrants according to the maximum wait times, derived from a 90% survival target**

Diagnostic category	Number of quadrants	Quadrants waiting to start dental care	Quadrants due for promotion activities	Quadrants due for prevention activities	Quadrants due for curative procedures	Quadrants due for rehabilitative procedures / dental review
1	3047	609	2175	0	0	263
2	2068	589	0	1328	0	151
3	1444	21	0	282	467	674
4	817	19	0	255	0	543
Total	7376	1238	2175	1865	467	1631

As can be seen, Table 20 shows the same total of 7 376 dental quadrants distributed in each category as shown in Table 16, but now these quadrants require a different level of dental care, due to the different set of wait times adopted.

The next step was to calculate the resulting cost of the dental staff for delivering the required activities/procedures, based on the same standard activities and cost per hour of each dental staff category used to simulate Model 1. Table 21 shows a total of R\$ 97 148.45, in Brazilian currency, that the Health Department would be expected to spend on dental staff to deliver comprehensive dental care for all quadrants assessed in the study, within the wait times derived from 90.0% probability of not getting worse while waiting for a dental visit.

**Table 21: Cost of the required dental staff for 7376 oral quadrants, taking into account maximum wait times derived from 90% survival probability**

Type of activity	Dental Staff	By experts	90% survival probability
		Model 1	Model 2
Rehabilitative/ dental review	Dentists	R\$ 89 197.60	R\$ 86 802.67
Promotive, preventive and curative	Dental Hygienists and CHWs	R\$ 14 913.28	R\$ 10 345.77
<b>Total</b>		<b>R\$ 104 110.88</b>	<b>R\$ 97 148.45</b>

With a similar budget, and still keeping a high survival probability for category 4, and by lowering it from 93.9% to 90.0%, it was possible to balance a 90.0% survival target for all quadrants waiting for a dental visit. However, with the decrease from 93.7% to 90.0% probability for category 4, one would expect an increase in the number of quadrants becoming urgent, i.e., turning in to category 5. Of the 817 quadrants in category 4, 32 quadrants would demand urgent consultations. Assuming the same timing per quadrant for the dentist to undertake an urgent consultation (1 hour per quadrant, according to Table 14), this would cost R\$ 2 157.44. By adding this cost of the additional urgent consultations with the total cost of Model 2 (Table 21), an amount of R\$ 99 305.89 was obtained.

In summary, it was determined that:

- Model 1 cost R\$ 104 110.88 for treating 7 376 quadrants, with imbalanced survival probabilities between diagnostic categories, ranging from 93.9 % to 12% and
- Model 2 cost R\$ 99 305.89 for treating the same 7 376 quadrants, with balanced survival probabilities of 90.0% for all diagnostic categories.

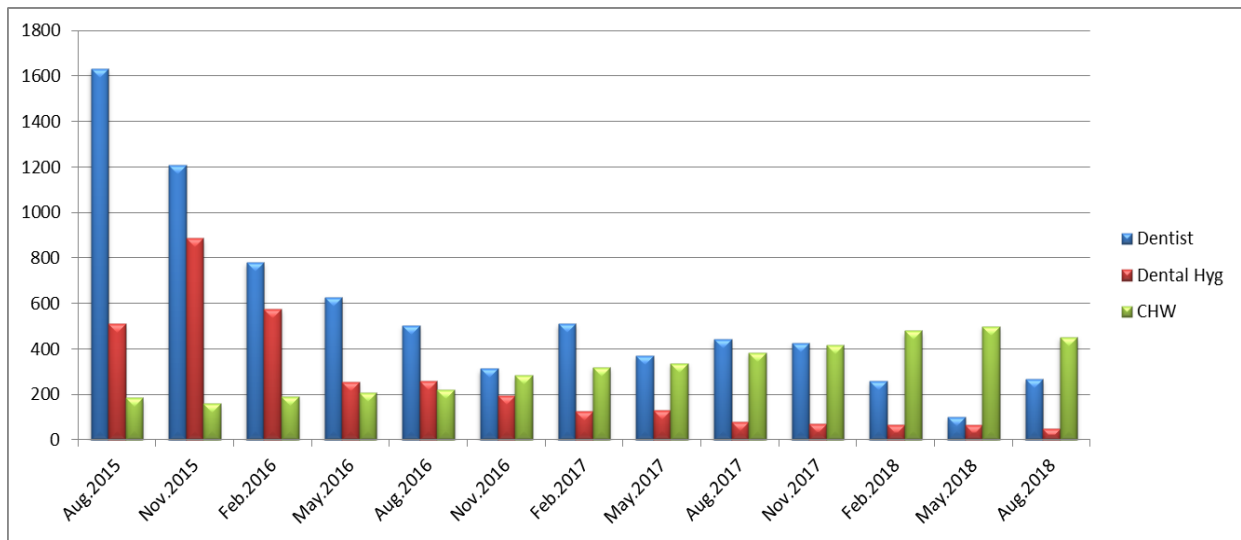
The next research step was to perform simulations projecting dental staff requirements and costs derived from the application of Model 2 criteria to guide a population oral health intervention.

As results from survival analysis showed, a total of 1 894 people were examined, classified and thus consecutively included in the sample throughout the study year (July 1<sup>st</sup>, 2014 to July 31<sup>st</sup>, 2015). For the projected simulation purposes, these 1 894 participants represented a simulated catchment population. The start of the projected simulation period occurred on the 3<sup>rd</sup> August 2015 and will last for three years until the 3<sup>rd</sup> August 2018. The projected simulation took the real clinical profile of these 1 894 participating residents existing in the database on the 3<sup>rd</sup> August 2015. The simulated intervention included all residents in the programming from the start, in order to simulate the universal access to dental care. Model 2 criteria were adopted in order to simulate an equitable distribution of comprehensive primary dental care.

Since Model 2 survival probability target reaches 90% of the catchment population, 10% of all persons' dental quadrants were randomly programmed to worsen from their previous status in the wait time for the following dental visit. For example, 10% of quadrants of category 1 got worse to category 2, quadrants of category 2 got worse to category 3 and so on.

Promotion, prevention, curative and rehabilitative activities were programmed according to the activity standards. The only change made in the activity standards for projected simulation purposes was the decrease in timings to perform rehabilitative procedures in quadrants of category 1, 2 and 3. One set 10 minutes per quadrant of category 1; one set 15 minutes per quadrant of category 2; one set 30 minutes per quadrant of category 3. The timing per quadrant of category 4 remained the same as that set by participating dentists, e.g., 1 hour.

