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The prevalence of impaired glucose tolerance and diabetes amongst the middle aged population of Bellville South Community, Cape Town, South Africa

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THE PREVALENCE OF IMPAIRED GLUCOSE TOLERANCE AND DIABETES AMONGST THE MIDDLE AGED POPULATION OF BELLVILLE SOUTH COMMUNITY, CAPE TOWN, SOUTH AFRICA

By:

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THESIS SUBMITED IN FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY OF PRIMARY HEALTH CARE IN THE FACULTY OF HEALTH AND WELLNESS SCIENCES AT THE CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

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DECLARATION

I, **David Jonah Soita** here by declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

7th   May   2009

Signed   **Date**

ABSTRACT

Numerous sources including the World Health Organization (WHO) and International Diabetes Federation (IDF) reported that a diabetes epidemic, with a parallel rise in obesity and insulin resistance is presently enveloping the world. Type 2 diabetes mellitus accounts for over 80% of all diabetics in most countries and has been recognized as a global epidemic, with its prevalence increasing at a rapid rate in both developed and developing countries. Up to 80% of type 2 diabetic cases can be preventable by changing diet, increasing physical activity and improving the living environment. The prevalence of diabetes in South Africa varies from one province to another and within different population groups. The highest rates have been reported among Asian Indians and the mixed ancestry populations, however, data is limited.

Urbanization and industrialization which come along with westernized lifestyles such as sedentarism, consumption of high fat diets consequently resulting into obesity are some of the factors implicated in the development of type 2 diabetes. With type 2 diabetes prevalence rate increasing at an alarming rate, both in industrialized and also in developing countries, every factor associated with the development of diabetes needs to be explored and addressed.

Before progression to diabetes, the diabetic state is preceded by a glucose regulation disorder commonly referred to as impaired glucose tolerance which may last for several years. Another form of glucose metabolism disorder other than diabetes is impaired fasting blood glucose level. While some cases of diabetes are often undiagnosed, it has also been noted that for every one diagnosed diabetic, there could be another that is undiagnosed. As has been shown in this study, many people could be walking with diabetes which is undiagnosed.

The aims of this study were to determine: The prevalence of impaired fasting glucose (IFG), impaired glucose tolerance (IGT), diabetes mellitus and the risk factors for developing diabetes amongst the 35 – 65 year old population of Bellville South, Cape Town South Africa.

In a cross-sectional survey, 600 subjects within the age group of 35-65 years selected through stratified random sampling within the Bellville South area of Cape Town

underwent an oral glucose tolerance test. Diabetes, IGT and IFG were determined using both the American Diabetes Association (ADA) and the revised WHO criteria. Subjects also underwent several anthropometric measurements. Personal demographic, family, health and lifestyle data were extrapolated by use of a questionnaire.

The prevalence of diabetes did vary between the two criterion used. The prevalence of newly diagnosed diabetes was 77 (12.8%) using the WHO criteria and 62 (10.3%) using the ADA criteria. Overall, the prevalence of diabetes was 25.6 % of which 12.8 % were newly diagnosed. IGT was present in 24 (4.0%) whilst IFG was in 179 (29.8%) using the WHO and ADA criterion respectively. Females were more affected than males and the prevalence of diabetes increased with age. Although overweight did not differ significantly between males and females, the latter were significantly more obese across all age groups ($p < 0.05$). Presence of a first degree relative with diabetes mellitus, particularly the father was significantly associated with development of diabetes, (odds ratio = 2.092, 95% CI 1.109 − 3.949, p = 0.023). Though more than 40% of the population studied was shown to engage in heavy drinking (30g of alcohol per day), it was not associated with diabetes.

There has been a 10.4% increase in the prevalence of diabetes in this population group compared to what was reported more than a decade ago. Of great concern is the number of individuals with undiagnosed diabetes.

