

**DEVELOPMENT OF A MODEL TO PREDICT THE COST OF
MANAGEMENT OF DIABETES MELLITUS AND ITS
COMPLICATIONS AT GROOTE SCHUUR HOSPITAL**



**DEVELOPMENT OF A MODEL TO PREDICT THE COST OF MANAGEMENT OF
DIABETES MELLITUS AND ITS COMPLICATIONS AT GROOTE SCHUUR
HOSPITAL**

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A thesis submitted in partial fulfillment of the requirements for the degree of *Magister
Pharmaceuticae* in the School of Pharmacy, University of the Western Cape



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KEYWORDS

Cost

Complications

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Tertiary hospital



ABSTRACT

Diabetes mellitus places a substantial financial burden on the funder for treatment of this disease. This burden is compounded by the development of diabetes mellitus related complications. The cost of management of diabetes mellitus and its complications in South Africa in a tertiary level hospital is unknown.

The objectives of this study were to: (1) develop a method to determine the cost of management of diabetes mellitus and its complications at Groote Schuur hospital, (2) quantify the direct medical costs associated with diabetes mellitus and its complications, and (3) develop models which could predict the cost of management of diabetes mellitus and its complications at Groote Schuur hospital.

Patients were conveniently selected from Groote Schuur Hospital. Retrospective data were collected for 20 months from the two data sources available at Groote Schuur hospital, i.e., (1) electronic patient records and (2) patient folders. Two methods of costing were developed, i.e., the combined method (using data from electronic database and patient folders) and the electronic method (using data from the electronic database only). The patient folders were used to complete any missing information from the electronic patient records. The combined method allowed better categorisation of costs compared to the electronic method. With the combined method the costs associated with diabetes mellitus (type I or type II) and diabetes mellitus complications could be categorized as the type of diabetes mellitus complications and the reasons for emergency room visits and hospitalisations were known. However, with the electronic method this categorisation could not be done. Both methods provided a total cost and cost per patient associated with diabetes mellitus and its complications.

Data from the combined method were arranged in the following main sub-groups for analysis: (1) type I diabetes mellitus, (2) type II diabetes mellitus, (3) diabetes mellitus, (4) diabetes mellitus with complications (5) diabetes mellitus complications only.

The electronic method estimated a total cost which was 6.4% more than the combined method. The electronic method did not require the perusal of patient folders for additional information and hence it is a simplified method that could be used. When comparing the total costs and the average cost per patient for diabetes mellitus and diabetes mellitus with complications, there was no statistically significant difference between the combined method and the electronic method ($p= 0.41$).

The average cost per patient per year for diabetes mellitus and diabetes mellitus with complications was R 1 231.54 and R 3 208.71, respectively. These results show that a patient with diabetes mellitus and its complications cost 2.6 times more to treat than a patient with diabetes mellitus only. The complications of diabetes mellitus contributed 60.7% to the total cost of diabetes mellitus and its complications. The cost of treating diabetes mellitus only and the cost of treating diabetes mellitus complications only were separated into 2 distinct categories. In this case, the cost of treating the complications of diabetes mellitus only was 2 times more than treating diabetes mellitus only. Type I diabetes mellitus cost R 3 011.32 and type II diabetes mellitus cost R 2 649.40 per patient per year. The treatment costs for type I diabetic patients was 13.7% more than that for type II diabetic patients.

The decision tree model determined a cost which was 0.23% more than the actual cost obtained by the combined method. Hence, the decision tree method could be used to predict the total cost of diabetes mellitus and its complications.

Patients who attended Groote Schuur Hospital also received treatment for their diabetes at community health centres. A method was developed which could predict the cost of management of diabetes mellitus at community health centres. This will allow the calculation of the total cost of diabetes mellitus and its complications from the perspective of the government. Four methods (i.e. combined, electronic, decision tree and prediction of costs at cost at community health centres) were developed in this study.



DECLARATION

I declare that *Development of a model to predict the cost of management of diabetes mellitus and its complications at Grootte Schuur hospital* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

SHAUN NOMAME

November 2012



Signed:.....

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The logo of the University of the Western Cape, featuring a classical building facade with six columns and a pediment, with the text "UNIVERSITY of the WESTERN CAPE" below it.

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LIST OF ABBREVIATIONS

CHC	Community Health Centre
DM	Diabetes mellitus
DMC	Diabetes mellitus complications
ECG	Electrocardiogram
GDP	Gross Domestic Product
GSH	Groote Schuur Hospital
ICD-10	International Statistical Classification of Diseases and Related Health Problems version 10
IDF	International Diabetes Federation
IHD	Ischaemic Heart Disease
NDoH	National Department of Health
NHI	National Health Insurance
PVD	Peripheral Vascular Disease
SD	Standard Deviation
UPFS	Unified Patient Fee Schedule



CHAPTER 1

INTRODUCTION

The International Diabetes Federation (IDF) has stated that diabetes mellitus is the most common non-communicable disease in the world (IDF. 2009). It was estimated that 4.5 % of the South African population was diabetic in 2010 and this prevalence is expected to increase in the next 20 years (Shaw *et al.* 2010). Diabetes mellitus (DM) is a chronic condition associated with a wide range of vascular complications (Winer *et al.* 2004).

Diabetes mellitus places a substantial financial burden on the funder of treatment for this disease. This burden is compounded by the development of diabetes mellitus related complications which further increases the cost of treatment (Pelletier *et al.* 2008).

The cost of managing diabetes mellitus and its complications has been documented in developed countries (Ramsey *et al.* 1999; Gandra *et al.* 2006; Clarke *et al.* 2008). In South Africa there is no published data on the costs of managing diabetes mellitus and its complications in a tertiary hospital. The increase in prevalence of diabetes mellitus will subsequently increase the need for relevant cost data. This study is therefore aimed at providing cost data on diabetes mellitus and its complications in a South African context.

The South African health care environment is changing with the introduction of the National Health Insurance (NHI). Therefore, an even greater emphasis will be placed on funding and distribution of scarce monetary resources. It has become important that costs of common diseases such as diabetes mellitus are known. Knowledge of these costs may help funders i.e. government, when it comes to financial planning for health care.

Costs for diabetes mellitus and its complications in South Africa are important, but of equal importance is the actual method of costing, using the data which is available. An important

consideration in costing is to evaluate the method which had been used to derive such costs. Such a method does not exist in South Africa for diabetes mellitus and its complications in a tertiary hospital.

The public health care system is predominantly used in South Africa and therefore plays an important role. The National Treasury estimates that 84 % of South Africans utilise the public health care system (National Treasury. 2011). This shows the importance of developing cost data, and more importantly, developing methods which are created for the public sector taking into account the specific strengths and weaknesses of the data sources.

This study was conducted in the public sector at Groote Schuur hospital (GSH). Costs in this sector are largely unknown and this presents a unique challenge to the government with regard to making health economic decisions. The study was conducted from the perspective of the funder of the treatment.

This study had three primary objectives to: (1) develop a method to determine the cost of management of diabetes mellitus and its complications at Groote Schuur hospital, (2) quantify the direct medical costs associated with diabetes mellitus and its complications, and (3) develop models which could predict the cost of management of diabetes mellitus and its complications at Groote Schuur hospital.

In addition to the above mentioned, the study had the following specific objectives:

- a) To determine the best method for costing diabetes mellitus and its complications at Groote Schuur hospital.
- b) To determine the cost of treating a patient with diabetes mellitus only at Groote Schuur hospital.
- c) To determine the cost of treating a patient with diabetes mellitus and complication(s) (DMC) at Groote Schuur hospital.
- d) To determine the cost components which have a substantial impact on the cost of diabetes mellitus and its complications.



CHAPTER 2

LITERATURE REVIEW

This literature review will focus on the cost of diabetes mellitus and its complications and the use of economic models to predict costs of diabetes mellitus and its complications. In addition to this, the first part of the review will provide an overview of the prevalence and aetiology of diabetes mellitus and its complications, as this informs the development of the methods involved in predicting costs.

The second part of this review will focus on economic models found in literature. These models will be assessed in terms of methods used.

The third part of this literature review will focus on the research which has quantified the costs associated with diabetes mellitus and its complications. This review will evaluate the methods used in these studies and highlight the differences and similarities in the methods used and assess what possible conclusions could be developed as a result. Some of the common limitations of these studies will be highlighted and the relevance thereof evaluated.

2.1 Diabetes mellitus

Diabetes mellitus is now regarded as one of the most common non-communicable diseases in the world. It has become evident that developing countries, such as South Africa, will face the greatest burden in combating this disease (IDF. 2007). These developing countries face challenges such as reduced physical inactivity due to urbanisation and increasing prevalence of obesity, which are considered lifestyle related risk factors for diabetes mellitus (Shaw *et al.* 2010).

Diabetes mellitus is a metabolic disorder which is characterised by resistance to the action of insulin, insufficient insulin secretion, or both (Gavin *et al.* 2003). Diabetes mellitus can be classified into two categories, type I diabetes mellitus and type II diabetes mellitus.

Type I diabetes mellitus is caused by a deficiency of insulin in the body. Type II diabetes mellitus is caused by insulin resistance and a relative lack of insulin secretion, with progressively lower insulin secretion over time (Kuzuya *et al.* 2002).

Type II diabetes mellitus is the most common form of diabetes mellitus with an estimated prevalence rate of 90 - 95%. Type I diabetes mellitus affects fewer diabetic patients with an estimated prevalence rate of 5 - 10% (Deshpande *et al.* 2008).

2.2 Global prevalence of diabetes mellitus

The global prevalence of diabetes mellitus is increasing rapidly. This increase is attributed to various factors such as population growth, aging, urbanisation and the increasing prevalence of obesity and physical inactivity (Shaw *et al.* 2010). The global prevalence rate for the year 2010 was estimated at 6.4%. This translates into about 285 million people with diabetes mellitus worldwide (Shaw *et al.* 2010). The prevalence of diabetes is set to increase in the next 20 years as a result of the increasing incidence of diabetes. The current estimate for the year 2030 is 439 million people worldwide. This indicates an increase in prevalence of about 50% over the next 20 years (Shaw *et al.* 2010). This shows the need for further research into diabetes mellitus and its impact on health care budgets.

2.2.1 Prevalence of diabetes mellitus in South Africa

The prevalence of diabetes mellitus in South Africa was estimated at 4.5% in 2010 but, in line with global trends, this number is set to increase over the next 20 years. An estimated 5.6% of the South African population will be diabetic in the year 2030 (Shaw *et al.* 2010).

2.3 Types of diabetes mellitus complications

Diabetes mellitus complications can be classified as either acute metabolic (short-term) complications or chronic (long-term) complications.

The acute complications of diabetes mellitus include hypoglycemia, hyperglycemia, hyperosmolar diabetic ketoacidosis and diabetic ketoacidosis (Pepper *et al.* 2007). These complications develop over a short period of time and are reversible when treated appropriately.

The chronic complications of diabetes mellitus are broadly classified into two distinct categories i.e., macrovascular and microvascular complications (Deshpande *et al.* 2008).

Macrovascular complications include cardiovascular disease (myocardial infarction, angina pectoris, heart failure, stroke and transient ischaemic attack) and peripheral vascular disease (foot ulcers, gangrene and amputations of the lower extremities) (Deshpande *et al.* 2008).

Microvascular complications include neuropathy, nephropathy and retinopathy (Deshpande *et al.* 2008). Table 1 indicates the economic implications of the various complications of diabetes mellitus. Treatment and management of these various complications will result an increase in the cost of treatment as indicated in Table 1 which was derived from a study by Williams *et al.* (2002).

Table 1: Chronic complications of diabetes mellitus and the economic implications

System affected	Disease	Economic implications
Eyes	Retinopathy Glaucoma Cataracts Blindness	Drug therapy Surgery for cataract removal Photocoagulation therapy Hospitalisation
Kidneys	Renal failure Renal disease	Drug therapy Dialysis Kidney transplant Hospitalisation
Blood vessels	Coronary artery disease Cerebral vascular disease Peripheral vascular disease Hypertension	Drug therapy Surgery Hospitalisation
Nerves	Neuropathies	Drug therapy Surgery Hospitalisation Rehabilitation

2.3.1 Prevalence of diabetes mellitus related complications

Table 2 represents the prevalence rates of the most common diabetes mellitus complications according to a survey conducted in the United States of America between 1999 and 2004 by the National Health and Nutrition Examination Survey (Deshpande *et al.* 2008).

Table 2: Prevalence of common diabetes mellitus related complications

Diabetes mellitus related complication	Prevalence rate
Chronic kidney disease (Nephropathy)	27.8%
Peripheral vascular disease	22.9%
Eye complications (Retinopathy)	18.9%
Heart attack	9.8%
Chest pain	9.5%
Coronary heart disease	9.1%
Congestive heart failure	7.9%
Stroke	6.6%

Cardiovascular disease ¹	42.9%
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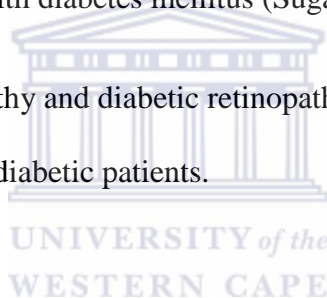
¹ Cardiovascular diseases grouped as a single disease using prevalence rates from the study.

Although nephropathy as a single disease has the highest prevalence, the cardiovascular complications when grouped as a single disease have the highest prevalence rate (Deshpande *et al.* 2008).

Although these chronic complications can occur in any person, they have shown to occur more frequently in diabetic patients. An estimated 65% of all deaths in people with diabetes mellitus have been caused by cardiovascular disease (Leibson *et al.* 2005; Booth *et al.*, 2006).

Lower extremity amputations, due to peripheral vascular disease, are at least 10 to 20 times more likely to occur in patients with diabetes mellitus (Sugarman *et al.* 1998).

Cardiovascular disease, nephropathy and diabetic retinopathy are the most common diabetes mellitus related complications in diabetic patients.



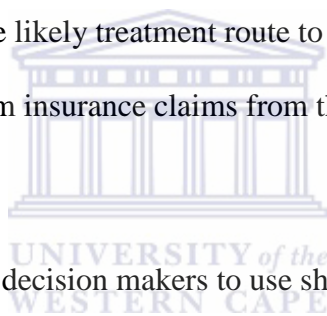
2.4 Economic models

Various studies have shown the value of economic models in costing diabetes mellitus and its complications (Coyle *et al.* 2002; Clarke *et al.* 2008; Zhou *et al.* 2005).

Many of the models currently available mainly focus on type II diabetes mellitus. These models have similar characteristics in that they follow Markov based microsimulation and utilises data from various epidemiological studies and databases. However, these models do vary significantly in the types and number of diabetes mellitus complications covered by the models (Coyle *et al.* 2002).

There are a number of computer simulated models that have been developed, these, however, have not been discussed here as they are not relevant to this study (Zhou *et al.* 2005).

A study by O'Brien and colleagues (2003) used a model to determine the costs of type II diabetes mellitus and its complications in Canada. This model used probabilities from published sources to determine occurrence of complications, then unit costs were applied to the likely course of treatment for each complication. Various cost sources were used in that study; namely, Alberta Ambulatory Care Costing project, Ontario Care Cost project, Canadian Diabetes Association and the Canadian clinical practice guidelines. A similar method of costing was used in other studies in the United States of America and Canada (O'Brien *et al.* 2001; Eastman *et al.* 1997). Clarke and colleagues (2008), used data from an Australian managed health care database to estimate the costs of diabetes mellitus and its complications. Probabilities for certain complications of diabetes mellitus were determined and unit costs were applied for the likely treatment route to be taken for these complications. Cost information was derived from insurance claims from the managed health care organisation.



Models have been found to allow decision makers to use short-term clinical data to forecast long-term costs and benefits. Many of the models discussed here are based on similar principles of construction and organisation. These models used published epidemiological data to obtain probabilities for occurrence of certain events. These models do, however, differ in the type and number of complications assessed and in the complexity of the model (O'Brien *et al.* 2001; 2003; Clarke *et al.* 2008).

2.5 Cost of diabetes mellitus and its complications

The third part of the literature review will evaluate the studies which have quantified the costs associated with diabetes mellitus and its complications. The various methods used in these studies and the economic impact thereof will be assessed.

2.5.1 Methods used in cost studies

2.5.1.1 Data sources (Electronic database versus Patient folders)

There are two main data sources used in cost studies, viz. patient folders and electronic databases containing claims data from managed health care organisations. Data from developed countries were extracted mainly from electronic databases. There were few studies described in the literature which used patient folders as the primary data source. Table 3 summarises the data sources in the literature.

Table 3: Data sources used in literature

Author, date	Electronic vs Patient folders	Time period studied	Study type	Number of patients in study	Country
Pelletier <i>et al.</i> 2008	Electronic	January 2003 to December 2004	Retrospective cohort analysis	44 021	United States of America
Riewpaiboon <i>et al.</i> 2007	Paper-based	October 2000 to September 2001	Retrospective cohort analysis	186	Thailand
Morsanutto <i>et al.</i> 2006	Paper-based and electronic	January 2001 to August 2002	Retrospective longitudinal analysis	299	Italy
Gandra <i>et al.</i> 2006	Electronic	January 2003 to December 2003	Retrospective cohort analysis	9 059	United States of America
Ramsey <i>et al.</i> 1999	Electronic	January 1992 to December 1995	Retrospective cohort analysis	8 905	United States of America
Clarke <i>et al.</i> 2006	Electronic	July 1995 to June 1999	Retrospective cohort analysis	20 538	Australia
Brandle <i>et al.</i> 2003	Electronic	April 2000 to February 2001	Retrospective cohort analysis	1 364	United States of America
Pelletier <i>et al.</i> 2009	Electronic	January 2002 to December 2005	Retrospective cohort analysis	15 326	United States of America
Stock <i>et al.</i> 2005	Electronic	January 1999 to December 1999	Retrospective cohort analysis	158 629	Germany

Clarke <i>et al.</i> 2008	Electronic	January 1990 to December 1999	Retrospective cohort analysis	70 340	Australia
Massi-Benedetti. 2002	Electronic		Bottom-up prevalence based study	> 7 000	Europe

2.5.2 Diabetes mellitus related complications in cost studies

There have been various complications of diabetes mellitus included in cost studies. The majority of these studies focussed on the chronic complications of diabetes mellitus, while only Pelletier *et al.* (2008) and Riewpaiboon *et al.* (2007) included short-term acute metabolic complications.