Figure 9 below depicts the projected a three-year simulation results on dental staffing requirements.

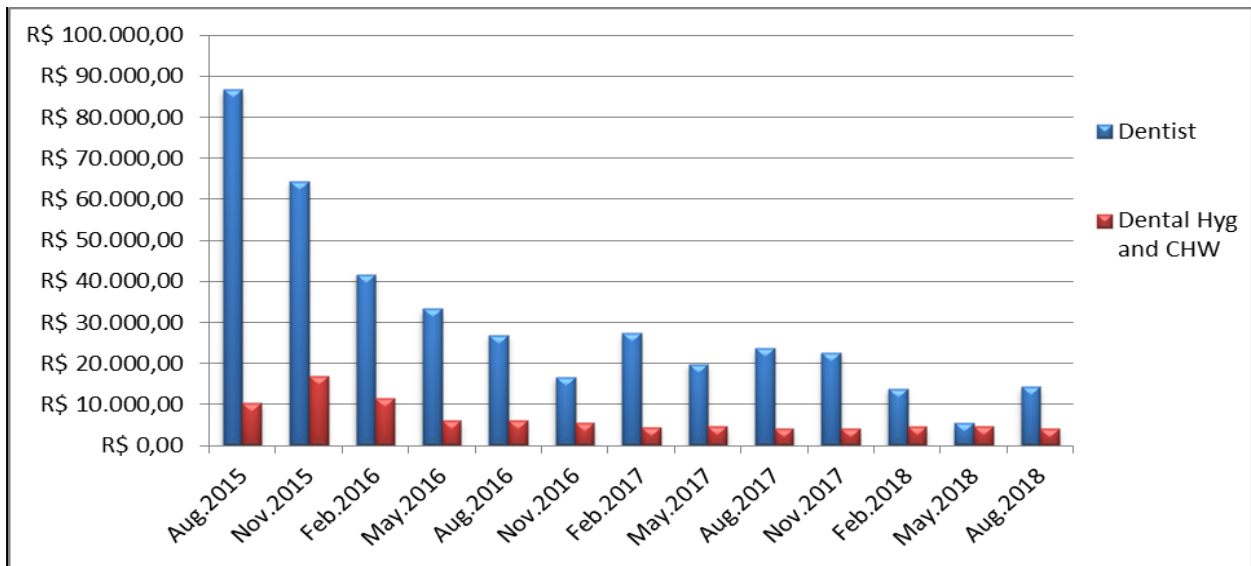


**Figure 9: A 3-year projected trend in working hour requirements applying Model 2 criteria to programming primary dental services for the simulated population (n=1,894)**

One can note that, in the short-term (first simulation year), there is an increasing demand of mid-level dental staff working hours (dental hygienist) due to the increasing demand for curative procedures. Such demand derives from those dental quadrants of category 4 which are being treated by the dentist. In the short-term, the sharp decrease in the requirement of dentists working hours occurs due to the programmed waiting time (76 days) for quadrants of category 4 to be treated by the dentists. On the other hand, in the long-term (third simulation year), the requirements of both CHW and dentist working hours reach a balanced level, insofar as the population reaches a healthier profile.

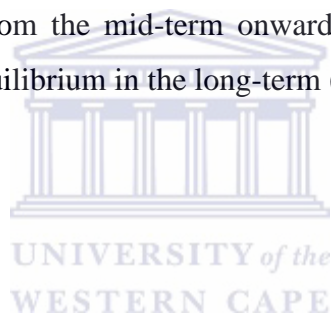
According to Model 2 criteria, dentists working hours are used for dental review performed in quadrants of category 1 and for minor rehabilitative procedures performed in quadrants of category 2. In the wait time for dental review, CHWs perform oral health promotion activities for dentally healthy persons (all quadrants in category 1). In the wait time for minor rehabilitative procedures, dental hygienists perform prevention activities for persons' oral quadrants in category 2.

Figure 10 shows the corresponding expenditure trend in simulating a 3-year oral health intervention.



**Figure 10: A 3-year projected trend in dental personnel expenditure applying Model 2 criteria to programming primary dental services for the simulated population (n=1,894)**

The total expenditure on mid-level dental staff (Dental Hygienists and Community Health Workers) reaches equilibrium from the mid-term onwards. The expenditure on high-level dental staff (Dentists) reaches equilibrium in the long-term (3<sup>rd</sup> year onwards).



## CHAPTER 6: DISCUSSION

The present study may be viewed as a focused primary dental services research since its methodology can be adapted for use by other primary health services research. The legal framework underpinning the Public Health System in Brazil is the broad context in which the present study was conceived. The conceptual thinking on which the proposed dental care model was based is the health-related legislation on equity access to universal healthcare. Despite the small scale of the study findings, the study results highlight the need for a national policy on equity allocation of primary dental care.

By using clinical status-based criteria for stratifying quadrants into risk categories for having future clinical deterioration, one could estimate future utilization of major service categories of comprehensive primary dental care, namely: promotion, prevention, cure and rehabilitation. By adopting survival analysis one could assess the validity of wait-time-based algorithms used to identify patients' quadrants at different risk levels.

For the survival analysis, it was necessary to collect primary data on the oral health status of typical users of primary health care clinics in order to find preliminary evidence on clinical, staffing and financial implications of setting wait times for dental services based on survival probabilities.

In a previous study (Nascimento, 2010), a group of expert dentists had validated a dental resource allocation framework, setting maximum waiting times for dental visits (Model 1). Model 1 was used in the present study as a base for staffing and costs simulations.

In this chapter, the limitations of the study are discussed together with the data from the empirical and the modelling phase supported the analysis of Model 1 and the simulations of Model 2. The conceptual thinking on which Model 2 was based and the implications of using it in a working health system are also discussed together with a comparison of Model 2 with other methods of estimating staff requirements.

### 6.1. Limitations of the study

The limitations are discussed under the calibration training exercises, the survival analysis study and the cost analysis.



### **6.1.1. Calibration**

The calibration exercise conducted in the present study was designed according to the guidelines of both the British Association for the Study of Community Dentistry (BASCD) (Pine *et al.*, 1997) and the Ministry of Health in Brazil (Brasil, 2001). However, one did not follow the advice of excluding from the survey those examiners who fail to maintain examiner consistency, because, in the real working scenario, no dentist is fired from the job due to diagnostic disagreements. This limitation in the design decreased the possibility of achieving higher intra and inter-rater reliability. Hence, even though examiners had been calibrated for clinical diagnosis, the issue of verification bias may have not been resolved.

