AN EXPLORATIVE REVIEW OF THE DISTRIBUTION, INCIDENCE, PREVALENCE, DIABETES RELATED AMPUTATIONS AND DEFAULTERS OF PATIENTS WITH DIABETES MELLITUS AND PODIATRISTS IN THE PUBLIC HEALTH CARE SECTOR OF KWAZULU-NATAL

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Submitted in fulfilment of the requirements for the degree of Master in Medical Science in the School of Clinical Medicine, University of KwaZulu-Natal

DECLARATION

I Nikita Sahadew declare that

(i) The research reported in this dissertation, except where otherwise indicated, is my original work.

(ii) This dissertation has not been submitted for any degree or examination at any other university.

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DEDICATION

To my parents, to whom I owe everything

ACKNOWLEDGEMENTS

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DEFINITIONS

For ease of reference the following terms and words used in this thesis are defined.

Crude prevalence: A crude prevalence is one that relates to results for a population taken as a whole, without subdivision or refinement.

Distribution of patients diagnosed with diabetes mellitus: the geographical arrangement of patients diagnosed with diabetes mellitus in the KwaZulu-Natal public health sector showing their recorded frequency of occurrence.

Incidence: Incidence is the rate of new (or newly diagnosed) cases of the disease.

Podiatrist: A medical specialist of the lower limbs.

Prevalence: The prevalence of a disease is the proportion of a population that are cases at a period or point in time.

Prevalence within the public sector: The prevalence of diabetes mellitus after the exclusion of the recorded private health sector population from the total district or provincial population.

Total diabetes prevalence estimate: The estimated prevalence of diabetes mellitus considering the estimated undiagnosed population. This total was calculated as below:

Total diabetes prevalence estimate = Prevalence within the public sector + Estimated undiagnosed population.

LIST OF ACRONYMS

1. Anti-retrovirals (ARVs)
2. Body mass index (BMI)
3. Distal Symmetrical Neuropathy (DSN)
4. District Health Information System (DHIS)
5. Kwazulu- Natal (KZN)
6. National Health Scheme (NHS)
7. National Health Trust (NHT)
8. Podiatry Association of South Africa (PASA)
9. South African Index of Multiple Deprivation (SAIMD)
10. South African National Health and Nutrition Examination Survey (SANHANES)
11. The International Diabetes Federation (IDF)
12. The Society for Endocrinology, Metabolism and Diabetes (SEMDSA)
13. The University of Johannesburg (UJ)
14. Tuberculosis (TB).
15. World Health Organization (WHO)

ABSTRACT

The prevalence of diabetes is increasing globally, especially in African countries, where 62% of cases are undiagnosed and are seen by a medical professional only once complications have manifested. Among the tangle of complications, the diabetic foot is a cause of morbidity and mortality. The management of foot ulcerations, non-ulcerative pathologies and the prevention of subsequent amputation is a challenge, resulting in physiological, psychological and economic consequences. Including a podiatrist in the multidisciplinary healthcare team involved in the care of the lower limbs of the diabetic patient has the potential to improve patient outcomes and reduce the economic burden incurred by both the patient and the state. The global increase in the prevalence of diabetes is most marked in African countries. The District Health Information System (DHIS) is the primary data collection system of the Department of Health in KwaZulu- Natal (KZN). Data is routinely collected at all public healthcare facilities in the province and is aggregated per facility. This study aimed to investigate the distribution of diabetic patients and podiatrists in the public health sector of the eleven KZN districts.

A retrospective audit was conducted of the KZN Department of Health databases on diabetes in and between the years 2010 and 2014. The data was cleaned, tested for capture errors, verified and analysed. Using pivot tables, derived metrics, and graphs using Microsoft Excel were constructed. Additional open source databases were accessed to allow further exploration of the data collected. The prevalence of diabetes in the public health sector of KwaZulu-Natal was found to be 14.3% higher than national prevalence estimates. Thirty-eight per cent of the cases were found in the highly urbanised district of eThekwini. A total of 1 329 275 diabetic patients were recorded and, according to national guidelines for the treatment of diabetes, required podiatric care. However, only two podiatrists work in the KwaZulu-Natal public health sector. The number of podiatrists is totally insufficient to serve the growing diabetic population in this province's public health sector. A major infusion of more podiatry graduates, appropriate distribution and inclusion of podiatric services into the diabetic foot care team needs to therefore be considered to enable compliance with national and international diabetic foot care guidelines. In the interim, existing public health care practitioners can be educated to offer diabetic foot care information to the patient and on the correct referral patterns to allow the patient access to a podiatrist.

The findings of this study are consistent with the well-established relationship between diabetes and urbanisation. Correlation calculations support the assumption of a directly proportional relationship between diabetes prevalence and the number of diabetes-related amputations. This study highlights the need for at least 319 podiatrists in the province of KwaZulu-Natal to satisfy the national guidelines for minimal diabetic care regarding assessment, screening and education of patients only; not considering the treatment of existing and future foot complications.

Short and long term recommendations such as changes in the data collection process at public health facilities and the assessment of existing tertiary medical institutions for the establishment of additional departments of podiatric medicine can greatly contribute to addressing the calculated shortage of podiatric practitioners in the public health sector.

CHAPTER 1 – INTRODUCTION

According to the World Health Organization (WHO), diabetes mellitus is a chronic disease caused by real or apparent insulin insufficiency (World Health Organization, 2015). Within the space of a few decades, diabetes has escalated to the level of a global epidemic, with more than 20 million people affected in Africa, 62.5% of whom are believed to be undiagnosed. Diabetes caused more than 68 thousand deaths in South Africa in 2013 (IDF, 2013). According to global estimations, developing countries are predicted to experience an increase of as much as 69% in the number of adults diagnosed with diabetes by 2030 (Shaw, 2009). Mortality estimates for the year 2000 found that within KwaZulu-Natal (KZN), diabetes was the fourth largest cause of death among adult women and ranked seventh in the leading causes of death among adult men (Bradshaw et al., 2003). The increase in the prevalence of the disease, especially in developing countries, is speculated to be due to a general increase in life expectancy, sedentary lifestyles urbanisation, and changes in dietary habits (Clarke, 2008).

In addition to the many physiological complications that occur as a result of diabetes, emotional and mental wellbeing of the newly-diagnosed diabetic is often affected as a result of changes in lifestyle and state of health (Berry, 2015). Micro-vascular disease as a result of diabetes has been found to be the leading cause of renal failure, retinopathy, nerve damage and consequent atherosclerosis resulting in an increased risk of myocardial infarctions, strokes and limb amputations (Brownlee, 2001). It has been reported that foot complications are a significant cause of morbidity and mortality, and that every 30 seconds a lower limb is lost somewhere in the world (SEMDSA, 2014; Boulton et al., 2005). Foot ulceration and subsequent amputations are preventable complications, provided that screening and foot care guidelines are followed by a health professional (SEMDSA, 2014). Easy-to-use foot care guidelines are available, such as those published by the Society of Endocrinology, Metabolism and Diabetes of South Africa. Taking into account factors such as limited available medical resources, high levels of poverty, the high burden of complications, and patient load, these foot care guidelines offer protocols designed to provide minimal care and are thus ideal for developing countries such as South Africa (Igbojiaku, Ross and Harbor, 2013; Gill, 2009). However, a 2012 study on compliance with these guidelines at a regional hospital in KZN revealed low standards of diabetic foot care.

The diabetic foot is understood as a series of pathologic changes that are found in the foot of a diabetic patient often characterised by neuropathy, ischemia and infection contributing to the development of a non-healing ulceration commonly resulting in amputation or death. (McGraw-Hill Concise Dictionary of Modern Medicine, 2002). Several studies have shown that a multidisciplinary approach to the diabetic foot can reduce amputations by up to 85%. According to the Centre for Disease Prevention and Control in the USA, a multidisciplinary team is typically composed of (but not limited to) pharmacists, podiatrists, optometrists, dental care professionals, primary care physicians, nurses, dieticians and certified diabetes educators (USA Centre for Disease Prevention and Control, 2015).

Podiatrists are uniquely qualified among health care practitioners to treat only diseases of the foot and ankle. Podiatrists might be the first to identify systemic diseases in patients, such as diabetes and vascular disease, and are an integral part of a multidisciplinary diabetic team (Clarke and Tsubane, 2008). Including podiatrists in the multi-disciplinary team managing the diabetic foot leads to better diabetic education, improvements in self-care practices, reduced emotional stress and depression, and a reduction in foot complications such as hyperkeratosis, the presence of which is found to cause a predisposition to development of subsequent ulcerations (Berry, 2015; Rönnemaa, 1997; Murray, 1996). The preventative treatment provided by a podiatrist can limit the progression of the diabetic foot and reduce limb loss (Kim et al., 2012). Masoetsa (2005) notes that the management of the diabetic foot is included in the scope of practice of South African trained podiatrists. According to national guidelines by SEMDSA, it is recommended that a diagnosed diabetic patient see a podiatrist annually for a comprehensive foot exam, and more often if the patient presents with additional pathologies of the foot and ankle (Butler, 2011).

Purpose of this study

One way to improve the level of care for the growing population of patients diagnosed with diabetes mellitus is to document the current distribution of the health care access facilities and note the assumed incidence and prevalence of diabetes based on health care access; this is important for a number of reasons. The findings may confirm previously described variances of prevalence based on the degree of urbanisation of the population or may show an unexpected prevalence in certain districts suggesting under-diagnosis or inaccurate

assessments of the presence of risk factors for the development of diabetes in the different districts of KZN (Akter et al., 2014). The public health implications of describing the distribution of health care access will allow for a more appropriate distribution of resources and podiatric services for the management of diagnosed diabetic patients or may highlight the need for more intensive screening for possible undiagnosed cases of diabetes.

Rationale

No previous studies have provided a current overview of neither distribution of diabetic patients nor podiatrists in KZN. This study aims to investigate the distribution, incidence, prevalence and defaulters of patients with diabetes mellitus and Podiatrists in the public health care sector of KZN and its various districts during the past five years (2010-2014).

Directed by the information collected in this study, recommendations for the provincial distribution of podiatric services for the public sector will be proposed according to national and international standards. The specific objectives of the study are outlined below:

- To ascertain the distribution of patients diagnosed with diabetes mellitus by district and age.
- To determine the distribution of patients diagnosed with diabetes that default on treatment in the province of KZN.
- To investigate the number of diabetes-related amputations
- To determine the 2010 to 2014 incidence of patients with diabetes mellitus
- To calculate the 2014 prevalence of patients in the public health sector who have been diagnosed with diabetes, out of the total susceptible adult population in the region based on the latest midyear provincial population estimates.
- To establish and investigate correlations and relationships between the calculated diabetes prevalence rate and urbanisation, amputations, defaulting patients and diabetes mortality.
- To evaluate the distribution of podiatrists in the public health sector based on national and international guidelines for diabetic foot care.

In the following chapters we present the background to the study and a review of the relevant literature. This is followed by the methodology, the study results, data analysis, and the implications of this study.

CHAPTER 2 – LITERATURE REVIEW

This chapter presents an overview of the literature on key issues relevant to this study, such as the state of diabetes, the prevalence of the disease by region, its complications (with particular emphasis on those of the foot), the guidelines for diabetic foot care, and the medical service providers fighting this disease and their role.

2.1 The State of Diabetes Mellitus: International, National and Provincial,

Classified as a global epidemic because of its rapid increase in prevalence, diabetes is ranked as one of the top ten causes of death worldwide. According to the World Health Organization, the burden of diabetes is increasing and currently afflicts approximately 347 million people worldwide. Now known as the main cause of kidney failure, blindness and amputations, diabetes has become a leading cause of premature death due to increased cardiovascular risk. Patients with diabetes have a ten-fold higher risk of limb amputation, and more than half of all non-traumatic amputations are linked to this disease (WHO, 2014, 2015). Approximately 90% of diabetics around the world have type 2 diabetes, a preventable form of the disease that has been associated with many modifiable risk factors.

Worldwide, the prevalence of diabetics is predicted to increase by 55% by 2035, increasing the diabetic population to 592 million people (IDF, 2013). A person loses their life every sixty seconds due to diabetes complications. Up to 80% of diabetes-related deaths are estimated to occur in lower or middle income countries. The International Diabetes Federation (IDF) predicts that the number of diabetic patients in Africa will double between 2013 and 2035 (WHO, 2015; IDF, 2014).

The increase in prevalence in Africa has been confirmed by studies conducted in Tanzania and Cameroon (Mbanya et al., 2010). Developing countries in Africa not only confront the challenge of resource depletion and urbanisation, but low-income countries also face the burden of communicable diseases such as HIV/AIDS, which is currently the continent's leading cause of death, and is commonly found to co-exist with diabetes (Mbanya et al., 2010; Boulton et al., 2005).

More than any other continent, Africa presents with the compounded effects of the presence of diabetes together with AIDS and Tuberculosis (TB). The interactions between these conditions and their treatment pose many challenges. Diabetes mellitus patients have been found to have an increased general risk of infection and are two to three times more likely to develop TB. HIV has been found to increase the re-occurrence of latent TB and drastically increase the progression to active disease (Harries, 2011). Some anti-retrovirals (ARVs) cause glucose intolerance, predisposing the HIV+ patient to developing diabetes. The drug interactions between the medications used to treat diabetes and TB reduce each other's effectiveness, making it difficult to treat both conditions in one patient (HEALTH24, 2010).

In addition to the above challenges, specific cultural issues in Africa have a significant impact on perceptions and management of the diabetic patient. The prevalence of obesity is increasing worldwide. In many African communities, obesity is seen as a sign of affluence and good health and solidifies social opinion that a provider is able to take good care of the family (Puoane, 2002). Diabetes prevalence increases with a higher body mass index (BMI) and waist circumference, increasing the risk of the development of type 2 diabetes. The positive correlation between the two factors is so prominent that a term, 'diabesity', has been coined to illustrate the strong connection between obesity and diabetes (Astrup, 2000). A 2006 review on obesity prevalence among the South African population reported the following results: '*black women, 75%; black men, 49%; coloured women, 66%; coloured men, 45.7%; Indian women, 37%; Indian men, 36%; white women, 42%; white men, 56%*' (van der Merwe 2006). Walking barefoot, unhygienic conditions, cultural practices, rodent and insect bites and poor self-care often interact and compound the situation of the diabetic foot (Boulton et al, 2005; Van Rensburg, 2009).

While there are approximately 20 million reported cases of diabetes in Africa, according to the IDF, 62% of diabetic patients remain undiagnosed (IDF, 2013). This suggests that a significant number of diabetics are at risk of developing chronic complications arising from abnormal blood glucose and are unaware of the prevention and control methods required to improve their prognosis until the presentation of the disease is already at an advanced stage (Mbanya, 2010). In most African countries, the public health prioritises communicable diseases, and so diabetic foot care tends not to be as comprehensive as per international guidelines. The distribution of diabetic foot care specialists in high risk areas will allow for a more rational use of scarce resources and better outcomes for the patient (Mbanya, 2010).

The International Diabetic Federation's 2013 Diabetes Atlas, indicates that South Africa is home to more than two and a half million diabetics, and an approximate further million who are estimated to be undiagnosed. The IDF estimates national prevalence at 8.39%, a figure that can be used when comparing the results of this study that aimed to determine the provincial and district prevalence of diabetes within KZN (IDF, 2013). It has been estimated that another 2.6 million South Africans have impaired glucose tolerance, an early metabolic abnormality known as a pre-diabetic state that leads to the eventual development of diabetes (IDF, 2013; Nathan, 2007).

2.2 Study location

KwaZulu-Natal, a subtropical province in South Africa, was chosen as the location for this study. KZN is the second most populated province in South Africa. Most citizens live in and around the city of Durban, known to be the city with the largest population of Indians outside India, and who form 7.4% of the KZN total population. (Mukherji, 2011; Census, 2012). Within the South African population, studies have revealed that the Indian population has the highest prevalence of diabetes, and a bimodality in the plasma glucose distribution with particular predisposing factors such as a high BMI, obesity and genetic influence (Omar, 1994; Motala, 2003). The prevalence of adult onset diabetes among the South African Indian population has been reported to be 13.5% (Dikeukwu, 2011; Rheeder, 2006). A recent study among a sample of the coloured population, previously known to exhibit the second highest diabetes prevalence rate, found a prevalence rate of 28%, compared with a rate of 8% reported by earlier studies (Erasmus et al., 2012; Dikeukwu, 2011). Indigenous black South Africans, who constitute 82% of KZN's total population, have been found to have a prevalence of diabetes of between 5 to 8% and the white Caucasian population has a prevalence of 5% (Omar, 2008; Dikeukwu, 2011). As the home to the largest proportion of Indian citizens in South Africa KZN is the ideal location for data collection specific to this high risk sample population (Omar, 1994; Statistics South Africa, 2012).

2.3 Urbanisation and Socioeconomic Status in South Africa

Several studies have indicated that the majority of the diabetic population are found in urban areas, hence the positive correlation between the prevalence of the disease and the consequences of an urban lifestyle (SEMDSA, 2014; Mbanya, 2010; IDF, 2013; Shaw,

2010). The increasing incidence of diabetes has been identified as an undesirable effect of urbanisation societies undergoing rapid social, demographic, industrial and nutritional changes such as those found in developing countries (Shaw, 2010; Assal, 2002).

Statistics South Africa (2006) defines urbanisation as:-'An increase in the urban population of a country or area due to the following components of urban population growth:

(a) Urban natural increase

(b) Urban net migration, and

(c) The reclassification of parts of the rural population into the category 'urban' (due to the sprawl of existing urban areas into their rural surroundings or the development of new towns in former rural areas)'.

Data released by the IDF suggest that 80% of the diabetics in South Africa are from urban areas (IDF, 2013).

In 2007 the South African Department of Social Development released the South African Index of Multiple Deprivation (SAIMD) report by Gemma Wright and Michael Noble. This report reflected the results of a study to determine the levels of deprivation in South Africa at municipal level. The most recent study of its kind, it is used to allocate socio-economic quintiles to districts and municipalities reflecting their different levels of urbanisation. The four domains of deprivation produced using the 2007 community survey to form the SAIMD 2007 are explained as follows (Wright G & Noble M, 2007):

Income and material deprivation

This domain captures the proportion of the population facing income and/or material deprivation in a municipality. The deprivation indicators used are as follows:

• The number of people living in a household with a household income (need-adjusted) below 40% of the mean equivalent household income (approximately R1 003 per month (Feb. 2007));

• The number of people living in a household without a refrigerator;

• The number of people living in a household with neither a television nor a radio.

A simple proportion was calculated of the people living in households with one or more of these deprivations.

Employment deprivation

The purpose of this domain is to determine the proportion of the working age population involuntarily excluded from employment in a municipality. The deprivation indicators used are as follows:

• The number of people who are unemployed;

• The number of people who are not working because of illness or disability.

A simple proportion was calculated of adults aged 15 to 65 who were unemployed divided by the total economically active population aged 15 to 65 plus those not able to work due to sickness/disability.

Education deprivation

The focus for this measure is adults aged 18 to 65 years with no secondary school education. This domain was calculated as a simple rate for 18-65 year olds.

Living environment deprivation

The purpose of this domain is to identify people living in poor quality environments. The deprivation indicators used are as follows:

• The number of people living in a household without piped water inside their dwelling or yard;

• The number of people living in a household without a pit latrine with ventilation or flush toilet;

• The number of people living in a household without electricity for lighting;

• The number of people living in a shack;

• The number of people living in a household that is crowded.

A simple proportion was calculated of people living in households experiencing one or more of these deprivations.

The domain scores were then standardised by ranking and were transformed to an exponential distribution. Each of the transformed domains has a score of between 0 and 100, with 100 representing the most deprived.

After the consolidation of the four domain scores, a single SAIMD 2007 score was allocated to each municipality (also from 0-100). The results were divided into quintiles, giving each area (municipality) a socio-economic rating. Areas with a value of 1 have the lowest socio-

economic status and are in the most deprived 25% in the range of SAIMD scores for South Africa, while areas with a value of 5 have the highest socio-economic status and are in the least deprived 25% in the range of SAIMD scores. Municipality readings were later converted for analysis by district.

Below is a map (Figure 1) illustrating the socioeconomic quintiles of KZN as determined by the SAIMD.
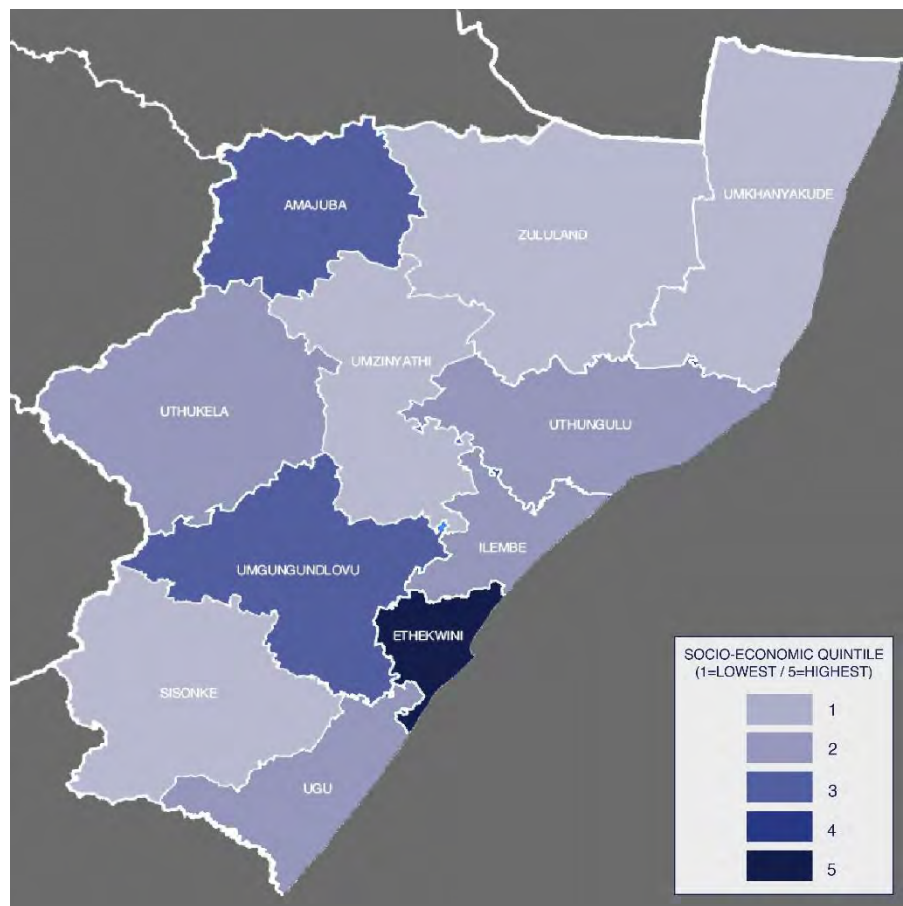
Figure 1: The socio-economic quintiles for the districts of KZN

As seen in Figure 1, there are various socioeconomic quintiles present in the province of KZN. Most districts belong to the first or second quintile while only one of the eleven municipal districts, eThekwini, is in the fifth quintile.