The United Kingdom Prospective Diabetes Study conducted in 2003 (Clarke *et al.* 2003) lists hypertension and hyperlipidaemia as risk factors for the development of diabetes mellitus complications. Some studies in the cost literature have recorded conditions such as hypertension and hyperlipidaemia as complications of diabetes mellitus (Riewpaiboon *et al.* 2007; Ramsey *et al.* 1999).

Cardiovascular complications were commonly investigated as single disease states. Similarly, the consequences of peripheral vascular disease such as gangrene, diabetic foot and amputations were reported as separate diseases states including peripheral vascular disease. As indicated in Table 3, the number of complications studied varied and not all the complications of diabetes mellitus were included. Stroke was only mentioned in 3 of the 9 studies presented in Table 3.

These resulting inconsistencies in the grouping or definitions of complications within the cost studies can cause difficulty in interpretation of the cost of diabetes mellitus and its complications.

Table 4: Most common diabetes mellitus complications included in cost literature

Reference	Prevalence of diabetes mellitus complications	Number of patients included in study
Pelletier <i>et al.</i> 2008	Retinopathy 28.7% Neuropathy 25.4% Heart Failure 14% Angina Pectoris 12% Renal disease 11% Peripheral vascular disease 10.6% Foot ulcer 8.5% Myocardial infarction 7.2% Ischaemic stroke 5% Blindness 0.9% Hypoglycaemic event 0.2% Ketoacidosis 0.2%	44 021
Riewpaiboon <i>et al.</i> 2007	Hypertension 41.1% Neuropathy 35.5% Hyperlipidaemia 16.1% Diabetic foot 13.4% Nephropathy 7% Ischaemic heart disease 4.3% Cerebrovascular accident 3.8% Hyperglycaemia 2.7% Hypoglycaemia 1.1% Retinopathy 0.5% Gangrene 0.5%	186
Morsanutto <i>et al.</i> 2006	Retinopathy 27.4% Nephropathy 20.5% Cardiopathy 19.7% Other 32.5%	299
Gandra <i>et al.</i> 2006	Retinopathy 12.6% Nephropathy 5.9% Neuropathy 5.5%	9 059
Ramsey <i>et al.</i> 1999	Eye disease 44.3% Hypertension 26.2% Myocardial infarction 9.3% Stroke 8.7% Foot ulcer 7.9% End-stage renal disease 5.9%	8 905
Clarke <i>et al.</i> 2005	Vascular disease 5.1% Ischaemic heart disease 3.9% Cerebrovascular disease 1.8% Acute Myocardial infarction 1.5% Renal disease 1.1% Amputations 0.5%	20 538

Brandle <i>et al.</i> 2003	Neuropathy Peripheral vascular disease Myocardial infarction Cerebrovascular disease Nonproliferative retinopathy Angina Proliferative retinopathy End-stage renal disease	40% 39% 27% 15% 12% 4% 3% 0.4%	1 364
Pelletier <i>et al.</i> 2009	Peripheral neuropathy Diabetic retinopathy Nephropathy Other diabetic complications Dialysis	60.5% 28.1% 18.9% 1.4% 1%	15 326
Clarke <i>et al.</i> 2008	Fatal myocardial infarction Non-fatal myocardial infarction Fatal stroke Non-fatal stroke Ischaemic heart disease Heart failure Renal failure Blindness Foot ulcer Amputation	Cost estimates provided. No patient level data	70 340



2.5.3 Cost components

The direct medical costs associated with the treatment of diabetes mellitus and its complications consist of various components. Campbell *et al.* (1997) described two types of cost components which included ambulatory and hospital care. Ambulatory care comprised of doctor consults, clinic visits, drug therapy and self-monitoring therapy. These costs occurred in an outpatient setting. The sub-components of hospital care were not provided. The most widely used cost components in cost analysis were medicines, laboratory/diagnostic tests, doctor/specialist consultations, emergency room visits and hospitalisations (Pelletier *et al.* 2008; Riewpaiboon *et al.* 2007; Morsanutto *et al.* 2006; Clarke *et al.* 2005).

An evaluation of the literature revealed that while medicine cost is commonly reported, some researchers have further categorised and identified the types of medicines which were included in the cost analysis. For example, Pelletier *et al.* (2008) further reported medicines

in four categories based on the type of medicines i.e., insulin, oral hypoglycaemic agents, ACE inhibitors and statins/antihyperlipidaemics. Riewpaiboon *et al.* (2007) also reported medicines according to the type of medicine but included vitamin B1-4, vitamin B12 and vitamin B complex in the cost of medicines. Vitamins are not commonly considered as medicines to treat diabetes mellitus or its complications, therefore this could result in an overestimation of medicine cost. O'Brien *et al.* (2003) categorised and clearly identified the medicines used in the treatment of diabetes mellitus and its complications. Riewpaiboon *et al.* (2007) included another component to the cost of medicine i.e., the cost of dispensing.

Hospitalisation can consist of various components such as bed stay, laboratory tests, medicines, doctor consultations, nursing care and surgery. Numerous studies reported hospitalisation as a component cost (Brandle *et al.* 2003; Ramsey *et al.* 1999; Gandra *et al.* 2006). These studies provide no further categorisation into the various components of hospitalisation which were included in the studies. The cost of hospitalisation may not reflect the true cost as some components such as laboratory tests conducted, nursing time and other general ward items used during the hospitalisation may not have been taken into account. Riewpaiboon *et al.* (2007) reported surgery and hospitalisation as two separate costs. No further explanation was provided as to whether the hospitalisation was due to surgery or a separate unrelated event. In an Australian study, Clarke *et al.* (2005) reported hospital costs which included day surgery.

The cost components have an immense effect on the cost results obtained. Detailed reporting of the cost components included in the cost analysis adds greater validity to the study and subsequent conclusions derived from the study.

2.5.4 Cost of treating diabetes mellitus and diabetes mellitus complications

The treatment of diabetes mellitus and its complications has been shown to be costly and a large proportion of health care budgets were used on these treatments. The International Diabetes Federation (IDF) estimated that the global health care expenditure for diabetes mellitus and its complications was 11.6% of the total health care expenditure in 2010.

During the same period, 7% of the total health care expenditure for both Africa and South Africa (individually) was spent on diabetes mellitus and its complications (IDF. 2009).

Numerous studies conducted on the treatment of diabetes mellitus and its complications showed that the diabetes related complications contribute the largest proportion of the total costs of diabetes mellitus treatment (Norlund *et al.* 2001; O'Brien *et al.* 2003; Simpson *et al.* 2003; Williams *et al.* 2002).

According to the American Diabetes Association (ADA) the cost of treating diabetes mellitus and its complications in the United States in 2007 was 174 billion US dollars and of this 58 billion US dollars was spent on the treatment of diabetes related complications (ADA. 2008).

The complications of diabetes mellitus therefore contribute 33.3% of the total cost of treating diabetes mellitus and its complications.

Diabetes mellitus complications may require hospitalisation for management. These hospitalisations have been documented as the largest cost drivers in the treatment of diabetes mellitus complications. Researchers found that hospitalisations contribute as much as 50% of the total cost of treatment. Dawson *et al.* (2000) found that 50% of the total cost of treatment was due to hospital care, while medication and doctor consultations accounted for 31% and 19%, respectively, of the total cost. Jonsson B. (2002) reported that hospitalisation accounted

for 55 % of the total cost on average but this figure ranged between 30% and 65% of the total cost.

Williams *et al.* (2002) reported that the complications of diabetes mellitus increased hospitalisation cost by 450% when compared to diabetic patients without complications. Patients with a macrovascular complication had a 7-fold increase in hospital costs compared to patients with no diabetes mellitus complications (Gandra *et al.* 2006).

An Italian study compared the distribution of annual treatment costs among patients with and without diabetes mellitus complications. These results indicated that for patients with a complication(s), 28% of the treatment cost was due to hospitalisations in comparison to 1% for patients without a complication (Morsanutto *et al.* 2006).

The CODE-2 study reported an increase of 70% in the treatment costs for patients with a microvascular complication compared to patients without any complications. This study also reported that patients with a macrovascular complication had double the treatment costs compared to patients with no complications (Massi-Benedetti, M. 2002).

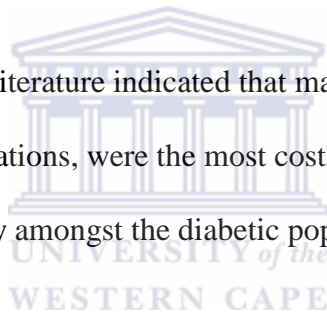
The number of diabetes mellitus complications will also have an impact on the costs of diabetes treatment. This was demonstrated in the study by Currie *et al.* (2005) who reported that patients with 3 complications had a 6-fold increase in annual treatment costs compared to patients with a single complication. Morsanutto *et al.* (2006) reported that patients who had two or more diabetes mellitus complications had a 3-fold increase in costs versus patients with no complication(s). Hospitalisation was the greatest contributor to the total cost, increasing from 1% for patients with no complication to 40% for patients with two or more complications.

A cost of illness study found that cardiac, coronary disease and stroke were the most costly diabetes mellitus complications among type 2 diabetic patients (Gonzalez *et al.* 2009).

Cardiovascular disease was found to be the most common complication and also the most costly diabetes mellitus complication by some researchers (Nichols and Brown. 2002; Morsanutto *et al.* 2006; Simpson *et al.* 2003). Pelletier *et al.* (2008) reported heart failure, myocardial infarction and renal disease as the most costly diabetes mellitus complications.

Similarly, results obtained in Mexico among type 2 diabetics indicated that chronic kidney failure was the most costly to treat, while cardiovascular disease resulted in significant resource use which increased treatment costs (De los Ángeles Rodríguez Bolaños *et al.* 2010).

In summary, a review of various literature indicated that macrovascular complications, in particular cardiovascular complications, were the most costly diabetes mellitus complications in addition to occurring frequently amongst the diabetic populations studied.



2.5.5 Cost studies in South Africa

Limited data is available in South Africa regarding the costs for treating diabetes mellitus and its complications. One published study reported the costs of treating acute metabolic diabetes mellitus complications in a secondary level hospital (Pepper *et al.* 2007). This study was conducted over a 2 month period and costs were calculated using the public sector pricing. Data were collected prospectively and patient folders were used as the primary source of data. A average cost of R 5 309.49 per admission was reported (2005 costs), the largest contributor to this cost was nursing care. The average hospitalisation period reported was 4 days (Pepper *et al.* 2007). The results of this study showed that acute prevenTable

complications of diabetes mellitus placed a huge financial burden on the funder of the treatment in South Africa.

A review of literature revealed that no studies have been published in South Africa on the total cost of diabetes mellitus and its complications in any particular setting in South Africa.

2.6 Limitations of cost studies

2.6.1 Data sources

Various data sources were used in the studies to quantify the costs of treating diabetes mellitus and its complications. The accuracy of the data sources directly affect the cost data which are collected and reported. If the data which were collected do not represent the entire diabetic population of the specific region and the results cannot be generalised to a wider population. The accuracy of the database is highly dependent on the data capturers and the coding process (Pelletier *et al.* 2005; Morsanutto *et al.* 2006; Gandra *et al.* 2006).

The full cost of diabetes mellitus treatment cannot be reported when using electronic claims from administrative health insurance data as the costs reported do not include patient co-payments and any other out of pocket payments (Clarke *et al.* 2008; Stock *et al.* 2005; Pelletier *et al.* 2009).

Data sources such as patient folders have several limitations. The data may be incomplete, some information may be missing or medical records may not be accurately completed and kept up to date (Riewpaiboon *et al.* 2007).

Data sources and their limitations have an effect on the results reported. These costs will in most cases be underestimated due to the limitations discussed above (Akobundu *et al.* 2006).

2.6.2 Cost perspective

An important consideration when assessing the cost studies is the perspective of the study as this can affect the way in which the cost results are interpreted. There are 3 main perspectives from which these studies were conducted i.e., (1) the patient, (2) the provider of health care and (3) the funder of the treatment (Akobundu *et al.* 2006). The perspectives of the funder of the treatment and the provider of health care are similar in that only direct medical costs are assessed. The patient perspective will assess both the direct and indirect medical costs (Kishore *et al.* 2009).

These differences in cost studies show that there is no standard method for estimating the costs of treating diabetes mellitus and its complications.

2.7 General comment on literature review

Diabetes mellitus is a complex chronic disorder with both short-term (acute) and long-term (chronic) complications which are costly to treat and manage. Studies (Pelletier *et al.* 2005; Morsanutto *et al.* 2006; Clarke *et al.* 2008; Chatterjee *et al.* 2011) have repeatedly found a large economic burden associated with the treatment of diabetes mellitus and its complications. Economic models predict costs and therefore aid the decision making process.

CHAPTER 3

PLAN OF WORK

The purpose of this chapter is to provide an overview of the methods which were used in the study. The details of these methods are described in chapter 4.

3.1 Study objectives

The overall objectives of this study were to (1) develop a method to determine the cost of management of diabetes mellitus and its complications at Groote Schuur hospital, (2) quantify the direct medical costs associated with the management of diabetes mellitus and its complications and (3) develop a model which could predict the cost of management of diabetes mellitus and its complications at Groote Schuur hospital.

3.2 Overview of the methods used

Patients who attended the adult diabetic clinic at Groote Schuur hospital were indentified from the electronic database for possible inclusion in the study. The inclusion and exclusion criteria were applied. Patient validation criteria were applied to ascertain a diagnosis of diabetes mellitus and the complications of diabetes mellitus. There were two data sources available at Groote Schuur hospital i.e., (1) electronic patient records and (2) patient folders.

3.2.1 Cost method

Two cost methods were developed in this study:

- (1) The combined method
- (2) The electronic method

3.2.1.1 Combined method

The combined method utilised data from the electronic patient records and patient folders.

The patient folders were used to complete any missing information from the electronic patient records. The patient folders provided additional clinical information which was used to categorise costs into (1) costs due to diabetes mellitus and (2) costs due to the complications of diabetes mellitus. The reasons for hospitalisation and emergency room visits were obtained from the patient folders.

3.2.1.2 Electronic method

The electronic method utilised data from the electronic patient records only.

Data which was obtained from the electronic database was used. Patient diagnoses were not available in this database. Patients' medicine history was used to categorise patients into (1) insulin dependent diabetes mellitus and (2) non-insulin dependent diabetes mellitus. It was assumed that if a patient had specific laboratory tests conducted or visited certain clinics at Groote Schuur hospital, it would reflect the presence of a complication of diabetes mellitus.

Each of these methods, i.e., the combined and electronic methods, provided a total cost and cost per patient.

3.2.2 Source of costs

In this study costs were obtained from the following sources:

- a) UPFS Provincial Gazette for Western Cape No. 6862, 25 March 2011. This included costs for doctor consultations, dispensing fee, electrocardiogram and radiological procedures, emergency room visits, hospitalisations and surgeries.
- b) Pharmacy department at Groote Schuur hospital provided the cost for the medicines and other pharmacy supplies.
- c) National Health Laboratory Services provided costs for the laboratory tests.

3.2.3 Categorisation of costs

In this study costs were broadly categorised into (1) costs due to diabetes mellitus and (2) costs due to the complications of diabetes mellitus. The categorisation of these costs was based on the clinical data of each patient.

3.3 Model development

The primary model developed was a predictive cost model for diabetic patients at Groote Schuur hospital. This model was based on the decision tree algorithm and utilised probabilities of the occurrence of type I or type II diabetes and whether or not complications would occur. Cost estimates for a period of one year were obtained for the following categories:

- a) Type I diabetes mellitus without complications
- b) Type I diabetes mellitus with complications
- c) Type II diabetes mellitus without complications

d) Type II diabetes mellitus with complications

Statistical analyses were applied to the results obtained to determine if the differences in the following total and average costs were statistically significant:

a) Combined method versus electronic method

b) Diabetes mellitus versus diabetes mellitus with complications

c) Type I versus type II diabetes mellitus



CHAPTER 4

METHODS

This chapter provides a detailed description of the methods used in this study. This research method consisted of two parts, (1) development of a cost method and (2) development of a predictive cost model for the diabetic population of Groote Schuur hospital.

4.1 Selection of the study site

Many of the complications of diabetes mellitus require hospitalisation and specialised care for treatment. Hence, Groote Schuur hospital (GSH) was conveniently selected as the study site. This tertiary level hospital is located in the Cape Metropole area and is part of the Associated Academic Hospitals' group. It is a government funded teaching hospital and many of the doctors employed at Groote Schuur hospital are specialists involved in training of medical professionals and research. This hospital was selected on the basis that it is a referral hospital for the treatment and care of patients with complications of diabetes mellitus.

4.2 Patient extraction from electronic database of patient records

Patients with diabetes mellitus and its complications were extracted from the electronic database of Medical Informatics at Groote Schuur hospital. The method of extracting patients from the electronic database was developed in consultation with Ms. Wendy Bryant (Director, Medical Informatics, Groote Schuur hospital) and Professor Naomi Levitt (Head Diabetic Medicine and Endocrinology, University of Cape Town and Groote Schuur hospital). The patients who attended the adult diabetic clinic at Groote Schuur hospital were identified for possible inclusion in the study. This method of extracting these patients was preferred over the conventional method of extracting patients by using International

Statistical Classification of Diseases and Related Health Problems (ICD-10) codes specific to diabetes mellitus and its complications.

The recording of ICD-10 codes in the electronic database was not considered to be accurate and it was possible that not all the diabetic patients would have been included if this method had been used.

4.3 Patient Selection

4.3.1 Inclusion criteria

Patients were included in the study based on the following criteria:

- a) had diabetes mellitus;
- b) had diabetes mellitus related complications; and
- c) over the age of 18 years.



4.3.2 Exclusion criteria

Patients were excluded from the study based on the following criteria:

- a) had a cancer co-morbidity as these patients have shown to incur high medical costs (Gandra *et al.* 2006); and
- b) had diabetes mellitus as a result of pregnancy, drug-or-chemical induced diabetes or diabetes as a result of an underlying condition (e.g. pancreatitis).

4.3.3 Sampling

A total of 1094 patient records were extracted from Groote Schuur hospital based on the extraction method. A convenience sampling method was applied. Patient folders were

requested from Medical Records at Groote Schuur hospital until a sample of 100 patients was obtained based on the inclusion criteria.

4.4 Study design

This was a retrospective cohort analysis.

4.5 Study period

Data were collected from 1st April 2009 until 31st December 2010.