Diagnostic measures used in this study derived from visual assessments rather than visual-tactile data. For this reason, data from this kind of oral health screening initiative is likely to be an underestimate when compared to those results reported by official epidemiological surveys.

Kappa statistics was chosen on account of its suitability as a statistical test for assessment of the level of agreement between examiners (Pinto, 2000). However, as this measure is influenced by disease prevalence, it cannot be used in comparative studies across different populations (Frias, Antunes and Narvai, 2004).

A further limitation is related to the source of agreements in a given diagnostic category, because each category encompasses various clinical sub-items and it was not in the purview of this study to collect such detailed information.

### **6.1.2. Survival Analysis study**

Although the survival analysis results are plausible, they should nevertheless be interpreted with caution due to the small size of the study population. This may have decreased generalizability of results for further primary health care settings. For instance, no facility-level factors were included in this analysis. By design, generalizability of results was limited to the municipal level. The adoption of Kaplan-Meier method was suitable for analysing survival probabilities, because no previous assumption about the functional distribution of hazard rate with time was made. However, since one has not made any assumption about hazard rate, it was not possible to extrapolate survival probabilities beyond the study time.

In the present study, the results of a first-hand usage of the proposed diagnostic classification tool in the real working scenario were documented. Hence, the diagnostic classification results preclude comparisons with other findings in this regard. Furthermore, the degree of reliability of the diagnostic classifications should have been improved by repeating the calibration trainings during the study year, in order to increase validity of the survival results. However, this was not possible due to time and resource constraints.

An important limitation in the survival estimates is due to the small percentage of remaining cases in the later stages as the study progressed. According to Rich *et al.* (2010), and Pocock *et al.* (2002), when just few cases remain, survival estimates are not as accurate, and survivor functions at the right of Kaplan-Meier curves must be interpreted with caution. Thus, the more dental quadrants were censored throughout the study time, the less reliable the survival curves become before the end of the follow up. Furthermore, according to these authors, if there are a high percentage of censored observations, one must question how the study was carried out. In fact, since data collecting process of the present study occurred in a real working scenario, where patients were scheduled for treatment within a short period of time, the occurrence of great percentage of censored observations was inevitable.

### **6.1.3. Cost analysis**

The sampling for calculating the costs of Model 1 and Model 2 created a threat to internal validity, because standard activities were set just by the participating dentists, and did not include opinions of dental hygienists and community health workers. Although the participating dentists were deemed to be “experts” in primary dental care practice and have considered a wide range of factors in determining timings to carry out procedures and activities, the lack of a more comprehensive investigation to establish activity standards is a limitation of this research. In view of this limitation, staffing costs findings derived from these activity standards cannot be generalized to other primary care settings. However, the methodology employed to perform cost-analysis is suitable for any family dental care teams in Brazil.

## **6.2. Survival Analysis study phase**

### **6.2.1. Diagnostic classifications**

Dentists play a major role on the identification of individuals and population oral health

status, as their primary responsibility is oral health diagnosis. Variability between dentists' diagnoses and treatment choices has been widely documented in the literature (Bader and Shugars, 1995; Bader and Shugars, 1997; Lewis *et al.*, 1996; Shugars and Bader, 1996). The level of diagnostic variability is actually a problematic issue when it contributes to making patterns of access to dental services less equitable and influences dental services outcomes negatively (Baelum, Heidmann and Nyvad, 2006). Whether access to primary dental care services is based on clinical assessments, dentists must keep a good level of intra- and inter-examiner agreement in order to assure equity of access within and between catchment areas. Furthermore, there has been a growing debate regarding over diagnosis, since it tends to generate not only over treatment but also over preventive measures. Over-diagnosis has been found as a more common practice than previously thought, leading to enormous financial implications for public health (Bulliard and Chiolero, 2015). In the present study, special attention was given to the calibration of the participating dentists. The training sessions provided dentists with the opportunity to debate their own diagnostic practices. During the trainings, they realized that over-diagnosis was a counter-intuitive decision that is usually imperceptible to them in their daily work.

The accuracy of a diagnostic classification method is determined by the accuracy of the classification itself. If the level of agreement is poor, the results will be inaccurate, either due to over- or under-estimating results. In the present study, the difficulty in achieving higher level of examiner agreements even after various calibration trainings may be deemed as a disadvantage in applying the proposed diagnostic classification tool to estimate survival probabilities. The diagnostic classification tool was developed for routine use at primary dental care clinics. Hence, for a long-term application involving a large number of primary dental care dentists, it is crucial that calibration training becomes part of the activities of the dental professional.

### **6.2.2. *Time-to-oral health deterioration***

Logistics of the survival study involved the development of on-line forms and database. As they are generic in nature, they can be adapted to the public health information system for use by any primary dental care team in Brazil. Further, the methodology for collecting diagnostic classifications is suitable for similar primary dental care services in the country and abroad.

The results of the survival analysis phase provided information for the relevant municipal authorities on potential inequities of access between individuals treated at the participating clinics. Due to the scheduling of patients pattern, results showed that at any point in time during the study year, oral quadrants presenting higher burden of dental disease (categories 3 and 4) had a lower probability of getting worse than more healthy quadrants (categories 1 and 2).

Overall, patients undergoing dental treatment at the participating clinics were given appointments for several dental visits regardless of their clinical conditions. This demonstrated that appointments did not take into account risk-based criteria for dental appointments. Furthermore, the existing scheduling pattern overloaded dentists' schedules with a large number of activities and procedures being performed on the same few patients. On the other hand, the majority of people living in the catchment areas had no access to dental care. According to the Family Health Strategy guidelines (Brasil, 2004), a catchment area of a Family Health clinic should encompass from two to four thousand residents. Therefore, it is expected that the five participating clinics cover between 10 000 to 16 000 people. Taking in consideration the study sampling, in which patients were selected consecutively, one expected that sample size would achieve nearly all people assigned to the participating clinics, given the assumption that the participating dental teams actually follow the Family Health programme guidelines, namely: (i) people covered by Family Health clinic dental services should be assessed by their family dentists at least once a year; (ii) family health teams should perform health care pro-actively in relation to the catchment population health needs. Considering that a total of 15 000 people live in the five catchment areas, the present study showed that, in the study year, less than 5% of the catchment population were covered by dental services.