2.4 Complications of Diabetes Mellitus

The Society for Endocrinology, Metabolism and Diabetes (SEMDSA), a scientific authority on diabetes in South Africa, defines diabetes mellitus as *a metabolic disorder with heterogeneous aetiologies which is characterised by chronic hyperglycaemia and*

disturbances of aetiological types of diabetes, and other categories of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both. Type 1 diabetes is an autoimmune disease of idiopathic deficiency of the beta cells of the pancreas, usually resulting in an absolute inability to produce insulin endogenously. Type 2 is a form of the disease resulting in insulin resistance, which varies in severity and/or insulin secretory defects and deficiency. Type 2 diabetes has been shown to be preventable but still accounts for approximately 90% of the diabetes mellitus cases. Gestational Diabetes causes hyperglycaemia during pregnancy due to the inability of the mother's pancreas to make sufficient insulin to meet the body's needs. Other types and aetiologies of diabetes include genetic defects, drug or chemically induced, infections and endocrinopathies (SEMDSA, 2014).Complications as a result of diabetes are related to microvascular, macrovascular and metabolic changes. These include peripheral arterial, cerebrovascular and cardiovascular disease, as well as retinopathy, neuropathy and nephropathy (Fowler, 2011).

Figure 2: The effects of Hyperglycaemia

Adapted from: Fowler (2011)
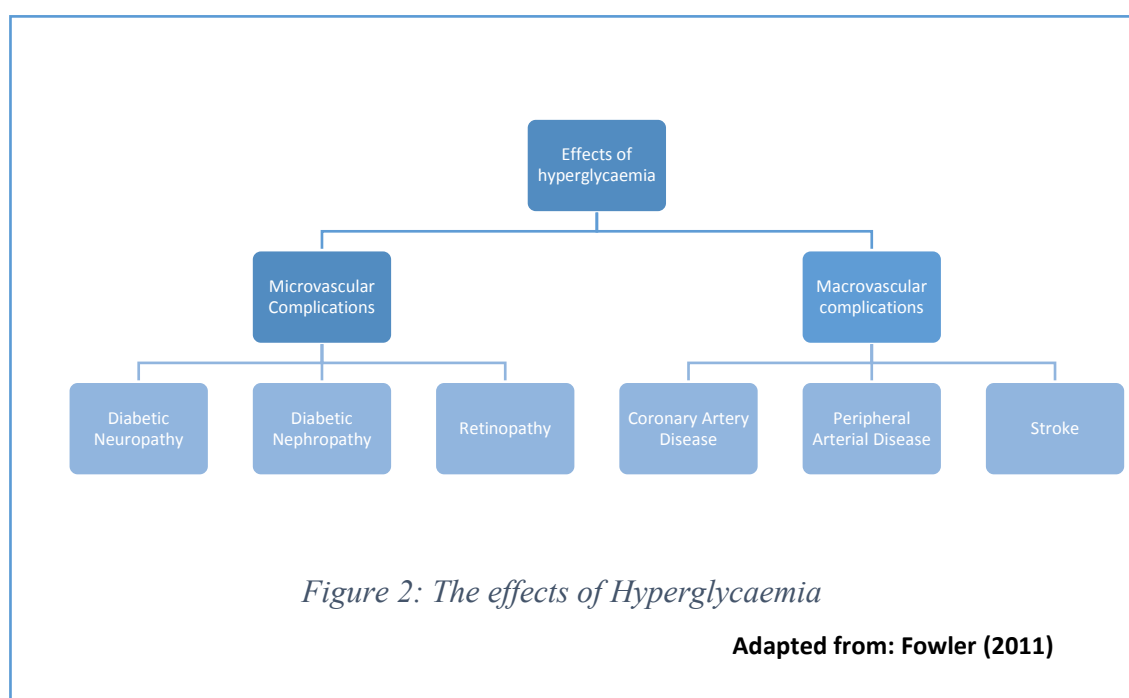
2.5 Diabetic Foot Complications

Among the cascade of diabetic foot complications, foot ulceration and subsequent amputation occur frequently, placing a strain on the health care system, especially in developing counties in Africa. Lower limb ulcerations and amputations have a negative

effect on the patient's quality of life and occur more frequently in diabetics than non-diabetics as a result of the imminent neuropathy and angiopathy (Frykberg, 2006).

Approximately 10%to15% of all patients with diabetes will develop foot ulcers at some stage of their lives. Lower limb amputations are preceded by foot ulceration in more than 85% of ulceration cases (Rheeder, 2004; Dikeukwu, 2011). While diabetic foot ulcerations are seen in every part of the world and in every socio-economic setting, amputation is often used as an early surgical solution for foot ulceration in developing countries (Assal, 2002). Risk factors contributing to the development of diabetic foot ulcers include the presence of neuropathy, structural deformity, peripheral vascular disease and microvascular complications (SEMDSA, 2014). Other seemingly minor consequences of diabetes such as hyperkeratosis and poor biomechanics not only cause pain and discomfort but predispose the diabetic patient to ulceration. These warning signs can be detected and managed by a podiatrist through regular foot care, limiting the progression and risk of foot ulceration (Leymarie, 2005; Van Rensburg, 2011; Clarke and Tsubane, 2008).

The Normal Foot	• There are minimal risk factors for the diabetic foot • Can include neglected nail pathologies, gout, poor footwear, common plantar warts, Eczema and Tinea Pedis
The High-risk Foot	• Risk factors are present but can go unnoticed because of the onset of neuropathy • Can include foot deformities and limited joint mobilities leading to the presentation of Claw toes, prominent metatarsal heads, fibrofatty padding depletion, Hallux rigidus/Limitus, Hallux Valgus, Foot drop and the developement of a rigid plantaflexed or Charcot's Foot. • Other unassumingly menacing dermatological complications such as corns, callus and fissues. • Signs of ischaemia can also present such as intermittent claudication, changes in colour, weakness, pain and paraesthesiae.
The Ulcerated Foot	• Once the skin is broken, the neuropathic and ischaemic changes that occur in the diabetic foot result in poor healing and likely development of an ulcer. Ulcers are either Neuropathic or Neuroischaemic and are compounded by pressure, Charcot's Osteoarthropathy, trauma and infection.
The Infected Foot	• For both neuropathic and neuroischaemic ulcers, infection is a common pathway to amputation. More people undergo major amputation because of combined diabetes and infection than for all other causes. The period of time for the infection to progress, from localized, to spreading and finally to severe, could take mere hours. • Types of infections can vary, and at times act synergistically, from the most common in the diabetic foot, Staphylococcus aureus, to drug resistant strains such as Methicillin-resistant Staphylococcus aureus. Other infecting organisms include Streptococcus, Anaerobes, Gram-negative organisms and Psedomonas.
The Necrotic Foot	• Necrosis in the neuroishchaemic foot, wet or dry, has been known to have a very poor prognosis because it serves as a marker of severe cardiovascular disease . • Necrosis can involve skin, subcutaneous and fascial layers and can be caused by infection if it is wet, or occulusive macrovascualr disease of the arteries if it is dry. • Necrosis in the diabetic foot should always be treated as a clinical emergency and together with regular care teams, antibiotics, debridement and revascularization, limb salvage is possible.
The Unsalvagable Foot	• At this stage the limb can not be saved and requires a major amputation although as mentioned before, most diabetic limbs can be salvaged. • There are instances when the limb needs to be amputated, however to allow the patient to walk better than he would have been able to on the dieased foot, to control intolerable pain from the wound or to save the patient's life from the overwhelming sepsis.

Figure 3: The progression of the diabetic foot

Adapted from: Edmonds, Foster and Sanders (2008)

The following neurological complications found in the diabetic foot contribute to the development of foot ulceration and are often not found in isolation, dramatically increasing the risk of ulceration if left undetected and poorly managed (Bowker, and Pfeifer, 2008). Foot screening tools such as those set out in Appendix 1 are used by podiatrists in the South African private sector to assess the neurological status of the diabetic foot and reduce the risk of ulceration.

2.5.1 Distal Symmetrical Neuropathy (DSN)

2.5.1.1 Peripheral Sensory Neuropathy

The most common form of distal symmetrical neuropathy found in the diabetic foot, is peripheral sensory neuropathy. When considered with regard to the sequel of unperceived trauma, it is the primary factor leading to diabetic foot ulcerations and has been recognised as the cause of 60% of diabetic foot ulcers (Van Rensburg, 2011). In addition to the expected paraesthesia and loss of protective sensation in the foot, patients can experience uncomfortable sensations such as tingling, burning, cramping and aching pain in the foot. This explains the apparent paradox of a patient who is in constant pain but has a loss of sensory perception and a resultant diabetic ulcer. Such symptoms are usually found to be more intense at night, preventing sleep and disrupting the patient's ability to function normally throughout the day, leading to fatigue and depressive symptoms (Boulton, Cavanagh and Rayman, 2006).

2.5.1.2 Sensorimotor Neuropathy

This form of DSN causes anterior crural muscle atrophy or intrinsic muscle wasting leading to structural deformities of the foot. The muscle strength usually remains unaffected in the early stages of the disease but as the pathology progresses, small muscle weakness, mild changes in foot structure such as the clawing of toes and corresponding alterations in the ranges of motion begin to arise. Such a scenario results in an increase in plantar pressures of the foot, increasing the risk of ulcerations and callus formation. The risk of ulceration is further increased with the use of inappropriate footwear and the development of more severe structural deformities

such as those associated with the Charcot arthropathy (Boulton, Cavanagh and Rayman, 2006).

2.5.1.3 Autonomic Neuropathy

Autonomic neuropathy causes a reduction of sweat output; this causes dry skin and cracking, resulting in an increased risk of infection. Arteriovenous shunting and microvascular thermoregulatory dysfunction impairs the tissue perfusion and the response to injury. A manifestation of such complications is the characteristic bounding arterial pulse and neuropathic oedema of the diabetic foot, commonly resistant to diuretic therapy (Edmonds, Foster and Sanders, 2008).

2.5.2 Proximal Motor Neuropathy

This form of neuropathy presents as a severe pain in the thigh extending to below the knee and is often described by patients as a deep or burning pain. On examination the Quadriceps muscles are found to be weak and have undergone muscle wasting. Other muscle groups of the hip and thigh can also be affected and the patella reflex is usually reduced or absent. Activities utilising the affected muscle groups such as getting up from a seat, bending to pick up something or climbing stairs, will become more difficult (Boulton, Cavanagh and Rayman, 2006).

2.5.3 Peripheral Arterial Disease

This change in macro vascular circulation rarely leads directly to ulcerations. The consequence of the disease is seen once the ulceration has developed and presents in the form of delayed healing and the impaired delivery of oxygenated blood or antibiotics in response to an existing infection. It is therefore vital to treat the ischemia of the foot to facilitate healing of the ulceration and promote limb salvation (Frykberg, 2006).

2.5.4 Plantar Pressure

The plantar pressures generated under the foot of non-diabetic individuals can be high enough to cause ulceration when the combined effects of sensory neuropathy and arterial disease found in the diabetic foot are taken into consideration. A study by Lavery et al. found that plantar pressure is an important risk factor for foot complications (Lavery et al., 2003). The potential for ulceration is much greater as the diabetic foot is subjected to various mechanisms that increase plantar pressure and the compound effects of additional microvascular and microvascular complications (Bowker and Pfeifer 2008). Simple manifestations of an increase in plantar pressure such as the hardening of the skin, have been shown to be strongly correlated with the severity of neuropathy and can be easily detected and managed by a podiatrist in the case of a diabetic patient (Piaggesi, 1999; Tudhope, 2008).

Table 1: Factors leading to an increase in plantar pressure in the diabetic foot

Factors leading to an increase in plantar pressure of the diabetic foot

Structural and Functional Relationships

* Different foot types do predispose the patient to developing specific areas which experience pressure, such as in the case of a patient who pronates ; they are more likely to develop an ulcer around the hallux area.

* Numerous studies have supported the idea of a directly proportional relationship between the presence of rigid deformities such as Hallux valgus or Rigidus, hammertoe or Charcots Arthropathy.

Tissue Changes

* In the diabetic patient, a reduced elasticity develops and an increase in plantar tissue thickness due to the glycosylation of tissue protiens.

* The above cause a reduced capacity of skin to distribute pressure across the plantar aspect of the foot.

Joint Mobility

* Limited joint mobility is a perceived result of nonenzymatic glycosylation.

* Many studies have shown that this limited motion in various foot and ankle joints is not just associated with an increased plantar pressure but also a higher risk of ulceration.

* The intervention of physical therapy has been investigated and proven to improve foot ranges of motion and reduce plantar pressures.

Plantar Hyperkeratosis

* Neuropathic patients are predisposed to developing callus and together with sheer stress, increased plantar pressure.

* Callus increases the pressure on the plantar aspect of the foot and the risk of ulceration 11 times more than if the patient had no hyperkeratotic build up. (A Practical Manual of Diabetic Footcare, Edmonds,2008)

Foot Fractures

* There has been found to be an increased occurance of fractures in the diabetic foot.

* These fractures result in alterations in weight bearing and load sharing by the different areas of the foot which are as a result withstanding an increased plantar pressure and have an increased risk of ulceration to the area.

Postural Instability

* As a result of the consequential motor neuropathy that accompanies diabetes

* This change plays a role in foot function and effects the distribution of plantar pressure and the biomechanics of the foot.

Lower limb Weakness

* As a result of peripheral neuropathy

* Patients lose their intrinsic muscle to fatty infiltration which contributes to foot deformity.

* Studies have found a 21% reduction in the dorsiflexion and plantar flexion in the ankle joints of diabetic patients and as much as a 50% reduction in the strength of their plantar flexors.

Previous Ulceration

* Prior ulceration is the leading risk factor for future ulceration as it serves as evidence of the presence of many other combined risk factors for ulceration.

* It has been hypothesized that scar tissue has the same effect as callus on the area and transfers a concentrated amount of pressure to the corresponding healthy underlying skin

Shear Stress

* Studies have found that there are forces which act on the foot during the gait cycle that cause the foot to slip from its position on the ground which may impact the distribution of plantar pressure.

* Currently there are many investigations testing the use of different instruments that measure shear stress.

Abnormal Posture and Gait

* Peripheral neuropathy has been shown to increase the risk of falls during gait.

* Studies have collectively proved that a neuropathic gait pattern is different from the gait of a patient that does not have neuropathy.

* The altered gait pattern may predispose the diabetic patient to experience an increased plantar pressure.

Footwear

* Studies done in the United States have provided evidence that poorly fitting footwear plays a key role in the initiation of foot ulcers.

* Shoe trauma, together with the loss of the protective sensation and foot deormity, is the leading event precipitating foot ulcerations in diabetic patients.

* Specialised prescribed footwear is nessesary in cases of severe ulcerations to allow healing, off-load pressure and prevent re-ulceration.

Adapted from: **Bowker and Pfeifer (2008)**

2.5.5 Ulcers

Defined as a full thickness (penetrates through the dermis layer of the skin) wound below the ankle, irrespective of duration, ulcers commonly mark the start of the road to amputation for many diabetic patients. As many as a quarter of diabetic patients will develop a foot ulceration at some point in their lives and are more at risk of the development of chronic wounds (Bowker and Pfeifer, 2008; Edmonds, Foster and Sanders, 2008).

The aim is always to close the ulcer as soon as possible, while they are shallow and small, so as to minimize the damage to the tissue and reduce the chances of reoccurrence. Diabetic ulcers are categorized as either Neuropathic or Neuro-ischaemic. Although there have been cases of ulcers occurring in a patient with little or no neuropathy, they have the same treatment protocol as neuroischaemic ulcers and are placed in that category (Edmonds, Foster and Sanders, 2008). The method of grading used for the diabetic ulcer varies around the globe but most clinicians use either the Wagner or Texas classification system (Frykberg, 2006). The pathophysiology of a diabetic foot lesion is multifactorial and complex. Factors that contribute to the state of the foot include neuropathy, vascular disease, potential infection, biomechanics and trauma to the areas. The pattern of the foot ulcer depends to different degrees on the interaction of these factors (Boulton, Cavanagh and Rayman, 2006).

2.5.5.1 Neuropathic Ulcers

Commonly found in areas with high plantar or vertical pressure and shear force causing the development of callus. The process below (Figure 3) occurs and failure to remove the callus results in ulceration (Edmonds, Foster and Sanders, 2008).
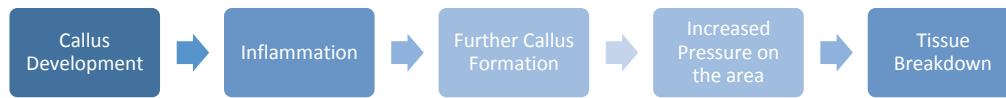
Figure 4: The progression of plantar keratosis

Adapted from: Edmonds, Foster and Sanders (2008)

As the development and establishment of neuropathic ulcers are usually painless, associated pain is commonly the first sign of infection (Edmonds, Foster and Sanders, 2008).

2.5.5.2 Neuroischaemic Ulcers

The common areas of development for neuroischaemic ulcers are the margins of the foot. Little or no callus develops and a small reddened area or blister progresses to a shallow ulcer and is then compounded by ischaemic and neuropathic factors. Signs of ischaemia such as erythema and of infection such as an unpleasant smell and pain are warning signs of further complications and an increased risk of amputation (Edmonds, Foster and Sanders, 2008).

An ulcer is a sign of multi-organ disease but is often underestimated and as such, at least 85% lead to amputations and a severe reduction in the patient's quality of life (Armstrong & Lavery, 2010).

2.5.6 Infection

Various types of infection have been shown to be more common and severe in a diabetic patient as opposed to these same infections, in a non-diabetic patient.

Studies have shown that soft tissue and foot infections are particularly associated with diabetes. Cellulitis is found more than nine times as often in a diabetic patient and

osteomyelitis of the foot and ankle in diabetic patients account for more hospitalisation than bone infections of any other area (Bowker and Pfeifer, 2008).

Diabetic complications such as hyperglycemia, neuropathy, an impaired immune response and arterial disease predispose the diabetic foot to limb-threatening infection. There are three phases of infection, localized, spreading and severe (Edmonds, Foster and Sanders, 2008). Ischemia reduces the body's ability to fight infection as it hinders the delivery of antibiotics to the infection site. Host leukocytes have an impaired ability to fight bacterial pathogens in an uncontrolled diabetic, further reducing healing capacity (Frykberg, 2006).

2.5.7 Charcot Joint Disease

In the diabetic patient, the combination of both sensory and autonomic neuropathy destroys the protective mechanisms of the joints and interferes with the nutritive trophic regulation of bone (Foster, 2006). The destructive mechanism is often exacerbated by a single injury or repetitive stress to the foot and ankle; however, trauma is not limited to injuries such as sprains or contusions (Bowker and Pfeifer, 2008). Previous amputations, infections of the joints, trauma as a result of surgery and foot deformities may cause adequate stress on the foot and lead to Charcot disease (Frykberg, 2006). This can lead to severe deformity or instability of the joint and is often associated with the development of ulceration.

Figure 5: Contributing factors of a Charcot's foot

Adapted from: Bowker and Pfeifer (2008*)*
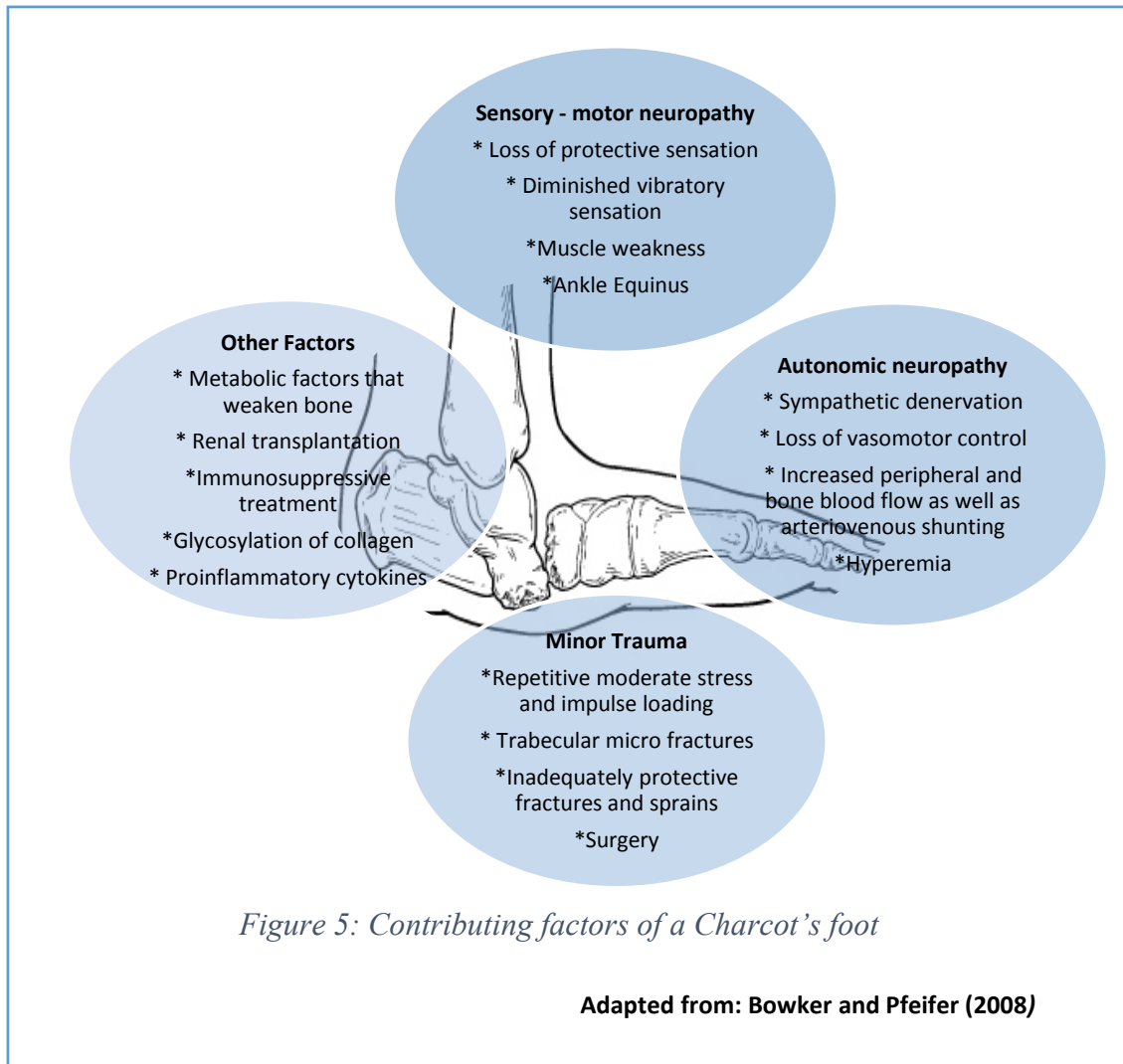
Charcot neuropathy is usually gradual in onset but can cause the rapid development of a deformity. The initial stages will present with a red, warm and swollen foot, with the affected foot having an increase in temperature of at least 2°C compared to the contralateral foot (Foster, 2006). To differentiate between Charcot's disease, gout, thrombophlebitis and osteomyelitis, a detailed clinical history is necessary. Patients often remember undergoing trauma. A physical examination and radiographic studies are required. Immobilisation, the use of specialised footwear and orthoses, infection management and surgery are treatment routes that can be used depending on the needs and stage of the specific deformity. Many cases of Charcot Foot Disease go undetected especially in its early stages and clinical progress should be monitored daily for signs of infection and the need for further treatment methods (Bowker and Pfeifer, 2008).