4.6 Data collection

The researcher was trained by Professor Levitt on how to extract and obtain relevant information from the patient folders.

Information on every patient was extracted from two sources:

- a) electronic patient records
- b) patient folders



Patient hospital identification numbers were obtained from the electronic database. A patient list was then compiled and presented to the Medical Records department at Groote Schuur hospital for retrieval of the patient folders.

The researcher extracted from each patient folder the information necessary for the cost analysis for the study period of interest. It took on average 45 minutes to one hour to complete the collection of data from each patient folder.

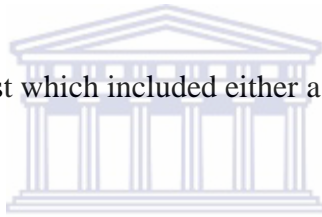
The main purpose of the manual extraction of information from the patient folder was to complete any missing patient data that had not been included in the electronic patient records.

The information in the patient folder was used to verify the information in the electronic database of patient records.

4.7 Patient validation

The following criteria were used to validate the diagnosis of diabetes mellitus for each patient. If the patient met any one of the following criteria, the diagnosis of diabetes mellitus was confirmed.

- a) a diagnosis of diabetes mellitus recorded in the patient folder;
- b) a medication history which included either insulin or an oral hypoglycaemic agent or both; and
- c) a record of a laboratory test which included either a glucose or glycated haemoglobin test or both.



The electronic patient record did not have information regarding the diagnosis of diabetes mellitus complications. Hence, the patient folders were used to complete missing information or to validate the diagnosis of a complication of diabetes mellitus together with the information in the electronic database. If conflicting information was present between the folder and electronic database, then the information obtained in the folder was accepted as the most accurate, as there probably would be no capture error from this source.

4.8.1 Electronic database of patient medical records

This was used as the primary source of the following patient information:

- a) general patient information which included the first name, surname, hospital identification number and date of birth;

- b) history of outpatient doctor consultations which included the date of consultation, clinic/department visited and reason for consultation;
- c) history of patient medication received which included the name of medicine, pack size, quantity, date and total cost per medicine dispensed for the study period;
- d) history of laboratory tests conducted which included the name, date and cost of the laboratory test;
- e) history of radiological and electrocardiography procedures performed which included the type and date of procedure;
- f) history of emergency room visits which included the date and reason for visit;
- g) history of inpatient hospitalisations which included the date of admission and discharge, length of stay and reason for hospitalisation; and
- h) history of surgeries conducted which included the date and type of surgery and duration of anaesthesia and surgery.

The information in the main database was compiled from various sources within the hospital. The accuracy of the information was subject to the accuracy with which the personnel captured the information into the database from the primary source. Data were entered at various points throughout the hospital into the central database of the Medical Informatics department.

The information on laboratory tests was compiled by the Medical Informatics department directly from the National Health Laboratory Services (NHLS). The medicine information was compiled from the pharmacy dispensing programme.

4.8.2 Patient folders

These were used as the secondary data source of patient information. The following information was obtained from this data source:

- a) general patient information which included the name, surname, gender, date of birth, contact numbers and address. This information was used for identification purposes only and was not disclosed at any time during the study or within the thesis;
- b) clinical information relating to the patient which included co-morbidities and diagnosis of patient, past and current medical history. A clinic consultation form was used by the doctor when consulting with a diabetic patient (Annexure 1). This form was designed by Groote Schuur hospital;
- c) information on medication, derived from the prescription charts which were issued by doctors at Groote Schuur hospital;
- d) consultations with doctors and other health care providers at Groote Schuur hospital, emergency room visits, inpatient hospitalisations and surgeries; and
- e) printed reports of laboratory tests, electrocardiography (ECG) tests and radiological procedures.

The accuracy of the information in the patient folders was subject to the accuracy of the healthcare staff recording such information. There were variations in the recording of information between various health care staff. For example, in a particular instance the diagnosis of the type of diabetes mellitus was recorded differently throughout the folder.

Patient co-morbid conditions were also not always documented.

4.9 Source of costs

The following cost sources were used in the study:

- a) the laboratory test costs were obtained from the Medical Informatics department at Groote Schuur hospital. These cost data were extracted from the National Health Laboratory Service (NHLS). This reflected the cost to Groote Schuur hospital for the laboratory test.
- b) the cost for medicines, diagnostic tests (e.g. blood glucose test strips), syringes and needles were obtained from the pharmacy department. The cost reflected the acquisition cost to Groote Schuur hospital.
- c) the costs for the following components were obtained from the Unified Patient Fee Schedule (UPFS), Provincial Gazette for Western Cape, No. 6862, 25 March 2011:
 - a. outpatient doctor consultation cost which consisted of two costs, viz. the facility fee and specialist fee;
 - b. medicine dispensing cost which consisted of a facility fee;
 - c. radiological and electrocardiography procedure costs which consisted of a facility fee and specialist fee;
 - d. emergency room visit cost which consisted of a facility fee and specialist fee;
 - e. inpatient overnight hospital cost which consisted of a facility fee and specialist fee; and
 - f. surgery cost which consisted of two costs, viz. anaesthetic fee and theatre fee.
The theatre fee consisted of two costs, a facility fee and specialist fee.

The UPFS is the price that the government charges private patients who attend government facilities.

Table 5 indicates the various components which are included in the facility fee.

Table 5 UPFS facility fee components

Facility fee	Components
Outpatient consultation	Cost of facility only
Emergency room visit	Nursing time Medicines used
Hospitalisation	Bed stay cost Nursing time Medicines used General ward items used
Surgery	Nursing time General surgery items used

Table 6 indicates the unit cost which was obtained from the UPFS fee schedule for the various cost components.

Table 6 Unit cost of UPFS fees

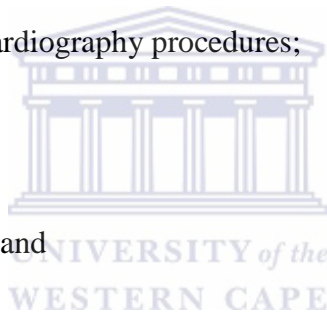
Component	Unit cost (Rands)
Specialist consultation	R 241.00
Dispensing fee	R 28.00
Radiological procedures	
X-ray	R 151.00
CT scan	R 2 030.00
Electrocardiogram procedure	R 189.00
Emergency room fee	R 400.00
Hospitalisation fee per day	R 1 430.00

4.10 Cost components studied

The cost components which impact the direct medical costs of treating diabetes mellitus and its complications were taken into account during the study. The cost components represent the resources which were utilised in the treatment of diabetes mellitus and its complications.

The following cost components were included:

- a) Outpatient doctor consultations;
- b) Pharmacy supplies;
- c) Laboratory tests;
- d) Radiological and electrocardiography procedures;
- e) Emergency room visits;
- f) Inpatient hospitalisations; and
- g) Surgeries.



4.11 Categorisation of costs

The costs were categorised into two categories:

- a) costs due to diabetes mellitus; and
- b) costs due to the complications of diabetes mellitus.

All costs which had a link to diabetes mellitus and its complications were included in one of the two categories of cost. These costs were categorised based on the clinical profile of the disease. Costs due to the complications of diabetes mellitus, were costs due to the complications of diabetes mellitus only and did not include diabetes mellitus cost.

4.11.1 Outpatient doctor consultation

Outpatient doctor consultations due to diabetes mellitus had either an ICD-10 code or a recorded diagnosis of diabetes mellitus. This was classified as an outpatient consultation cost due to diabetes mellitus.

Outpatient doctor consultations due to the complications of diabetes mellitus either had an ICD-10 code or a recorded diagnosis which related to a complication of diabetes mellitus. Patients who visited specific clinics at Groote Schuur hospital, which related to the complications of diabetes mellitus, were recorded as consultations due to the complications of diabetes mellitus. This was classified as outpatient consultation costs due to the complications of diabetes mellitus.

4.11.2 Pharmacy supplies

These included the items which patients obtained from the pharmacy department at Groote Schuur hospital. These were divided into four distinct categories i.e., insulin, oral hypoglycaemic agents, medicines for the treatment of the complications of diabetes mellitus and diagnostic agents. The cost of needles and syringes used to administer insulin were included as part of the insulin cost. Diagnostic agents included blood glucose test strips.

The medicine classes used to treat the complications of diabetes mellitus are indicated in Table 7. The cost for these medicines was categorised as costs due to the complications of diabetes mellitus.

Costs due to diabetes mellitus included insulin, oral hypoglycaemic agents and blood glucose test strips. The dispensing fee was included in the cost due to diabetes mellitus as patients would have to collect medicines regardless of whether or not they had a complication.

Therefore the dispensing fee is attributed as a cost due to diabetes mellitus.

Table 7 Medicine classes used to treat the complications of diabetes mellitus

Anti-coagulants	Calcium channel blockers
ACE-inhibitors	Diuretics
Alpha blockers	Fibrates
Aldosterone antagonists	Ophthalmic preparations
Angiotensin II inhibitors	Nitrates
Beta blockers	Statins

4.11.3 Laboratory tests

Laboratory tests were divided into two distinct categories i.e., routine laboratory tests and laboratory tests conducted due to the treatment of the complications of diabetes mellitus.

Routine laboratory tests were those tests that were usually conducted at every visit to Grootte Schuur hospital. These tests included the blood glucose and glycated haemoglobin tests.

Laboratory tests conducted due to the treatment of the complications of diabetes mellitus are indicated in Table 8.

Table 8 Laboratory tests conducted due to the treatment of diabetes mellitus related complications

Albumin	Full blood count including platelet
Calcium	Microalbumin in urine
Cholesterol HDL	Phosphorous
Cholesterol total	Potassium
Creatine kinase	Profile discrete analyser urea & electrolyte
Creatinine	Sodium
Creatinine – Automated	Triglyceride
Erythrocyte sedimentation rate (ESR)	Total protein
Urea	

Laboratory test costs attributed to diabetes mellitus were those costs for routine laboratory tests. The remaining laboratory test costs were attributed to the costs associated with the treatment of the complications of diabetes mellitus.

For patients who had no diabetes mellitus related complications but had laboratory tests referred to in Table 8, these costs were attributed to diabetes mellitus. It was assumed that these were conducted to screen for the complications of diabetes mellitus.

For patients who had diabetes mellitus related complications and for whom laboratory tests were conducted that did not match their specific complications, these costs were attributed to the complications of diabetes mellitus. It has been documented that patients with diabetes mellitus complications are at risk of developing other complications related to diabetes mellitus (Zhao *et al.* 2008; Girach *et al.* 2006).

4.11.4 Radiological and electrocardiography procedures

The costs of radiological and electrocardiography procedures were attributed to the complications of diabetes mellitus. These were commonly performed procedures at Groote Schuur hospital when managing diabetes mellitus patients with complications.

For patients who did not have diabetes mellitus related complications and for whom radiological and electrocardiography procedures were performed, these costs were attributed to diabetes mellitus. These were noted as screening procedures.

4.11.5 Emergency room visits

Emergency room visits which were due to the complications of diabetes mellitus either had an ICD-10 code or a recorded diagnosis which related to a diabetes mellitus complication. The costs of these visits were attributed to the complications of diabetes mellitus.

4.11.6 Inpatient hospitalisations

Inpatient hospitalisations which were due to the complications of diabetes mellitus either had an ICD-10 code or a recorded diagnosis which related to a diabetes mellitus complication.

The costs of these visits were attributed to the complications of diabetes mellitus.

4.11.7 Surgeries

Surgeries which were due to the complications of diabetes mellitus either had an ICD-10 code or a recorded diagnosis which related to a diabetes mellitus complication. The costs of this visit were attributed to the complications of diabetes mellitus.

4.12 Cost template

The cost template was developed using an Excel[®] spreadsheet and all patient data were entered into the spreadsheet. The cost template provided the framework for which patient costs were recorded, calculated and analysed. The cost was reported for the 20 month study period. This cost template was structured in two parts as discussed below, i.e. costs for diabetes mellitus and the complications of diabetes mellitus. The fields which were developed for this cost template are presented in Annexure 3(page 111).

4.12.1 Cost template for diabetes mellitus

The following cost components were used to quantify the direct medical costs associated with treating diabetes mellitus: outpatient doctor consultations, pharmacy supplies and laboratory tests.

4.12.2 Cost template for the complications of diabetes mellitus

The following cost components were used to quantify the direct medical costs associated with treating the complications of diabetes mellitus: outpatient doctor consultations, pharmacy supplies, laboratory tests, radiological and electrocardiography procedures, emergency room visits, inpatient hospitalisations and surgeries.

4.13 Cost calculation

The fees which are referred to as UPFS were derived from UPFS Provincial Gazette for Western Cape, No. 6862, 25 March 2011. The cost was calculated for each patient for the 20 month study period and the total cost for all the patients was calculated. In addition, an average cost per patient was calculated.

4.13.1 Outpatient doctor consultations cost

The unit cost per consultation was multiplied by the number of consultations per patient to obtain a cost per patient.

4.13.2 Pharmacy supplies cost

The unit cost for each medicine was multiplied by the quantity dispensed for each medicine to obtain a cost per patient. A similar approach was used for diagnostic tests.

The dispensing fee (UPFS) was billed per prescription issued per day at Groote Schuur hospital. A patient would only be charged the dispensing fee once regardless of the number of prescriptions obtained on the same day. This is different to the practice in the private sector, where the dispensing fee is dependent on the number of items per prescription. The dispensing fee unit cost was multiplied by the number of prescription collection days per patient and a cost per patient was calculated for the study period.

4.13.3 Laboratory test cost

Each laboratory test had a unit cost and the cost for laboratory tests per patient was calculated.

4.13.4 Radiological and electrocardiography procedure cost

Each procedure had a unit cost (UPFS) and the cost for radiological and electrocardiography procedures per patient were calculated.

4.13.5 Emergency room visit cost

The cost for an emergency room visit consisted of the following components:

- a) cost of the emergency room consultation;
- b) cost of the laboratory tests conducted during the emergency room visit; and
- c) cost of radiological and electrocardiography procedures conducted during the emergency room visit.

The cost per emergency room visit per patient was calculated based on the above components.

4.13.6 Inpatient hospitalisation cost

The cost for an inpatient hospitalisation consisted of the following components:

- a) cost of the inpatient hospitalisation per day multiplied by the length of stay;
- b) cost of the laboratory tests conducted during the hospitalisation; and
- c) cost of radiological and electrocardiography procedures conducted during the hospitalisation.

The cost per hospitalisation per patient was calculated based on the above components.

4.13.7 Surgery cost

The cost for surgery consisted of the following components:

- a) cost of the anaesthesia; and
- b) cost of the theatre.

The cost for the surgery per patient was calculated.

4.13.8 Cost per patient

The cost of treatment for diabetes mellitus and the complications of diabetes mellitus were separately calculated for each patient, using the sum of the component costs to obtain a cost per patient.



4.13.9 Total cost

The total cost of treatment for all the patients for the study period was calculated by adding the cost for each patient. This cost was calculated at both patient and cost component levels.

The total cost per cost component for all patients was also obtained.

4.13.10 Average cost per patient

The average cost per patient was calculated at both the patient and cost component levels.

The average cost per patient was obtained by dividing the total cost by the number of patients. The average cost per patient for each cost component was obtained by dividing the total cost per component by the number of patients who utilised that particular component.

4.14 Cost methods developed

This study developed two cost methods:

- a) Combined method i.e., using data from the electronic patient records and patient folders; and
- b) Electronic method i.e., using data from the electronic database only.

4.14.1 Combined method

This method utilised data from electronic database (primary source) and patient folders. The purpose for this combination has been described in section 4.6 and 4.7. This method has been described throughout Chapter 4.

4.14.2 Method to determine the costs associated with diabetes mellitus and its complications using the electronic database only

A method was developed which determined the direct medical costs associated with diabetes mellitus and its complications at Groote Schuur hospital, using data from the electronic database only. This method is referred to as the electronic method.

Table 9 summaries the problems associated with this database and solutions which were used to overcome these problems.

Table 9 Problems with the electronic database and solutions

Incomplete information	Solution to the problem
Type of diabetes mellitus	Use the medicine history to categorise the type of diabetes mellitus
Identification of complication	Based on laboratory tests conducted AND specialist consultations, clinics visited at GSH
Type of complication	Specialist consultations and clinics visited at GSH
Incorrect medicine costs	Obtain costs from GSH pharmacy department based on tender prices
Reason for hospitalisation	Assumption ¹
Reason for emergency room visit	Assumption ¹

¹ All hospitalisations and emergency room visits were due to diabetes mellitus and/or its complications.

The method which was developed to determine the costs for diabetes mellitus and its complications using the electronic database only was tested. The same sample of 100 patients as used for the combined method was used in this analysis but using data obtained only from the electronic database. The following procedure was used:

- a) patient identifiers were removed from the database and only hospital numbers were left. This was to remove any bias and prior knowledge which the researcher had as the same 100 patients whose folders were perused were used in this analysis;
- b) using the patient hospital numbers, all data for the study period was extracted from the electronic database;
- c) data were entered into the framework of the cost template;
- d) patient's medicine history was used to categorise patients into two categories, (1) insulin dependent diabetes mellitus and (2) non-insulin dependent diabetes mellitus;

- e) a diagnosis of a complication of diabetes mellitus was assumed if the following criteria were met:
- a. history of doctor consultations which had a reason associated with the complications of diabetes mellitus;
 - b. a visit to one of the following clinics, which relate to the complications of diabetes mellitus:
 - i. ophthalmology;
 - ii. nephrology;
 - iii. venous;
 - iv. amputation; and
 - v. neurology.
 - f) laboratory tests mentioned in Table 8 (page 34);
 - g) health care resources used during the study period were allocated costs (as explained in section 4.13); and
 - h) costs were categorised into (1) costs due to diabetes mellitus and (2) costs due to the complications of diabetes mellitus, as mentioned in section 4.11.

The results obtained were compared to the results obtained using the combined method.

4.15 Predictive cost model

4.15.1 Decision tree model

A model was developed which used a decision tree to predict costs in a diabetic population.

The following categories were used in the decision tree:

- a) Type I diabetes mellitus with no complications
- b) Type I diabetes mellitus with complications
- c) Type II diabetes mellitus with no complications
- d) Type II diabetes mellitus with complications

Probabilities of the occurrence of the types of diabetes mellitus and its complications and the costs derived from the combined method when these events occur were used in a decision tree. The purpose of this analysis was to predict the costs of diabetes mellitus and its complications at Groote Schuur hospital. These costs were then compared with those costs derived using the combined method. The same sample of 100 patients was used in the decision tree. The cost per event can be predicted by multiplying the cost estimate for the particular outcome by the outcome probability. The total cost for the diabetic population can be obtained by the sum of these costs. The costs per year were used in this analysis.