Currently, a national programme in Brazil, the so-called PMAQ is in place with the aim of improving access and quality of primary health across the country. PMAQ adopted an indicator to monitor population covered by family dental teams. Such an indicator uses the 40-contracted dentists hours per week (full-time equivalent) per three thousand residents in a given area and time. The limitation of using this indicator is that it is not able to show how many people are actually undergoing primary dental care.

The assumption for the proposed classification tool is that diagnostic categories are proxies of long-term oral health outcomes. In this way, by using this classification tool at every dental visit, family dentists and health managers could obtain a comparable timeline of the clinical status at both individual and population levels. That would help to more accurately set performance target timeframes for achieving clinical targets. Besides that, a timeline for primary dental care would assist primary care dentists in managing and coordination dental care within their catchment areas. At a patient level, diagnostic classification records may contribute to a lifelong patient management and ensure that each patient is streamlined in the appropriate course of primary dental care. At a macro-level, diagnostic classification records may enable the dentist to understand the need for primary dental care of the whole catchment population and thus allocate dental services more equitably. Additionally, routine classification data, collected at local clinics in health districts, for example, can be combined to produce a broad picture on the dental staffing requirements in a city. Such aggregations can be powerful tools to ensure equity allocation of dental staff in a given area as long as dentists are classifying consistently. Moreover, since diagnostic classifications are dynamic in nature, they can show current imbalances between dental staff categories in a health facility, e.g. a shortage of dental hygienist and a surplus of dentists. Where such a kind of imbalance exists, dentists may be forced to undertake some activities that can, for example, be performed by dental hygienists. That shift of activity leads to an uneconomic use of dentists, thereby making the primary dental care system more expensive.

Since the coverage of primary dental care in Brazil has been expanded mainly by dentists' work (Brasil, 2016), these professionals have to undertake activities and procedures that could be performed by dental hygienists. Moreover, dental education activities and tooth brushing trainings at schools, for example, which can be performed by community health workers have largely been performed by dentists. By June, 2016, less than 10% of all dental teams working in the Family Health programme across the country have a dental hygienist as part of the team (Brasil, 2016). Such kind of dental workforce profile increases dental personnel expenditure of the Family Health programme, since a more qualified and expensive professional has been paid for undertaking less complex dental procedures and activities.

### **6.3. Modelling phase**

#### ***6.3.1. Survival probabilities at the times recommended by the experts.***

Previous studies have shown a marked variation in the criteria for access to public dental care existing across Australian jurisdictions, leading to inequitable access to these services (Davidson *et al.*, 2007). In order to tackle inequities of access to public dental care, the Departments of Health of Queensland and New South Wales in Australia instituted a waiting list triage system. The current triage system was developed in consultation with a number of senior public sector dentists in Queensland and New South Wales who established maximum waiting times for public dental services, according to clinical urgency (Queensland Health, 2015). The Queensland Health Department guidelines provide recommendations on the management of different waiting lists (e.g. General wait list, Priority wait list, Recall wait list, Referral wait list and General Anaesthetic wait list) in which eligible patients are allocated after administrative or clinical assessments. In order to ensure consistency across services, clinical assessments have been generally restricted to the experienced staff which had undergone basic training. However, no information was found on the level of agreement between Australian dentists. The waiting list triage system is indeed a relevant initiative to foster equity access to public dental services in Australia. However, the scientific evidence of the set of waiting times adopted in Queensland and in New South Wales is limited to face validity, since they rely on expert opinions. No publications were found on studies being conducted in Australia with the aim to raise further evidence on the validity of the adopted wait times.

The Municipal Health Department of Porto Alegre in Brazil also published a comprehensive guideline for primary dental services in which a set of waiting times for access to primary dental services was included (Secretaria Municipal de Saúde de Porto Alegre, 2014). In Porto Alegre, the waiting times were established by a group of public health dentists. The same as in Queensland, the validity level of wait times proposed in Porto Alegre is limited to face validity. Furthermore, the guideline of Porto Alegre provides no information about the need of calibration of dentists in order to ensure consistency across primary dental care services. The results of the present study showed that if dentists' diagnosis is to be used to guide access to primary dental care, calibration training must become an on-going activity at the primary dental care level and further evidence on the validity of wait times determined by experts is needed.



### ***6.3.2. Dental workload components and dental activity standards***

In setting activity standards for rehabilitative procedures, the group of dentists determined the average time that a dentist takes to lower the urgency level of a quadrant. However, the group of participating dentists determined equal timing, i.e., one hour, for dentists to treat any type of quadrant, regardless of its classification category. If one considers that an hour is enough to lower quadrants' classification from category 4 to category 3, for example, one can assume that the same timing would be more than enough to lower classification from category 2 to 1, since quadrants of category 2 required less complex rehabilitative procedures than those required by quadrants of category 4. Therefore, the total dentist working hours required to perform rehabilitative procedures may have overestimated the actual time taken by dentists to perform less complex rehabilitative procedures.

Although dental practices may differ greatly between countries and dental staff categories may have different titles, such as dental hygienists, dental therapists, etc., they might be performing very similar functions. In Brazil, there is just one mid-level dental staff whose job description includes dental procedures to be performed at individual basis. Dental auxiliaries are also part of the Family dental care teams. Dental assistants were not included in the present study, because the study methodology took into account staff categories whose main tasks were directly related to treating patients. Job descriptions establish that dental assistant's main tasks are related to dental office logistics and to assisting dentists and dental hygienists in their clinical procedures.

The parameters of activity standards, workload components, and cost of dental staff working hour used in this study can be adapted to different primary care settings in Brazil. However, they must be tested in a further experimental research setting to verify how useful and realistic they are, and how much of these standards are really doable. By consulting a larger group and more representative group of experts, a national activity standards parameter could be agreed upon. This would help to identify staffing inequities between local clinics across the country and to determine what specific managerial actions must be taken in order to balance workload pressure between primary dental teams working in different provinces.

### ***6.3.3. Setting survival targets***

The modelling phase produced many outputs, but the most relevant output parameter was the set of wait times that emerged from the 90% survival target. The theoretical decision-making

exercise conducted by the researchers in the present study produced a starting point for further research on the use of survival analysis studies for the establishment of evidence-based wait time benchmarks.

Studies on wait times usually analyse waiting lists in order to better manage them or to reduce them. A number of international comparisons of waiting times have required considerable analysis (Viberg *et al.*, 2013). Waiting times have been measured in different countries as mean, median, 90<sup>th</sup> percentile, 95th percentile, number of patients waiting, number of patients waiting per inhabitant, and number of patients waiting within a certain time interval (Viberg *et al.*, 2013; Queensland Health, 2016). The majority of the 23 countries studied by Viberg *et al.* (2013) provide their citizens with some type of national waiting time care guarantee. However, such studies did not mention the level of survival probabilities that derive from such wait time guarantees. There has been a lack of evidence on the expected increase of survival probabilities after improvements on wait lists management are made.