2.5.8 Diabetic Foot Amputations

The National Health Scheme (NHS) of England (2012) notes that the risk of amputation in diabetes is 23 times that of people without diabetes. In most cases, diabetic foot amputations are due to the formation of a gangrenous wound usually initiated by trauma and exacerbated by the poor neurological and vascular mechanisms of the diabetic foot (Assal et al, 2002). Amputation of a foot or toe is a method of limb salvage, so as to prevent the spread of infection up the leg. It is also performed on patients with large non-healing ulcers but might not necessarily embody spreading infection or be growing in size (Leung, 2007). Reduced wound healing capacity, systemic sepsis or unresolved infection often leads to tissue necrosis and gangrene; thus, amputation prevents more proximal limb loss. The reoccurrence rate of diabetic foot amputations is high because of an abnormal distribution of plantar pressure and the change of osseous architecture and subsequent amputation can be attributed to non-healing wounds, hyperglycaemia and additional diabetic foot complications (Frykberg, 2006). It is evident from studies abroad that diabetic foot amputations are a common and disruptive complication of the disease. In Russia, ulcerations and amputations are the leading causes of hospital admission for patients with diabetes and in America diabetes is the leading cause of non-traumatic lower extremity amputations (Assal et al, 2002). Various studies have indicated that a multidisciplinary approach to the diabetic foot, including a podiatrist, can reduce amputations by as much as 85% (Clarke and Tsubane, 2008; Tudhope, 2009).

2.5.8.1 Consequences of Foot Amputations

Increased mortality and morbidity rates and a reduced quality of life are the health consequences of diabetic foot amputations, the severity of which can distract from another major consequence, the various economic implications. These include surgical costs, a hospital stay, and sick days or government disability grants as well as aftercare such as check-ups, prostheses and wound dressings. It is not always considered that the cost of the amputation does not just impact the patient, but also the family and state who are required to assist to compensate for the lost limb (Tennvall and Apelqvist, 2004). Early recognition of the high risk foot is thus imperative to

reduce the mortality and morbidity associated with amputations and is best conducted by a podiatrist (Van Rensburg, 2011; Clarke and Tsubane, 2008).

2.5.8.2 Health-economic Consequences of Diabetic Foot Amputations

Numerous studies have identified the advantages and reduced rate of diabetic foot amputations which occur after the introduction of a multidisciplinary diabetic foot care team (Tennvall and Apelqvist, 2004). The team includes Diabetic nurses, a Podiatrist, Dieticians, Endocrinologist and surgeons. Their treatment will not only be of a clinical nature, but include education and counselling (Assal et al., 2002). This approach has not only improved clinical outcomes, but the economic burden on the health system is significantly reduced in proportion to the reduction in the rate of diabetic foot amputations (NHS, 2012; Carls, 2011; Assal et al. 2002). Studies have shown that the cost of implementing such a multidisciplinary team for a year was equivalent to the cost of a mere nine below the knee amputations. Thus, a multidisciplinary team approach to diabetic foot care as opposed to amputations not only drastically improves the patient's health outcomes but the costs to the state and the patient are reduced two fold. It is not only the cost of the amputation surgery that must be considered but also, ulcer dressings and limb salvage procedures, inpatient care, post-amputation care, orthopaedic and prosthetic devices, sick days and disability grants (NHS, 2012). A budget submission by the Australasian Podiatry Council in 2012 noted that the employment of podiatrists would not only prevent 600 deaths but also prevent up to 3 527 amputations and save approximately 397.3 million Australian dollars (Australasian Podiatry Council, 2012). Another study done by the Southampton University Hospital NHS Trust revealed that the implementation of a multidisciplinary diabetic wound team consisting of three podiatrists, two wound care sisters and a part time dietician would result in a net annual saving of approximately 709 119 British pounds (NHS, 2012).

Figure 6: The multifactorial etiology of the diabetic

Frykberg (2006)
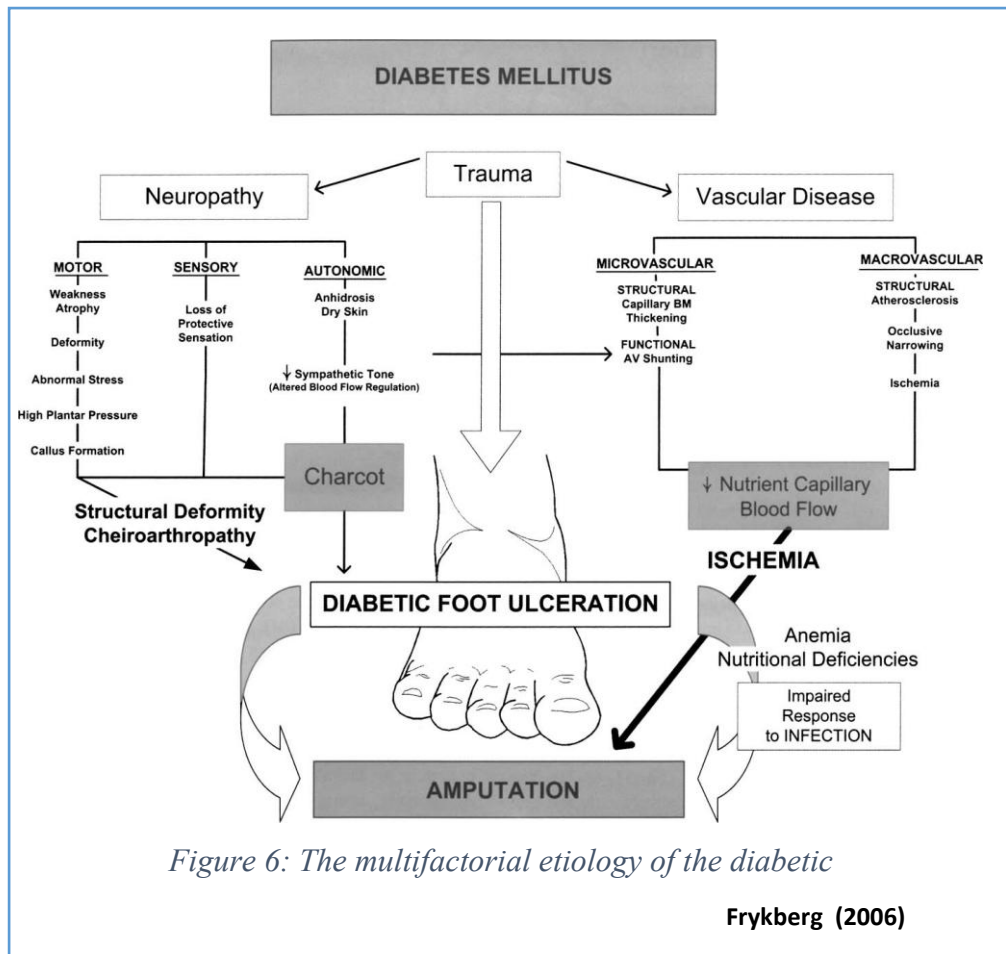
While various bodies of literature have indicated the positive effects of the inclusion of a podiatrist in the multidisciplinary team managing the diabetic patient, few podiatrists are found within the KZN public sector (Dikeeukwu, 2011).

2.6 The Role of a Podiatrist in Diabetic Foot Care

With regard to diabetic foot care, the podiatrist is seen as the gatekeeper of care and is involved in regular assessment and care of the diabetic foot, as well as introducing other medical consultants when needed. According to the International Working Group on the Diabetic Foot, the following elements are involved in podiatric care of the diabetic foot:

- Diabetic foot screenings and assessments
- Foot risk identification
- Diabetic Education
- Management of non-ulcerative foot pathologies
- Management of ulcerative foot and ankle pathologies

- Biomechanical Components

(Clarke and Tsubane, 2008; Kim et al, 2012)

2.6.1 Screening and Assessment

The diabetic foot is infamous for its susceptibility to the commonly occurring macro and micro vascular complications of diabetes. It is not uncommon for patients to present with foot complaints and as a result of routine history and examination, signs of diabetes can be identified and after appropriate diagnostic tests have been sent for diabetes can be diagnosed (Kim et al., 2012). Early detection and accurate risk classification of the diabetic foot is imperative to ensure efficient and effective management of the inevitable foot complications. In an effort to standardise and create time efficient management of the diabetic foot, several foot screening tools have been developed and implemented with varied results worldwide (Armstrong & Lavery, 2010).

An annual foot inspection, recommended for a diabetic patient presenting without foot complications, is the single most important tool available to podiatrists to prevent ulcerative foot pathologies and complications (Clarke and Tsubane, 2008; IDF, 2012). Such an assessment ensures that the vascular, dermatological, neurological and orthopaedic status of the patient is determined. Footwear is also assessed and advised upon. Foot care advice such as hygiene, inspection methods and general home care practices are explained to the patient and its importance is re-enforced (Clarke and Tsubane, 2008; Bowker, and Pfeifer, 2008). A study conducted at a regional KZN hospital to assess compliance with diabetic guidelines found that only 6% of 750 diabetic patient records noted foot examinations (Igbojiaku, Ross and Harbor, 2013).

2.6.2 Foot Risk Identification

The results of a patient's assessment and screening, together with the patient's blood glucose control, are co-related and the patient can be allocated to a specific risk category, the appropriate number of check-ups can be scheduled and a management plan can be drawn up to cater for any presenting foot complications (Boulton, Cavanagh and Rayman, 2006). Risk identification also facilitates appropriate

education, foot care and referral for each patient depending on their needs and specific situation to reduce the incidence of ulcerations and subsequent amputations (Frykberg, 2006; Clarke and Tsubane, 2008).

2.6.3 Diabetic Education

Various studies have noted that poor patient awareness and a lack of structured, continuous diabetic education lead to increased incidence of foot ulcerations and sub-optimal diabetic care (Dikeukwu, 2011; Van Rensburg, 2009). A recent research study by Saurabh et al. (2014) assessed the effectiveness of foot care education among type 2 diabetics before and after an education protocol was implemented. This study, among many others, supported the notion that the introduction of education, even when delivered infrequently in annual group sessions, has a positive impact on the outcomes of diabetic foot complications such as lower limb ulcerations (Valk, Kriegsman and Assendelft, 2001). Other studies found that the majority of patients diagnosed with sensory neuropathy had a poor understanding of their condition and performed inadequate diabetic self-care (Van Rensburg, 2009). A reduction of as much as 50% in the rate of amputations has been observed when foot care and diabetic foot education are included as part of the multi-disciplinary approach to ulcer management of the diabetic patient (Apelqvist and Larsson, 2000). The above mentioned effects have been observed in both high and low risk patients, indicating the importance of education as part of treatment as well as a prevention strategy at all levels of diabetic foot pathology (Harwell et al., 2001). In South Africa, a small study conducted in the Eastern Cape found that poor foot care knowledge and practices were common among diabetic patients with amputations and foot ulcerations (Van Rensburg, 2009). A recent qualitative study done in a rural area of KZN revealed that a major obstacle to adequate diabetes management is a lack of diabetes education, with the result that patients were not exercising, eating correctly or taking their medications correctly (Wicklund 2015).

Different types of education intervention has different effects on patient outcomes. Information from such studies can be used to identify the most effective form of education, thereby increasing compliance and maximising benefits for the patient.

The effect of lecture type education, or group education, on diabetic foot care was found to have produced only short term knowledge retention, and influenced few changes in good foot care practices (Mayfield et al., 2003). Consistent education re-enforcement has been shown to produce the best results when combined with improved diet, foot care and physical activity (Matwa et al., 2003). A study by Barth et al.(1991) found that the implementation of a more intensive education protocol than that which is usually delivered by doctors to patients in consultations yielded surprising results – an improvement in the severity of foot problems patients presented with, better patient self-care compliance, and the increased likelihood of the practitioner referring the patient to a podiatrist (Saurabh et al., 2014; George et al., 2013) These results increase the patient's chances of attaining a more favourable prognosis and recovery from the presenting foot complication (Litzelman et al., 1993). However, it has been observed that patients categorised as high risk are more likely to be advised on good foot care behaviour and risk management by practitioners, possibly pointing to the tendency of health care practitioners' delivering education in the advanced stage of the complication. If delivered earlier, the prognosis might have improved (Aguila, Reiber and Koepsell, 1994).

Podiatrists trained in South Africa are well versed in providing diabetic education. Their capacity to administer an adequate quality and quantity of diabetic education is more than adequate based on their training (University of Johannesburg Handbook, 2014; Rotchford and Rotchford, 2002). South African podiatrists are well-qualified to be a part of the multi-disciplinary team that provides care to the diabetic patient (Clarke and Tsubane, 2008).

The level, frequency and implementation of diabetic foot care education has been closely correlated with socio-economic status and literacy. Poverty and illiteracy present more frequently in a developing such as South Africa as opposed to wealthier countries where the health care system operates more efficiently (Viswanathan et al., 1999; Somroo et al., 2011). Many education strategies, such as new protocols, special training and lectures, have been implemented in other countries and could prove effective in South Africa.

There is an emerging understanding that education is more effective when delivered in combination with additional components, such as the introduction of motivational techniques, improving the focus of the education administered to address the gaps in the patient's knowledge, and educating society at large, thereby providing a support structure for diabetic patients (Rotchford and Rotchford, 2002; Weerdt et al., 1990). There is also a need for specialized training for nurses in South Africa in order to improve patient compliance, and to provide a better support structure for the diabetic patient. The benefits of such training has been observed in other countries (Rotchford and Rotchford, 2002). A study conducted at three primary health care clinics in KZN found that there is an urgent need for diabetic education at primary health care level (Moodley, 2007).

2.6.4 Management of Non-ulcerative Pathologies

This involves the management of the diabetic foot before the formation of an ulcer. Nail pathologies, dermatological lesions and conditions, topical infections, foot deformities, and the potentially harmful consequences of aging such as heel fissures as well as the consequences of poor fitting footwear or biomechanics such as blisters and minor abrasions are all assessed and treated. Nail infections such as onychomycosis, which is often neglected because it is seen as a merely aesthetic problem, can lead to more serious complications such as cellulitis in the diabetic patient. A podiatrist can offer treatment advice and administer laser therapy to treat the fungal nail infection and reduce the risk of diabetic foot complications (Thompson, 2013). Early intervention in response to these seemingly trivial manifestations of the diabetic foot can reduce plantar pressure, foot discomfort and the potential for ulceration (Clarke and Tsubane, 2008; Bowker, and Pfeifer 2008).

2.6.5 Management of Ulcerative Pathologies

The initial assessment of the diabetic ulcer is comprehensive and involves defining its parameters and the presence and severity of the factors affecting its healing (Frykberg, 2006),

The classification and microscopy of ulcerated tissue serve to provide more insight into the specific wound. The possible aetiology is determined and infection control is prioritised (Clarke and Tsubane, 2008).

Debridement, dressings and more advanced forms of wound management such as growth factors and negative pressure application can be attempted. For ulcers that are in contact with footwear, a strict offloading protocol is imperative for wound healing and methods such as special shoes, total contact casting, crutches and bed rest are usually the most common. Failure of the wound to heal would require surgical management such as deep debridement, deformity correction and plastic surgery. Once the ulcer is healed, education, orthosis and general podiatric care is re-instated and emphasised. Throughout the process of ulcer management, co-morbidities are managed and the vascular and neurological status is monitored (Frykberg, 2006).

The categories discussed above are addressed by a podiatrist and best suited to each patient's needs. In hospital settings abroad, podiatrists take on additional roles such as liaising with the other members of the multidisciplinary team, booking the investigations required such as angiograms, ensuring that the correct type and dosage of medication and treatment regimens are administered to diabetic patients, organising specialised off-loading tools such as pressure relieving mattresses and orthopaedic devices, checking pathology results, attending ward rounds and educating nurses and student doctors (Foster, 2006).

The guidelines set by authorities such as SEMDSA and the IDF can be more easily adhered to when podiatry is integrated into the general diabetic care protocol. International evidence-based guidelines provide standard foot care for diabetic patients, and have been adapted to differences in resource availability, access to care, level of education and health structures in developing and developed countries. According to the IDF, the formal guidelines include three levels of care, recommended, comprehensive and limited for countries with limited resources (IDF, 2012).

2.6.6 Biomechanical Components

The altered biomechanics in the diabetic patient result in distal muscle atrophy, digit deformities, migration of the plantar fatty padding, limited joint motion, changes to the Achilles tendon and plantar fascia and changes to the plantar pressure distribution. To assess such musculoskeletal variations, podiatrists often conduct an examination to assess any structural or functional variations that could cause potential damage to the patient. Various conservative biomechanical strategies that allow for a reduced ulceration risk can be implemented by a podiatrist. Therapeutic footwear can be prescribed or current footwear modified by adding components such as rocker bottom soles that reduce plantar pressure. These measures reduce the risk of reulceration by 50% (Van Rensburg, 2011). The use of total contact casting in the management of diabetic foot ulcerations have been proven to be highly effective in studies done abroad, and more recently, in a South African setting (Howard, 2012). Other palliative and preventative measures such as prescription accommodative or functional orthoses, comfort innersoles, and padding and strapping reduce or prevent trauma, promote healing and contribute to limb salvage (Frykberg, 2006; Kim et al., 2012).

2.7 Conclusion

Every 30 seconds a lower limb is lost somewhere in the world as a consequence of diabetes (Clarke and Tsubane, 2008). It has been estimated that diabetes will kill more than half of those suffering from this disease in Africa within a relatively quick period after initial presentation of complications, reducing their life expectancy to that of a patient in Europe or North America before the insulin became widely available (Azevedo, & Alla, 2008). More efficient and effective treatment strategies are needed to deal with the surge in diabetic patients expected in coming years. Several studies have shown that a multidisciplinary team approach to managing the diabetic foot not only improves the efficiency and quality of the care provided, but significantly reduces the rate of lower limb amputations and promotes greater compliance with the foot care guidelines set by international and national authorities (Armstrong and Lavery, 2010). In addition to the immediate benefits for the patient, numerous studies have shown that this approach reduces health care costs when compared to standard care (Frykberg, 2006).

This literature review highlighted the need for podiatrists to be part of the multidisciplinary team that manages the diabetic patient in health care. Diabetic foot care provided by podiatrist in a team setting includes footwear assessment and advice, and musculoskeletal, vascular, dermatological and neurological assessment as well as education on the disease, treatment and self-care practices (Thompson, 2012). The integration of podiatrists in the public health systems abroad has been proven to not only reduce the number of diabetes-related foot complications and amputations but also reduce the cost of these complications (NHS 2012; Tennvall and Apelqvist, 2004). With the impending surge of newly-diagnosed diabetics predicted by the IDF, improving outcomes and reducing the cost of providing health services are priorities. The strategy of appropriately distributing podiatrists within the public health care system can contribute greatly to achieving these se priorities. To implement such a strategy, the current incidence, prevalence and distribution of diabetic patients and the present availability of podiatrists in the country needs to be established. This permits the appropriate placement of practitioners into different areas, depending on patient needs. A provincial distribution plan could lead the way for national distribution of not only health care services in podiatry but also create impetus to review the distribution of health care services in other health care disciplines.

CHAPTER 3 – RESEARCH METHODOLOGY

This chapter discusses the context, research design, and data collection methods and analysis and highlights the ethical considerations taken into account in conducting the study.

3.1 Context

This study was conducted in the province of Kwa-Zulu Natal, a coastal province of South Africa. The province is known to have the busiest harbour in the country and one of the 10 biggest in the world. KZN has a rich cultural diversity and contains 11 districts (SAinfo reporter, 2011). The city of Durban, said to be one of the fastest growing urban areas in the world, is the city with the largest population of Indians outside of India (SAinfo reporter, 2011; Mukherji, 2011). South African Indians have been found to have a genetic predisposition to diabetes mellitus (Omar, 1994; Motala, 2003). It is for the great diversity between the socioeconomic status of the districts of KZN and the presence of a high risk population (South African Indians) that the province of KZN was chosen for this study (Wright G & Noble M, 2007).

3.3 Study Design

This study set out to collect, analyse and interpret data on the distribution of patients diagnosed with diabetes and podiatrist employed in the public health sector of KZN. Such data offers a broad view of the state of diabetes in the KZN public health sector and as such, introduces the concept of identifying high risk areas that are in need of more intensive diabetic services. Hence a retrospective audit was conducted of the KZN Department of Health database. This exploratory review serves to inform the research objectives and suggest possible solutions for specific problems (Research Methodology, 2015).

3.4 Study Sample

The number of patients diagnosed with diabetes in the public health care sector between 2010 and 2014 was extracted from the KZN Department of Health database. The sample of podiatrists was obtained from those currently registered with the Department. The sample size was recorded as 503 data entries after raw data was cleaned with entries ranging from 0

to 262 827 on patients diagnosed with diabetes in KZN. Only 2 data entries were found on the number of podiatrists employed in the KZN public health sector. Both groups (Diabetic patients and podiatrist in the KZN public health sector) were used at 100% attendance or involvement, thus reducing the sampling error and ensuring a full representation of the sample. This sample was sufficient to draw reliable inferences and ensured the external validity and reliability of the study.

3.5 Data Collection

The District Health Information System (DHIS) is the primary data collection system of the Department of Health in KZN and served as the instrument of collection for this study. Data is routinely collected at all public healthcare facilities in the province and is aggregated per facility with no individual patient identifiers. Data collected by DHIS for all diabetic patients seen at public health care facilities within KZN from 1 January 2010 to 31 December 2014 was obtained and analysed after ethics approval by the University of KwaZulu-Natal (Biomedical Research Ethics Committee, (HSS/0036/015M)) (Annexure 1) and the KwaZulu-Natal Department of Health (HRKM 033/15) (Annexure 2).