4.15.2 Potential costs incurred at other health facilities during the study period

The purpose was to develop a method for a model which incorporated additional costs which the study population could have incurred during the study period at other hospitals besides Groote Schuur hospital i.e. community health centres (CHC). This model was developed by simulating the utilisation of the following health care resources at the CHC: doctor consultations, medicine collections and laboratory tests.

The model was developed for health care services which were used routinely and took into account resources which were utilised at Groote Schuur hospital.

The following process was followed in developing this model:

- a) The patient's duration in the study was calculated by determining an index point for each patient. The index point was the first date at which the patient was identified in the electronic database during the study period;
- b) The number of months from the index point until the end of the study period was determined for each patient;
- c) The following was assessed for the study period:
 - a. number of doctor consultations required;
 - b. number of medicine collections required; and
 - c. laboratory tests required and the time intervals for these tests.
- d) The model determined which of the above mentioned resources were utilised at Groote Schuur Hospital and the time intervals thereof;
- e) Based on the data obtained from Groote Schuur hospital for the patients, it was then determined which resources would have been utilised at community health centres and the frequency thereof. The following assumptions were based on expert view (Prof Levitt):
 - a. Doctor consultations and medicine collections will occur on a monthly basis;and

- b. Laboratory tests will be conducted at specific time intervals. It was assumed that the laboratory tests not conducted at Groote Schuur hospital would be conducted at the CHC.

Patients would be classified into two categories, stable and unstable patients. The health care resource utilisation assumptions for these categories of patients were based on expert view (Prof Levitt) and are presented in Table 10.

Table 10 Health care resources used and the time intervals thereof

Health care resource	Time interval for utilisation for stable patients	Time interval for utilisation for unstable patients
Specialist consultations	Every 6 months	Every 3 months
Doctor consultations	Every 3 months	Every month
Medicine collections	Every month	Every month
Blood glucose tests	Every 3 months	Every month
Laboratory tests:		
Routine	Every 6 months	Every 3 months
Tests conducted due to diabetes mellitus complications	Every 6 months	Every 3 months

Various health care resources were utilised at Groote Schuur hospital during the study period e.g. doctor consultations, medicine collections and laboratory tests. These were health care services utilised routinely, either monthly or at defined time intervals.

Health care services such as electrocardiogram and radiological procedures, emergency room visits, inpatient hospitalisations and surgery were only utilised in emergency situations and would therefore occur less frequently as compared to the health care services mentioned above. The functionality of this method was tested in a sample of 10 patients and both categories were used i.e. stable and unstable patients as indicated in Table 10.

4.15.2.1 Model costing

The costing of this model was based on patient specific simulated data points. This included doctor consultations, medicine collections and laboratory tests which could have been conducted at the CHC. In addition, the actual costs obtained from Groote Schuur hospital were incorporated into the model.

The total cost for each patient consisted of simulated costs at the community health centres and actual costs at Groote Schuur hospital. Table 11 refers to the various cost components used in this model to obtain the final total cost.

TABLE 11 Cost components at Groote Schuur hospital and community health centre

Cost components at Groote Schuur hospital	Cost components at community health centres
Doctor consultations	Doctor and/or nurse consultations
Pharmacy supplies	Pharmacy supplies
Laboratory tests	Laboratory tests
Electrocardiogram and radiological procedures	
Emergency room visits	
Hospitalisations	
Surgeries	

The cost for consultations was presented in two parts, viz. either a cost for a consultation with a doctor or a nurse as depending on the community health centre, the patient would either see a nurse or a doctor. The unit cost per consultation (either doctor or nurse) was obtained from the UPFS fee schedule and then multiplied by the number of consultations which could have been conducted at the community health centre. A cost for a consultation with a doctor or a nurse was calculated. This was done by multiplying the unit cost per consultation (doctor or

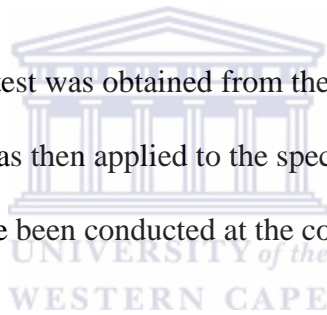
nurse) by the number of consultations which would have been conducted at the CHC. This cost was presented as a range between the two health care professionals.

The cost for medicines was presented in two parts, the medicine cost and the dispensing fee at the community health centre. For each patient, the average cost per prescription was calculated. This was done by using the actual patient medicine data obtained from Groote Schuur hospital, the total medicine cost per patient and dividing it by the number of medicine collections. The average medicine cost was then multiplied by the predicted number of medicine collections at the community health centre. The unit cost for the dispensing fee was multiplied by the number of medicine collections at the community health centres. These costs combined represented the medicine cost for the patient at the community health centre.

The unit cost for each laboratory test was obtained from the National Health Laboratory Service (NHLS). This unit cost was then applied to the specific laboratory tests which according to the model could have been conducted at the community health centres.

The model consisted of two distinct costs i.e., the actual cost from Groote Schuur hospital and the simulated cost from the community health centre. These two costs provided the total cost of diabetes mellitus and its complications for each patient for the study period.

The cost for each patient was standardised to a 12 month period, by determining the cost per month for each patient based on the number of months the patient was in the study. This figure was extrapolated to a cost per year.



4.15.2.2 Model assumptions

The model made the following assumptions:

- a) the patients did visit other health care facilities when they did not come to Grootte Schuur hospital during the study period;
- b) resources such as emergency room visits, hospitalisations and surgeries for this population were utilised at Grootte Schuur hospital only during the study period;
- c) no additional laboratory tests, electrocardiogram and radiological procedures, and doctor consultations were conducted during the study period at other health facilities which were outside the standard treatment guidelines;
- d) the patient's medication did not change during the study period; and
- e) 70% compliance with regard to collection of medicines.

These assumptions are in addition to the criteria set out in Table 10 which describe the category of patients and the frequency with which specific health care services would be utilised at the community health centres.

4.16 Total cost of diabetes mellitus and its complications using sample of 1094 patients

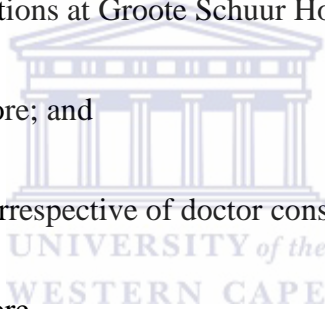
The full sample of 1094 patients was used in this analysis to obtain the best possible cost estimates. Data from the electronic database were used to determine the total cost of diabetes mellitus and its complications. Hospitalisations and emergency room visits which had reasons related to diabetes mellitus and its complications recorded in the database were included in the cost analysis.

The cost was obtained for each cost component and a cost per patient was obtained. Due to the inconsistencies within the database costs could not be attributed to diabetes mellitus or diabetes mellitus complications accurately. Therefore total cost for diabetes mellitus and its complications was presented.

4.17 Patient data analysis

The patient data were arranged into four main sub-groups:

1. type I or type II diabetes mellitus;
2. diabetes mellitus or diabetes mellitus with complications;
3. number of doctor consultations at Groote Schuur Hospital
 - a. 5 or less or 6 or more; and
4. number of visits to GSH, irrespective of doctor consultations
 - a. 5 or less or 6 or more.



The total and average cost per patient for each sub-group of patients was calculated. This cost was presented in two parts, a cost per 20 month study period and a cost per year.

Patients were divided into two groups based on the number of visits to Groote Schuur hospital. As Groote Schuur hospital is a tertiary facility, patients would receive their routine care at lower level facilities. The frequency with which the study patients visited Groote Schuur hospital varied. Therefore the patients were then grouped according to the number of visits for the cost analysis.

For the purpose of this study a visit was defined as a visit to any one of the following departments at Groote Schuur hospital: pharmacy department, inpatient hospitalisation,

emergency room and surgery at any point during the study. These visits occurred on different dates, if a patient visited more than one department on the same date, then it was noted as one visit. Patients were also grouped based on the number of consultations with the doctor at Groote Schuur hospital. The patients were further grouped according to the type of diabetes mellitus and whether they had a diabetes mellitus related complication or not.

4.18 Statistical analysis

Statistical analyses were used to describe the results which were obtained. Non-parametric statistical analyses were used due to the small sample sizes of the various sub-groups. The median is usually nearly equal to the average for the various sub-groups, however, some monetary means displayed long-tailed distributions towards the larger amounts, thus making the medians differ from the means. Therefore, the cost data was presented as means and medians. The Number Cruncher Statistical System (NCSS. 2001) was used to analyse the following cost data for statistical differences. The following groups (1) type I versus type II diabetes mellitus and (2) diabetes mellitus versus diabetes mellitus with complications, were compared for statistical differences using the Kruskal-Wallis test (non-parametric ANOVA statistical test) and z-values greater than 1.96 were considered to be statistically significant.

The Kruskal-Wallis test was used in this study due to the following: (1) the groups which were examined were unequal in size, (2) the groups are independent and not related and (3) the distribution is skewed and not symmetrical. The differences in cost obtained between the combined and electronic method were analysed using Fisher's exact test to determine whether the differences were statistically significant or not. P-values less than 0.05 were considered statistically significant. Fisher's exact test was used in this study due to the following: (1) the small sample size and (2) the same sample of patients was used but two different cost methods were applied.

4.19 Ethics

Approval for this study was obtained from the Research Ethics Committee of the University of the Western Cape (Ref: ScRIRC2010/09/08) and the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town (HREC ref: 416/2010).

Additional approval was obtained from the Western Cape Provincial Department of Health to conduct the study at Groote Schuur hospital. Patient records were only accessible to the researchers (Prof P. Valodia and S. Nomame) directly involved in the study. Patient confidentiality was maintained at all times.



CHAPTER 5

RESULTS

The focus of this chapter is on the cost results obtained using the combined method. The results obtained using the combined and electronic methods were compared and analysed for statistically significant differences. The costs for the various sub-group analyses are presented, using data from the combined method. This chapter also highlights the various methods which were developed to cost the management of diabetes mellitus and its complications at Groote Schuur hospital.

Data for 100 patients were included in the study as depicted in Figure 1. There were 67.3% of the patient folders missing from the Medical Records department. Patient folders were requested from the Medical Records department until a sample of 100 patients was achieved. There were 8 patient folders which did not meet the selection criteria. Patients who attended the adult diabetic clinic were extracted from the electronic database and it was found that out of the convenient sample selected (of patient folders available) only 0.93% of the patients were not diabetic. This result indicates that this could be an alternative method of extracting patients from electronic databases as opposed to using ICD-10 codes.

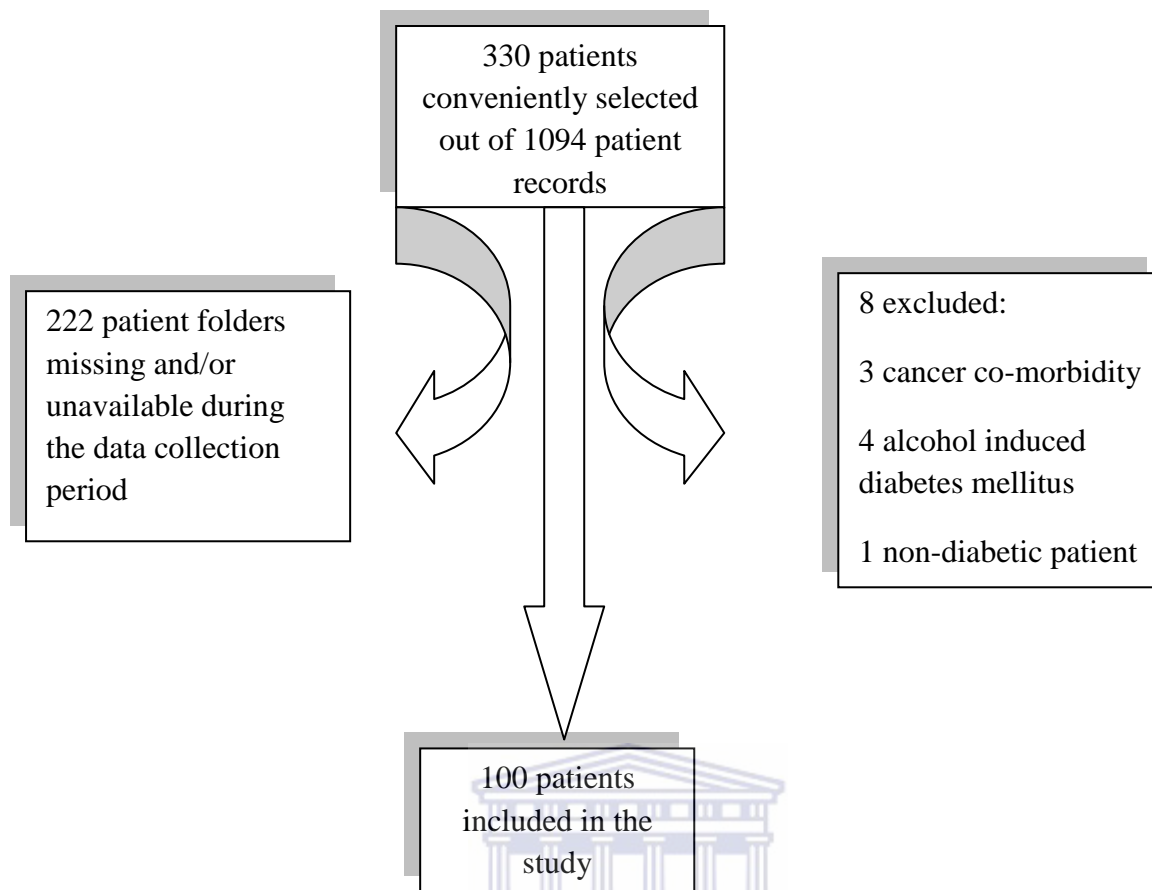


Figure 1 Patient selection

5.1 Patient characteristics

Table 12 provides information on the patient characteristics of the 100 patients who were selected from the electronic database. Seventy-two percent (72%) of the patients were type II diabetics and 28% were type I diabetics.

Table 12 Patient characteristics

Number of patients	100
Number of male patients	41
Number of female patients	59
Number of type I diabetes mellitus patients	28
Number of type II diabetes mellitus patients	72
Average age (\pm) of patients (years)	51.81 (\pm 13.84)
Age range of patients (years)	22 – 81

Table 13 indicates the other disease conditions which affected the patients. These are defined as co-morbid conditions and differ from the complications of diabetes mellitus. Table 13 indicates that hypertension and dyslipidaemia were the highest ranking co-morbid conditions in this study population, 66% and 52%, respectively. This result also shows that these patients suffered from hypertension and dyslipidaemia concomitantly.

Table 13 Patient co-morbidities (n=100)

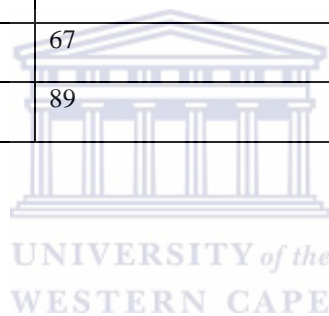
Co-morbidity	% of patients
Hypertension	66
Dyslipidaemia	52
Arthritis	5
Asthma	5
Depression	4
Other	21

The other co-morbid conditions were chronic hepatitis C, epilepsy, glaucoma, Human Immunodeficiency Virus, liver dysfunction, hypothyroidism, menopause, pancytopenia, psoriasis and tuberculosis. These affected 21% of the patients.

Table 14 indicates the frequency of use of diabetes mellitus medicines by the study population. Insulin and metformin were the most commonly used diabetes mellitus medicines. There were 61 (84.7 %) of the type II diabetics on insulin and oral hypoglycaemic medicines. This large figure was due to the fact that patients who attended Groote Schuur hospital were those whose diabetes mellitus was poorly controlled on oral hypoglycaemic medicines.

Table 14 Frequency of anti-diabetic medicines used by the study population

Medicine (Generic name)	Number of patients
Glibenclamide	5
Gliclazide	21
Metformin	67
Insulin	89



5.2 Diabetes mellitus complications

5.2.1 Types of diabetes mellitus complications

Table 15 Frequency of the various types of diabetes mellitus complications

Type of complication	Percentage of patients
Microvascular	
Neuropathy	48%
Nephropathy	45%
Retinopathy	27%
Macrovascular	
Ischaemic heart disease (IHD)	21%
Peripheral vascular disease (PVD)	5%
Acute	
Acute metabolic complications	16.7%

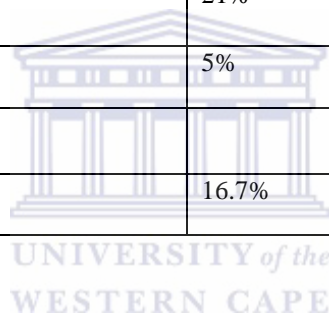


Table 15 indicates the type of diabetes mellitus complications found in the study patients and the frequency thereof amongst type I and type II diabetes mellitus patients. Microvascular complications of diabetes mellitus were the most frequently occurring, with neuropathy ranking the highest, affecting 48 % of the study population. Ischaemic heart disease (IHD) was the most common macrovascular complication of diabetes mellitus. In the study population the chronic complications of diabetes mellitus were more common than the acute metabolic complications. The acute metabolic complications are reversible and are mainly treated at secondary and primary level hospitals. These patients would not necessarily be referred to Groote Schuur Hospital. The acute metabolic complications of diabetes mellitus mainly affected the type I diabetic patients.

5.2.2 Number of diabetes mellitus complications

Patients who had complications related to diabetes mellitus consisted of 77% of the study population as shown in Table 16.

Table 16 Number of diabetes mellitus complications

Number of complications	% of patients affected
No complications	23%
1 complication	27%
2 complications	30%
3 complications	15%
4 complications	5%

Of the patients who had diabetes mellitus complications, it was found that 64,9% of these patients had two or more diabetes mellitus complications as indicated in Table 16. Groote Schuur hospital is a tertiary level facility and therefore it is not uncommon for a high proportion of these patients to suffer from complications of diabetes mellitus.

In this study it was found that 64.3% and 82% of type I and type II diabetes mellitus patients, respectively, had complications due to diabetes mellitus.