ACKNOWLEDGEMENTS

DEDICATION

My heart felt appreciation go to my wife, Jane who sacrificed and braved through the hardship of looking after the family for the entire period of four years that I was away in Cape Town, South Africa. You are a great woman. For our kids Grace, Joel and baby Tim that recently joined the family. I appreciate your cooperation and thanks for being good children while daddy invested into studies at the expense of looking after you. We missed each other for a worthwhile cause. I also want to take this opportunity to express my gratitude to my parents, paternal and maternal relatives and friends. I do acknowledge and appreciate their role in contributing towards my up bringing and education. You laid the foundation on which my academic success rests.

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Glossary
The following definitions are obtained from the free medical dictionary

Anthropometric- It is the measurement of body size, weight and proportion.

Adipose tissue- These are special fat containing cells.

Adiponectin- A protein hormone produced by fat cells and is responsible for metabolism of lipids and glucose. It influences the body's response to insulin.

Alcohol- An intoxicating chemical substance formed by action of natural or added yeast on sugar grapes during fermentation. It is expressed as percentage of volume or weight.

BMI- Body Mass Index is a method used to measure whether a person is over weight or obese. It is calculated as weight (kg) divided by height (m) squared.

Cardiovascular- Pertaining to the Heart and blood vessels.

Coloured- A Race of mixed ancestry in South Africa.

Cholesterol- A fatty substance produced by the body and also taken in with food. Excessive amounts cause heart diseases.

Developing Countries- A nation where the average income is much lower compared to the highly industrialized and developed ones.

Dyslipidaemia- Abnormal blood fat levels.

Ethnic- A group of people sharing a common origin.

Fasting Glucose- A blood test done to determine the blood sugar level in a fasting state (not eaten for 8-12 hours).

Fat- Animal tissue containing glycerol and fatty acids.

Fat Diet- Are food products containing fatty acids. E.g. fried foods, meat pies, full cream milk, high fat butter and fatty meat products.

First degree relatives- This refers to the biological brothers and sisters of an individual.

Glucose- A simple sugar that is the body's main source of energy. When absorbed into the blood stream, it requires insulin so as to provide energy to the body cells.

Glycogenolysis- Biochemical process occurring in the liver and in muscle by which glycogen is broken down into glucose.

Gluconeogenesis- Biochemical process in which glucose is synthesized from non carbohydrate sources such as amino acids so as to meet the needs of the body during starvation. It occurs in the liver and kidneys.

HbA1c- The ratio of glycosylated haemoglobin in relation to the total hemoglobin in circulation.

Hyperglycemia- Excessive blood glucose concentrations, a sign that diabetes is not well controlled.

Hypertension- Raised blood pressure.

Hypoglycemia- Low blood sugar level often causing confusion, headache, muscle pains and other symptoms.

Impaired Glucose Tolerance- A condition associated with elevated blood sugar after a meal but not meeting the criteria for diabetes. It precedes the on set of diabetes.

Industrialized Countries- Countries of middle/high income. Also called developed countries such as USA, UK, Japan etc.

Insulin- A hormone secreted by the pancreas and helps to regulate carbohydrate metabolism.

Insulin resistance- A condition in which the body does not respond normally to the action of insulin.

Lipolysis- Process by which lipids particularly triglycerides in fat are broken down into fatty acids.

Metabolism- The physical and chemical processes by which substances are produced or broken down into energy or products for the uses of the body.

NIDDM- Type 2 Diabetes. type II diabetes: mild form of diabetes mellitus that develops gradually in adults; can be precipitated by genetic or environmental factors.

Obesity- A condition of being extremely over weight. It is defined by having BMI of over 30.

OGTT- Oral Glucose Tolerance Test- is a test of the body's ability to utilize carbohydrate. It is performed by giving a standard dose of glucose solution and measuring the blood for glucose after two hours.

Proteolysis- Process where by protein molecules obtained from the diet are broken down by digestive enzymes in the stomach and small intestines into amino acids which are then absorbed into the blood stream.

Urinalysis- A test that examines the content of urine in order to detect infection or its content.