Primary data is collected by a manual process involving the recording of each newly-diagnosed diabetic patient in a logbook. The logbooks are then collected by the facility's information officer, who is responsible for transferring the handwritten information in the logbooks to an electronic spread sheet containing collection fields specified by the Department of Health.

Since 2013, data on the number of newly diagnosed diabetic patients in the public sector has been recorded as the fields 'Diabetes client 18 years and older new', 'Diabetes client treatment new' and 'Diabetes client under 18 years new'. Additional data collection fields were added to the DHIS database in 2013 to document the number of diabetic patients who have defaulted treatment and the number of diabetes-related amputations. The distribution of defaulting patients among the districts of KZN was analysed to determine the degree of noncompliance and assess its relationship with mortality as recorded by the diabetes mortality estimates as reported in Statistics South Africa in 2013. The distribution of diabetes-related amputations was analysed to determine high risk districts and assess the

relationship of this distribution with mortality as recorded by the diabetes mortality estimates.

Information was collected within the following variables:

1. The total number of newly diagnosed diabetic patients registered within the KZN public health sector from 2010 to 2014 grouped by the type of health facility and district

2. The total number and location of diabetic patients on register within the KZN public health sector in and between 2010 and 2014 grouped by the type of health facility and district

3. The number of amputations and defaulting patients recorded for 2010 to 2014 grouped by district.

4. The number of podiatrists within the KZN public health sector grouped by geographical area of service.

All the data, which was secondary in nature, was selected and extracted by the Department of Health after permission was granted according to their prescribed permission form. The data was obtained in raw spread sheet form.

The open-source database of the National Health Trust (NHT) was accessed for estimated medical scheme coverage. The SAIMD was accessed for data on socio-economic status to assess the relationship between diabetes and urbanisation of the districts in KZN (Wright & Noble, 2007).

Data from the South African National Health and Nutrition Examination Survey (SANHANES) was used to determine the undiagnosed diabetic population. The SANHANES is a continuous population health survey that explores the evolving and specific health needs of South Africans, especially non-communicable diseases such as hypertension and diabetes. Utilising a population sample that closely represents the population of South Africa, participants reported their specific health problems through a questionnaire-based interview and afterwards underwent a physical examination and provided a blood specimen.

Data on the number of South African podiatry graduates was requested from and provided by the University of Johannesburg, South Africa, at present the only academic institution that educates podiatrists in South Africa.

3.6 Data Analysis

Following the data extraction process, the data was manually cleaned and captured in a Microsoft Excel 2013 worksheet. Each individual data entry was recorded in a row-column format. Column headers were logically sequenced, with successive columns encompassing more detail. Each column header provided a description of the contents of each of data entry, with the leftmost column providing a reference or key to the original data. Prior to analysis, the data was checked for any errors which may have been captured in the recording process. This process was repeated once more by an independent, third party to ensure error-free capture, robust analyses, and well-founded inferences.

Pivot tables were used to automatically categorize and display summarized results in rows and columns, and to generate cross tabulations and visualize correlations.

Time series analyses were conducted on several data categories which provided insight into data trends and rates. Cross-sectional analyses were also conducted to understand the general dispersion of different variables, to identify areas of high incidence as well as to identifier outliers. Graphical representation of the analyses was conducted using Think-Cell, version 6 software. The individual analyses under each category were represented by various chart forms and illustrations which provided a visualization of trends and highlights. Anomalies were identified, and cross referenced back to the data record and raw data to ensure accuracy and robustness of the data. Where applicable, these anomalies informed additional research in order to provide a more comprehensive view of the results.

A normalised average (Standardization of data obtained from different sources at different periods (BusinessDictionary.com)) would have been skewed by older data, and thus a more accurate reflection of the current distribution of new cases in KZN was drawn from the most recent two years (2013 and 2014). Data points closer to the start of the five-year period may contain extraneous factors which could compromise the current distribution. Economic and social factors such as urbanisation, employment trends, and

population migration may change over the five-year period under scrutiny, thus affecting the validity and robustness of the results. In order for policy recommendation to be properly formulated and executed, it is recommended that the information extracted be the most recent reflection of the current state.

Data provided from the NHT was used to exclude private health care users and calculate the incidence of diabetes within the public sector. The total number of new diabetic patients recorded by district was divided by the public sector populations and then multiplied by 10 000 to allow for the comparison of whole numbers. The resultant incidence rates are represented per 10 000 patients.

To calculate the incidence of diabetes in the public sector, the denominator or population would ideally be the population of patients that are seen by public facilities. Unfortunately only a headcount is available and in most districts this figure is larger than the population. This occurs because a patient is counted as part of the total every time they visit the public health facility during a particular year. The public health utilization rate could not be used as it is calculated using the total population and the public health head count and thus does not account for the private health sector. The number of patients on the register for each district and public health facility could not be determined as the current data collection process does not assign patients an individual Department of Health patient number. To determine the public sector population, the total population was reduced by the individual private scheme utilisation data to exclude from the population, those who were registered with private medical aid schemes and allow both the numerator and denominator to represent public sector populations.

The prevalence rates analysed in this study between the years of 2010 to 2014 and not for a five-year period to avoid ambiguity. In essence, by determining the incidence rate, the growth of the condition between the years analysed would ideally equal the rate of change of prevalence over the same time series. Medical scheme coverage data was used to exclude the population of private health users from the denominator in order to determine the prevalence of diabetes mellitus within the public sector.

Various studies estimate the proportion of undiagnosed diabetic patients at between 30% and 70% of the known diabetic population. Using the data from South African National

Health and Nutrition Examination Survey (SANHANES) the undiagnosed diabetic population was calculated to be 48% (Human Sciences Research Council, 2013) and was used to calculate the estimated prevalence of diabetes mellitus.

3.7 Limitations

As anticipated a limitation of the study was the occurrence of data inconsistencies and errors. Duplicated and inconsistent data entries were identified such as the recording of a different number of facilities in a district between different years. These errors may be attributed to the manual data collection process that occurs at the primary level as highlighted earlier in this chapter. Furthermore, it was expected that, as data was manually cleaned, human error before data analysis could pose an additional limitation.

3.8 Ethical Considerations

Ethical clearance was obtained from both the University of KwaZulu-Natal (Biomedical Research Ethics Committee, (HSS/0036/015M)) (Annexure 1) and the KwaZulu-Natal Department of Health (HRKM 033/15) (Annexure 2). In order to ensure anonymity, personally identifiable data of patients and podiatrists that might allow them to be identified was not recorded.

CHAPTER 4 - RESULTS

This chapter presents the results as per study objectives outlined earlier:
- The distribution of patients diagnosed with diabetes by district and age.
- The distribution of defaulting patients and diabetes-related amputations recorded for 2014.
- The incidence of diabetes mellitus in the KZN public health sector and between the years 2010 to 2014.
- The prevalence of patients diagnosed with diabetes in the KZN public health sector in 2014, by province and by district.
- Correlations and Relationships
- The number and distribution of podiatrists working in the KZN public health sector.

4.1 **The Distribution of Patients Diagnosed with Diabetes Mellitus in KZN**

4.1.1 Distribution by District

The district previously known as Sisonke is now known as Harry Gwala but appeared as 'Sisonke' in the raw data. 'Sisonke' is thus used throughout this report. Additionally eThekwini is known as a metropolitan municipality, but, for the sake of data collection, eThekwini is represented as a district of KZN and will be referred to as such throughout this thesis (The local government handbook).

A normalised two year average (2013/2014) was used to represent the true distribution. The data is presented in Table 2 below and graphically in Figure 7.

Table 2: The distribution of diabetic patients within the public sector

District	2013	2014	Total	Two-year average
Amajuba	51 741	57 952	109 693	54 847
eThekwini	480 531	518 878	999 409	499 705
iLembe	83 783	87 144	170 927	85 464
Sisonke	41 739	48 220	89 959	44 980
Ugu	103 331	111 790	215 121	107 561
uMgungundlovu	147 522	152 263	299 785	149 893
Umkhanyakude	36 919	40 364	77 283	38 642

Umzinyathi	44 917	50 809	95 726	47 863
Uthukela	45 645	48 368	94 013	47 007
Uthungulu	137 264	149 472	286 736	143 368
Zululand	67 246	72 047	139 293	69 647
Total	**1 240 638**	**1 337 307**	**2 577 945**	**1 288 973**

The values in Table 2 are illustrated in the form of bar graphs in Figure 7 that shows each district's proportion of the total number of diabetic patients in the province. The normalised averages for each district are recorded on the top of each bar. The map in Figure 8 provides a clear view and allows for simple comparison of the districts. Both figures show the same values.

Figure 7: Number of diabetic patients by district
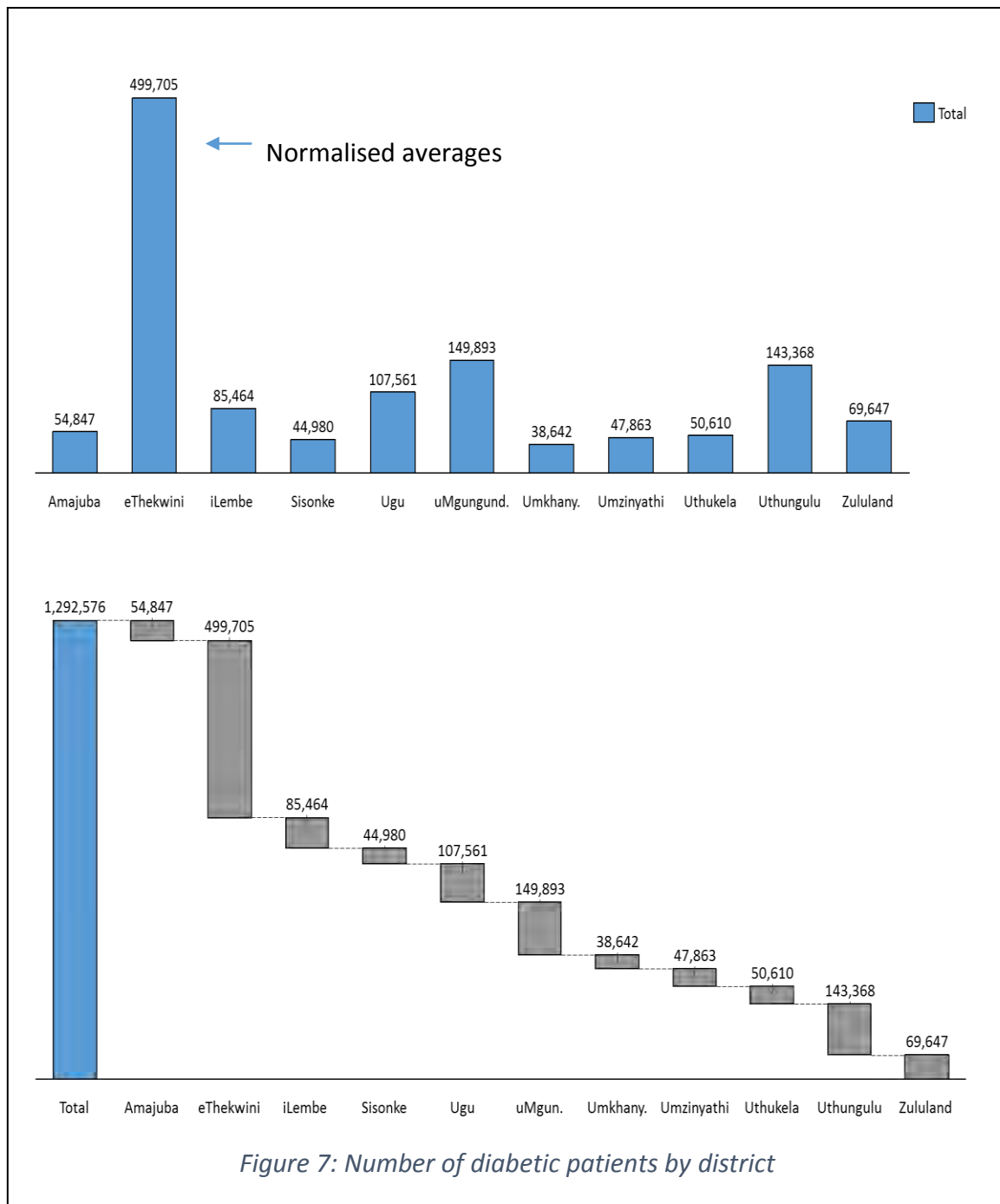
The heat map in Figure 8 is of the same data and allows for simple comparison of the districts. The normalized average values were converted to percentages and mapped by district. Darker colours represent greater density. Of the total number of diabetics in the province, 38.8%, were treated in the district of eThekwini.
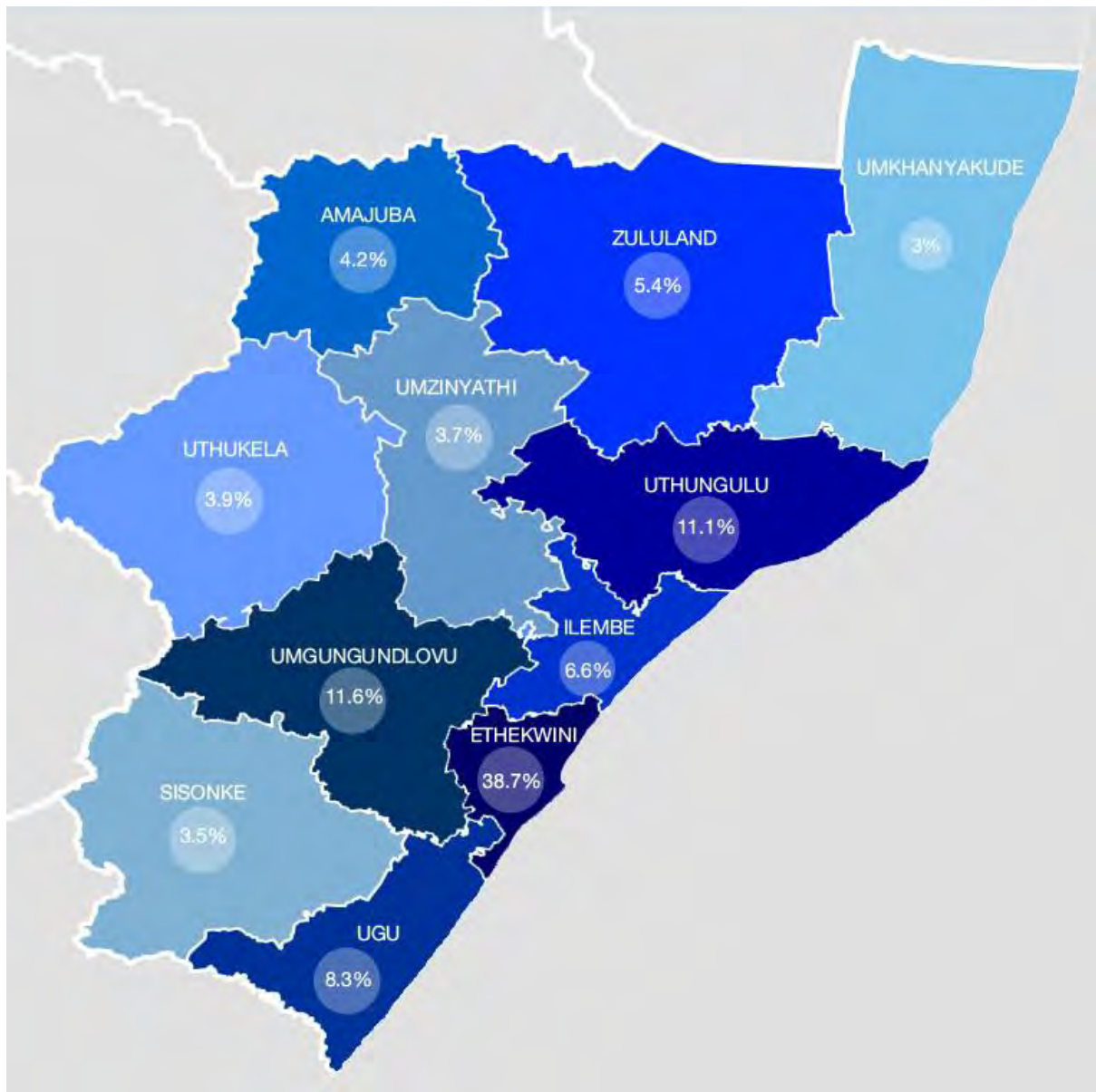
Figure 8: Map of the distribution of patients diagnosed with diabetes in the public sector in KZN

4.1.2. Distribution by Age

The two-year (2013 to 2014) normalised values on the distribution of patients diagnosed with diabetes categorised by age (18 years and younger / above 18 years of age) were determined by analysing the data from the KZN Department of Health database, the absolute values of which are tabulated in Table 3 below. The collection of age specific data is a relatively recent field addition (from 2013) to the KZN Department of Health's database.

Table 3: The distribution of new diabetic patients in the public sector by age

	Two-year average of new patients 18 years and older	Two-year average of new patients younger than 18 years	Total new patients
Amajuba	305	63	368
eThekwini	6 635	657	7 292
iLembe	483	75	558
Sisonke	695	69	764
Ugu	1 152	109	1 260
uMgungundlovu	1 535	202	1 737
Umkhanyakude	340	52	392
Umzinyathi	402	32	434
Uthukela	298	45	343
Uthungulu	855	65	919
Zululand	793	44	837
Total	**13 491**	**1 410**	**14 901**

Figure 9 presents the above distribution information in a 100% graph so as to compare the normalised distribution of age between the different districts of KZN.

Figure 9: Age distribution of newly diagnosed patients (two year average)
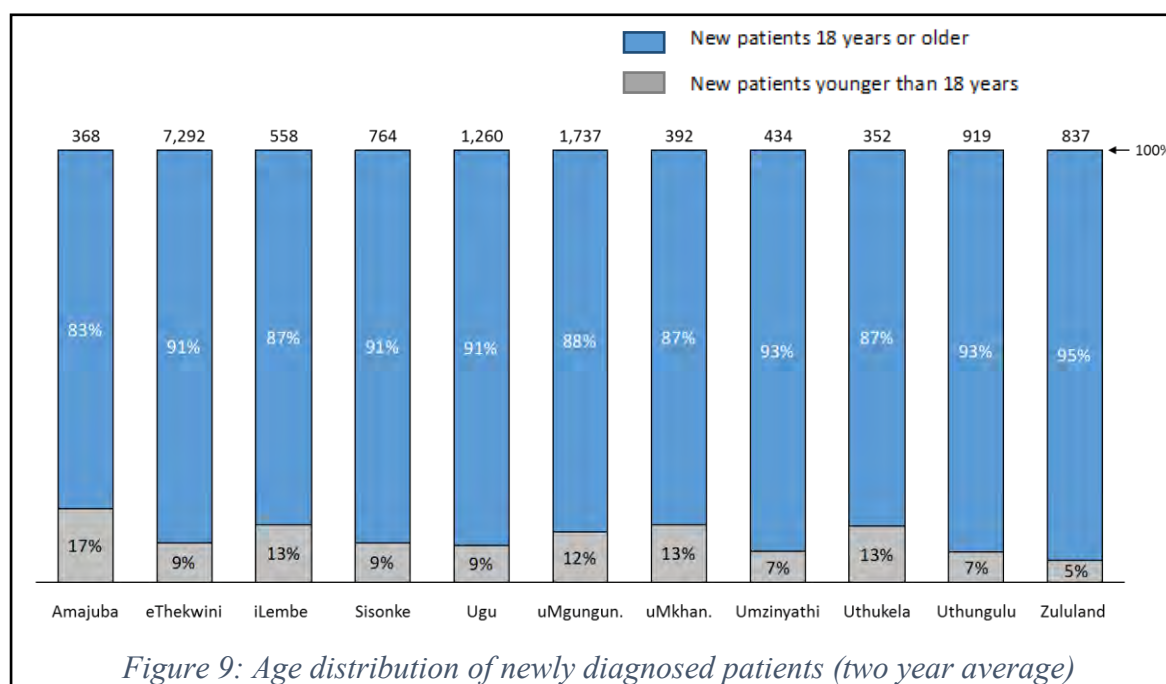
4.1.3 The Distribution of Defaulters in KZN

Figure 10 presents the data collected on the distribution and number of defaulters (diabetic patients who did not return for regular treatment), and indicates the percentage difference between 2013 and 2014 by district.

Figure 10: The distribution of defaulting diabetic patients in the districts of KZN
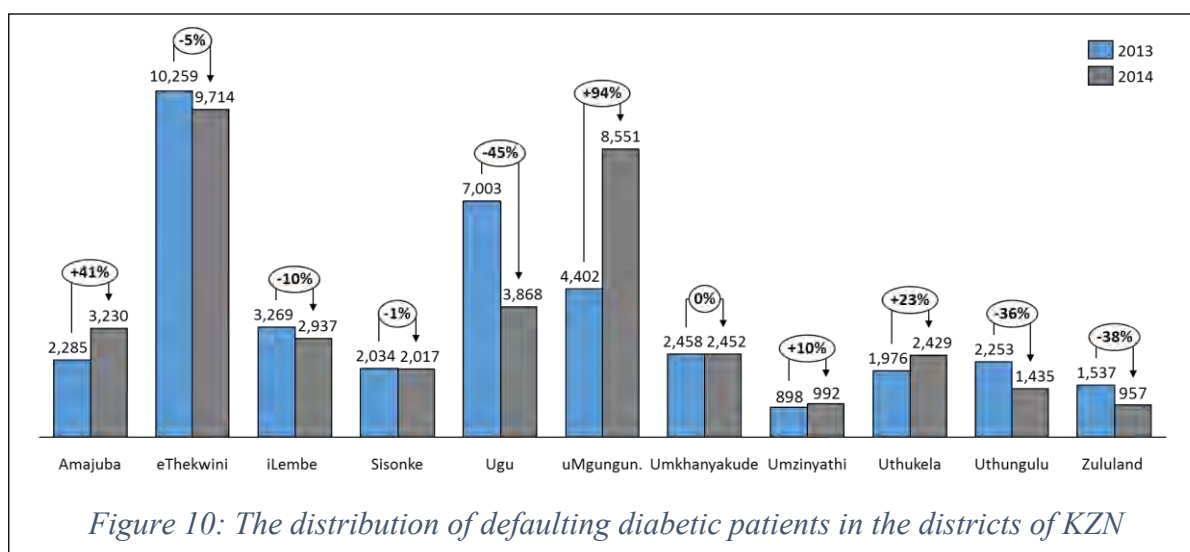
Figure 10 shows that the district of eThekwini had the highest number of defaulters, followed by Umgungundlovu and Ugu.