5.2.3 Number of complications and age of patients

As indicated in Figure 2, the number of complications a patient suffers from follows an increasing trend as the patient age increases.

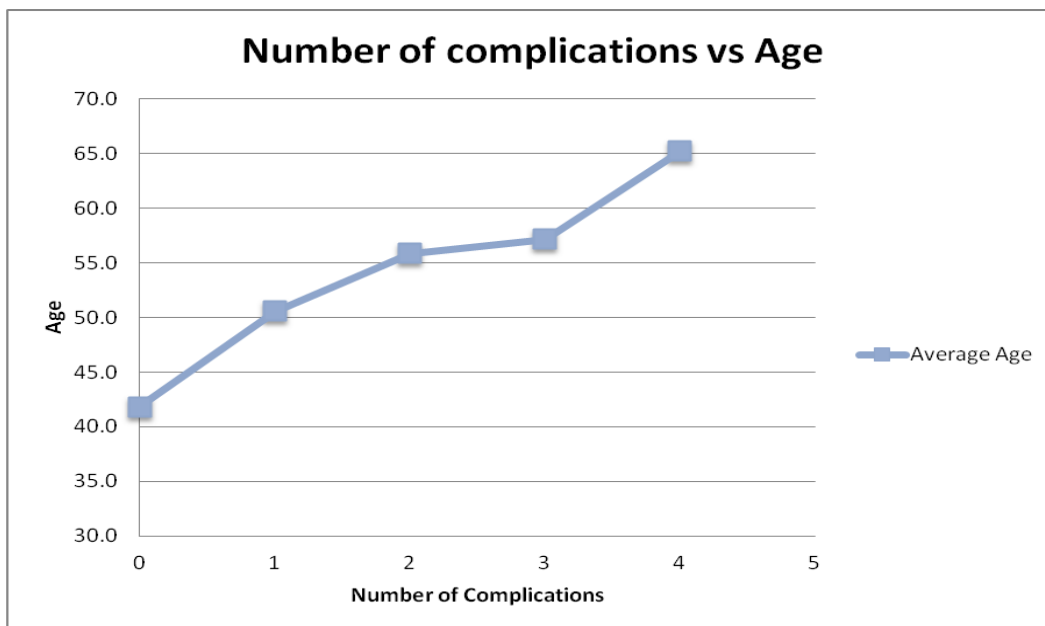


Figure 2 Number of complications versus patient age

5.3 Development of costing method

A successful method was developed using the electronic database and patient folders (combined method). The cost results presented in this chapter utilise data from the combined method of costing. The results from the electronic method of costing are presented as a comparison to the results obtained using the combined method.

5.4 Cost of diabetes mellitus and its complications

The costs associated with the treatment of diabetes mellitus and its complications are reported in Table 17. All costs are reported in South African Rands (R) for the study period.

5.4.1 Total cost of diabetes mellitus and its complications

Table 17 represents the cost associated with diabetes mellitus and its complications for the 20 month study period and also expressed as a cost per year. The data presented in Table 17 were taken from the combined method

Table 17 Total cost of diabetes mellitus and its complications

Cost component	Cost (20 months)	Cost per year
Diabetes mellitus (n=100) ¹	R 179 675.06 (39.3%)	R 107 805.04
Diabetes mellitus complications (n=77) ²	R 277 792.28 (60.7%)	R 166 675.37
Total ³	R 457 467.34	R 274 480.41

¹ Cost due to the management for diabetes mellitus only, all patients in the study had costs due to diabetes mellitus only.

² Cost due to the management of the complications of diabetes mellitus (excluding diabetes mellitus).

³ Total cost for diabetes mellitus and its complications. This cost is the sum of diabetes mellitus and diabetes mellitus complications with no overlap in cost.

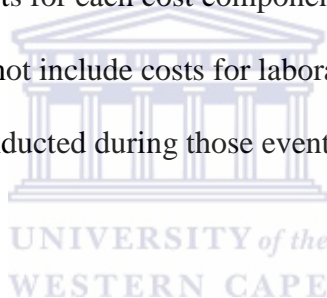
Table 17 indicates that 100 patients had costs due to diabetes mellitus and of these patients 77 had complications and costs due to these complications. This result indicates that the complications of diabetes mellitus cost 1.5 times more to treat than diabetes mellitus. The complications of diabetes mellitus contributed 60.7% of the total cost. This result shows the impact of diabetes mellitus complications on the total cost of treatment.

Table 18 Total costs of the various cost components

Cost component	Cost 20 months (%)	Number of items	Cost per year
Consultations (outpatient)	R 101 702.00 (22.2%)	422	R 61 021.20
Pharmaceutical supplies	R 95 143.92 (20.8%)	1642	R 57 086.35
Laboratory tests	R 86 750.42 (19%)	2044	R 52 050.25
Electrocardiogram procedures	R 6 048.00 (1.3%)	32	R 3 628.80
Radiological procedures	R 8 656.00 (1.9%)	26	R 5 193.60
Emergency room visits ¹	R 6 000.00 (1.3%)	15	R 3 600.92
Hospitalisations ¹	R 108 680.00 (23.8%)	16	R 65 208.05
Surgery	R 44 487.00 (9.7%)	6	R 26 692.20
Total	R 457 467.34		R 274 481.41

¹Does not include costs for laboratory, electrocardiogram and radiological procedures conducted during these events.

Table 18 indicates the various costs for each cost component in the study. Emergency room visits and hospitalisation cost do not include costs for laboratory tests, radiology and electrocardiogram procedures conducted during those events as these have been reported separately.



Consultations, pharmacy supplies, laboratory tests and hospitalisation contributed 22.2%; 20.8%; 19% and 23.8%, respectively, of the total cost. When evaluating the cost per patient for the various cost components, then hospitalisation and surgery costs were R 8 360.00 and R 7 414.50, respectively. These were main cost drivers on a per patient basis.

Table 19 List of each hospitalisation during study period

Reason for hospital visit	Number of hospitalisations	Frequency of hospitalisation (%)	Length of stay (days)
Hypoglycaemia	1	6.3%	1
Hypoinsulinaemia	1	6.3%	11
Diabetic coma	1	6.3%	4
Uncontrolled diabetes mellitus	1	6.3%	7
Diabetic cataract	1	12.5%	2
Diabetic cataract	1		2
Diabetic foot ulcer	1	6.3%	3
Peripheral vascular disease	1	6.3%	20
Ischaemic heart disease	1	6.3%	1
Stroke	1	6.3%	3
Hospitalisations due to surgery			
Day surgery (diabetic cataract)	1	25%	½
Day surgery (diabetic cataract)	1		½
Day surgery (diabetic cataract)	1		½
Day surgery (diabetic foot)	1		½
Diabetic foot ulcer including surgery	1	6.3%	7
Infection following surgery for diabetic foot	1	6.3%	14

Table 19 indicates the various hospitalisations which occurred during the study period.

Hospitalisations due to the acute metabolic complications of diabetes mellitus and day surgery were 25.2% and 25%, respectively, of the hospital events. During the 20 month study period, there was only one hospital event due to stroke. Peripheral vascular disease which results from neuropathy (most commonly occurring diabetes mellitus related complication), had the highest number of hospital days. As this was only one case, no conclusions should be derived from this result. Hospitalisations are unique and the length of stay will be different for each patient. Various factors such as duration of diabetes mellitus, levels of haemoglobin A_{1c}, presence of co-morbid conditions and risk factors (Pagano *et al.* 2007) affect hospitalisation.

Hospitalisations due to diabetic cataract accounted for 37.5% of the total hospital events, 60% of these were due to day surgery. This was expected as Groote Schuur hospital is a tertiary level institution and patients would be referred here for specialised treatment.

Consultations contributed 22.2% of the total cost and all the patients utilised this resource. There were a total of 422 consultations during the study period. The percentage of consultations due to the complications of diabetes mellitus was 40.5%.

The percentage contribution of pharmaceutical supplies and laboratory tests to the total cost was 20.8% and 19 % respectively. These resources were utilised by 98% of the patients. The data presented in Table 19 were derived from the combined method.

5.4.2 Cost per patient for diabetes mellitus and its complications

Table 20 Cost per patient

Cost component	Average cost	Median cost	Cost per year
	20 month period		
Diabetes mellitus (n=100) ¹	R 1 796.75 SD R 972.83 (R 310.37 - R 6 298.82)	R 1 625.50	R 1 078.05
Diabetes mellitus complications (n=77) ²	R 3 753.95 SD R 7 806.94 (R 58.81 - R 48 634.74)	R 789.18	R 2 252.37
Total ^{3,4}	R 4 574.67 SD R 6 935.53 (R 682.45 - R 49 720.74)	R 2 845.42	R 2 744.80

¹ Average cost per patient due to diabetes mellitus only, all patients had costs due to diabetes mellitus.

² Average cost per patient due to the complications of diabetes mellitus (excluding diabetes mellitus).

³ Average cost per patient for diabetes mellitus and its complications. This is an average cost per patient for the entire sample of patients, calculated by the total cost divided by 100 patients.

⁴ Total average cost is not the sum of average diabetes mellitus and diabetes mellitus complications cost.

Table 20 indicates the average cost per patient for the 20 month study period, also expressed as an average cost per year per patient. The range, standard deviation and median for the 20

month study period are presented Table 20. The complications of diabetes mellitus contribute 82.1 % of the average cost of treating a patient at Groote Schuur hospital.

The large difference observed between the median and average cost in the total and diabetes mellitus complications cost, was due to the long-tailed distribution of the cost. The data presented in Table 20 were derived from the combined method.

Table 21 Cost per patient for the various cost components

Cost component	Number of items	Average cost	Median cost	Cost per year
		20 month period		
Consultations	422	R 1 017.02 SD R 731.13 (R 241 – R 4 820)	R 723.00	R 610.21
Pharmaceutical supplies	1642	R 980.87 SD R 813.11 (R 38.58 – R 4 178.04)	R 710.31	R 588.52
Laboratory tests	2044	R 876.27 SD R 466.48 (R 97.36 – R 2 782.19)	R 840.73	R 525.76
Electrocardiogram procedures	32	R 232.62 SD R 97.22 (R 189 – R 567)	R 189.00	R 139.57
Radiological procedures	26	R 541.00 SD R 710.30 (R 151 – R 2 181)	R 151.00	R 324.60
Emergency room visits	15	R 545.45 SD R 323.62 (R 400 – R 1 200)	R 400.00	R 327.27
Hospitalisations	16	R 8 360.00 SD R 10 856.59 (R 715 – R 32 890)	R 3 575.00	R 5 016.00
Surgery	6	R 7 414.50 SD R 6 365.26 (R 1 105 – R 17 114)	R 4 225.00	R 4 448.70
Total ¹		R 4 574.67 SD R 6 935.53 (R 682.45 - R 49 720.74)	R 2 845.42	R 2 744.80

¹ Average cost per patient derived from Table 20. The average costs for each of the cost components do not add up to the average cost per patient. The average cost per patient per cost component is calculated based on the number of patients utilising that particular cost component.

Table 21 indicates the average cost per patient for each of the cost components for the 20 month study period, also expressed as an average cost per patient per year. The range, standard deviation and median for the 20 month study period are presented Table 21.

The average cost per patient hospitalised is 1.8 times more than the average cost per patient when taking all the cost components into account. This result shows the large impact which hospitalisation has on the cost of treating the complications of diabetes mellitus. The average cost per patient for hospitalisation and surgery is more than the average cost per patient when taking all the cost components into account. The average costs were calculated only for the patients who had utilised those resources. The data presented in Table 21 were derived from the combined method.

5.4.3 Cost of management of diabetes mellitus and its complications at Groote Schuur hospital using the electronic method

The convenient sample of 100 patients was used but only data which were collected from the electronic database were used and the method assumptions were applied. The method found that 29 % of patients were type I diabetics, 68 % were type II diabetics and in 3 % of the patients the diabetes mellitus type was unknown. It was found that 94 % of the patients had diabetes mellitus complications. This result was different from the information obtained in the folder. This method estimated that an additional 17 patients had diabetes mellitus complications.

The cost of diabetes mellitus and its complications are presented in the Table 22. The total cost for each cost component and the average cost per patient for each component for the 20 month study period are presented. The cost results presented are for the 97 patients who were able to be classified as diabetic patients.

The percentage of the total cost is presented for the various cost components, as the sum of these components represent the total cost.

Table 22 Cost of diabetes mellitus and its complications using electronic method

Cost component	Total cost (% to total cost)	Average cost per patient	Median cost per patient
Diabetes mellitus (n=97) ¹	R 167 717.85 (35.8 %)	R 1 729.05 SD R 934.02 (R 310.37 – R 5 867.92)	R 1 532.12
Diabetes mellitus complications (n=94) ²	R 304 567.38 (64.2 %)	R 3 274.89 SD R 7 218.70 (R 58.81 – R 48 823.74)	R 1 053.98
Total ³	R 472 285.23	R 4 868.92 SD R 7 171.86 (R 696.13 – R 49 909.74)	R 2 855.78

¹ Cost due to the management for diabetes mellitus only, all patients in the study had costs due to diabetes mellitus.

² Cost due to the management of the complications of diabetes mellitus (excluding diabetes mellitus).

³ Total cost for diabetes mellitus and its complications. This cost is the sum of diabetes mellitus and diabetes mellitus complications, with no overlap in cost. The average costs for each cost component does not add up to the total average cost per patient. The average cost per patient per cost component is calculated based on the number of patients utilising that particular cost component.

Table 22 indicates that the complications of diabetes mellitus cost 1.8 times more to treat than diabetes mellitus. The complications of diabetes mellitus contributed 64.2 % of the total cost of diabetes mellitus and its complications. These results can be compared with those presented in Table 20 to evaluate the difference in costs obtained when using either the combined or electronic method of costing.

Table 23 Cost per patient for each cost component using the electronic method

Cost component	Number of items	Total cost (% to total cost)	Average cost per patient	Median cost per patient
			20 month period	
Consultations	412	R 99 292.00 (21.4%)	R 1 023.63 SD R 741.21 (R 241 – R 4 820)	R 723.00
Pharmaceutical supplies	1644	R 95 871.95 (20.2%)	R 988.37 SD R 816.56 (R 44.46 – R 4 354.52)	R 747.75
Laboratory tests	2037	R 87 061.29 (18.4%)	R 897.54 SD R 465.02 (R 97.36 – R 2 782.19)	R 863.42
Electrocardiogram procedures	35	R 6 615.00 (1.4%)	R 228.10 SD R 92.86 (R 198 – R 567)	R 189.00
Radiological procedures	27	R 9 260.00 (1.9%)	R 514.44 SD R 661.41 (R 151 – R 2 181)	R 151.00
Emergency room visits	16	R 6 400.00 (1.3%)	R 581.82 SD R 414.29 (R 400 – R 1 600)	R 400.00
Hospitalisations	20	R 125 125.00 (26.3%)	R 8 937.50 SD R 10 788.06 (R 715 – R 32 890)	R 3 575.00
Surgery	6	R 44 487.00 (9.4%)	R 7 414.50 SD R 6 365.26 (R 1 105 – R 17 114)	R 4 225.00
Total ¹		R 472 285.23	R 4 868.92 SD R 7 171.86 (R 696.13 – R 49 909.74)	R 2 855.78

¹ Average cost per patient derived from Table 22. The average costs for each of the cost components do not add up to the average cost per patient. The average cost per patient per cost component is calculated based on the number of patients utilising that particular cost component.

There were 20 hospitalisations incurred by 14 patients during the study period. Not all hospitalisations had reasons for hospitalisation, therefore, it was assumed that any hospitalisations were due to diabetes mellitus. Hospitalisations contributed 26.3 % of the total cost and a further 41.1 % of the cost treating the complications of diabetes mellitus.

As the same 100 patients were used the results obtained when using the combined method of costing can be compared. According to the combined method, the complications of diabetes mellitus contributed 60.7% of the total cost whereas the electronic method of costing obtained a result of 64.2 %. The Fisher's exact test indicated that the difference in the total cost (diabetes mellitus and complications of diabetes mellitus) was not statistically significant ($p= 0.41$). Furthermore, there was no statistically significant difference ($p= 0.64$) between the diabetes mellitus cost between the two methods. Similarly, the cost due to the complications of diabetes mellitus between the two methods was not statistically significant ($p= 0.49$). This result indicates that the electronic method can be used to cost diabetes mellitus and its complications at Groote Schuur hospital.

5.4.4 Cost of diabetes mellitus and diabetes mellitus with complications

The cost of diabetes mellitus and diabetes mellitus with complications is represented in Table 24. This data were obtained from the combined method. Patients were separated into 2 categories i.e., diabetes mellitus only and diabetes mellitus with complications. These were two different sub-groups of patients. The cost data obtained in these two groups are independent of each other and there is no duplication or overlap in cost. Patients who had diabetes mellitus only and diabetes mellitus with complication(s) consisted of 23% and 77%, respectively, of the study population. The data presented in Table 24 were derived from the combined method.

Table 24 Cost of diabetes mellitus and diabetes mellitus with complications

Category	Cost	Average cost per patient	Median cost per patient	Cost per patient per year
Diabetes mellitus (n=23)	R 47 208.97	R 2 052.56 SD R 1 321.20 (R 682.45 – R 6 298.82)	R 1 800.79	R 1 231.54
Diabetes mellitus with complications (n=77)	R 411 784.11	R 5 347.85 SD R 7 741.56 (R 792.37 – R 49 909.74)	R 3 038.08	R 3 208.71

It was found that the cost of managing diabetic patients with complication(s) was 2.6 times more than patients with diabetes mellitus only. The Kruskal-Wallis test found that this cost difference between diabetes mellitus and diabetes mellitus with complications was statistically significant ($z = 3.8$). The box plot on page 104 of Annexure 2 illustrates the distribution of the cost data in this sub-group of patients.

5.4.5 Cost of pharmacy supplies

Table 25 indicates the cost associated with the various categories of pharmacy supplies as well as the cost of the dispensing fee. This is the cost for the 20 month study period and for all the patients who collected medicines at Groote Schuur Hospital (97%). The “number of items” column refers to the number of medicine items issued during the study period.