In the present study, a 90% survival probability was set for all diagnostic categories, and it was still expected that a certain number of quadrants would deteriorate. That included a predicted number of urgencies which result from deterioration of quadrants in category 4. Currently, family health clinics have adopted a common urgent patient scheduling technique that involves keeping a pre-established block of time available each day for patients who call that day for an urgent dental appointment. While it allows patients with an urgent dental problem to see the dentist in the same day, it potentially makes the wait time for non-urgent problems longer as there remain fewer dental appointment times for non-urgent cases. Furthermore, fixed blocks of times for dental prevention activities as well as for dental curative and rehabilitative procedures have also been suggested by the National Oral Health Policy (Brasil, 2014a) The model proposed in the present study makes it possible to set a more rational scheduling scheme for both urgent and non-urgent dental consultations, as one can predict the amount of future urgent and non-urgent consultations by estimating survival probabilities and setting survival targets.

#### **6.4. Models of access to health services**

Some studies in Brazil have analysed various family health care models, comparing them in a variety of ways of access to services and coming to different conclusions (Rocha and Goes, 2008; Sanches Marin, Dutra Moracvick, and Marchioli, 2014; Vidigal, 2015; Nascimento,



2016). However, thus far there is no conclusive evidence that any one particular model is better than others in providing timely access to primary health care, particularly access to dental care. Most local clinics have adopted different types of dental risk assessment for prioritizing patients. However, patients are appointed according to the availability of dental services and not necessarily according to dental needs. Moreover, a priority access to treatment is usually given to those patients who are already being treated. Such scheduling scheme, the so-called “Completed Treatment” has been used for many years in Brazil (Brasil, 2016b). It suggests that primary care dentists must complete dental treatment of a patient before starting dental treatment of another resident of the catchment area. The ratio between the number of patients starting and those completing dental treatment has been used by the Ministry of Health as a service performance indicator (Brasil, 2016b). However, the key limitation of this indicator is that performance is based just on the patients who actually got access to treatment. Under the assumption of universal access to dental care, a performance indicator should include those patients who are still waiting to start dental treatment. For this reason, the three-year prospective simulation of Model 2 took from the start (August 2015) the dental care programming of the entire simulated catchment population.

The WISN method has been considered a powerful tool for estimating health workforce (McQuide, Kolehmainen-Aitken and Forster, 2013; Namaganda, 2015; Mollahaliloğlu *et al.*, 2015; Bonfim *et al.*, 2016). The WISN method suggests that the standard workload should represent the amount of work and timing in delivering services which can be accomplished by a “competent and motivated” health staff member working to acceptable professional standards (Shipp, 1998). The source of data used by WISN method to represent demand for health services is the annual services workload statistics. This means that WISN calculates retrospectively, as it bases the staffing requirements in the past year workloads. According to WISN methodology, a percentage level can be applied to the results to correct for possible annual trends in the services’ workload (Shipp, 1998).

The source of data on service workload is the key difference between WISN method and the model proposed in the present study (Model 2). In the WISN method, workload statistics are based on the supply situation that is: the volume of service being delivered. Thus, WISN can reflect the staffing requirements when there is a shortage and also when there is an increase in supplies, thereby calculating the staff requirements in the both situations. However, by using just service workload figures, WISN calculations demonstrates just the levels of workload

pressure and staffing inequities that may arise within a given supply and budgeting context. In Model 2, on the other hand, workload calculations are based on the demand-side. It calculates prospectively the staffing requirements that are necessary to meet the health needs in given length of time. Since such elapsed time determines survival probabilities for people living in the catchment area, the adoption of Model 2 may allow for a genuine popular pressure for improvements in dental staffing levels.

### **6.5. Implications of the Model 2 for a working health system**

A major implication of using the proposed allocation framework (Model 2) in a working health system is the need to adopt waiting times benchmarks that are based on survival probability targets. However, the use of survival analysis studies for the establishment of wait times for primary dental care is not a tradition in health systems research. To improve the catchment population flow through a comprehensive and life-long primary dental care involves the use of scheduling management techniques that must be necessarily based on wait times benchmarks. The diagnostic classification categories suggested in this study place an emphasis on predicting clinical deterioration with a sufficient lead time, before actual deterioration, to allow a preventive dental care action to be scheduled. Therefore, health managers can have up-to-dated information on the predicted amount of dental demands that should be met within a certain time. Hence, whether the predicted demand is not in balance with a future dental staff supply it will not be possible to offer patients an appointment within the appropriate length of time until the number and type of dental staff be adjusted.

The simulations performed in the present study demonstrated in practical terms how an equitable allocation of primary dental resources can be programmed to achieve the whole catchment population. When local health authorities propose strategies aiming at reducing wait times for primary dental services, the most commonly regarded solution to the problem is to increase the number of dentists in that area. However, the study results indicated that access can be largely increased when mid-level dental staff undertakes promotion, prevention activities and curative procedures. Furthermore, in the present study, it was demonstrated that while waiting times be adjusted to meet survival targets, it does not necessarily reduce wait times. Moreover, while a number of co-morbidities that present to primary care dentists may influence the level of dental urgency, the need to provide patients with timelier access to primary dental care should not be deferred just because better evidence is still missing.

A starting point is to agree on what will be measured in primary dental care and on how to discriminate the streams of comprehensive primary dental care.

Another implication of applying Model 2 in the allocation of primary dental care is that, by projecting clinical status of the catchment population, decreasing number of dentists working hours would be needed for rehabilitative procedures and increasing number of dentists working hours would be used for dental review, diagnosis, supervision and coordination of individual and population dental care.

Despite being a small scale simulation, the three-year projection showed the financial implication of applying Model 2. It revealed that a significant volume of resources (dentists working hours) would be necessary in the first stages of the model implementation, because of the relatively short waiting time for treating quadrants with high burden of disease. On the other hand, in medium term, a sharp decrease in the primary dental care expenditure is expected, before a balanced situation is achieved. Whether the set of wait times are adjusted to new survival probabilities, this trend will remain in a larger of shorter period of time.