4.1.4 Distribution of Amputations

Since 2013, the KZN Department of Health has collected data on the frequency of diabetes-related lower limb amputations. The data is represented in absolute values in Figure 11 below.

Figure 11: The distribution of diabetes-related amputations recorded in the districts of KZN
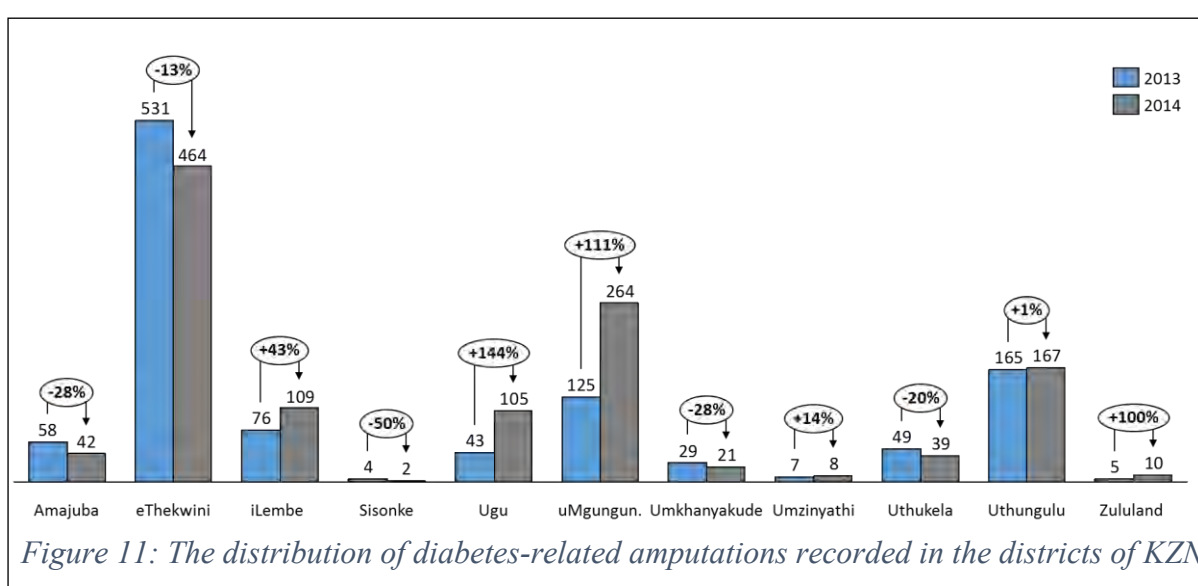
Figure 11 shows that the district of eThekwini had the highest record of amputations for both 2013 and 2014 and the district of Sisonke had the lowest record of amputations in both years.

4.2 The Incidence of Diabetes Mellitus in KwaZulu-Natal in and between 2010 to 2014

Incidence rate/ density is calculated as shown below:

Incidence rate = $\dfrac{\text{The number of new cases over a period of time}}{\text{The population at risk in that period of time}}$

The total numbers of new patients recorded for each district are presented in the tables below, followed by the corresponding charts.

Table 4: The number of new diabetic patients recorded for the years 2010 to 2014

	2010	2011	2012	2013	2014	Total
Amajuba	4 570	509	653	414	321	6 467
eThekwini	12 581	11 377	11 833	6 692	7 891	87 535
iLembe	927	825	850	375	740	3 717
Sisonke	322	442	559	904	623	2 850
Ugu	707	1 019	1 054	1 090	1 430	5 300
uMgungundlovu	2 539	2 615	1 795	1 537	1 937	10 423
Umkhanyakude	935	500	406	361	423	2 625
Umzinyathi	392	318	342	506	361	1 919
Uthukela	322	320	320	239	446	1 647
Uthungulu	2 491	2 547	3 134	1 023	815	10 010
Zululand	2 107	896	865	795	878	5 541
Grand Total	27 893	21 368	21 811	13 936	15 865	138 034

A drop in numbers was recorded for most districts in 2013. This marked the Department of Health's introduction of new data collection fields to record diabetes-related data (Health Systems Trust[2], 2014).

Figure 12 shows the number of patients newly diagnosed with diabetes from and including the years 2010 to 2014, for all districts in KZN.

Figure 12: Percentage of new patients in KZN by district 2010 to 2014
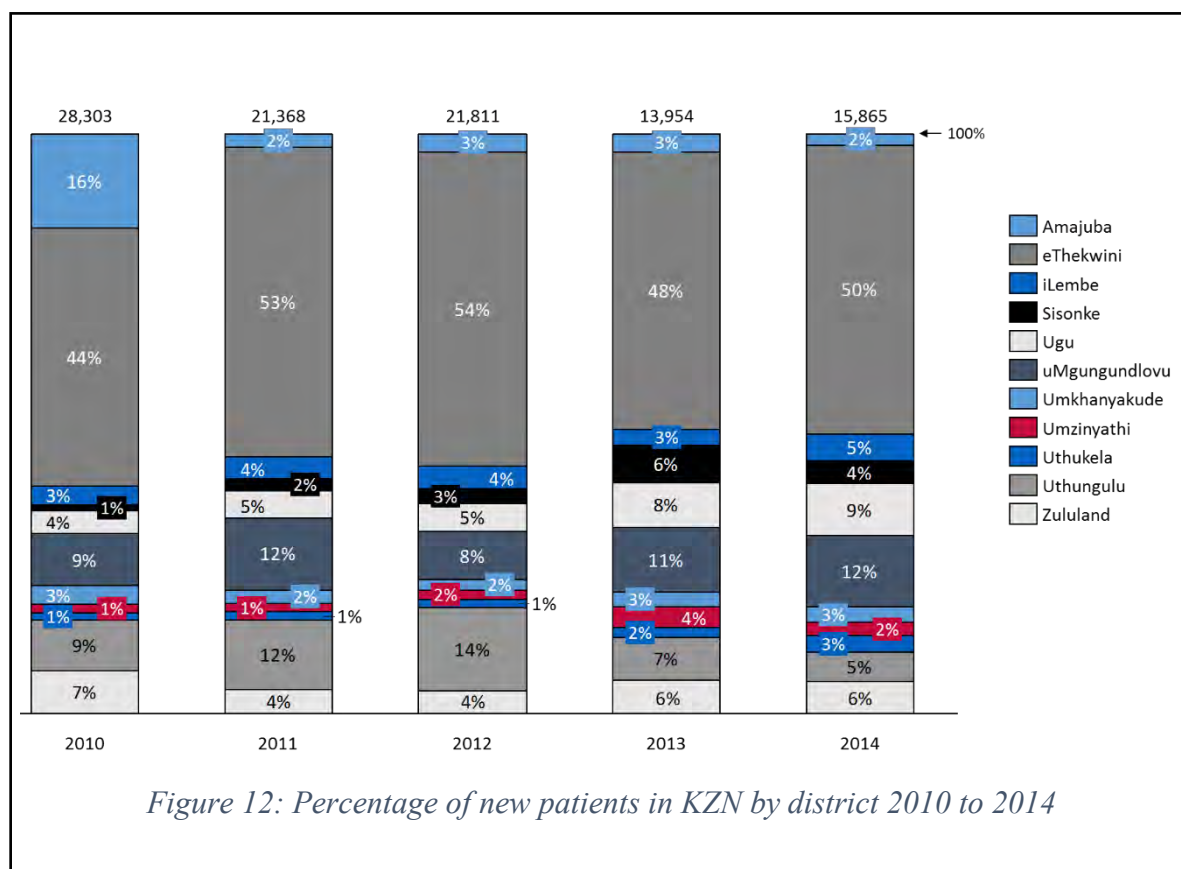
As illustrated in Figure 12, the total number of newly diagnosed diabetic patients fell by approximately 7 000 in 2013. In each year covered, close to 50% of the total number of newly diagnosed diabetics was recorded in the district of eThekwini. The districts with the lowest numbers of diabetic patients during these years were Sisonke, Umzinyathi and Uthukela.

Incidence rates from 2010 to 2014 were calculated using the number of newly diagnosed patients as previously displayed and the population of each district. The total population of each district includes those using private health care. Data provided by the National Health Trust on estimated medical scheme coverage was obtained so as to exclude private health care users and calculate the incidence of diabetes within the public sector. It should be noted that while citizens who use private health care are not likely to brave the poor facilities

provided by the public health care sector, they can access public health care if they wish to do so.

The denominator used to calculate the incidence of diabetes mellitus within the public health sector in KZN was determined by subtracting the individual private medical scheme coverage from each of the total district population totals. These results are represented per 10 000 patients in Figure 13 so as to allow for the comparison of whole numbers.

Figure 13: Incidence rate timeline by district: 2010 to 2014
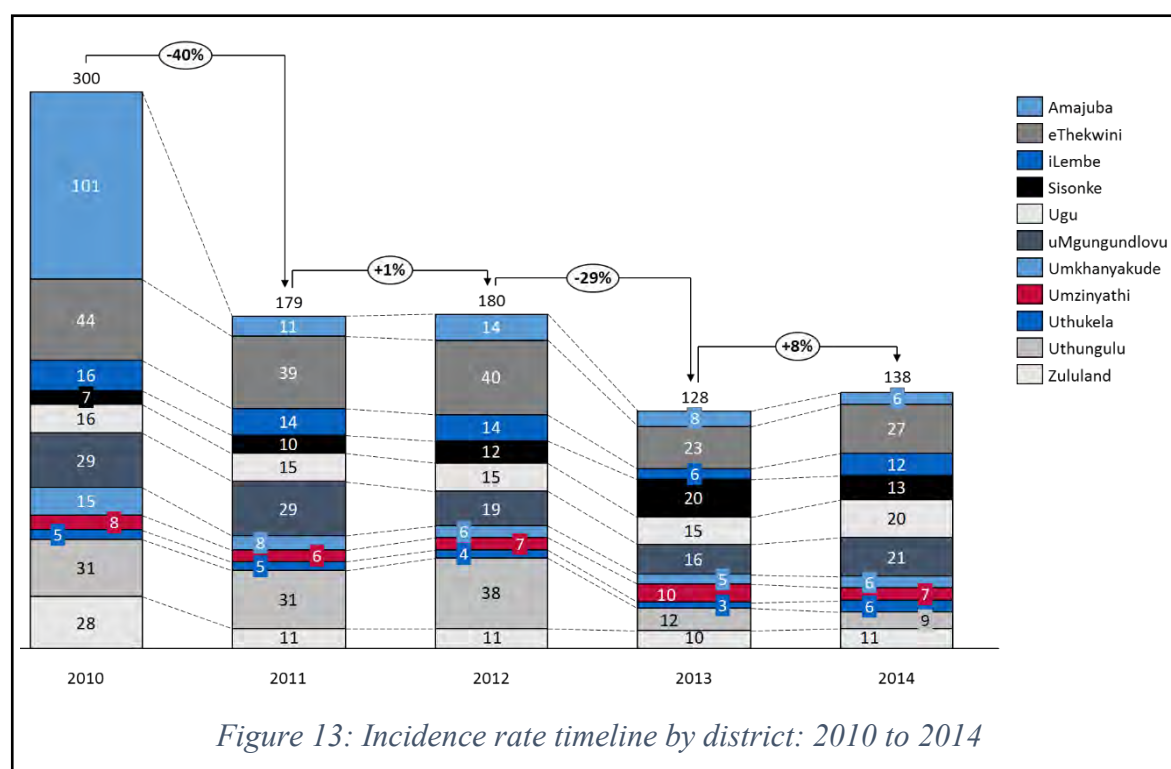
Figure 13 shows that, the number of newly diagnosed patients declined from 2010 to 2011. The number of patients decreased in eThekwini, Zululand, Umzinyathi, and Umkhanyakude, with the largest decrease occurring in the district of Amajuba. The incidence rate in KZN between 2010 and 2014 is depicted at the top of each bar and is seen to fluctuate.

The incidence of diabetes by age group was determined using data retrieved from Statistics South Africa on the mid-year population estimates by year as well as the data collected from the KZN Department of Health database. The private sector utilisation rate was not taken into account for this set of results; they are therefore solely based on age distribution.

Table 5 shows newly diagnosed patients sorted by age (younger and older than 18) in KZN for 2013 and 2014. This field of data was only collected since 2013. The population data used to calculate the incidence was obtained from Statistics South Africa and was also categorised by age with slightly different categories (younger and older than 19).

Table 5: Number of newly diagnosed patients with diabetes

	2013		2014	
	Under 18	Over 18	Under 18	Over 18
Amajuba	94	320	31	290
eThekwini	697	5 995	617	7 274
iLembe	70	305	79	661
Sisonke	90	814	48	575
Ugu	81	1 009	136	1 294
uMgungundlovu	96	1 441	308	1 629
Umkhanyakude	51	310	53	370
Umzinyathi	35	471	28	333
Uthukela	29	210	61	385
Uthungulu	69	954	60	755
Zululand	22	773	65	813
	1 334	**12 602**	**1 486**	**14 379**

Figure 14: Incidence of diabetes by district and age profile (per 10 000 people)
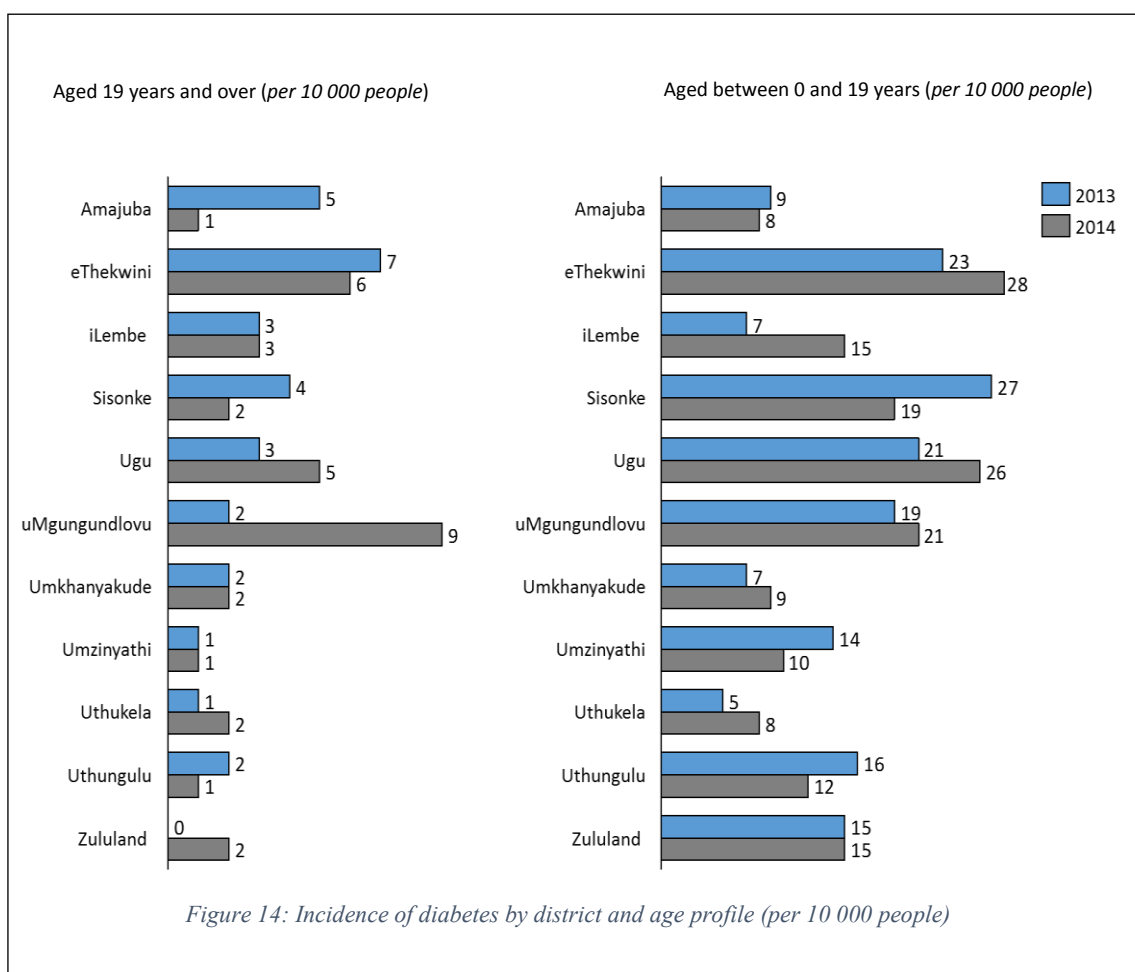
As seen in Figure 14 above, in all districts in both 2013 and 2014, the number of newly diagnosed diabetics over the age of 19 was more than those younger than 19.

4.3 The Prevalence of Patients diagnosed with Diabetes in the KZN Public Health Sector in 2014

4.3.1 Provincial Prevalence

In this study, prevalence is defined as the proportion of a population found to have a condition (in this case diabetes in 2014). These patients appeared on the KZN Department of Health register as being diagnosed with diabetes and were seen at the public health facility in 2014.

Crude prevalence is the rate that applies to the population as a whole (total population), and has not been adjusted to account for differences in population structures such as age and gender. It is calculated using the formula below (Understanding public health data, NHS public health network, Bristol):

4.3.1.1 Provincial Crude Prevalence of Patients in the Public Health Sector

Crude Prevalence   = (cases/population) x 100

                             = 1 337 307/10 694 437 x 100

                             = 0.1250470104 x 100

                             = 12.5 %

According to the data collected from the KZN Department of Health, a total of 1 337 307 diabetic cases appeared on the register for 2014 from the months of January to December for all public health facilities in all 11 districts of the province. Using the mid-year population estimates for 2014, a crude prevalence of 12.5 % was calculated for the entire province of KZN, not considering diabetic patients in the private health sector and those who were undiagnosed.

Figure 15: Crude prevalence of diabetes in KZN within the public health sector

4.3.1.2 Provincial prevalence of diabetes mellitus in the public sector

As Figure 15 does not include those in the KZN population using private health care schemes data was obtained from the National Health Trust on the estimated medical scheme coverage so as to exclude private health users and calculate prevalence within the public sector. The estimated medical scheme coverage is 12.63% and was calculated using the totals of the district calculations.

Figure 16: Total number of people in KZN with access to public sector healthcare only (2014)
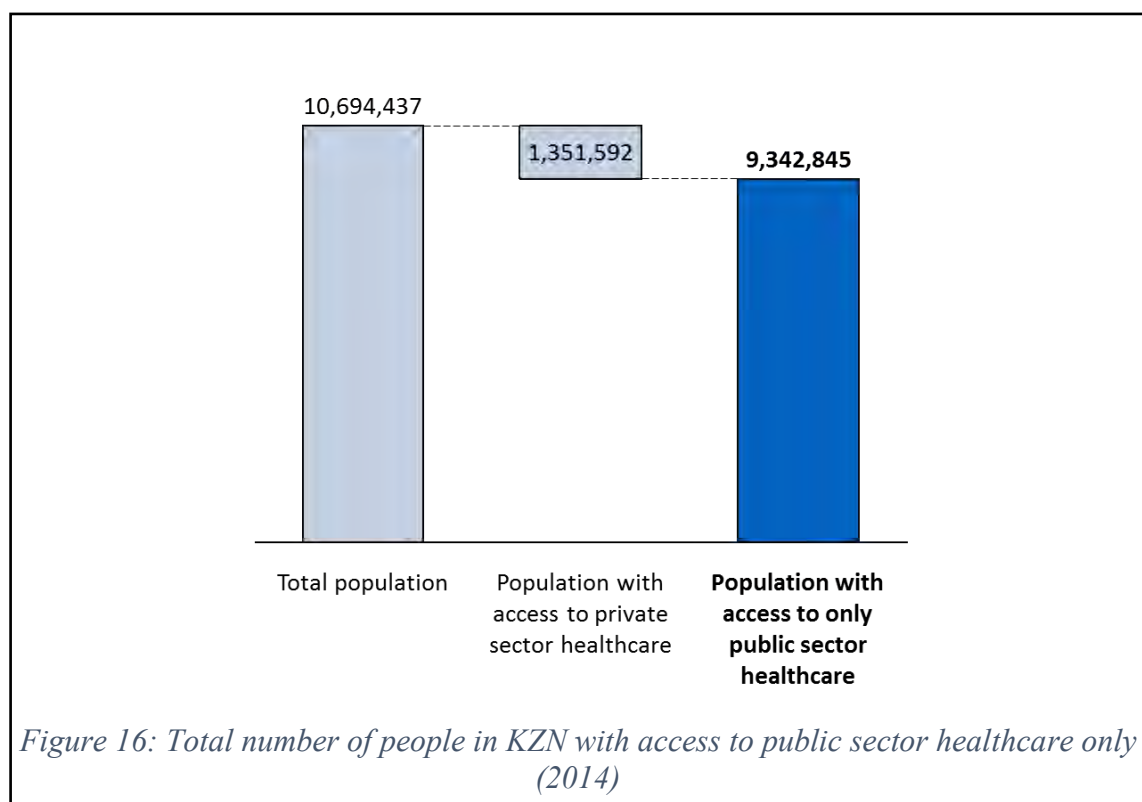
The reduced total population which excludes private health users resulted in a new population of 9 342 845. Prevalence within the public health sector was thus 14.3% as illustrated in Figure 17.