Table 25 Pharmacy supply cost

Category	Number of items	Cost (%)
Insulin	575	R 28 546.79 (30.1%)
Oral hypoglycaemic medicines	170	R 3 315.94 (3.5%)
Medicines used to treat diabetes mellitus complications	765	R 20 397.71 (21.4%)
Diagnostic agents	132	R 29 443.48 (30.9%)
Dispensing fee		R 13 440.00 (14.1%)

Table 25 indicates that insulin and diagnostic agents were the highest contributors to the total cost of pharmacy supplies. The acquisition cost for these items is more than the other medicines i.e. oral medicines. The cost of medicines for the treatment of diabetes mellitus complications was 21.4% of the total cost. This shows the impact of the complications of diabetes mellitus on the cost of pharmacy supplies. The unit cost for the oral hypoglycaemic medicines is low when compared to insulin and therefore insulin has a higher cost, even though more patients were on oral hypoglycaemic medicines compared with insulin. The data presented in Table 25 were derived from the combined method.

5.4.6 Cost of laboratory tests

Table 26 Cost of laboratory tests

Category	Number of items	Cost	Average cost per patient
			20 month period
Routine laboratory tests (n=99)	945	R 43 955.85	R 444.00 SD R 250.58 (R 96.40 – R 1 492.21)
Laboratory tests conducted due to the complications of diabetes mellitus (n=69)	1099	R 42 794.57	R 620.21 SD R 377.55 (R 25.27 – R 2 008.11)
Total ¹	2044	R 86 750.42	R 876.27 SD R 466.48 (R 97.36 – R 2 782.19)

¹ Average cost per patient is derived from Table 21. The sum of the average costs per patient for routine lab tests and lab tests conducted due to the complications of diabetes mellitus does not add to the average cost per patient, as there is overlap in these costs as patients can have costs in both the categories.

Laboratory tests conducted due to the complications of diabetes mellitus cost 1.4 times more than routine laboratory tests; this can be attributed to the number of tests conducted. As would be expected, tests conducted due to the complications of diabetes mellitus were greater in number than those conducted due to diabetes mellitus. As indicated in Table 26, the number of patients who had tests conducted due to the complications of diabetes mellitus is

less than those patients who had routine laboratory tests conducted, therefore resulting in a higher average cost per patient when compared to patients having routine laboratory tests. The “number of items” column in Table 26 refers to the actual number of tests conducted in each category for the study period. The data presented in Table 26 were derived from the combined method.

5.4.7 Cost of emergency room visits and hospitalisations

Table 27 indicates the cost associated with emergency room visits and hospitalisations, which included the costs for laboratory tests, electrocardiogram and radiological procedures conducted during these events. The average cost per patient is included for the 20 month period.

Table 27 Cost of emergency room visits and hospitalisations

Category	Number of items	Cost of event	Average cost per patient ¹	Cost of lab tests, ECG and radiological procedures	Average cost per patient ²
					20 month period
Emergency room visits	15	R 6 000.00	R 400.00 SD R 0 (R 400 – R 1 200)	R 5 908.20	R 393.88 SD R 310.08 (R 151 – R 2 030.00)
Hospitalisations	16	R 108 680.00	R 8 360.00 SD R 10 856.59 (R 715 – R 32 890)	R 6 614.08	R 734.90 SD R 854.79 (R 244.31 – R 2 954.68)

¹ Average cost per patient for the event, either emergency room visit or hospitalisation.

² Average cost per patient for laboratory tests, ECG and radiological procedures conducted during the event (emergency room visits or hospitalisation).

As indicated in Table 27, the “number of items” column refers to the number of emergency room visits and hospitalisations which occurred during the study period. The data for Table 27 were derived from the combined method.

5.4.8 Cost of type I versus type II diabetes mellitus and its complications

Table 28 shows the cost of diabetes mellitus and its complications between type I and type II diabetic patients. The costs are presented over the 20 month period. The patient data from the combined method were grouped according to the type of diabetes mellitus. The costs presented in Table 28 refer to this patient sub-grouping and are costs in distinct categories i.e., costs due to diabetes mellitus only and costs due to the complications of diabetes mellitus only.

TABLE 28 Average cost per patient for type I versus type II diabetes mellitus and its complications

Cost component	Type I diabetes mellitus (n=28)	Median cost	Type II diabetes mellitus (n=72)	Median cost
	Cost (20 months)		Cost (20 months)	
Diabetes mellitus ¹	R 1 975.27 SD R 1 232.25 (R 553.93 – R 6 298.82)	R 1 499.45	R 1 727.33 SD R 851.31 (R 310.37 – R 4 387.08)	R 1 666.86
Diabetes mellitus complications ²	R 5 326.29 SD R 10 339.59 (R 426.58 – R 40 819.65)	R 1 611.06	R 3 337.25 SD R 7 019.22 (R 58.81 – R 48 823.74)	R 1 389.99
Total ³	R 5 018.87 SD R 8 106.52 (R 723 – R 42 245.81)	R 2 938.42	R 4 415.67 SD R 6 492.94 (R 682.45 – R 49 909.74)	R 2 836.42

¹ Average cost per patient due to the management for diabetes mellitus only.

² Average cost per patient due to the management of the complications of diabetes mellitus (excluding diabetes mellitus).

³ The average cost for each cost component does not add up to the average cost per patient. The average costs per patient per cost component are calculated based on the number of patients utilising that particular cost component.

In both groups, the cost of treating the complications of diabetes mellitus is more than diabetes mellitus; for type I diabetes mellitus it is 2.7 times more and for type II diabetes mellitus it is 1.9 times more. The cost of treating type I diabetic patients is 13.7% more than type II diabetic patients. This result shows that type I diabetic patients cost more than type II

diabetic patients to treat. Due to the higher acquisition cost of insulin versus oral hypoglycaemic medicines, the medicine cost per patient for type I diabetes mellitus should be higher than type II diabetes mellitus, but in this case there is only a 13.7% difference in the cost. This difference can be due to the number of type II diabetic patients who are on insulin and oral hypoglycaemic medicines; 84.7% were on this regimen in this study. The Kruskal-Wallis test found that the difference in cost between type I and type II diabetes mellitus was not statistically significant (z -value = 0.27). The box plot on page 107 of Annexure 2 illustrates the distribution of the cost data.

TABLE 29 Average cost per patient for the various cost components for type I versus type II diabetes mellitus

Cost component	Type I diabetes mellitus (n=28)	Median cost	Type II diabetes mellitus (n=72)	Median cost
	Cost (20 months)		Cost (20 months)	
Consultations	R 1 041.46 SD R 899.48 (R241 –R 4 820)	R 723.00	R 1 007.51 SD R 661.34 (R 241 – R 3 856)	R 723.00
Pharmacy supplies	R 1 073.63 SD R 1 025.76 (R 168.82 – R 4 178.04)	R 723.18	R 945.08 SD R 720.23 (R 38.58 – R 3 610.12)	R 753.30
Laboratory tests	R 871.67 SD R 572.58 (R 193.76 – R 2 782.19)	R 763.04	R 877.99 SD R 424.61 (R 97.36 – R 2 200.77)	R 888.15
Electrocardiogram procedures	R 378.00 SD R 267.29 (R 189 – R 567)	R 378.00	R 228.38 SD R 70.72 (R 189 – R 378)	R 189.00
Radiological procedures	R 1 079.33 SD R 957.05 (R 453 – R 2 181)	R 604.00	R 416.77 SD R 623.55 (R 151 – R 2 030)	R 151.00
Emergency room visits	R 666.67 SD R 413.12 (R 400 – R 1 200)	R 400.00	R 400.00 SD R 0 (R 400 –R 400)	R 400.00
Hospitalisations	R16 683.33 SD R 15 751.65 (R 1 430 – R 32 890)	R 15 730.00	R 5 863.00 SD R 8 973.50 (R 715 – R 30 030)	R 2 145.00
Surgery	NONE	NONE	R 7 414.50 SD R6 365.26 (R 1 105 – R 17 114)	R 4 225.00

Total ¹	R 5 018.87 SD R 8 106.52 (R 723 – R 42 245.81)	R 2 938.42	R 4 415.67 SD R 6 492.94 (R 682.45 – R 49 909.74)	R 2 836.42

¹ Average cost per patient derived from Table 28. The average cost for each of the cost components do not add up to the average cost per patient. The average cost per patient per cost component is calculated based on the number of patients utilising that particular cost component.

Hospitalisation is a key cost driver, in particular for type I diabetic patients. The average cost per patient hospitalised is more than the average cost of treating diabetes mellitus and its complications per patient when all cost components were taken into account, with this figure being 3.3 times more.

The cost for a period of 12 months was obtained for the following categories:

TABLE 30 Cost of diabetes mellitus and its complications per year

Category (n)	Cost per year
Type I diabetes mellitus no complication (n=11)	R 15 237.43
Type I diabetes mellitus with complication(s) (n=17)	R 68 599.54
Type II diabetes mellitus no complication (n=12)	R 13 087.96
Type II diabetes mellitus with complication(s) (n=60)	R 178 230.92
Total (n=100)	R 275 155.85

The patients were categorised into four groups as indicated in Table 30 and the costs were presented as total cost per category i.e., costs due to diabetes mellitus and costs due to the complications of diabetes mellitus. These costs were derived from the combined method.

These costs were used in the decision tree analysis and are different to the costs presented in Table 28, which represent costs for sub-grouping of patients according to type of diabetes.

There was a 159.8% difference in cost between type I diabetes mellitus with complications and type II diabetes mellitus with complications. This was expected, as there were more patients with type II diabetes mellitus.

5.4.9 Impact of number of visits to Groote Schuur hospital on costs

In our study we assessed what impact the number of visits to Groote Schuur hospital had on the cost (as indicated in Table 31) of diabetes mellitus and its complications per patient.

Table 31 Impact of number of visits and doctor consultations at GSH on cost of diabetes mellitus and its complications

Cost component	5 or less group		6 or more group	
	Doctor consults ¹ (n= 75)	Visits ² (n= 61)	Doctor consults ¹ (n= 25)	Visits ² (n= 39)
Diabetes mellitus ³	R 1 728.38	R 1 446.96	R 1 933.51	R 2 343.86
Diabetes mellitus complications ⁴	R 1 875.44	R 1 485.48	R 8 223.06	R 6 455.85
Total ⁵	R 3 028.69	R 2 421.05	R 9 169.80	R 7 972.03

¹ Doctor consultations at GSH, either 5 or less doctor visits or 6 or more doctor visits.

² Visits to GSH, irrespective of doctor consultations, either 5 or less visits to GSH or 6 or more visits to GSH.

³ Cost per patient due to the management for diabetes mellitus only.

⁴ Cost per patient due to the management of the complications of diabetes mellitus (excluding diabetes mellitus).

⁵ Cost per patient for diabetes mellitus and its complications. The cost of the cost components do not add up to the cost per patient. The cost per patient per cost component is calculated based on the number of patients utilising that particular cost component.

Patients who had 6 or more doctor consultations at Groote Schuur hospital had an average cost which was 3 times more than the patient who had 5 or less doctor consultations. This result can suggest that patients who have more doctor consultations have more serious complications and require more care which, in turn, increases the cost of care. Eighty-eight percent (88%) of the patients who had 6 or more doctor consultations at Groote Schuur hospital had complications due to diabetes mellitus and 77. 3% of these patients had two or more complications of diabetes mellitus.

The number of visits influenced the average cost. Patients in the group of 6 or more visits had 3.3 times more cost than patients in the group of 5 or less visits. The group of 6 or more visits had 70.6% of its cost due to diabetes mellitus complications and the group of 5 or less visits had 40.2% of its cost due to diabetes mellitus complications. This result emphasises the impact of complications on the cost of treatment.

5.5 Predictive cost models

5.5.1 Predicting costs using decision tree analysis model

The results of this model were based on actual costs at Groote Schuur hospital for a 12 month period. Table 32 summaries the probabilities of certain events occurring and the costs thereof, using data which was obtained from the sample of 100 patients. This data were obtained from the combined method. The cost per patient in Table 32 was derived from the costs obtained in Table 30 (page 73) for the various categories.

Table 32 Probabilities of events occurring and cost thereof

Event occurring	Probability of event occurring	Cost of event
Diabetes mellitus type I	0.28	-
Diabetes mellitus type I no complication	0.36	R 1 385.22
Diabetes mellitus type I with complication(s)	0.64	R 4 035.27
Diabetes mellitus type II	0.72	-
Diabetes mellitus type II no complication	0.18	R 1 090.66
Diabetes mellitus type II with complication(s)	0.82	R 2 970.52

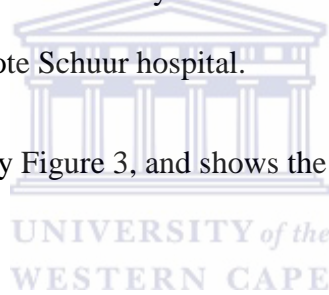
The following example illustrates how this algorithm could be used. If a diabetic population of 100 patients is treated at Groote Schuur hospital for a period of 12 months using the above

probabilities of events occurring and the costs thereof, the financial impact of treating these patients can be determined; $100 \text{ patients} \times 0.28 \text{ (probability of being type I diabetic)} \times 0.64 \text{ (probability of type I diabetic patient having a complication)} \times R 4\,035.27 \text{ (cost per patient per year)} = R 72\,312.04$.

The costs for four categories are calculated for 100 patients and the sum of these categories represents the total cost for the population.

The total cost for treating these patients over a period of 12 months was R 275 789.51. This cost was 0.23% (R 633.66) higher than the actual cost. This result was expected as the cost estimates, probabilities of type of diabetes mellitus and complications occurring for the various categories were derived from the study. This indicates that this model can therefore be applied to predict costs at Groote Schuur hospital.

The decision tree is represented by Figure 3, and shows the event probabilities and cost estimates for certain events.



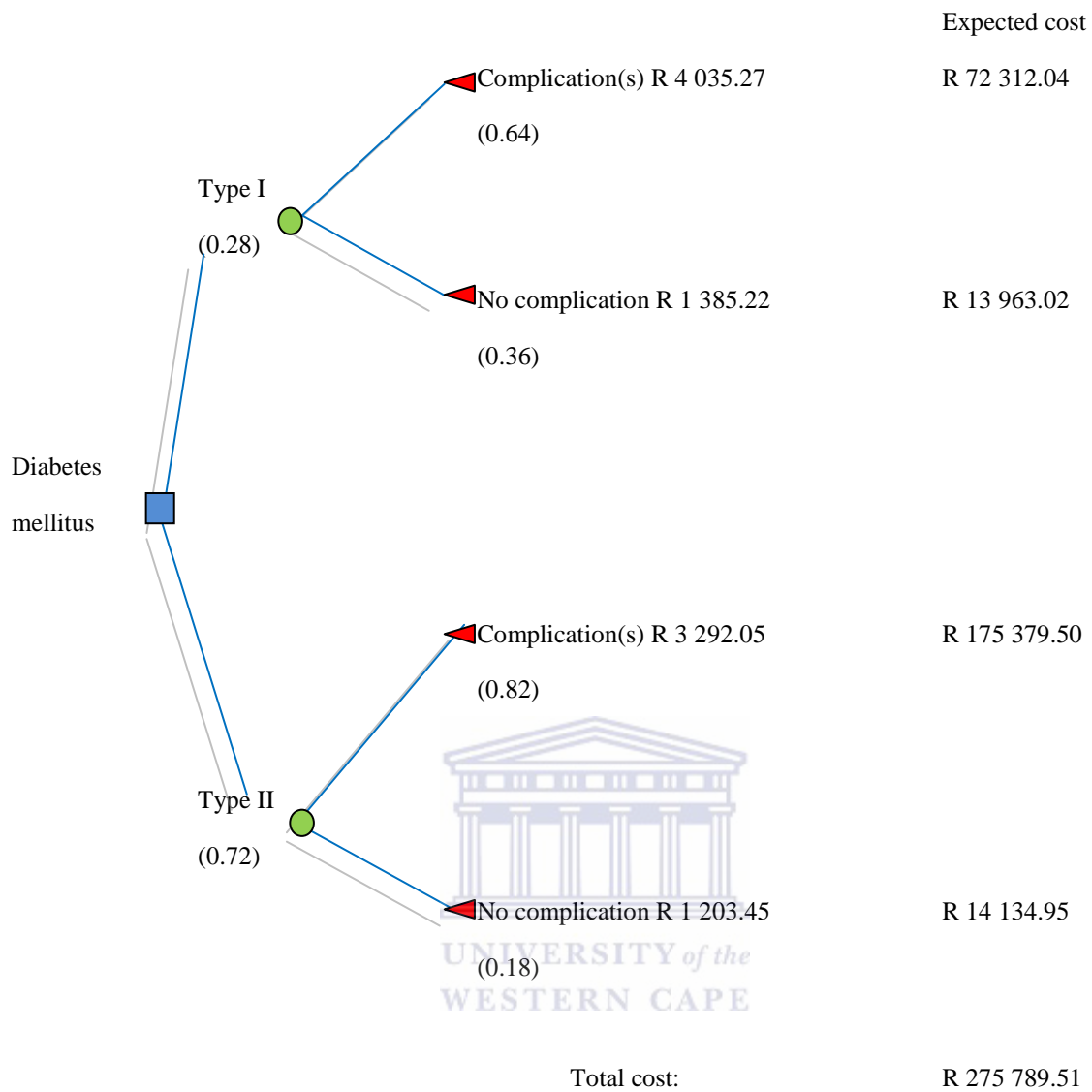


Figure 3 Decision tree with costs

Table 33 indicates the probability of certain diabetes mellitus complications occurring in either type I or type II diabetic patients. This data was obtained from the sample of 100 patients using the combined method.

Table 33 Probabilities of complications

Complication	Probability of complication occurring	
	Type I diabetes mellitus	Type II diabetes mellitus
Neuropathy	0.56	0.64
Nephropathy	0.56	0.59
Retinopathy	0.39	0.34
Ischaemic heart disease (IHD)	0.11	0.32
Peripheral vascular disease (PVD)	No data	0.08
Acute metabolic	0.17	0.02

The probabilities presented in Table 33 were not used in the cost analysis due to the small sample size and the fact that cost estimates for the various complications could not be obtained. The probabilities of these complications occurring can be used in future studies if cost estimates for the various complications are obtained.

5.5.2 Model of potential costs incurred at other health facilities

The method which was developed for a model which could predict additional costs incurred at other health facilities such as community health centres. Patients will visit Groote Schuur hospital intermittently for specialised care and management of their conditions. This model assumed that patients would visit community health centres to collect medicines and for doctor consultations.