Urban- An urban area refers to town or city and is characterized by dense population usually not less than 2000 people per kilometer.

Venous Blood- Blood obtained from the veins but not the pulmonary vein.

Euglycaemia- Normal blood glucose level. Also known as normoglycaemia.

List of abbreviations

ADA-   American Diabetes Association

CDC-   Centre for Disease Control

DM-   Diabetes Mellitus

IDDM-   Insulin Dependent Diabetes Mellitus

IFG-   Impaired fasting glucose

IGT-   Impaired glucose tolerance

WHO-   World Health Organization

NIDDM-   Non Insulin Dependent Diabetes Mellitus

OGTT-   Oral Glucose Tolerance Test

SES-   Social Economic Status

CHAPTER ONE
LITERATURE REVIEW

1.1 Introduction

Diabetes Mellitus (DM) is a chronic disease that occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces resulting in hyperglycemia. The two major types of diabetes are Type 1 or insulin dependent diabetes (IDDM) and type 2 or non-insulin dependent diabetes (NIDDM). These two terminologies are no longer in use Type 2 diabetes is the most common type accounting for more than 80% and is characterized by hyperglycaemia due to an individual's resistance to insulin with an insulin secretory defect (CDC, 2005; Bishop, Duben-Engelkirk & Fody, 2000:221).

The aetiology of Type 2 diabetes is a complex interaction between environmental and genetic factors. The major environmental factors include a high fat diet, obesity, physical inactivity and family history of diabetes, (Mahler & Adler, 1999). Various sources (Avramoglu, Basciano & Adeli, 2006; Yoon, Lee, Kim, Cho, Choi, Ko, Zimmet & Young, 2006) reported that a diabetes epidemic, with a parallel rise in obesity and insulin resistance is presently enveloping the world. The common presenting symptoms of diabetes mellitus include an excessive urge to eat (polyphagia), passing of large amounts of urine within short intervals (polyuria), poor vision and weight loss. However, in some individuals it is asymptomatic (Turner & Wass, 2002:348). There is increasing evidence that many people are living with undiagnosed diabetes which is a danger to their health. In some instances, the diagnoses is made when individuals develop complications or go into a coma (Hodgson & Cohen, 1999; Costa, Vizcaino, Pinol, Cabre & Fuentes, 2007).

The implication of late diagnosis of type 2 diabetes is that by the time the individual is diagnosed with diabetes, he has already developed complications which could have otherwise been avoided if diagnosed early. The complications of long-term diabetes mellitus include damage to the blood circulation (vascular) system, dysfunction and failure of various organs such as the kidneys, eyes, nerves and recurrent skin infection (Mundet, Pou, Piquer, Isabel, Sanmartin, Tarruella, Gimbert & Farrus, 2008).

Poor access to health care and lack of knowledge about the disease are the major attributing factors to undiagnosed diabetes. In remote communities where unemployment is high, individuals may find it unaffordable to travel to health care centers, besides having to pay for medication as may occur in places where user fees are applicable. Coupled with this could be the lack of affordable means of transport such as taxis, buses or trains. As a result, individuals seek medical attention at a late stage usually when they are gravely ill, by which time it is too late to reverse the damage caused (Ramaraj & Alpert, 2008).