Figure 17: Crude prevalence of the proportion of the total population of KZN versus the total population of KZN with access to public sector healthcare only
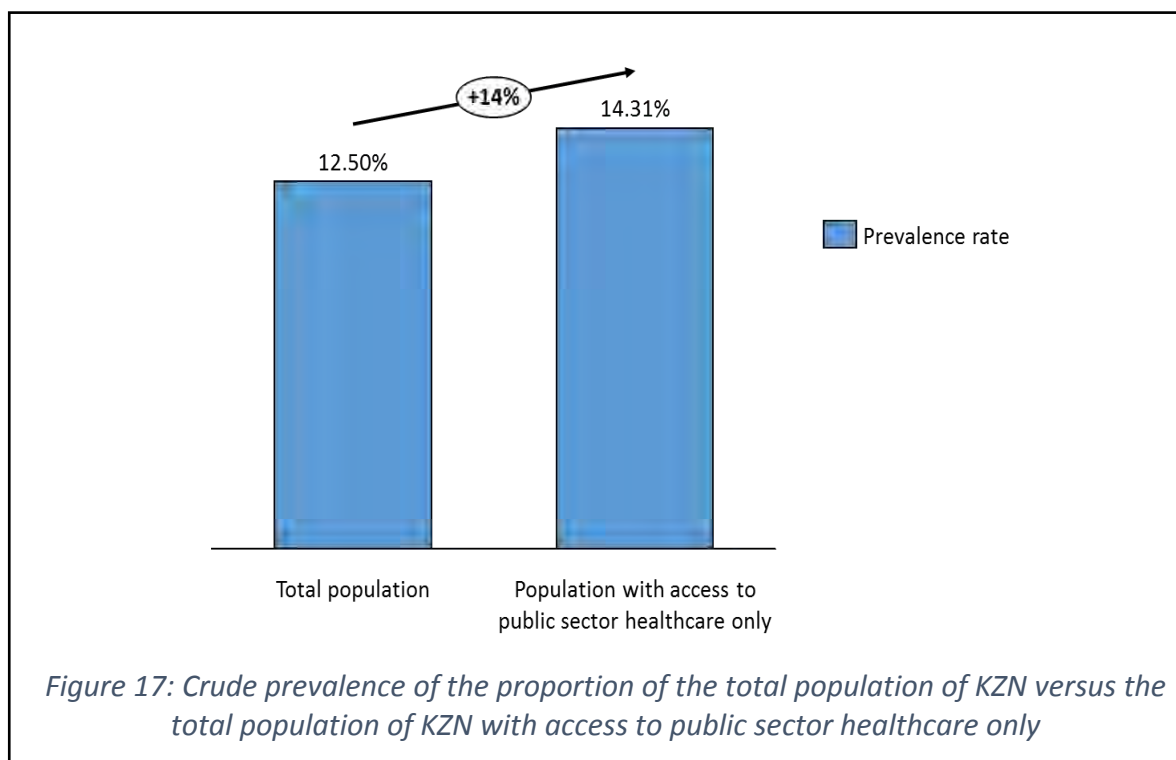
4.3.1.3 Provincial Total Diabetes Prevalence Estimate

Various studies estimate the proportion of undiagnosed diabetic patients at between 30% and 70% of the known diabetic population but few present data that take race and age into account.

As described in Chapter 3, SANHANES was used to establish the undiagnosed diabetic population and was calculated to be 48%. This is factored into the following figure to determine the KZN and estimated total district diabetes prevalence.

Figure 18: Diabetes prevalence rates in KZN
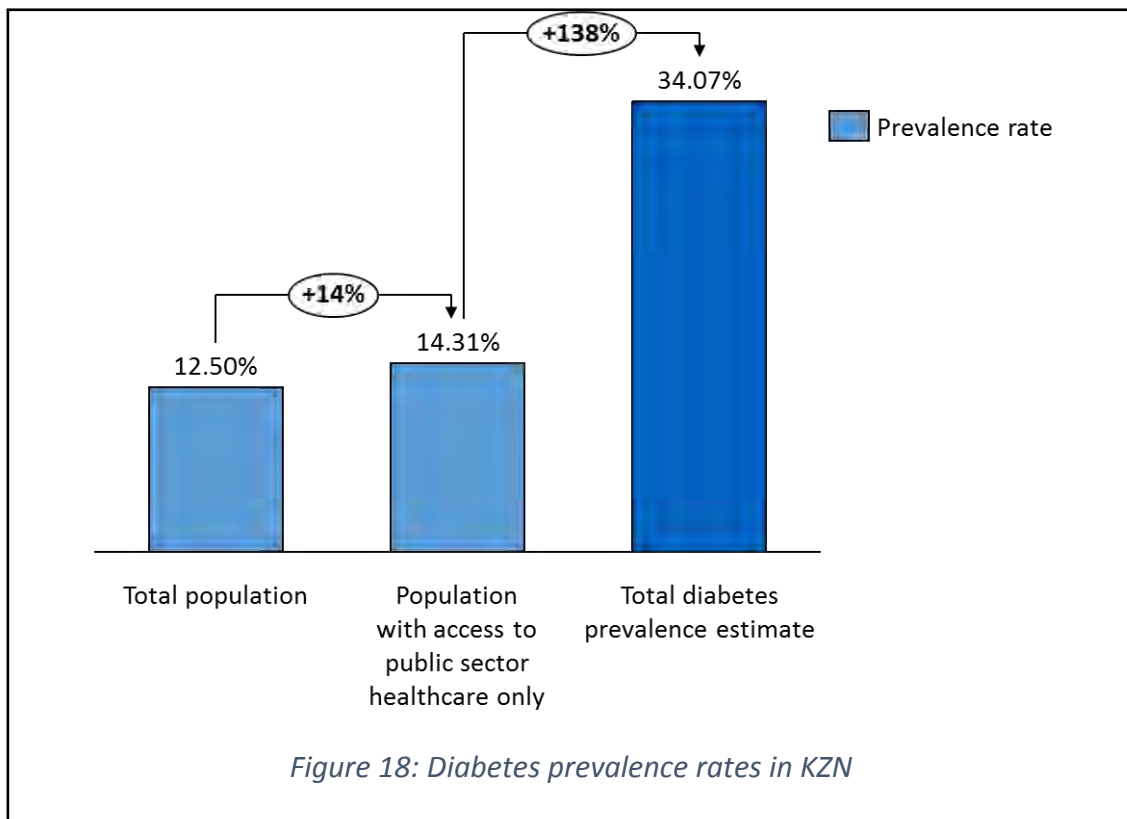
4.3.2 District Prevalence

4.3.2.1 District Crude Prevalence

Table 6 below illustrates district populations as recorded by Statistics South Africa's 2014 midyear estimates as well as the crude prevalence rates per district (Stats SA, MYE report, 2014).

The column 'Number of patients' refers to the total number of diabetic patients registered at public health facilities in 2014, per district, by the KZN Department of Health.

Table 6: Prevalence of diabetes in the KZN public health sector by district, 2014

District	Number of patients	Total District population	Prevalence rate
Amajuba	57 952	521 690	11.11%
eThekwini	518 878	3 574 132	14.52%
iLembe	87 144	633 656	13.75%
Sisonke	48 220	480 924	10.03%
Ugu	111 790	753 299	14.84%
uMgungundlovu	152 263	1 076 593	14.14%
Umkhanyakude	40 364	650 998	6.20%
Umzinyathi	50 809	528 657	9.61%
Uthukela	48 368	689 965	7.01%
Uthungulu	149 472	940 071	15.90%
Zululand	72 047	844 452	8.53%
Grand Total	1 337 307	10 694 437	

The following are graphic representations of the data previously tabulated.

Figure 19: Bubble chart indicating the relative prevalence of diabetes in the different districts
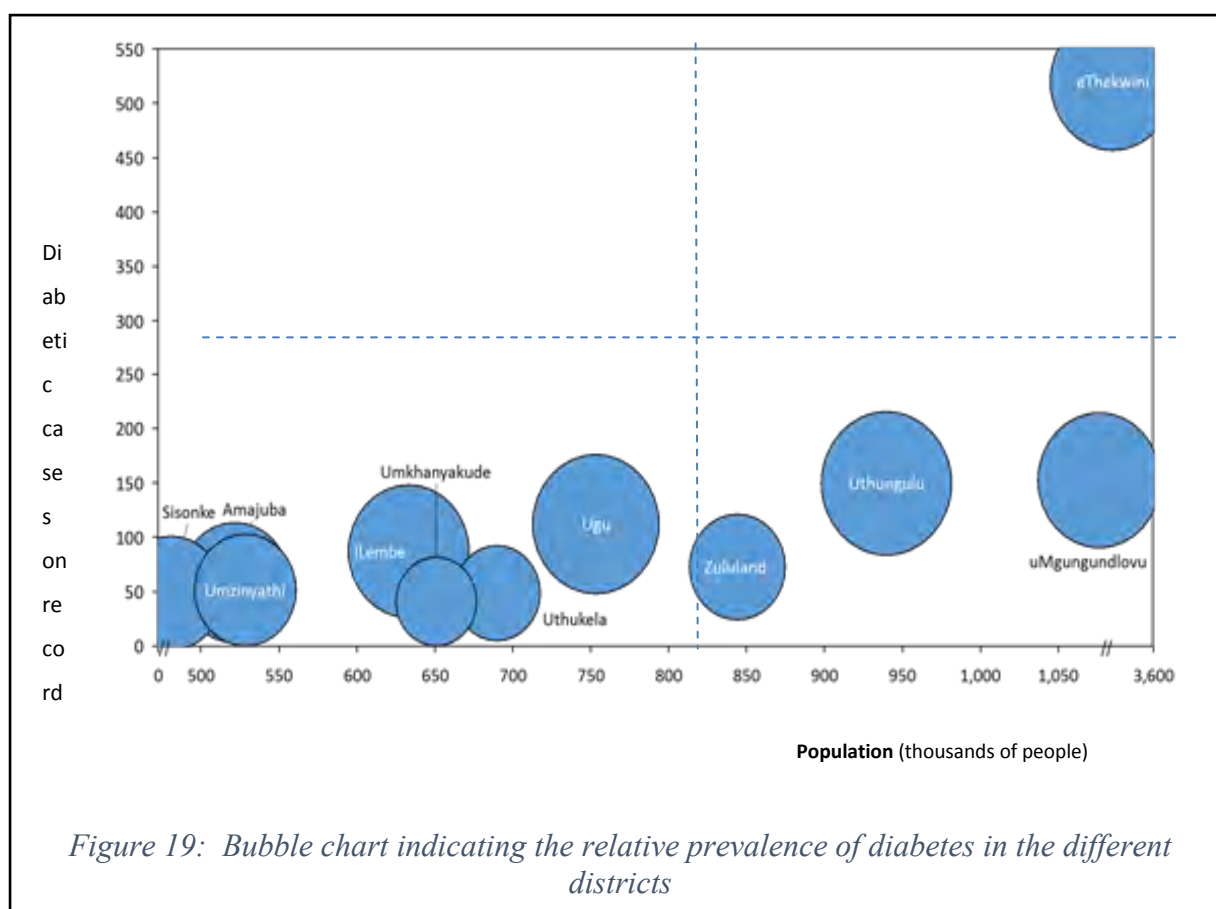
The x axis of Figure 19 indicates the population of KZN while the y axis displays the number of patients diagnosed with diabetes in the public health sector in 2014. Both scales are in increments of 1 000. Each bubble represents a district in KZN, showing its corresponding population and number of diabetic cases. The bubble's size indicates its prevalence rate relative to other districts. The district with the highest prevalence rate is that represented by the biggest bubble, in this case, the district of Uthungulu. The district with the lowest prevalence rate is Umkhanyakude.

Once divided into quadrants, the districts can be grouped by similar characteristics.
Quadrant 1 – Districts with a high population and a high level of diabetic cases (high priority districts). This quadrant contains only one district, eThekwini.
Quadrant 2 – Districts with a relatively low population and a high level of diabetic cases. No districts are found in this quadrant.

Quadrant 3 – Districts with a small population and number of diabetic cases. Most of the districts are found in this quadrant, namely, Amajuba, iLembe, Sisonke, Ugu, Umkhanyakude, Umzinyathi and Uthukela.

Quadrant 4 – Districts with a relatively low number of diabetic cases but a larger population. The districts of Zululand, Uthungulu and uMgungundlovu feature in this quadrant.

Figure 20 shows the prevalence rate in each district and compares it to the provincial crude prevalence (12.5%).

Figure 20: Bar representation of the prevalence rates across all districts in KZN in 2014
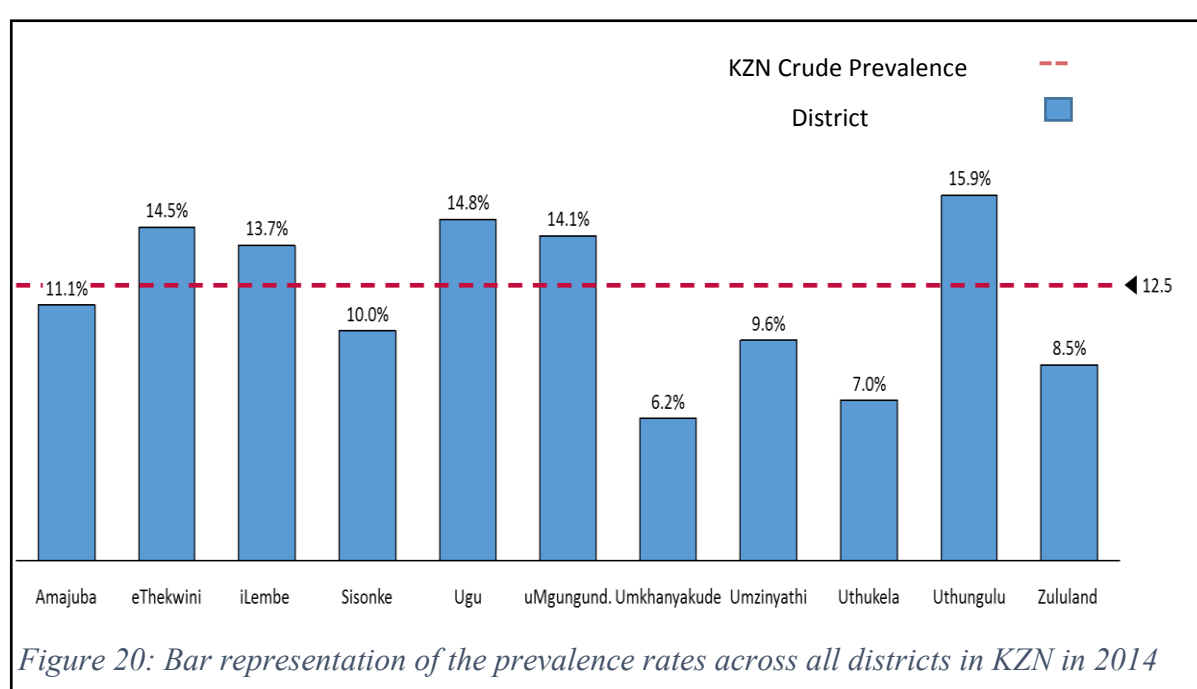
As shown in Figure 20, the district with the lowest prevalence rate is Umkhanyakude and that with the highest crude prevalence rate of diabetes is Uthungulu.

As directed by the information displayed in Figure 20, in order of descending prevalence, the districts are as follows:

1. Uthungulu
2. Ugu
3. eThekwini
4. uMgungundlovu
5. iLembe
6. Amajuba
7. Sisonke
8. Umzinyathi
9. Zululand
10. Uthukela
11. Umkhanyakude

The district of Uthungulu, exhibits the highest crude prevalence rate, followed by Ugu, eThekwini and uMgungundlovu.

4.3.2.2 District Prevalence within the Public Sector

Private sector coverage for the districts of KZN was obtained and is represented in Figure 21.

Figure 21: Proportion of population by district with access to public sector healthcare
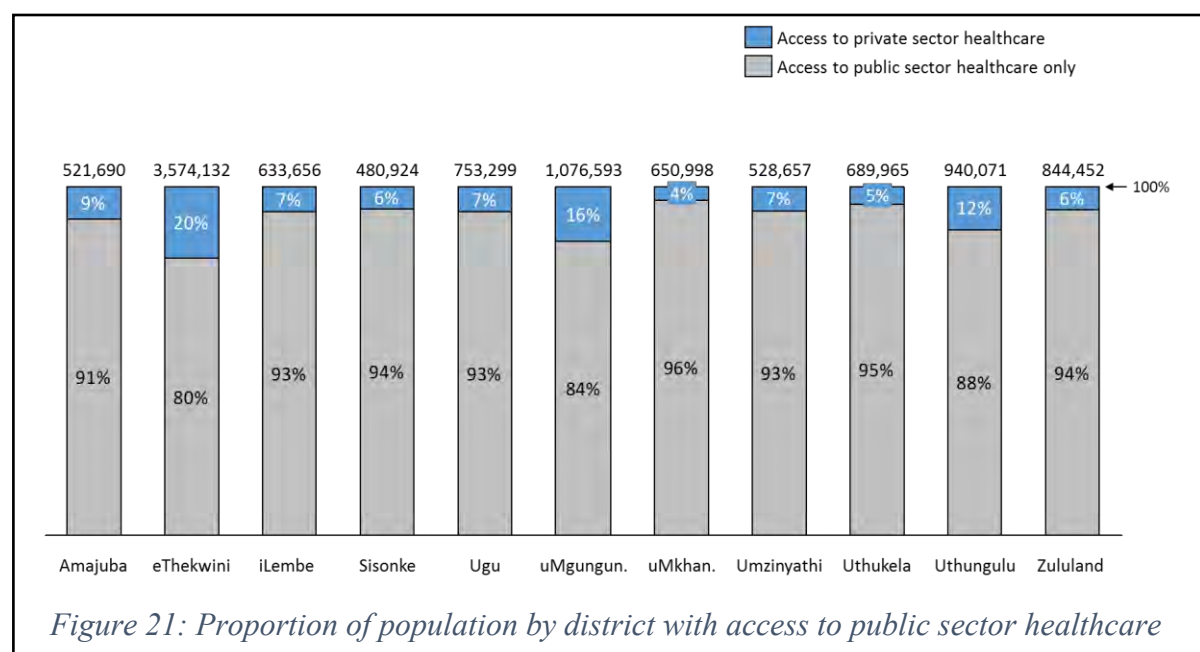
As illustrated in Figure 21, the distribution of private healthcare schemes varied among the different districts of KZN. EThekwini had the highest private healthcare population, i.e., 20% of its total population, while only 4% of uMkhanyakude's total population was covered by a private medical aid scheme.

Figure 22: Percentage prevalence rate by district as a proportion of total district versus as a proportion of population with access to public sector healthcare only (2014)

After calculating the district prevalence rates of diabetes mellitus, a new prevalence rate which factors in the individual private medical scheme coverage of each district was determined and is displayed above. Figure 22 represents the closest possible estimation of the district prevalence rates of diabetes mellitus within the public health sector given the fact that data on a once-off public sector head count could not be obtained from the Department of Health database. All the districts exhibited an increase in prevalence rates due to the reduced population, some more so than others because of a larger private health sector population.

It was important to exclude the private health sector from the population at risk when calculating prevalence, especially at district level because, as shown in Figure 21, each district had an individual private sector utilisation rate. The district of eThekwini had the highest private health sector utilisation rate at 20%; hence one in every five people in eThekwini is insured by a private medical aid scheme. A truer representation of prevalence by district is displayed in Figure 22 where the districts of eThekwini, Ugu, uMgungundlovu

and Uthungulu are seen to have prevalence rates above 15%. The new list in descending order of prevalence is as follows:

Table 8: The order of KZN districts in descending prevalence when considering private medical scheme utilisation rate

1. eThekwini
2. Uthungulu
3. uMgungundlovu
4. Ugu
5. iLembe
6. Amajuba
7. Sisonke
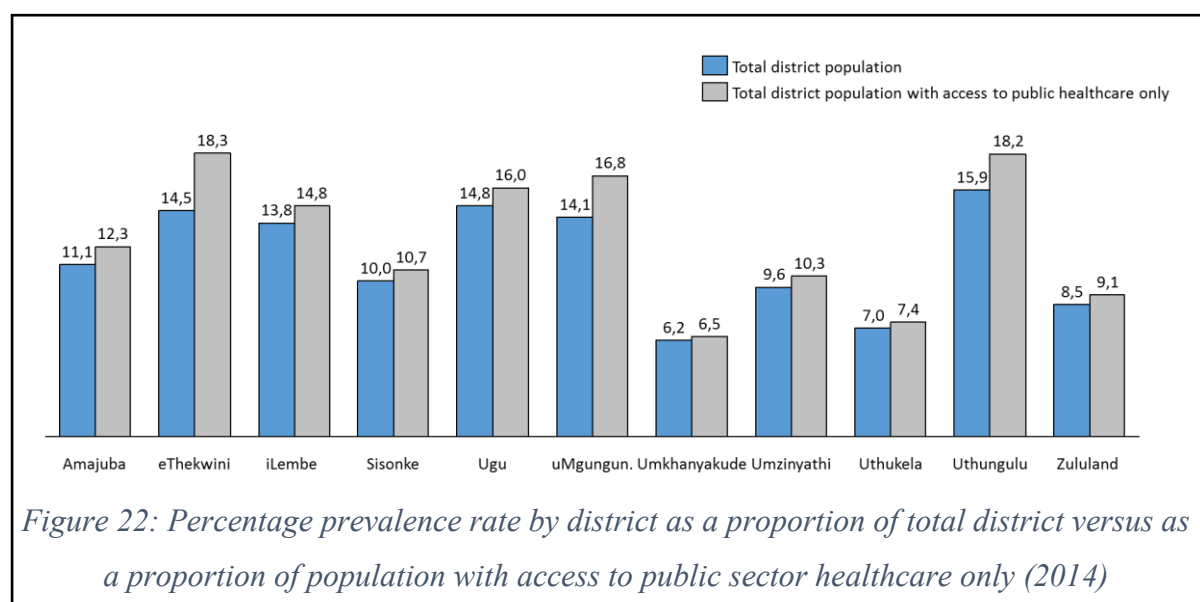8. Umzinyathi
9. Zululand
10. Uthukela
11. Umkhanyakude

The situation only changed in the top four districts due to the high private medical scheme coverage in these districts. The adjusted prevalence rates depict a truer representation of the prevalence of diabetes mellitus but still do not cater for the population of undiagnosed diabetic patients.

4.3.2.3 Total Estimated Diabetes Prevalence in the Districts of KZN

According to the SANHANES report, 48% of diabetic patients in South Africa are undiagnosed. This figure percentage was added to each district after reducing their overall population according to their private medical aid coverage to determine the total diabetes prevalence estimates for the districts of KZN and is displayed in Figure 23.