In the present study, the potential issues that may drive changes in the family dental workforce profile were addressed. Currently, the Ministry of Health in Brazil provides financial incentives for two types of primary dental teams, with no other composition option. The first option is a dental team consisting of one dentist (and dental assistant) and the second is a team consisting of one dentist and one dental hygienist (and dental assistant). In the study simulations, the one-year prospective dental care programming showed an increasing need of working hours of dental hygienists in proportion to the need of dentists' working hours. This trend impacts on the family dental care teams' costs and therefore this may require changes in the current financing scheme adopted by the Ministry of Health. The prospective simulation results indicated the need for an adequate permanent dental staff profile to work on the oral health status of the population served, allowing for a flexible dental team composition, in which, for example, several dental hygienists could work under supervision of one dentist. From mid- to long-term of the implementation of Model 2, the projected growth of a dentally healthy population within the catchment area would require more and more skilled community health workers for health promotion activities until a balance is achieved. As mentioned earlier, Model 2 is based on the assumption that 90% of patients' dental quadrants do not experience any deterioration in oral health while waiting for the next dental consultation.

## CHAPTER 7: CONCLUSIONS and RECOMMENDATIONS

This final chapter summarises the main conclusions and achievements of this research, highlights academic contributions of the thesis, recommending some directions for practice, policy and research.

### 7.1. Main conclusions

The present study was innovative and broke new ground in dental resource allocation research in Brazil by proposing survival analysis for setting primary dental staffing levels. While there are several models for primary dental care delivery operating in the Family Health Programme in Brazil, none of them establishes waiting time benchmarks for dental services based on survival probability targets.

For the first time, a research methodology applied survival analysis to a longitudinal data of patients assigned to family health clinics to identify maximum wait times for primary dental services. This study created an easy-to-apply data collection on-line scheme with the ability to measure and track oral quadrants wait times along the continuum of the patient's dental care at local clinics. The use of survival analysis enabled researchers to simulate survival targets in order to calculate the costs of the required dental services. By conducting a 3-year simulation, the dental resource allocation framework (Model 2) was assessed on its ability to deliver timely dental service for a catchment population as it progress through different clinical conditions.

Considering the novelty of the proposed resource allocation framework, and the information it produces, now one needs to implement the method in an experimental primary care setting to demonstrate how the method works in the real life and its value for achieving more equitable access to dental services.

The framework aimed to bring about improvements in local clinics service delivery by allocating the right dental staff category at the right time. The findings of the present study, not only provides new evidence but also raises awareness among dental profession, fosters discussion on “acceptable wait times” and contributes towards developing wait time benchmarks that will ultimately enhance equity access to primary dental care.

The present study methodology has contributed to the development of empirical research on waiting times for primary dental services in Brazil, and found preliminary evidence of wait time benchmarks that can be adopted in experimental primary health care settings. The present study has shown how survival analyses can be used to generate rigorous evidence to inform policy development in the area of dental health workforce planning. Additionally, one simulated the application of Model 2 which broadly established the way primary dental services may be delivered. Furthermore, it has outlined appropriate and timely dental services for each person's dental quadrants as they progressed through clinical conditions in the course of three years.

In the present study, one had to be realistic about the limitations the data collected in the real working circumstances imposed on the analysis. For the survival analysis, researchers observed time-to-event data under the current working routine, without making any interference in the scheduling scheme in place at the local clinics, since the present research was not experimental. However, it is imperative that Model 2 be further assessed for validity, in a real-life experimental setting, in order to draw further conclusions based on more accurate results.

Given the current structure of the Family Health clinics, the model for data collection itself was quite easy and inexpensive to apply. The calibration training was performed in the real settings where dentists work. That raised a number of issues for future research concerning model implementation, acceptability by its end-users (dentists) and by dental service-users. The design of the model being assessed in the present study took into account technical and legislative factors involved in public dental care as well as the scope of practice of the dental health professionals who are expected to implement the model. The results showed that what could be done to improve primary care dentists' ability to gradually take on additional patients, would be to improve patients flow with more efficient dental scheduling procedures. Importantly, the wait time benchmarks used to simulate interventions did not take into account possible constraints on the public system's capacity to achieve these benchmarks.

The dental resource allocation assessed in this study (Model 2) could be misinterpreted as being another dental scheduling system. Moreover, it is not about re-allocating dental resources from one type of patient to another, to the detriment of the former. It is in fact a pioneer approach to a cost-effective management of primary dental care delivery, based on the Brazilian public health principles of fairness, equality and social justice.

The fundamental question underpinning this research was “how to programme equitable access to comprehensive primary care services for all people living in the local clinic catchment area”. To answer this question, the present study conducted a survival analysis and developed a resource allocation model to address demand of primary dental care. The first part of the research (empirical phase) was carried out in order to describe survival estimates of persons’ dental quadrants waiting for dental visit, and obtain inputs for the second part of the research, the modelling phase.

While there is no definitive conclusion on the best models for access primary dental care, the present study provides other investigators with a range of innovative approaches to primary dental service research. Given the research expertise derived from this research process, the principal investigator is now in a unique position to use her knowledge to contribute to future research on wait times for primary dental care.

The model proposed in the present study can be easily modified to suit other primary dental care settings in Brazil and even in other countries whose primary health care system is similar to Brazil. Moreover, the resource allocation framework described is easy to comprehend. Most importantly, by conducting simulation, the present study was able to identify the future dental workforce profile that can meet varying demand for primary dental services.

In developing the dental resource allocation framework, there was no intention of proposing something conceptually new for the Family Health programme, but rather to offer practical suggestions for the programming primary dental care. For example, the proposed model enhances dental staff accountability in the implementation of promotion and preventive actions, making auditable their outcomes within the catchment area.

From the survival study results one concluded that the maximum wait times for dental visits set by the experts may engender inequitable survival probabilities between individuals. From the perspective of equity of access to primary dental services and costs of dental staff, one concluded that, it was possible for the Model 2 to distribute a balanced-high probability level of survival for all individuals sampled, without exceeding the budget used by Model 1.

From, the overall results of the 3-year simulated intervention, it was concluded that the dental staff profile should be flexible enough to meet dental health needs of the catchment populations and to allow equity allocation of primary dental services with rational use of resources.



## 7.2. Recommendations

The following recommendations seek to inform primary dental care decision makers from the local level at the Municipal Health Department of Sapucaia do Sul and also from the national level at the Ministry of Health, on dental practice, dental research and oral health policy, based on the results of the present study.