A sample of 10 patients was used to test the functionality of the model. The results of this model are summarised in Tables 34 and 35. This model utilised actual patient data obtained in the study using the combined method. Patients were divided into two categories i.e., unstable and stable patients, and the simulation was conducted for 5 patients for each category. This model is based on actual events that occurred at Groote Schuur hospital and

simulated events that could have occurred at community health centres during the study period.

Table 34 Simulated costs for unstable patients

Simulated cost for unstable patients											
Category	Time in study, months	Consults @ GSH ¹	Medicine collection @ GSH ²	CHC simulated events and cost					Cost @ GSH ⁸	Total cost ⁹	Cost per 12 months ¹⁰
				Consults ³	Medicine collections ⁴	Consults cost ⁵	Medicine cost ⁶	Simulated cost total ⁷			
Patient 1	19	3	9	10	10	R1050- R1410	R4630	R5680- R6040	R8821	R14501- R14861	R9135- R9362
Patient 2	15	2	4	11	11	R1155- R1551	R600	R1755- R2151	R1685	R3441- R3837	R2752- R3069
Patient 3	17	3	8	9	9	R945- R1269	R1917	R2862- R2986	R3162	R6025- R6149	R4278- R4366
Patient 4	18	3	3	15	15	R1575- R2115	R2937	R4512- R5052	R2893	R7405- R7945	R4961- R5323
Patient 5	18	3	4	14	14	R1470- R1974	R3256	R4726- R5230	R2502	R7229- R7733	R4843- R5181

¹ Number of specialist consultations at Groote Schuur hospital during the study period.

² Number of medicine collections at Groote Schuur hospital during the study period.

³ Number of consultations at the community health centre which would be conducted during the study period based on the model and actual consultations at GSH.

⁴ Number of medicine collections at the community health centre during the study period based on actual medicine collections at GSH.

⁵ Cost for consultation with nurse and doctor presented as a range and includes the cost of a blood glucose test.

⁶ Total medicine cost at the community health centre including the dispensing fee based on the average cost per prescription and the number of medicine collections at the community health centre.

⁷ Total simulated cost for consultations and medicine at the community health centre.

⁸ Actual cost at GSH for study period.

⁹ Total cost for the study period, includes the community health centre and GSH cost.

¹⁰ Total cost converted to a cost per year.

Table 35 Simulated costs for stable patients

Simulated cost for unstable patients											
Category	Time in study, months	Consults @ GSH ¹	Medicine collection @ GSH ²	CHC simulated events and cost					Cost @ GSH ⁸	Total cost ⁹	Cost per 12 months ¹⁰
				Consults ³	Medicine collections ⁴	Consults cost ⁵	Medicine cost ⁶	Simulated cost total ⁷			
Patient 6	17	2	3	4	14	R420-R564	R2547	R2967-R3111	R2883	R5851-R5995	R4154-R3733
Patient 7	18	3	4	4	14	R420-R564	R2594	R3014-R3158	R3970	R6984-R7128	R4679-R4775
Patient 8	12	2	1	3	11	R315-R423	R395	R710-R818	R682	R1392-R1500	R1392-R1500
Patient 9	20	3	9	4	13	R420-R564	R2359	R2779-R2923	R9771	R12551-R12695	R7530-R7617
Patient 10	19	3	6	4	13	R420-R564	R3766	R4186-R4330	R3038	R7224-R7368	R4551-R4642

¹ Number of specialist consultations at Groote Schuur hospital during the study period.

² Number of medicine collections at Groote Schuur hospital during the study period.

³ Number of consultations at the community health centre which would be conducted during the study period based on the model and actual consultations at GSH.

⁴ Number of medicine collections at the community health centre during the study period based on actual medicine collections at GSH.

⁵ Cost for consultation with nurse and doctor presented as a range and includes the cost of a blood glucose test.

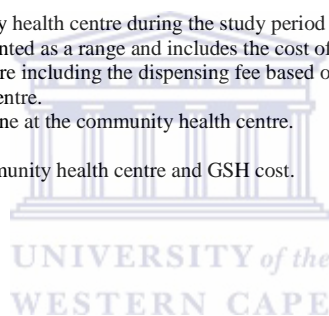
⁶ Total medicine cost at the community health centre including the dispensing fee based on the average cost per prescription and the number of medicine collections at the community health centre.

⁷ Total simulated cost for consultations and medicine at the community health centre.

⁸ Actual cost at GSH for study period.

⁹ Total cost for the study period, includes the community health centre and GSH cost.

¹⁰ Total cost converted to a cost per year.



5.6 Total cost of diabetes mellitus and its complications

Table 36 Total cost of diabetes mellitus and its complications at GSH

Cost component	Number of items	Number of patients utilising resource	Total cost (% to total cost)	Cost per patient
			20 month period	
Consultations	4811	1094	R 1 159 451.00 (26.8%)	R 1 059.83
Pharmaceutical supplies	45701	893	R 1 003 101.94 (23.2%)	R 1 123.29
Laboratory tests	22536	1090	R 703 190.13 (16.3%)	R 645.13
Electrocardiogram procedures	91	61	R 17 189.00 (0.4%)	R 281.95
Radiological procedures	111	75	R 16 761.00 (0.4%)	R 223.48
Emergency room visits	66	42	R 26 400.00 (0.6%)	R 628.57
Hospitalisations	301	200	R 990 275.00 (22.9%)	R 4 951.38
Surgery	91	71	R 406 446.00 (9.4%)	R 5 724.59
Total			R 4 322 814.07	R 3 951.38

Table 36 indicates the total cost for diabetes mellitus and its complications for the sample of 1094 in the electronic database. The results obtained from the combined and electronic methods using 100 patients were reported based on the cost template which was developed (Table 21 and 23). For these methods the data were arranged in the cost template at patient level which allowed for calculation of costs at individual patient level. However, when using the sample of 1094 (Table 36), the electronic database of Groote Schuur hospital was used as presented without using the cost template to arrange data at patient level. In this case, the data were presented at cost component level in various databases.

Hospitalisation data was presented in two databases i.e., one database had information on the admission date and reason for hospitalisation and the other database had information on the discharge date and length of stay. Hence, in this evaluation only the total costs for all the cost components were determined.

The database as it was presented by Medical Informatics did not allow for re-arrangement of data at patient level. The information was not available at individual patient level, hence, the cost per patient is reported and not the average cost per patient with the application of descriptive statistics. The cost per patient was found to be R 3 951.38 and was calculated by dividing the cost per component by the number of patients utilising that particular component. This approach could be used to determine the cost of diabetes mellitus and its complications at cost component level using the database in its current form.



CHAPTER 6

DISCUSSION

There is no documented data in South Africa on the cost of treating diabetes mellitus and its complications at a tertiary level hospital. This study was conducted to address this issue. This retrospective study was conducted primarily to: (1) develop a method which is unique to Groote Schuur hospital for determining the cost of management of diabetes mellitus and its complications, (2) quantify the direct medical costs associated with the management of diabetes mellitus and its complications and (3) develop models which could predict the cost of management of diabetes mellitus and its complications. This study was conducted from the perspective of the funder i.e., the government.

Our study found that 28% of the patients were type I diabetics; this is higher than literature findings of 5 – 10% (Deshpande *et al.* 2008). An explanation is that Groote Schuur hospital is a tertiary level facility and therefore it is not uncommon for more patients with type I diabetes mellitus to be treated at this facility. The majority of the patients had diabetes mellitus related complications (77%) and certain co-morbid conditions are risk factors for the development of these complications. According to a UKPDS study (Clarke *et al.* 2003) conditions such as hypertension and dyslipidaemia are risk factors for various complications of diabetes mellitus. These co-morbid conditions were also the highest ranking co-morbid conditions in our study. The most commonly occurring complication of diabetes mellitus in our study was neuropathy (48%), this is in line with what has been found in literature, viz. that 50 – 60% of diabetic patients suffer from neuropathy (Zhao *et al.* 2010).

6.1 Development of the costing method

The primary focus of our study was to develop a method to quantify the cost associated with the treatment of diabetes mellitus and its complications. This method was unique to Groote Schuur hospital and was based on the data sources which were available. Two distinct methods were developed i.e. combined method (patient folders and electronic patient records) and electronic method (electronic patient records). Patients were selected from the electronic database based on their attendance to the adult diabetic clinic. This was the preferred method of extraction in our study as opposed to the conventional method of using ICD-10 codes as used in most cost studies (Ramsey *et al.* 1999, Gandra *et al.* 2006, Clarke *et al.* 2008). The accuracy of recording ICD-10 codes in the electronic database of patient records was reported to be 70 % by the Medical Informatics department at Groote Schuur hospital. The method used in our study indicated that 99.1% of the patients extracted were diabetic. Therefore, our method can therefore be useful for extracting patients when ICD-10 codes are not available. The combined method provided advantages such as primary diagnosis and other patient co-morbidities. This information is important when the costs are separated into costs due to diabetes mellitus or complications of diabetes mellitus. A further advantage of this method is that the reasons for every hospital and emergency room visit will be known, this is important as hospitalisation is a large contributor to the total cost of treatment. The electronic method is not able to categorise costs as the combined method which is a disadvantage. Hence, the electronic method can only report the total cost for diabetes mellitus and its complications. This information can be useful when assessing the overall financial impact that diabetes mellitus and its complications had on the total expenditure of the hospital. Using a method which is able to categorise costs such as the combined method is more useful as the funder is able to determine the percentage of the total cost being used to treat the complications of diabetes mellitus and therefore impact decisions which affect allocation of monetary

resources. These two methods were compared with regards to the total cost obtained and the electronic method obtained costs which were 6.4% higher than the combined method. The cost differences between these two methods were not statistically significant. Therefore, the electronic method can be used as it is similar to using the combined method.

A study by Morsanutto *et al.* (2006) combined two data sources i.e., patient folders and electronic patient records. This study was conducted from the perspective of the funder and costs were derived from the Italian health ministry reference price list. The health care facility was a diabetes specific facility. This study did not assess what value the patient folders added to the cost of illness study. The study by Riewpaiboon *et al.* (2007) utilised patient folders as the only data source and was conducted from the perspective of the funder of treatment in a primary health care facility. Our study is able to assess the impact which the patient folders has on the categorisation of costs and the difference in the total costs obtained when using two different methods of costing.

Studies which have been conducted in developed countries utilised large databases from managed health care organisations (Pelletier *et al.* 2008; Gandra *et al.* 2006; Clarke *et al.* 2006). The costs presented in these studies represent the cost to the managed health care organisation, whereas our study presented costs from the perspective of the government. The perspective of our study and those studies mentioned above are the same, but for the funder of the treatment. The advantage of using an electronic database is the large sample size which is obtained. The electronic method which was developed in our study can provide a larger sample of patients, but the database in its current form will have to be changed (as will be recommended in Chapter 7) in order to provide this advantage to future researchers.

6.2 Cost of diabetes mellitus and its complications

The cost data which are presented in various studies including our study are influenced by a number of factors. Studies conducted in some European countries (Morsanutto *et al.* 2006; Massi-Benedetti. 2002) have the advantage of a national reference price list, which is not available in South Africa. Our study used prices from the UPFS Provincial Gazette for Western Cape No. 6862, 25 March 2011, these being the prices that were used by the hospital to bill patients who are privately funded. However, these prices do not represent what it costs the hospital to provide its patients with specific health care services. This is currently the only source of costs available in the public sector. This did pose a particular challenge for this study as one of the main objectives was to cost diabetes mellitus and its complications from the perspective of the government. Therefore, using prices charged to private patients would not fully achieve this objective although the prices obtained in the UPFS fee schedule are conservative. The UPFS fee was developed by the National Department of Health (NDoH) of South Africa. The NDoH was contacted to enquire about the method of calculating this fee schedule. This information would then have been used to determine whether a profit margin was incorporated into the fee schedule and we would be able to determine what the true cost was for providing the services outlined in the UPFS fee schedule. The NDoH was unable to provide the information requested as they had used no specific method to determine these prices. The fees in the UPFS were merely estimated in 2004 and thereafter inflation adjusted for each year. This is another area in which South Africa lacks information which would be greatly beneficial to health care decision makers, particularly taking account the implementation of the NHI.

In order to obtain the actual cost for providing services at Groote Schuur hospital, a comprehensive cost study will have to be undertaken based on the financial statements, time

motion studies and determining the cost per bed and facility. This falls outside the scope of this study. For the purpose of this study, we have explored what is needed for a comprehensive cost study to be conducted.

Time motion studies would provide a cost for each of the above health care services. This cost is obtained per time spent conducting these services. These studies provide an average time spent per patient (for doctor and nurse time) that can then be multiplied by the hourly rate of the health care provider conducting the consultation from which a final cost can be obtained. The pharmacy personnel cost is calculated by determining the average time it takes to dispense a diabetes mellitus related prescription. The time unit is then multiplied by the hourly rate for the pharmacy staff involved in dispensing the prescription.

A national reference price list would enable results obtained in the same country to be compared if the same sources of costs are used. This would enable the collection of cost data in that particular country that could be used by government and other funders.

The perspective of the study is important as this is an indicator of which costs will be assessed. Our study assessed the direct medical costs associated with diabetes mellitus and its complications. Many diabetes mellitus cost studies assessed the direct medical costs (Pelletier *et al.* 2008; Gandra *et al.* 2006; Clarke *et al.* 2006) which were the same as our study. These studies were conducted from the perspective of the managed health care organisations. Our study's perspective is that of a government which reports acquisition costs which are different to the costs reported in the studies mentioned above.

The studies by Morsanutto *et al.* (2006); Massi-Benedetti. (2002) and Riewpaiboon *et al.* (2007) report acquisition costs which is similar to our study. Although these results cannot be compared to our study due to differences in source of costs, currency differences and health

care system differences, we are able to compare the impact of various cost components on the total cost and draw some conclusions and similarities.

In our study the cost of treating diabetes mellitus and its complications was R 2 744.80 per patient per year (Table 17, page 59). Patient grouping had an impact on the cost, the cost of treating a patient with diabetes mellitus only (n=23) was R 1 231.54 per year (Table 24, page 68). Treating a patient with diabetes mellitus and complication (s) (n=77) was R 3 208.71 per year (Table 24, page 67). This showed the importance of categorising costs and reporting costs based on whether the patient had a diabetes mellitus complication or not.

Our study showed that the cost of treating the complications of diabetes mellitus is more than diabetes mellitus with 60.7% (Table 17, page 59) of the total cost being attributable to the complications of diabetes mellitus. Studies by Norlund *et al* (2001) and Williams *et al* (2002) found that 50% of the total treatment cost was due to the complications of diabetes mellitus.

Our study indicated that diabetes mellitus with complications cost 2.6 times more to treat than diabetes mellitus without complications. There have been studies which support this finding. Pelletier *et al* (2009) and Massi-Benedetti (2002) assessed microvascular complications of diabetes mellitus in type II diabetics and found that the costs were increased 2-fold versus diabetic patients without any complications.

6.2.1 Cost of various components

The cost components described in our study have different impacts on the cost of diabetes mellitus and its complications. Our study found that hospitalisation was the major cost driver, contributing 23.8% of the total cost (Table 18, page 60). Morsanutto *et al.* 2006 found similar results in that hospitalisations contributed 28 % of the total cost. Dawson *et al.* (2000) found that 50 % of the cost was due to hospitalisations. Jonsson B. (2002) reported that as

much as 65 % of the total cost was due to hospitalisations. While all these results indicate that hospitalisation is a major cost driver, the variation may be due to different methods used in costing the hospital event and the different cost components included in the final hospital cost.

In our study only 13 % of the patients were hospitalised, at an average cost of R 8 360.00 per patient (Table 21, page 63). This was 1.8 times more than the average cost per patient to treat diabetes mellitus. This further emphasised the financial impact of hospital care on the cost of treating the complications of diabetes mellitus.

Health care resources such as doctor consultations, pharmacy supplies and laboratory tests had a substantial impact on the total cost but this is to be expected as almost all the patients (98%) utilised these. Our study found consultations, pharmacy supplies and laboratory tests to be 22.2%, 21.4% and 19.2%, respectively, of the total cost. Dawson *et al.* (2000) reported doctor consultations and medicines as 31% and 19%, respectively, of the total cost. Morsanutto *et al.* (2006) reported doctor consults, medicine and laboratory tests as 6%, 52% and 11%, respectively, of the total cost. The results reported by Dawson *et al.* (2000), showed that only the doctor consultations were comparable to our study.

In the study of Morsanutto *et al.* (2006) medicine cost was taken from the Italian official market reference price list which represented market prices. This was different to our study in that medicine cost was taken from state tender prices (representing acquisition costs) and these tender prices are lower than the market prices (single exit price (SEP) as it is referred to in South Africa). In the study of Morsanutto *et al.* (2006) medicine cost was 52% of the total cost and this could be a contributing factor. The source of costs impacts the conclusions which can be made from the various studies and therefore it is important that this factor is taken into account when comparing cost studies.

Our study reported the acquisition cost for medicines and the study by Riewpaiboon *et al.* (2007) was same in this respect. Riewpaiboon *et al.* (2007) reported that medicines were 45 % of the total cost. This difference with our study is that vitamins were included in the cost of medicines and the acquisition cost for various medicines does vary in Thailand as reported by the researchers. The study was conducted in a primary health care facility and it was expected that medicine costs would be the greatest contributor to the total cost as patients visited this facility monthly to collect medicines. This was further highlighted by the finding that the outpatient cost in that study was found to be 1.5 times more than the inpatient cost. This was not the case with Groote Schuur hospital, as patients receive specialised care and would collect their monthly medicines at the primary health care facilities.

6.2.2 Categorisation of costs

Our study was able to categorise costs into either (1) costs due to diabetes mellitus or (2) costs due to the complications of diabetes mellitus. This categorisation was possible when the combined method was used. Our study found that the patient folders added value to the overall cost estimates. The patient folders provided valuable information such as the type of diabetes mellitus and the type of diabetes mellitus complications. This information is important as it allows for costs to be categorised. The patient folders were of value when completing missing information in the electronic database, particularly the reasons for emergency room visits and hospitalisations. Hospitalisations can greatly affect the cost. Hence, the reasons for these events should be accurately recorded and incomplete information can lead to under- or over-estimation of the hospital cost. None of the other studies was able to distinctly categorise costs as effectively as has been accomplished in our study. Our study further identified the various sub-components which were included in the

cost components i.e., hospitalisation cost which consisted of the cost per day, laboratory tests, electrocardiogram and radiological procedures conducted during the hospital event.