Figure 23: Total estimated diabetes prevalence for the districts of KZN
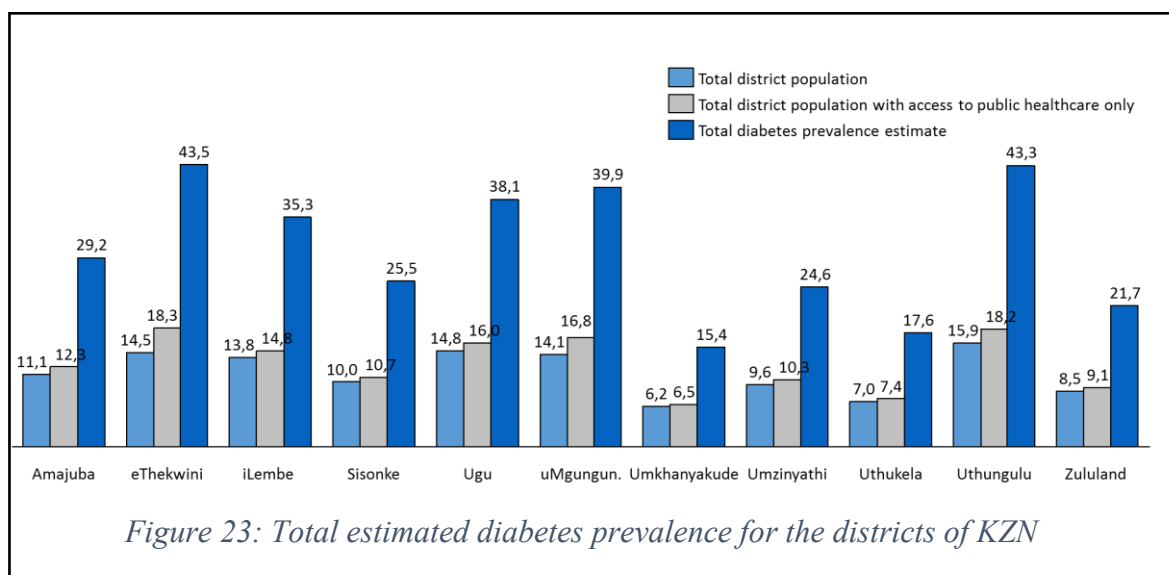
As seen from Figure 23, once the estimated undiagnosed population is considered, prevalence rates are as high as 43.5 (eThekwini).

4.4 Correlation Coefficients

The South African Index of Multiple Deprivation (SAIMD) study was used to determine how socio-economic status affected the prevalence of diabetes. Each municipality rather than district, was allocated a score that indicated its socio-economic status based on average income, employment, level of education and living environment.

4.4.1 Socio-economic Domains

A correlation coefficient (r), which is a number between +1 and −1 that represents the linear interdependence of two variables or sets of data, was calculated for each domain to determine its individual relationship with the prevalence of diabetes within the public health sector. The results are as follows:

Table 9: Correlation coefficients of diabetes prevalence and socio-economic domains

Correlation	Value	Result
Prevalence and Income	-0.54	A moderate negative relationship
Prevalence and Employment	-0.14	A weak negative linear relationship
Prevalence and Education	-0.45	A moderate negative relationship
Prevalence and Living environment	-0.41	A weak - moderate negative relationship

As seen from the table above, there is a negative relationship between the calculated crude prevalence of diabetes and the types of deprivation as categorised by SAIMD.

4.4.2 Crude Prevalence of Diabetes and the Number of Amputations

The correlation between the prevalence rate and the number of amputations was calculated to determine the relationship between the variables.

Correlation coefficient $\rho = 0.66$

Indicating a strong, positive relationship between the diabetes prevalence rate and the number of amputations in KZN

Figure 24: The correlation between the number of amputations and the prevalence rate
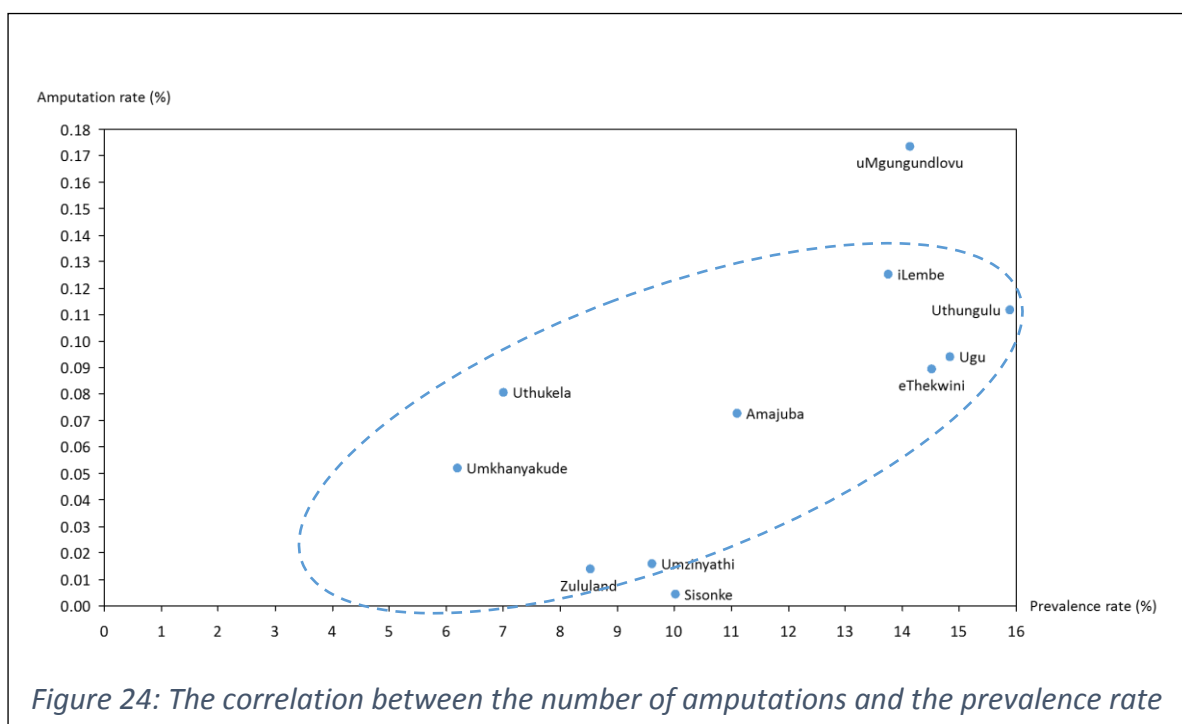
Figure 24 shows a strong positive correlation between the prevalence rate and the number of amputations in a district.

4.4.3 Diabetes Mortality Rate and the Number of Amputations

The diabetes mortality rates for the districts of KZN for 2013 were correlated with the number of amputations recorded for that year.

Correlation coefficient $\rho = 0.85$

Indicating a very strong, positive relationship between the diabetes mortality rate and the number of amputations in KZN as depicted by Figure 25.

Figure 25: Scatter graph depicting the relationship between the number of amputations and the diabetes mortality rate, by district (2013)
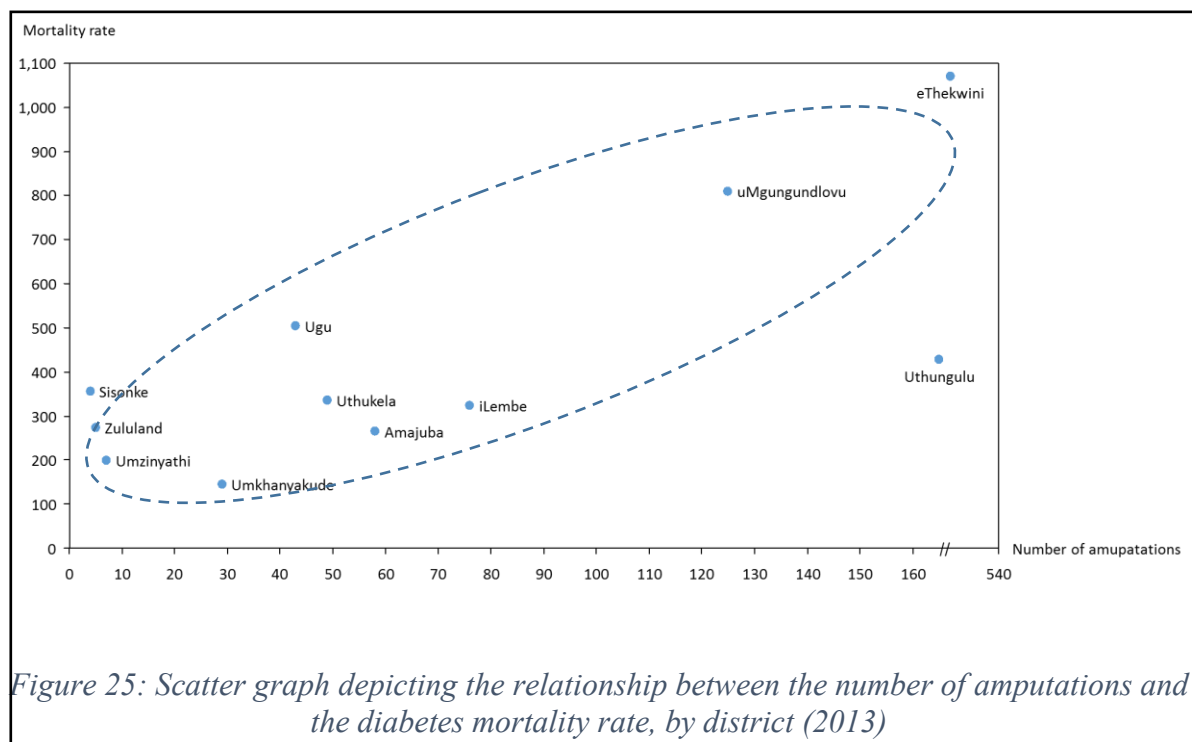
4.4.4 Diabetes Mortality Rate and the Number of Defaulters

The diabetes mortality rates for the districts of KZN for 2013 were correlated with the number of diabetes defaulters recorded for that year.

Correlation coefficient $\rho = 0.85$

Indicating a very strong, positive relationship between the diabetes mortality rate and the number of defaulters in KZN as depicted in Figure 26.

Figure 26: Scatter graph depicting the relationship between the number of defaulting diabetes patients and the diabetes mortality rate, by district (2013)
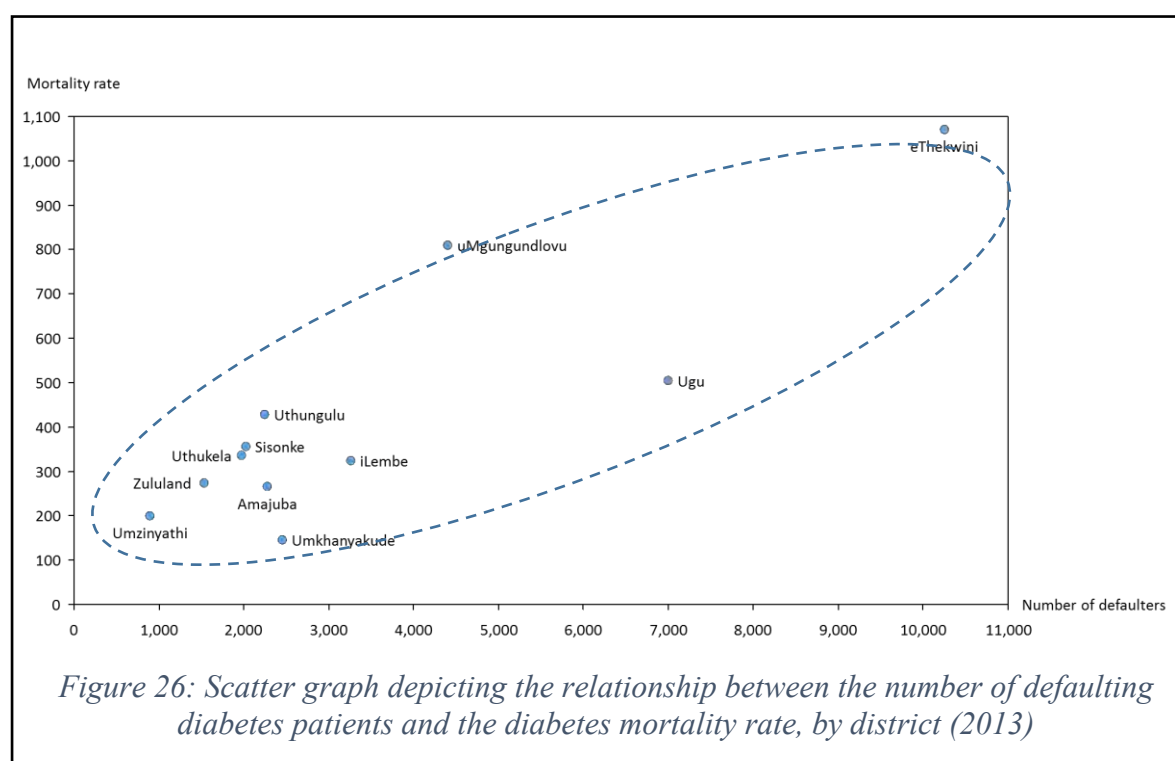
4.6 The Distribution and Number of Podiatrists Required Within the Public Health Sector

According to data from the KZN Department of Health and the Podiatry Association of South Africa, only two podiatrists were practicing in the public health sector in 2014, in the districts of Umgungundlovu and eThekwini, and were only present at hospital level.

To determine the number of podiatrists required to cater for the growing diabetic population, the following assumptions and calculations were done.

Average consultation time	= 30 minutes
Average number of hours worked per day	= 8 hours
Theoretical maximum number of patients attended to per day	= 16 patients
Average number of annual working days (2013/2014)	= 251 days
Number of patients seen by a podiatrist annually	= 4 016 patients
Total number of diabetic patients in KZN	= 1 288 973 patients

Number of podiatrists in the public sector   = 2

HENCE

The maximum number of patients that could have been seen in the KZN public health sector by podiatrists in 2013/2014, assuming they have no complications   = 8 032 patients

This results in a total of **1 280 941** diabetic patients that do not receive minimal podiatric care. Figure 27 below represents this data.

Figure 27: The number of patients who can be attended to by the current number of podiatrists in KZN
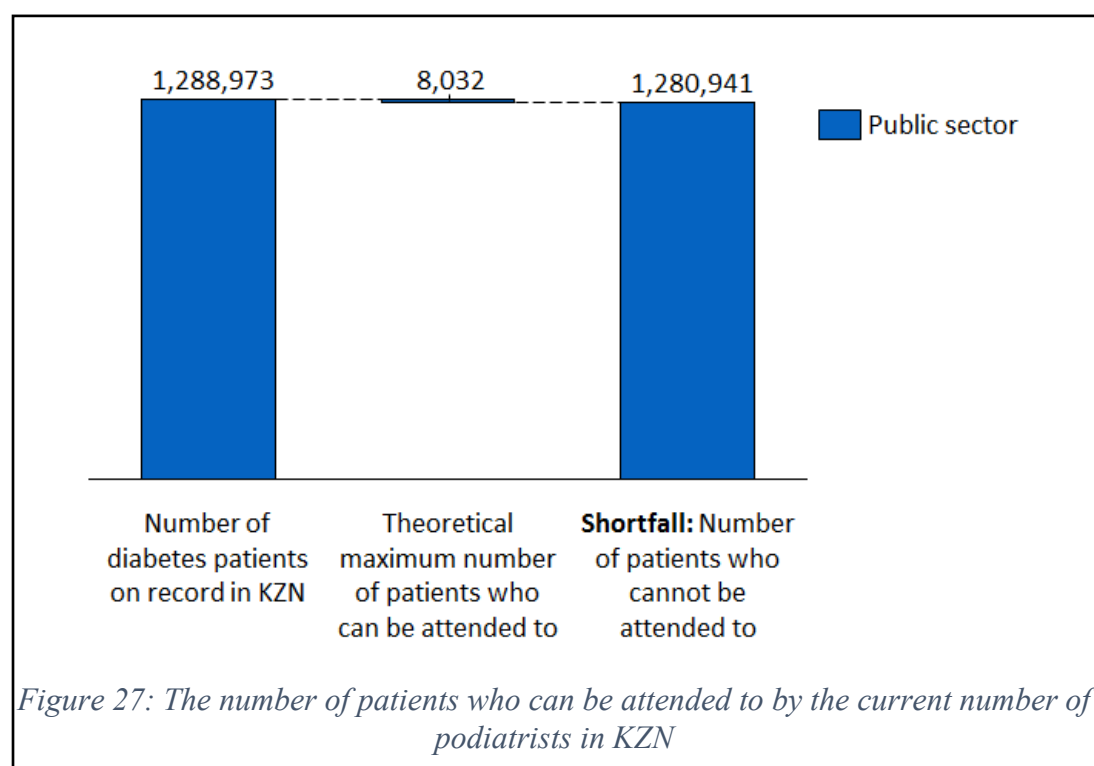
The calculation to determine the number of patients that could be seen by the existing podiatrists working in the KZN public health sector indicated a consultation time of 30 minutes. This is based on the average time taken to screen a diabetic patient in private podiatric practice with access to the required screening tools such as a 10 g monofilament, 125Hz tuning fork, a Tiptherm or equivalent temperature discriminator, patella hammer, Doppler ultrasound machine, sharp/blunt sensory instrument, two-point discriminator and cotton wool. The working day was calculated from 8:00 – 17:00 including an hour break and public holidays and weekends were excluded.

In accordance with national and international guidelines (Butler, 2011), every diagnosed diabetic patient should be screened by a podiatrist once annually therefore KZN is lacking

319 podiatrists. It is important to notes that this is only the number required to perform basic diabetic screenings only and excludes those needed to treat both ulcerative and non-ulcerative pathologies.

The University of Johannesburg (UJ) was approached and released data on the number of podiatrists qualifying between 2010 and 2014, involving one rotation of students. The results are displayed in Table 10 below.

Table 10: The number of qualifying podiatrists in Africa between the years 2010 to 2014

Year of Graduation	Number of graduates
2010	6
2011	16
2012	3
2013	16
2014	15

The implications and correlations of the aforementioned results presented in this chapter will be discussed in Chapter 5.

CHAPTER 5: DISCUSSION

This purpose of this chapter is to discuss the findings as presented in Chapter 4 and the correlations found between them and paradigm of urbanisation.

The distribution of diabetic patients by district, determined by a two-year normalised value in order to best express the true distribution, indicated that the district of eThekwini had the largest number of diabetic patients. According to the data and as shown in Figure 8, approximately 38% of the total registered diabetic population within the public sector of KZN was from the district of eThekwini. The district of Umgungundlovu for which the second highest number of diabetic patients were recorded, displayed a normalized figure of nearly a quarter of the number as recorded in the district of eThekwini. The distribution of defaulting patients and diabetes-related amputations follows a similar trend; as shown in Figures 10 and 11. Both variables were highest in the district of eThekwini thus highlighting the district as one of high risk. To gain more insight into the state of diabetes within the districts of KZN, more precise analyses such as incidence and prevalence that take into account population density was conducted.

The incidence was reduced by 40% between 2010 and 2011 due to the reduction in the number of new patients recorded in the district of Amajuba in 2011. It is suspected that this is due to inconsistent collection or capture errors. A second drop in incidence is seen to occur between 2012 and 2013 and appears in seven of the nine districts from which data was collected. This decline in incidence figures, is suspected to have been caused by the introduction of additional collection fields as implemented by the KZN Department of Health and could have been misunderstood by administrative staff. The incidence of diabetes in KZN fell by 56% between 2010 and 2014. This figure is not consistent with literature as many sources report a growing incidence and prevalence of diabetes, especially on the African continent (JEMDSA Editorial Office, 2007). Between 2013 and 2014, the incidence of diabetes in KZN increased by 8%. While additional audits or accurate epidemiological studies are often logistically difficult, monitoring this new collection field of the Department of Health database over an extended period of time would allow for greater insight into the incidence of diabetes in this province as no further data changes are expected and it is anticipated that collectors will have an improved understanding of the use

of the incidence indicators. This study found differences between diabetes incidence rates in the different districts of KZN. In every year for which data was examined (2010 to 2014), the district of eThekwini had the largest number of new diabetic patients, again highlighting its priority as a high risk district among those in KZN.

The results pertaining to the incidence of diabetes by age profile were consistent with the existing literature, indicating that the prevalence of diabetes in people older than 19 is far greater than those younger than 19 years of age (Healthline, 2014). A further classification that records the type of diabetes would allow for cross comparisons to be made and for better insight as 90% of diabetes mellitus cases are type 2, a form of diabetes directly related to advancing age, while type 1 is typically associated with a younger age group (Healthline, 2014). The distribution of diabetes by age in the districts of eThekwini, iLembe, UMgungundlovu, Umkhanyakude, and Uthukela as displayed by Figure 9, showed a diabetic population below the age of 18 of greater than 10%, suggesting that the number of patients over the age of 18 is grossly under reported.

Prevalence

This study aimed to determine the prevalence of diabetes mellitus in KZN and found that 12.5% of citizens were diagnosed with diabetes and accessed public health care in 2014. This figure of crude prevalence is higher than anticipated as previous studies on the crude prevalence rate not specific to a high risk demographic group, is estimated at no higher than 10%. In 1998, the first South African demographic and health survey estimated the prevalence of diabetes at 2.4% and 3.7% for males and females, respectively, while its more recent report in 2003 reported diabetes prevalence rates of 2.6% and 3.9% in the year 2000, and the prevalence of diabetes among South African adults older than 30 years was estimated to be 5.5% (Molleutze and Levitt, 2005). The National Health and Nutrition Examination Survey calculated the prevalence of diabetes at 9.5% (Human Sciences Research Council, 2013). According to the IDF, the national prevalence of diabetes is 9.2% (IDF, 2013). Our calculations for the province of KZN show that provincial prevalence is higher than the known national prevalence, possibly due to the bigger population of Indians in this province of KZN who have a genetic predisposition to diabetes mellitus (Human Sciences Research Council, 2013; Omar et al., 1994; Bradshaw et al., 2007). These findings are consistent with other epidemiological studies conducted in South Africa that reported a prevalence of above 12% among the Indian population (Dikeukwu, 2011). According to the

2011 census, 51% of South African Indians are resident in KZN whose total population comprises of 7.4 % Indians, 4.2% whites, 1.4% coloureds, 86.8% black Africans and 0 3% other ethnic groups (Statistics South Africa, 2012).

As seen in Figure 17, after excluding the private health sector population, a prevalence of 14.3% was calculated for the province of KZN. This increase in prevalence was expected as the population used was reduced as indicated in Figure 16. The new prevalence rate calculated increased by 14% to a prevalence of 14.31%, a more accurate representation of the prevalence of diabetes within the public health sector.

As previously discussed, early detection of diabetes enables early intervention and the prevention of damaging and costly complications. Worldwide, as many as 50% of diabetic patients are estimated to remain undiagnosed. The population of undiagnosed patients is thought to be higher in African countries where the minimum standard of diabetes care and screening is difficult to achieve (IDF, Atlas ed6, 2013). Additional challenges faced by African countries include the management of communicable diseases such as HIV and TB and the fact that the diabetes care agenda in African countries is dominated by poverty and places less emphasis on prevention (Gill, 2009).

Diabetes in KZN

According to the SANHANES study, only 5% of the participants reported a history of diabetes whereas, after the data was analysed, diabetes was diagnosed in 9.5%, resulting in a proportion of 48% of who were undiagnosed diabetics (Human Sciences Research Council, 2012). This proportion of the total number of diabetic patients who were undiagnosed was utilised in this study as the sample used in the SANHANES was a good representation of the South African population. Once the undiagnosed percentage was factored into the calculation, a diabetes prevalence of 34.07% was determined for the province of KZN. The change in diabetes prevalence figures for the province of KZN as calculated in this study implies that more than one in every three patients seen at a public health care facility has diabetes. A diabetes prevalence estimate of such magnitude emphasizes the need for better management of the disease and its complications through prevention initiatives, screening protocols, the establishment of multidisciplinary teams and an improved data collection system that will enable accurate measurement of disease progression.