The results of the present study will be disseminated and discussed with the various stakeholders of Municipal Health Department of Sapucaia do Sul at the associated department head office level. Furthermore, the findings will be shared with community health advocacy groups of the participating areas and will be used by Health Departments of Sapucaia do Sul and of other municipalities for further research on the validation process of the dental resource allocation framework (Model 2). This would allow further improvements in the model and would demonstrate the institution's commitment to tackling inequities of access to primary dental care.

### 7.2.1. Primary dental care practice

As the Family Health Programme model evolves, intra-dental team collaboration in dental care delivery should be stimulated. Strategies aimed at increasing dental practice capacity should be developed and tested.

The vital role of dentists for communities requiring access to primary dental services extends beyond dental profession to include dental care provided by the dental hygienists, dental assistants as well as the community health workers. The importance of all these health workers' competencies in the delivery of comprehensive primary dental care within primary dental care settings should not be neglected, otherwise, one would fail to acknowledge the full waiting times that communities might experience. For this reason, it is recommended that the adoption of the proposed model should not impose barriers to the full use of the dental team's skill-mix in the provision of comprehensive primary dental care. Moreover, a further exploration of the potential of dental hygienists and community health workers in the provision of primary dental services would go towards achieving the goal of expanding equitable access to primary dental services.

The resource allocation framework (Model 2) does not aim to be a static formula, by which the extremely complex process of delivering timely dental services should be dealt with. In fact, Model 2 may serve as a more formal framework for commissioning primary dental care delivery in a more holistic approach.

The proposed diagnostic classification tool, in contrast to protocols for resource-intensive and detailed visual-tactile oral examinations, with multiple data fields, intends to be a simpler and less costly instrument for routine assessment of the burden of dental disease. Moreover, it is expected that non-dental decision makers and laypersons can easily understand the diagnostic classifications results. Because disease prevalence is highly influenced by the kind of instrument adopted (Stevens and Gillam, 1998), the proposed diagnostic tool be further tested against findings of comprehensive visual-tactile oral examinations in order to determine validity of its results. Additional breakdown into sub diagnostic categories should be made in the tool and tested for its ability to streamline access to specific dental interventions.

It is important not to ignore the role of diagnostic classifications in striving for equity of access to primary dental services, as there has been an increasing recognition on the accountability of health professionals for the allocation of health resources (Pitt *et al.*, 2003). This is both an ethical and a legal issue to be addressed in Brazil, where the legislation in place imposes to the public health system the accountability for the provision of health services (Brasil, 1988). A current example of such recognition is the call released by the Supreme Court of Brazil for a nationwide debate among health professionals and authorities towards consensus about the responsibility of the public health system in providing or not whatever prescribed diagnostic procedure or health treatment (Supremo Tribunal Federal, 2009).

The findings from the present study can assist with the creation of training programmes for the Family Health Programme personnel, with a focus on competencies and not on professions and could particularly enhance the community health workers' skills in oral health promotion. Furthermore, research could address the respective roles of the Family Health doctors and nurses in providing dental care, particularly among children.

It is also recommended that further studies be carried out to investigate dentists' attitudes, cultural, and methodological aspects of their diagnostic practice and how such practices influences access to dental needs at the primary health care level. In addition, dentists must



be trained to improve consistence of diagnostic classifications because it is envisaged that high level of reliability between dentists allow that similar dental needs have equal chance of accessing dental services.

As dentists are end-users of the diagnostic classification tool, one recommends that they be surveyed regarding specific usability attributes of such tool. High level of usability may encourage dentists to adopt the tool in their daily practice.

The simulated intervention showed that timely patient access to dental care would require enhanced management practice efficiency. For this reason, primary care dentists must be trained on how to run a comprehensive primary dental care from a population flow perspective as well as a financial one. To address this, management training should be provided during under-graduation. Furthermore, dental education programmes should be institutionalized by the health departments from local to national level.

### ***7.2.2. Primary dental services research***

It is recommended that the Ministry of Health addresses primary dental services research associated with wait time benchmarks. This would fall into the following areas:

- Research on further development and improvement of primary care diagnostic tools and methods.
- Health system research that investigates the impact of wait time benchmarks for the oral health outcomes in primary care settings.

A number of studies have identified differences in self-perceived dental treatment needs when compared to needs professionally assessed. Such differences may have huge financial implications for the public health system (Locker and Miller, 1994). Further research to elicit local community's views may help clarify their perception regarding diagnostic classifications and the subsequent streams of dental care. In addition, research on benchmarks for primary dental services should not only tell us that a defined dental treatment cannot be delayed but should also address the appropriateness of those treatments. Moreover, results on evidence-based wait time benchmarks for dental services may serve as accepted standards in litigations and could guide the establishment of targets set by Family Health team as performance goals.

Before one can state with certainty that access to primary care will be improved through the adoption of Model 2 criteria, a longitudinal study should be conducted, preferably collecting data for 3-year period or more. The advantage in conducting this type of population research is that a number of family health care facilities in Brazil are already equipped with the essential structure required for this kind of long-term field research, (e.g., computers connected to the internet).

Further research is needed to address co-morbidities which may influence the differentiation of levels of urgency thereby influencing decisions about the best course of primary dental treatment. However, because the best evidence is not yet available, the need to provide individuals with timelier access to primary dental care should not be delayed by the health authorities.

### ***7.2.3. Primary dental care policy***

From a policy perspective, the present study raised preliminary evidence on the need for a dental workforce reform in Brazil to address inequities of access to primary dental care services. The researchers' interest in equity in access and utilization of primary dental services was guided by the concern for equity in oral health, assuming that improved health care services contribute to better health (Starfield, 2007).

Since tackling inequalities is one of the main aims of all public health policies, the results of the modelling phase of the present study can be used to inform the relevant health authorities regarding potential inequities of access to primary dental services and how could survival analysis studies could help to guide equity allocation of dental staff. The framework under investigation may assist the Ministry of Health to plan ahead for adequate provision of public dental services and the Ministry of Education for the intake of students at both graduate and non-graduate levels. Additionally, the proposed model intends to be an evidence-based, transparent, and accountable process of allocating primary dental services by which communities are aware of their dental care needs.

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## Appendix 1

# ETHICAL CLEARANCE



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UNIVERSITY OF THE WESTERN CAPE  
Private Bag X1, Tygerberg 7505  
Cape Town, SOUTH AFRICA



Date: 08<sup>th</sup> November 2013

Dear Dr Antunes,

**STUDY PROJECT:** Assessment of a framework for the allocation of primary dental services

**PROJECT REGISTRATION NUMBER: 13/10/71**

**ETHICS:     Approved**

At a meeting of the Senate Research Committee held on Friday 8<sup>th</sup> November 2013 the above project was approved. This project is therefore now registered and you can proceed with the work. Please quote the above-mentioned project title and registration number in all further correspondence. Please carefully read the Standards and Guidance for Researchers below before carrying out your study.