6.3 Predictive cost models

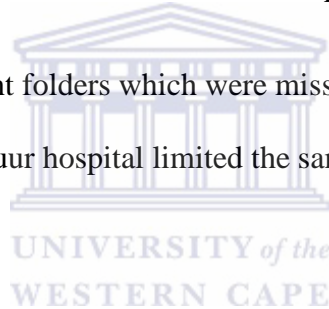
Models which use probabilities of events occurring are more commonly found in literature. Clarke *et al* (2008); Riewpaiboon *et al* (2007) and O'Brien *et al* (2003) developed models which can predict costs. The study by Clarke *et al* (2008) used estimates of the occurrence of diabetes mellitus complications to predict the cost of these events using costs obtained from the national reference prices. The decision tree model which we developed used a different approach with regard to obtaining probabilities of diabetes mellitus complications occurring as our study obtained the probabilities for various categories and the cost estimates for these using the data obtained at Groote Schuur hospital. This model (as shown in the Chapter 5) is able to predict costs in the Groote Schuur hospital diabetic population and it was found that the cost results obtained varied by only 0.23% from the actual cost. These cost estimates and probabilities were obtained using a sample of 100 patients.

Our study demonstrated that a method for a model could be developed which took into account potential costs which the study population would incur at community health centres. To obtain total costs including those incurred at primary health care facilities, a simulated cost model could be used.

6.4 Limitations of the study

The study had the following limitations:

- a) The sample size of 100 was small and as a result cost estimates for the individual complications of diabetes mellitus was not possible.
- b) Data for 20 months only was collected as this was what was available at the time of data collection. Data should be collected for an extended period of time. This would allow for costs to be analysed over time as complications progress.
- c) The use of UPFS Provincial Gazette for Western Cape No. 6862, 25 March 2011, fee schedule as acquisition costs for Groote Schuur hospital were not available.
- d) The high number of patient folders which were missing from the Medical Records department at Groote Schuur hospital limited the sample size of the patients for this study.



CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

This study was the first of its kind in a tertiary level hospital in South Africa. The methods developed in this study can be used and validated in future research. This study successfully achieved its objectives and provided cost estimates for diabetes mellitus and its complications which can be used in future research and assist in the financial decision making process of funders such as the government.

7.1 Conclusions

The following conclusions were drawn from this study:

- a) Four unique methods were developed to determine the cost of management of diabetes mellitus and its complications at Groote Schuur hospital (combined, electronic, decision tree and CHC cost model). Although these methods have been specifically designed for Groote Schuur hospital, there is no reason why these methods cannot be applied to other public tertiary level hospitals which have patient folders, and an electronic database of patient records.
- b) The two main methods developed were the combined and electronic method. The electronic method estimated a total cost which was 6.4% more than the combined method. However, there was no statistically significant difference between the two methods. The electronic database method provides the total and average cost per patient. The costs associated with sub-groups such as type I and type II diabetic patients could not be determined using this method. Despite this, the electronic method does not require the perusal of patient folders for additional information and hence is a simplified method.

- c) The combined method allowed better categorisation of costs compared to the electronic method. With the combined method the type of diabetes mellitus complication, the reasons for emergency room visits and hospitalisations are known. Therefore, costs associated with diabetes mellitus (type I or type II) and diabetes mellitus complications could be categorised.
- d) The average cost per patient per year for diabetes mellitus and diabetes mellitus with complications was R 1 231.54 and R 3 208.71, respectively. These results show that a patient with diabetes mellitus and its complications cost 2.6 times more to treat than a patient with diabetes mellitus only.
- e) When cost of treating diabetes mellitus and the cost of treating the complications of diabetes mellitus were separated into 2 distinct categories, the cost of treating the complications of diabetes mellitus was 1.5 times more than treating diabetes mellitus.
- f) When evaluating the cost per patient for the various cost components, then hospitalisation and surgery costs were the main cost drivers on a per patient basis.
- g) Type I diabetes mellitus cost R 3 011.32 and type II diabetes mellitus cost R 2 649.40 per patient per year. The type of diabetes mellitus had an impact on the average cost of treatment. The treatment costs for type I diabetic patients was 13.7% more than that for type II diabetic patients.
- h) The decision tree model obtained a cost result which was 0.23% more than the actual cost. This indicates that this model can therefore be applied to predict costs at Groote Schuur hospital.

- i) The study developed a method which could be used to predict the cost of management of diabetes mellitus at community health centres. This will allow the calculation of the total cost of diabetes mellitus from the perspective of the government.

7.2 Recommendations

- a) In future research the methods and models developed in this study can be used at other tertiary level facilities to provide costs for diabetes mellitus and its complications. These methods developed in this study can be validated for reproducibility in other public tertiary level hospitals in South Africa.
- b) In order to conduct future cost studies at Groote Schuur hospital in the future which will allow for categorisation of costs, i.e., diabetes mellitus and the complications of diabetes mellitus, the combined method should be used.
- c) If, in the future, cost studies are conducted at Groote Schuur hospital the electronic method could be used to obtain average and total costs of diabetes mellitus and its complications. The electronic database at Groote Schuur hospital should be upgraded in order to improve the capturing of clinical information such as the patient diagnosis and co-morbid conditions. The reasons for hospitalisation and emergency room visits should be provided for each patient and incorporated into the database. This will allow for the categorisation of costs. More consistent and accurate ICD-10 codes will make it easier for patients to be selected for inclusion into cost studies.
- d) Medicine costs could not be extracted from the electronic database as these costs were incorrect. These costs should be extracted directly from the pharmacy department at Groote Schuur hospital.

- e) The decision tree model should be developed further by obtaining cost estimates and probabilities of the individual complications occurring from a larger sample size.



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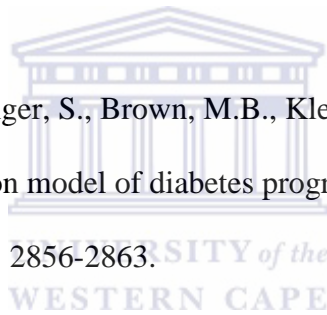
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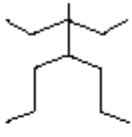
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GSH Diabetic Clinic		Date _____
<div style="border: 1px solid black; width: 100%; height: 100%;"></div>		Glucose _____ HbA1C _____ Weight _____ Urine dipstix _____
PROBLEMS Type 1 DM <input type="checkbox"/> Type 2 DM <input type="checkbox"/> Other DM _____ HPT <input type="checkbox"/> IHD <input type="checkbox"/> PVD <input type="checkbox"/> Dyslipidaemia <input type="checkbox"/> COPD/Asthma <input type="checkbox"/> Other _____ _____	MEDICATION Actraphane Actrapid Protophane Gliclazide/Glibenclamide Metformin Simvastatin Aspirin Enalapril	COMPLICATIONS None <input type="checkbox"/> Retinopathy - background <input type="checkbox"/> proliferative <input type="checkbox"/> Neuropathy - peripheral <input type="checkbox"/> autonomic <input type="checkbox"/> Nephropathy microalbuminuria <input type="checkbox"/> macroalbuminuria <input type="checkbox"/> creatinine _____ Other _____
PRESENT HISTORY Smoking Y/N Alcohol Y/N Hypoglycaemia Y/N HbGM Y/N _____ Compliance : Diet Y/N Meds Y/N _____ Chest pain Y/N _____ Calf claudication Y/N _____ Other : _____ _____ _____ _____ _____		
EXAMINATION Not done Lipohypertrophy Y/N _____ BP _____ Pulses  Feet : AJs Y/N Sensation N/AbN Vibration N/AbN Ulcer Y/N _____ Fundoscopy Not done Retinopathy Y/N _____ Other : _____		
ASSESSMENT 1) DM control - poor adequate good 2) BP - poorly-controlled borderline well-controlled		
PLAN Insulin _____ Oral agents _____ Dietary advice Y/N Diabetic sister Y/N Ophthalmologist Y/N Podiatrist Y/N Renal function Y/N Lipid profile Y/N Microalbumin-creatinine ratio Y/N ECG Y/N Referral _____ Other _____ TCA x _____ months		
Repeat CEU/ Microalbumin-creatinine ratio _____ /20 Annual review _____ /20 PRINT _____ SIGN _____		

Annexure 2 Statistical analysis

Diabetes mellitus versus diabetes mellitus with complications

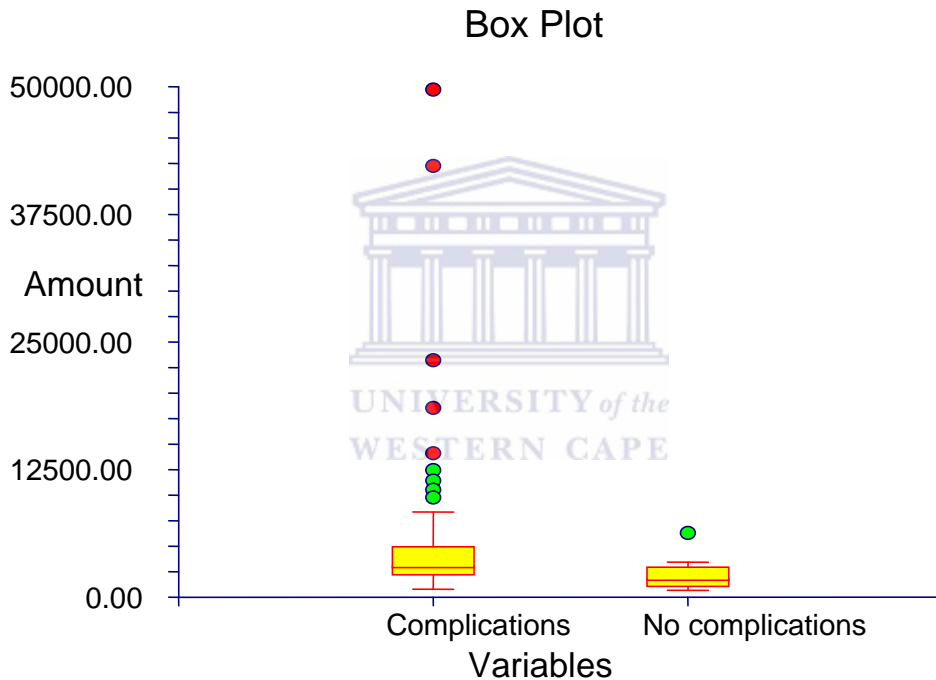
Analysis of Variance Report

Response Total Cost

Tests of Assumptions Section

Assumption	Test Value	Prob Level	Decision (0.05)
Skewness Normality of Residuals	9.26	0.00	Reject
Kurtosis Normality of Residuals	6.82	0.00	Reject
Omnibus Normality of Residuals	132.49	0.00	Reject
Modified-Levene Equal-Variance Test	2.12	0.14	Accept

Box Plot Section



Diabetes mellitus versus diabetes mellitus with complications

Analysis of Variance Report

Response Total Cost

Kruskal-Wallis One-Way ANOVA on Ranks

Hypotheses

Ho: All medians are equal.

Ha: At least two medians are different.

Test Results

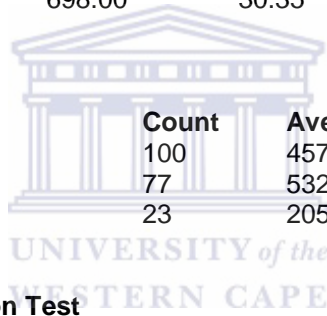
Method	DF	Chi-Square (H)	Prob Level	Decision(0.05)
Not Corrected for Ties	1	14.41	0.000147	Reject Ho
Corrected for Ties	1	14.41	0.000147	Reject Ho
Number Sets of Ties	0			
Multiplicity Factor	0			

Group Detail

Group	Count	Sum of Ranks	Average Rank	Z-Value	Median
Complications	77	4352.00	56.52	3.79	3038.08
No complications	23	698.00	30.35	-3.79	1800.79

Means and Effects Section

Term	Count	Average	Standard Error	Effect
All	100	4574.67	73.80	
Complications	77	5328.03	778.38	5254.22
No complications	23	2052.56	1424.22	1978.75



Tukey-Kramer Multiple-Comparison Test

Response: Total Cost

Alpha=0.05 Error Term=S(A) DF=98 MSE=4.66E+07 Critical Value=2.80

Group	Count	Average
No complications	23	2052.56
Complications	77	5328.03

Notes:

This report provides multiple comparison tests for all pairwise differences between the means.

Diabetes mellitus versus diabetes mellitus with complications

Analysis of Variance Report (ANOVA)

Response Total Cost

Kruskal-Wallis Multiple-Comparison Z-Value Test

Total Cost	Complications	No complications
Complications	0.00	3.79
No complications	3.79	0.00

Regular Test: Medians significantly different if z-value > 1.96



Type I versus Type II diabetes mellitus

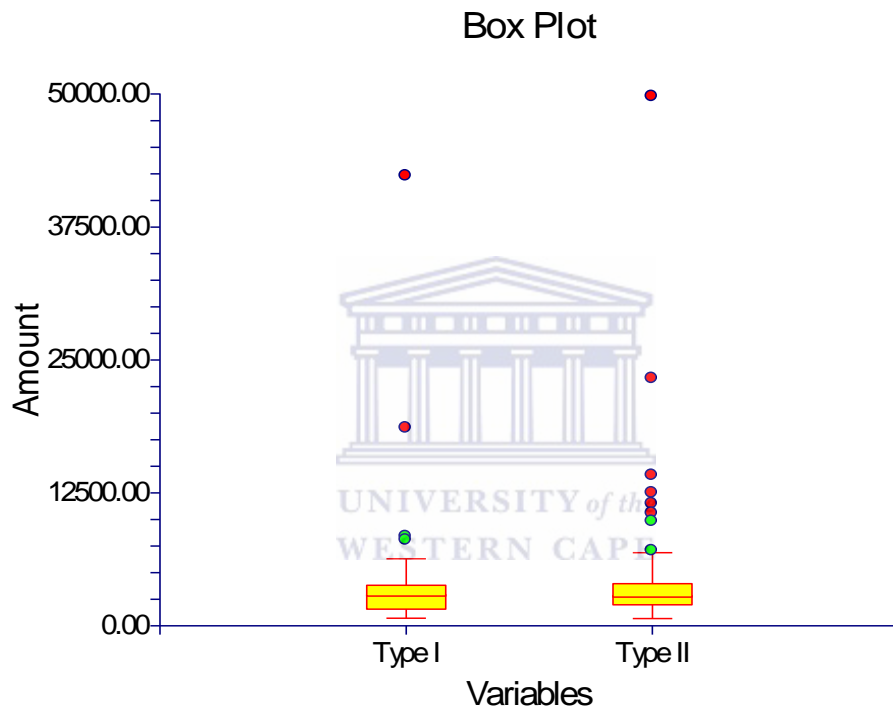
Analysis of Variance Report

Response Total Cost

Tests of Assumptions Section

Assumption	Test Value	Prob Level	Decision (0.05)
Skewness Normality of Residuals	9.26	0.00	Reject
Kurtosis Normality of Residuals	6.81	0.00	Reject
Omnibus Normality of Residuals	132.32	0.00	Reject
Modified-Levene Equal-Variance Test	0.32	0.56	Accept

Box Plot Section



Type I versus Type II diabetes mellitus

Analysis of Variance Report (ANOVA)

Response Total Cost

Kruskal-Wallis One-Way ANOVA on Ranks

Hypotheses

Ho: All medians are equal.

Ha: At least two medians are different.

Test Results

Method	DF	Chi-Square (H)	Prob Level	Decision(0.05)
Not Corrected for Ties	1	7.21E-02	0.788	Accept Ho
Corrected for Ties	1	7.21E-02	0.788	Accept Ho
Number Sets of Ties	0			
Multiplicity Factor	0			

Group Detail

Group	Count	Sum of Ranks	Average Rank	Z-Value	Median
Type I	28	1379.00	49.25	-0.2687	2938.42
Type II	72	3671.00	50.99	0.2687	2836.42

Means and Effects Section

Term	Count	Average	Standard Error	Effect
Type I	28	4990.29	1316	4896.26
Type II	72	4413.04	820.94	4319.00

Bonferroni (All-Pairwise) Multiple Comparison Test

Response: Total Cost

Term A: Type

Alpha=0.05 Error Term=S(A) DF=98 MSE=4.85E+07 Critical Value=1.98

Group	Count	Average
Type II	72	4413.04
Type I	28	4990.29

Notes:

This section presents the results of all paired comparisons among the means.

Since this procedure uses the Bonferroni inequality, it is not as accurate as the Tukey-Kramer's method.

Type I versus Type II diabetes mellitus

Analysis of Variance Report (ANOVA)

Response Total Cost

Tukey-Kramer Multiple-Comparison Test

Response: Total Cost

Alpha=0.05 Error Term=S(A) DF=98 MSE=4.85E+07 Critical Value=2.80

Group	Count	Average
Type II	72	4413.04
Type I	28	4990.29

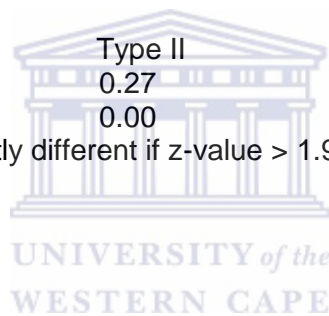
Notes:

This report provides multiple comparison tests for all pairwise differences between the means.

Kruskal-Wallis Multiple-Comparison Z-Value Test

Total Cost	Type I	Type II
Type I	0.00	0.27
Type II	0.27	0.00

Regular Test: Medians significantly different if z-value > 1.96



Annexure 3 Fields within Cost Template

Cost Template Fields	
Demographics Patient hospital identification number Gender Date of birth Type of diabetes mellitus Complications of diabetes mellitus Co-morbid conditions	Emergency room visits Date of emergency room visit Reason for emergency room visit (if available) Cost of laboratory tests, electrocardiogram and radiological procedures Total cost
Outpatient consultations Date of consultation Reason for consultation (if available) Cost of consultation	Hospitalisations Date of hospitalisation Length of stay (in days) Reason for hospitalisation (if available) Cost of laboratory tests, electrocardiogram and radiological procedures Total cost
Radiological procedures Date of procedure Type of procedure Cost of procedure	Medicines Date of dispensing Name of medicine Quantity and strength dispensed Cost of medicine Cost of dispensing
Electrocardiogram procedures Date of procedure Type of procedure Cost of procedure	Laboratory tests Date of test Type of test Cost of test