The previous categorisation of eThekwini as a high priority district is further justified by the prevalence calculations per district as depicted in Figures 19 and 20. While there are few studies that compare the prevalence of diabetes between districts, the trends identified by this study support the recurring global issue of the relationship between diabetes and urbanisation. As presented in Table 8, a truer prevalence rate is determined by considering the individual district private medical scheme utilization rate and the previous top five high priority districts as seen in Table 7, remained the same, although their positions changed. The inference that this is due to their levels of urbanisation is supported by a study on urbanisation carried out by the KZN Department of Economic Development and Tourism in 2010. The study makes mention of the four major districts of KZN on the basis that they cover the largest share of the province and contain major cities. These major districts are eThekwini, iLembe, uMgungundlovu and uThungulu, all of which presented as high priority districts in this study (KZN Department of Economic Development and Tourism, 2010).

As previously noted, the district trend is supported by the findings on the estimated undiagnosed population by district shown in Figure 23. The top five high-risk districts were the only districts calculated to have an estimated total diabetic prevalence above the estimated provincial total diabetic prevalence of 34.08% (see Figure 18). These findings infer that more than every third person in the public sector of the aforementioned districts has diabetes, diagnosed or undiagnosed. eThekwini exhibited the highest estimated total diabetes prevalence rate at 43.5%. It was found that of the 11 districts within KZN, eThekwini is the most densely populated, is the only district to fall within the fifth or highest socio-economic quintile and is highly urbanised (Health Systems Trust[1], 2014; KwaZulu-Natal Department of Health, 2010). The district of eThekwini is home to many citizens of Indian origin, who have been, as previously mentioned, proven to have a genetic predisposition to diabetes, as well as a high population of citizens that subscribe to traditional African culture that believes that gluttony is a symbol of affluence and good health (Omar, 1994; Statistics South Africa, 2011). The findings of this study also support numerous others that have indicated an increase in the prevalence of diabetes in response to urbanisation and its related consequences as risk factors for diabetes (Mbanya, 2010; Gill, 2009).

Diabetes and Urbanisation

Urbanisation is understood as the movement of the population into urban areas, which has been thought to improve the standard of living by improving access to public healthcare, transport, stable housing and clean drinking water, but is not without its disadvantages. In developing countries such as South Africa, the infrastructure is often inadequate to support densely populated urban areas and as such, there is an increase in environmental pollution, unemployment and the development of slums. According to a report released by the Department of Economic Development and Tourism in 2010, eThekwini is 45% urbanised and the rate is steadily increasing (KwaZulu-Natal Department of Economic Development and Tourism, 2010).

Along with the above-mentioned disadvantages of urbanisation, there is a change in lifestyle and a consequent increase in the risk of Type 2 diabetes mellitus. Such factors include infrequent physical activity due to the use of motor vehicles as opposed to walking between destinations, and a change in diet to cheaper, more processed fast foods which increase salt and calorie intake. The dietary habits of the typical urban citizen are known to increase the risk of diabetes (Akter et al., 2014). Opie (2006) observes that hypertension is more common in urbanised populations, the increased prevalence of which contributes directly to an increased risk of diabetes and other co-morbidities.

To further assess the relationship between diabetes prevalence and urbanisation, data from the South African Department of Social Development's 2007 South African Index of Multiple Deprivation (SAIMD) were correlated, the results of which are presented in Table 9. Once correlated with the prevalence scores within the public sector, all deprivation domains yielded a negative result; hence, the more deprived an area, the lower the prevalence of diabetes mellitus. These findings, together with those previously presented support the inference that urbanisation and its consequent unhealthy lifestyle changes increase the risk of diabetes.

In considering these results, we can assume that the more urbanised an area, the greater the rate of diabetes. However, it is possible that districts with a higher deprivation score or those of low socio-economic status are ill-equipped or educated on the importance of diabetic screening and the recording of diabetics, resulting in a relatively low number of patients being recorded as having diabetes.

The Relationship between Diabetes and Amputations, Defaulters and Mortality

The prevalence rates determined by this study were not only correlated with deprivation scores, but were used in a further calculation to determine the relationship between the prevalence of diabetes and the number of diabetes-related amputations. Figure 24 shows that, there is a strong positive relationship between the two variables, suggesting that as the prevalence of diabetes increases, so too do the number of amputations related to diabetes. The detrimental effects of diabetes on the lower limb have been discussed in previous chapters, highlighting the different presentations of neurological, vascular, dermatological and orthopaedic complications. In addition to the negative effects on physical health, metal well-being is also affected (Berry, 2015).

Further correlation calculations were done to determine the relationship between diabetes-related amputations, defaulting patients and the diabetes mortality rates as displayed in Figures 25 and 26. As expected, there was a strong positive relationship between the variables investigated, consistent with the literature that notes that diabetic foot amputations or a lack of compliance results in an increase in morbidity and mortality (SEMDSA, 2014; Boulton et al., 2005).

Preventing Lower Limb Problems

The IDF has set out structured guidelines for diabetic foot care categorised by the level of care. According to these guidelines, minimal care protocol indicates that a diabetic patient without complications should have their foot screened by a podiatrist once a year to assess foot health. Should the patient present with neurological or vascular complications, more frequent podiatric treatments will be required to manage the patient (International Diabetes Federation, 2012).

The SEMDSA released comprehensive guidelines for the treatment and prevention of foot problems in diabetes in 2012 in the Journal of Endocrinology, Metabolism and Diabetes of South Africa. These included a summary on the methods of foot screening and ulcer treatments and detailed the inspection of the diabetic shoe, the formation of ulcerations, risk stratification and the prescribed treatment protocols for various types of infections (SEMDSA, 2014).

An easy to use one page Diabetic Foot Care Guideline was also created by the SEMDSA for primary health care professionals. It recommends annual foot screenings for diabetic patients. The guideline is a concise overview of the preferred approach to the diabetic foot, including aspects such as footwear screenings, patient education, prevention of ulcerations and when to refer to a podiatrist. It is printed in an easy to read A4 poster format which is ideal as a wall poster or reference for busy practitioners.

Diabetes Care in KZN

Despite these commendable efforts, a study conducted to assess compliance with the SEMDSA guidelines at a regional hospital in KZN revealed very poor compliance. Only 6% of the sample had undergone a comprehensive foot examination, an annual requirement set by diabetes authorities to reduce the various foot complications that may arise (Igbojiaku, Ross and Harbor, 2013; Gill, 2009). An additional study by Dikeukwu (2011) assessed the awareness and performance of prescribed diabetic foot care practices in a Gauteng Hospital. It was found that not only were the practices inadequate, but 94% of patients had never made use of a podiatrist. Such results not only address the issue of the lack of podiatrists within the public health sector, but also the lack of understanding of diabetic foot care. It is speculated that the reason for poor compliance with foot care guidelines is not a lack of understanding among doctors and nurses, but that the current patient and workloads carried by these practitioners might not allow the administration of foot screenings, education and general podiatric care. The importance of diabetic education should not be overlooked. As shown in Figure 26, the rate of defaulting patients and diabetes mortality rates depicts a strong positive relationship. Defaulting patients are patients that are diagnosed with diabetes, but do not return for follow up treatment. If such patients had followed the stipulated guidelines once diagnosed, they would have received diabetic education during their annual podiatry consult; this would improve compliance, reducing complications and improving their quality of life.

Podiatry for Improved Diabetes Care and Management in KZN

The IDF recommends that the training and provision of podiatrists need to be assured. In terms of the syllabus, podiatrists are fully trained to manage the diabetic foot at every level of severity as detailed by the above mentioned guidelines (International Diabetes Federation, 2012).

According to the Podiatry Association of South Africa (PASA), the University of Johannesburg (UJ) is currently the only tertiary institution in Africa that trains podiatrists under a Bachelors of Health Sciences Degree, previously a Bachelor of Technology in Podiatry since 2013 and prior to that, a national diploma.

Throughout the four-year degree, specialised podiatric subjects as well as many medical subjects are covered, including anatomy, physiology, pathology, pharmacology, sports medicine, clinical studies, podiatric medicine, physics, chemistry, psychology, microbiology , specialised paediatric, geriatric and minor surgery modules ,however, training on surgical interventions such as amputation, biomechanically focused tendon release and osseous reconstruction have not been included to the syllabus as is such in the United States (Kim et al., 2012). Students undergo practical clinical training and see patients under supervision at the podiatric clinic located on campus. They also visit public health facilities such as Chris Hani Baragwanath Hospital, Alexander Public Hospital, Charlotte Maxeke Johannesburg Academic Hospital, and Coronation Hospital to run clinics where they gain experience and refine their skills and are involved in rotations of Dermatology, Rheumatology, Orthopaedic, Endocrinology and Vascular clinics, observing specialising registrars.

Many newly qualified podiatrists leave South Africa to practice abroad. According to PASA, approximately 33.3 % of qualified South African podiatrists have emigrated since 1980. In 1996, Gauteng province was found to be home to the majority of qualified podiatrists (58%) in the country, contributing to the uneven distribution throughout other provinces such as KZN. (Masoetsa, 2005)

As noted in chapter 4, the number of podiatrists within the public health sector is grossly insufficient to cater for the growing diabetic population in KZN. Ideally, a total of 333 podiatrists are required in KZN to satisfy the national guidelines for minimal diabetic care in terms of screening patients only, not considering the treatment of existing and future foot complications.

The introduction of podiatrists to the public health sector is not a new issue and has been tackled by the Podiatry Association and private practitioners in the past. Presentations, meetings with Department of Health officials and research studies have all been attempted with poor results. Masoetsa's dissertation on 'Positioning of podiatric medicine within the

South African health care system' (2005) notes that there is a long history of attempts to include podiatry in the public health sector , military and correctional services. Masoetsa's (2005) interviews with three Department of Health officials as well as the Head of Department for Podiatry revealed the following reasons for the exclusion of the profession from the national health scheme:

- A lack of knowledge including education, marketing and communication on the profession
- Ignorance amongst policy makers and the general public
- Aesthetic perceptions of the profession
- Poor representation within the Department of Health
- Few students and a single training institution in South Africa
- A lack of evidence-based research

The issue of prioritising the types of health care within the public sector was also discussed and while more emphasis is placed on life threating conditions such as HIV and Aids and TB, the 2015 KZN budget speech reported that the prevention, early screening and treatment of chronic conditions such as diabetes will be given more attention.

In 2008, an article in the medical journal, Wound Healing South Africa by Clark and Tsubane focused on the role podiatrists play in the healing of diabetic ulcers. PASA highlighted the need for podiatrists, the shortage of foot care practitioners and possible solutions to the National Human Resources Committee in a 2011 presentation. Individual practitioners have presented talks on various radio stations such as Talk 702 and Al-Ansaar in an effort to promote an understanding of podiatric medicine.

Bursaries were provided to podiatry students by the Gauteng Department of Health which also ensured qualified students' placement in a public health facility. The establishment of means-tested bursaries or achievement scholarships would not only increase the enrolment of first year students, promote knowledge of the profession and result in the placement of podiatrists in the public sector, but also provide tertiary education opportunities to young adults that are otherwise unable to access them after completing grade 12. A detailed investigation is required into the reasons for bursary cessations and possible solutions to improve the rate of production of podiatrists in South Africa.

As noted earlier, there is a shortage of academic institutions offering qualifications and training in podiatric medicine. The establishment of entirely new facilities is unnecessary as most of the subjects, equipment and resources used at the University of Johannesburg to train podiatrists are available at tertiary medical schools. As communicated by the Podiatry Association of South Africa's executives, according to the current chief podiatrist working at Chris Hani Baragwanath Hospital in Gauteng, the structure for a podiatric medicine department has already been established, with different grades of podiatrists identified, including provincial and national directors and policy makers. As this pilot study is still underway and the results have yet to be analysed, most of these positions remain vacant.

Limitations

This study presented the following limitations:

- The data collection at the primary level was not done by the researcher and is currently a manual process, affecting the reliability of the data and exposing it to human error and interpretation and compromising the internal validity of the study.

- Upon inspection of the raw data collected from the Department of Health, many inconsistencies were identified. Data irregularities included duplicated entries for subsequent data fields, inconsistence in the types and number of public health facilities from which data was collected and empty data fields. These irregularities were noticed in the raw data for each year analysed and the reasons were explored. The migration statistics presented in the KZN midyear estimate report released by Statistics South Africa indicated negative migration patterns for KZN for every year since 2006. Considering the manual process of data collection at the primary level, human error is highly likely. Changing, or multiple employees, poor understanding and incorrect capturing by the information officer or the administrative worker would result in such data inconsistencies.

- According to clinicians practicing in the public health sector, the field of 'Defaulters – Diabetes' that was collected from the KZN Department of Health is not a field of data collected by information officers and could have been misinterpreted by data handlers.

- External validity can be insured as the population sampled is a good representation of the South African populace.

As highlighted in this chapter, the treat of diabetes is increasing exponentially every year. Inevitable urbanisation and genetic predispositions place many in the South African population at a greater risk of developing the disease. All previously estimated prevalence and incidence rates are, according to this study, not an accurate description of the current state of diabetes in the province of KZN. There is a drastic shortage in the number of podiatrists available to manage the current diabetes population however changes at tertiary education level can allow for the adequate distribution of podiatrists and improve limb salvation in the public health sector.

CHAPTER 6 – CONCLUSION

The literature notes that the African continent is expected to have the greatest increase in the prevalence of diabetes over the next 20 years; thus, interventions to better manage the growing burden of disease have never been more critical.

The incidence of diabetes was found to be inconsistent with current literature on the subject and is suspected to have been due to incorrect data collection at the primary level. The estimated total diabetes prevalence was calculated to be as high as 43% in some districts of KZN. The study's findings support current views on the relationship between urbanisation, amputation rates and mortality. The district of eThekwini was categorised as a high priority due to its high diabetes prevalence rate and socioeconomic status. Together with data on the distribution of patients diagnosed with diabetes mellitus, a shortage of 319 podiatrists was found to exist in the province of KZN according to accepted guidelines.

The insufficiency of podiatrists, while statistically vast, can be remedied. As emphasised in previous chapters, podiatric diabetic care is vital to the wellbeing of millions of citizens of the province of KZN. The distribution of podiatrists in state health has already been piloted in Gauteng and may be adapted to suit KZN. Collaboration between podiatric practitioners and the Department of Health could lead to an improved level of diabetic care in KZN. In order to address the problems as highlighted by this study and meet national standards of minimal diabetic care, the following long and short term strategies are proposed.

Recommendations

The following recommendations are made to the KZN Department of Health

Long-term strategy:
- The automation of data collection, comprising a simple interface with easy to use drop box functions to reduce human error and inconsistencies such as duplicate data entries.
- The inclusion of new data collection fields that record the annual total headcount of patients as well as the number of visits to the facility to more accurately determine the burden of disease and identify priority areas and facilities.

- The establishment of a podiatry department in existing medical schools for the increased production of podiatrists in highly urbanised provinces such as the Western Cape and those that have a high population of high risk patients such as KwaZulu-Natal.

- The creation of additional podiatry posts nationally within the public sector as distributed by district population density and socioeconomic status.

- The establishment of interdisciplinary diabetic foot teams at tertiary public health facilities comprising podiatrists, diabetic educators, dieticians, footwear technicians and physicians.

- The implementation of the suggested structure of podiatrists that includes different levels of practitioners, policy makers, supervisors and directors.

- The revision of the syllabus of undergraduate medical doctors to include education on the scope of practice of podiatry, given that it is a discipline represented in Health Professions Council on the same board as Physiotherapy and Biokinetics

- Routine foot care education and counselling g*iv*en to all newly diagnosed diabetic patients.

- Interaction with the WHO and the FIP (World Representative Body for Podiatric Medicine) on programmes to bring in assistance for diabetic education and resources.

Short-term strategy:

- Training of data capturers and information officers on data collection methods and accuracy.

- The assessment of current tertiary medical institutions and the undertaking of economic exploration studies to determine the feasibility and timeframe for the establishment of additional departments of podiatric medicine.

- The reinstatement of bursaries offered by the Department of Health for podiatry students.

- The revision of the current scope of podiatry to include the more recent diabetic foot manifestations as experienced in a more urbanised society.

- The unfreezing of existing podiatry posts at public health facilities.

- The training of nurses by podiatrists or doctors in the methods and tools available for screening and adequately referring a diabetic patient to other health care specialists

such as podiatrist. This study places on record the reminder that a newly qualified podiatrist learns sharp debridement skills and biomechanical diagnostic and treatment skills over a four-year period, with over 400 hours of clinical practice before graduating. This level of skill cannot be transferred to nurses by means of short courses.

- The development of easy to read bilingual diabetes foot care and podiatry information pamphlets to be distributed at diabetic clinics and placed in the rooms of endocrinologists and dietitians at public health facilities.

- This study suggests that the Department of Health in KwaZulu-Natal review the tele-medicine system designed by Dr Mars which would allow diabetic team members (including podiatrists) to review diabetic patients via camera feed from outlying clinics and instruct/train nurses on who and when to refer from such clinics (A Thompson 2015, pers. comm., 7 October).

Recommendations for future research:

- It would be interesting to calculate the prevalence of diabetes mellitus in the time series analysed if only to compare the change in the rate of prevalence to that of the incidence rate found to determine the accuracy of data collection and capturing.

- Prevalence of diabetes mellitus calculated by age, race and in both the public and private sector will allow greater insight into specific prevalence trends that occur within our South African population.

It is believed that with the implementation of the above measures and the correction of the distribution of podiatrists, the appropriate management of the expected surge in diabetes numbers is possible. Such an initiative will not only allow for more efficient use of the nation's medical and financial resources but also save the limbs and improve quality of life for millions of patients throughout South Africa.

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ANNEXURE 1

UNIVERSITY OF
KWAZULU-NATAL

INYUVESI
YAKWAZULU-NATALI

27 February 2015

Ms Nikita Sahadew 209504281
School of Clinical Medicine
Medical School Campus

Dear Ms Sahadew

Protocol reference number: HSS/0036/015M
Project title: The distribution of Type 2 Diabetes Mellitus patients and podiatrists in the province of Kwa-Zulu Natal, within the public health sector

Full Approval – Expedited Application

In response to your application received on 22 January 2015 , the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of **3 years** from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....
Dr Shamila Naidoo (Deputy Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Dr Veena Singaram & Dr S Brown
Cc Academic Leader Research: Dr V Singaram
Cc School Administrator: Ms Veronica Jantjies

Humanities & Social Sciences Research Ethics Committee
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Reference : HRKM 033/15
Enquiries : Mr X Xaba
NHRD: KZ_2015RP22_240
Tel : 033 – 395 2805

Dear Ms N. Sahadew

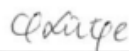### Subject: Approval of a Research Proposal

1. The research proposal titled **'The distribution of Type 2 diabetes mellitus patients and podiatrists in the province of KwaZulu Natal, within the public health sector'** was reviewed by the KwaZulu-Natal Department of Health.

   The proposal is hereby **approved** for data to be collected from the Department's databases (District Health Information System)

2. You are requested to take note of the following:
   a. Make the necessary arrangement with the identified facility before commencing with your research project.
   b. Provide an interim progress report and final report (electronic and hard copies) when your research is complete.

3. Your final report must be posted to **HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200** and e-mail an electronic copy to hrkm@kznhealth.gov.za

For any additional information please contact Mr X. Xaba on 033-395 2805.

Yours Sincerely

Dr E Lutge
Chairperson, Health Research Committee
Date: 18/02/15 .

uMnyango Wezempilo . Departement van Gesondheid

Fighting Disease, Fighting Poverty, Giving Hope

CDE Diabetes Management Programme

Centre for Diabetes and Endocrinology (Pty) Ltd

PODIATRY Screening
For Patients Registered on the CDE STANDARD CARE PLAN

Foot Examination and Risk Assessment Report (For completion by examining Podiatrist)

Patient: _____ **Consultation Date:** _____ / _____ / _____

Please circle appropriate findings & comment as needed. N.B. Report structured so that "Y" response indicate an ABNORMAL or HIGH-RISK finding

Orthopaedic / Musculoskeletal			Right – Comments			Left – Comments
Bony Deformities / Prominences	N	Y		N	Y	
Charcot Neuroarthropathy	N	Y		N	Y	
Plantar pressure ABNORMAL	N	Y		N	Y	
Joint mobility range: ankle, 1st MPJ ABNORMAL	N	Y		N	Y	
Lower Leg Amputation/s	N	Y		N	Y	
Gait abnormalities	N	Y		N	Y	
Inappropriate Footwear	N	Y		N	Y	
Dermatology						
Corns and Calluses	N	Y		N	Y	
Fissures	N	Y		N	Y	
Infections: soft tissue, nail	N	Y		N	Y	
Ulcers: University of Texas Classification:-	N	Y		N	Y	
Vascular						
Pulse NOT palpable – Dorsalis pedis	N	Y		N	Y	
Pulse NOT palpable – Posterior tibialis	N	Y		N	Y	
Skin Temperature ABNORMALITIES	N	Y		N	Y	
Capillary refill time (CRT) >2 sec	N	Y		N	Y	
Intermittent Claudication	N	Y		N	Y	
ABPI range NOT >0.9<1	N	Y		N	Y	
Chronic Ischaemic changes	N	Y		N	Y	
Neurological: Distal Symmetrical Polyneuropathy						
10 g Monofilament: <⅔ applications felt	N	Y		N	Y	
Temp perception (dorsum) ABNORMAL	N	Y		N	Y	
Sharp / Blunt perception ABNORMAL	N	Y		N	Y	
Vibration perception: 128 Hz Tuning Fork < ⅔ felt	N	Y		N	Y	
Proprioception ABNORMAL	N	Y		N	Y	
Patellar Reflex ABNORMAL	N	Y		N	Y	
Ankle Reflex ABNORMAL	N	Y		N	Y	
Neuropathic Symp. (Visual Analogue Scale)	N	Y		N	Y	
Balance Impairment noted	N	Y		N	Y	
Tone & function of interosseous & anterior tibial muscles ABNORMAL	N	Y		N	Y	
Asymmetrical neuropathy present	N	Y		N	Y	
Self-care practices INADEQUATE	N	Y		N	Y	
Foot Risk according to SIGN		Low	Moderate	High		Low	Moderate	High

Clinical Notes:

_____

_____

_____

_____

_____

Right Plantar Left Plantar

Podiatrist Name & Pr No.: _____ **Signature:** _____