Patients participating in a research project at the Tygerberg and Mitchells Plain Oral Health Centres will not be treated free of charge as the Provincial Administration of the Western Cape does not support research financially.

Due to the heavy workload auxiliary staff of the Oral Health Centres cannot offer assistance with research projects.

Yours sincerely

Professor Sudeshni Naidoo  
Deputy Dean: Research

## Appendix 2

# UNIVERSITY OF THE WESTERN CAPE Faculty of Dentistry

### PARTICIPANT INFORMATION SHEET

**Project Title:** Assessment of a Framework for the Allocation of Primary Dental Services

#### **What is this study about?**

This is a research project being conducted by Denise Antunes at the University of the Western Cape. We are inviting you to participate in this research project because you, as a Family Health clinic user are a key element in the validation process of the proposed approach to improving provision and access to dental services for communities. The purpose of this research is to contribute to equity access to primary dental services by testing a dental resources allocation framework. The information you give during this study will allow the services coordinators to develop a more equitable way to allocate primary dental services.

#### **What will I be asked to do if I agree to participate?**

You will be asked to undergo a sequence of oral examinations conducted by the dentist who work in the Family Health clinic you are assigned to. The dentist will exam your mouth using disposable tongue depressors each time you come to undergo dental treatment. The oral exam will last just few minutes. This exam will allow the dental surgeons to classify your oral health status according to your need of dental treatment. The classification code will define an experimental length of time for your next dental appointment.

#### **Would my participation in this study be kept confidential?**

We will do our best to keep your personal information confidential. To help protect your confidentiality, all data collected will be kept at locked filing cabinets at the Primary Care Clinics. Data collected from your mouth will be only identified by a code. Through the use of an identification key, the researcher will be able to link the data from your oral health classification to your identity. Only the researcher will have access to the identification key. If we write a report or article about this research project, your identity will be protected to the maximum extent possible.

#### **What are the risks of this research?**

The risks from participating in this research study might be related to fear of being examined by a dentist.

Apart from that, there are no other known risks associated with participating in this research project. You will be allowed to contact the dental team you are assigned to every time you have a doubt or request related to the classification of your oral health.

**What are the benefits of this research?**

This research is not designed to help you personally, but the results may help the investigator to make recommendation to the managers of the participating Family Health clinics for future improvements in the access to dental services for your community. We hope that, in the future, not only your community but also communities within the metropolitan area of Porto Alegre might benefit from the results of this study as a way to improve equity access to dental services. At the moment, this will help public health officers to improve access to and provision of dental services in the Family Health clinics they manage.

After the oral examination, your dental treatment needs will be passed on to the Family Health clinic you have been assigned to so that an appointment can be made for you to see a dentist.

If you have any doubt or question, please do not hesitate to ask us before you decide whether or not to participate. You may also withdraw from the study whenever you wish, and your participation will be completely free of charge.

**Do I have to be in this research and may I stop participating at any time?**

Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify. You do not need to give reasons if you decide to withdraw from the study. You can also choose how to use or not the information you have already given to this study.

**Is any assistance available if I am negatively affected by participating in this study?**

The Family Health clinic you are assigned to will be available for referral to your dental health care.

**What if I have questions?**

This research is being conducted by Dr. Denise Antunes, in the Faculty of Dentistry at the University of the Western Cape. If you have any question about the research study itself, please contact Denise Antunes at: Rua José Honorato Santos, nº 100 apt 608 Porto Alegre, RS, Brazil, phone numbers: (51) 9913 6086, (51) 30293302 or (51) 32224662. You can also email to [deni.atn@gmail.com](mailto:deni.atn@gmail.com)

The University of the Western Cape's Senate Research Committee and Ethics Committee has approved this research. It is also has been approved by the Moinhos de Vento Hospital Association's Research and Ethics Committee. Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problem you have experienced related to the study, please contact:

Faculty of Dentistry, Private Bag X1, Tygerberg, 7505, Republic of South Africa  
Tel: 021 937 3030, Fax: 021 931 2287  
Ms. Zulfah Smith Tel: 021 937 3184 / 3101  
E-mail: [zsmith@uwc.ac.za](mailto:zsmith@uwc.ac.za)

## Appendix 3

### INFORMED CONSENT FORM

University of the Western Cape, South Africa

Faculty of Dentistry

#### RE: Study in Dental Health

We would like to invite you to participate in a study of oral health, which will take place in Porto Alegre and its metropolitan area from October 2013 to October 2015.

The purpose of this project is to study the access to oral health care of Family Health Clinics users. Participants will be selected according to their demand for dental services at the clinics they are registered.

Your participation is completely voluntary, and involves an examination of your mouth, which will be carried out by the dentist of the Family Health Clinic. The dentist will use a disposable tongue depressor. The data collected from the examinations will be classified, but your privacy will be respected, and you will be assisting in the setting up of a more equitable way to provide dental health care among the community registered in your local clinic.

After the oral examination your dental treatment needs will be passed on to your local clinic so that an appointment can be made for you to see a dentist. If you have any doubt or question, please do not hesitate to ask us before you decide whether or not to participate. You may also withdraw from the study whenever you wish, and your participation will be completely free of charge.

If you require further clarification, please contact the coordinator of the study: Dr. Denise Antunes, by phone number: (51) 9913 6086 or by email: [deni.atn@gmail.com](mailto:deni.atn@gmail.com) or in the physical address: Rua José Honorato Santos, nº 100 AP 608 Porto Alegre, RS, Brazil.

\_\_\_\_\_  
Participant

\_\_\_\_\_  
Researcher

Date: \_\_\_/\_\_\_/\_\_\_\_\_

Researcher: Denise Antunes, Brazilian, Dental Surgeon,

ID 5008572496, CRO RS 5851

Address: Rua José Honorato Santos, nº 100 AP 608 Porto Alegre, RS

Phone Numbers: (51)9913 6086

Faculty of Dentistry, Private Bag X1, Tygerberg, 7505, Republic of South Africa

Tel: 021 937 3030, Fax: 021 931 2287

Ms. Zulfah Smith Tel: 021 937 3184 / 3101

E-mail: [zsmith@uwc.ac.za](mailto:zsmith@uwc.ac.za)