1.2 Physiology of Normal Glucose Metabolism

Following a carbohydrate rich meal, carbohydrates are broken down to simple sugars such as glucose which is the primary source of energy for humans. The nervous system cannot store energy and depends entirely on extra-cellular glucose. Therefore it is vital to maintain plasma glucose at a narrow range. Within the first thirty minutes following a carbohydrate rich meal, the liver enzyme, glucokinase is activated by insulin and facilitates the conversion of glucose into a storable form of glucose known as glycogen (Beardsall, Yuen, Williams & Dunger, 2003). Glycogen is converted into glucose by the hormone glucagon when plasma glucose levels are diminished (Figure 1.1).
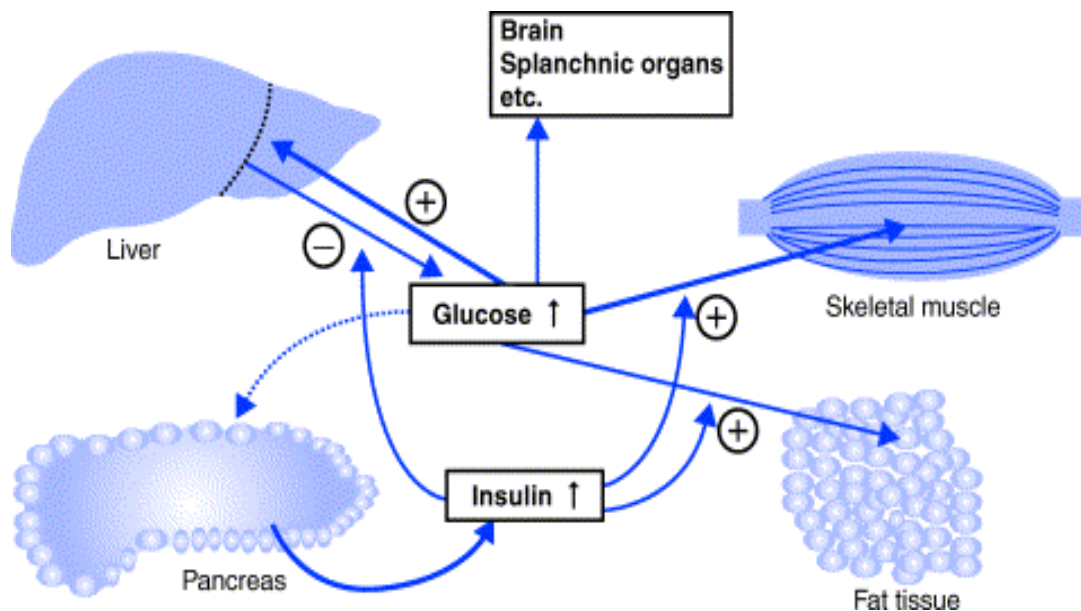
Figure 1.1: Path way of glucose utilization following a carbohydrate meal. (Adapted from, Zierath & Kawano, 2003).

When plasma glucose levels are increased again, they stimulate insulin secretion by the pancreas to facilitate its up take by the cells. The raised insulin levels lead to suppression of hepatic glucose production, and stimulate insulin-dependent glucose uptake into muscle and adipose tissue (Beardsall *et al.*, 2003).

1.2.1 The Plasma Glucose balance

Control of plasma glucose is influenced by two major hormones, insulin and glucagons, which allow the body to respond to demands as well as survive prolonged fasting. However, other hormones and neuroendocrine substances are also involved (Le Roith, Taylor & Olefsky, 2004:423). See, (Figure 1.2). The pancreas responds to increased plasma glucose levels by secreting insulin. The hormone insulin is a peptide hormone that is exclusively produced by pancreatic beta cells. Beta cells are located in the pancreas in clusters known as the islets of Langerhans. Insulin is the principal hormone that regulates uptake of glucose into most cells from the blood (primarily muscle and fat cells, unlike the central nervous system cells whose glucose up take is independent of insulin) (Le Roith *et al.*, 2004:425). Insulin is released in response to changes in blood glucose concentration. Insulin molecules circulate throughout the blood stream until they bind to their associated (insulin) receptors. The insulin receptors promote the uptake of glucose into various tissues that contain type 4 glucose transporters (GLUT4) (Holloszy, 2003:456; Harmel & Mathur, 2004:30). The initial binding of insulin to its receptor initiates a signal transduction cascade that communicates the message delivered by insulin, for example, "remove glucose from blood plasma" ,(Harmel *et al.*, 2004:31). Deficiency of insulin or the insensitivity of its receptors plays a central role in all forms of diabetes mellitus (Le Roith *et al.*, 2004:425).
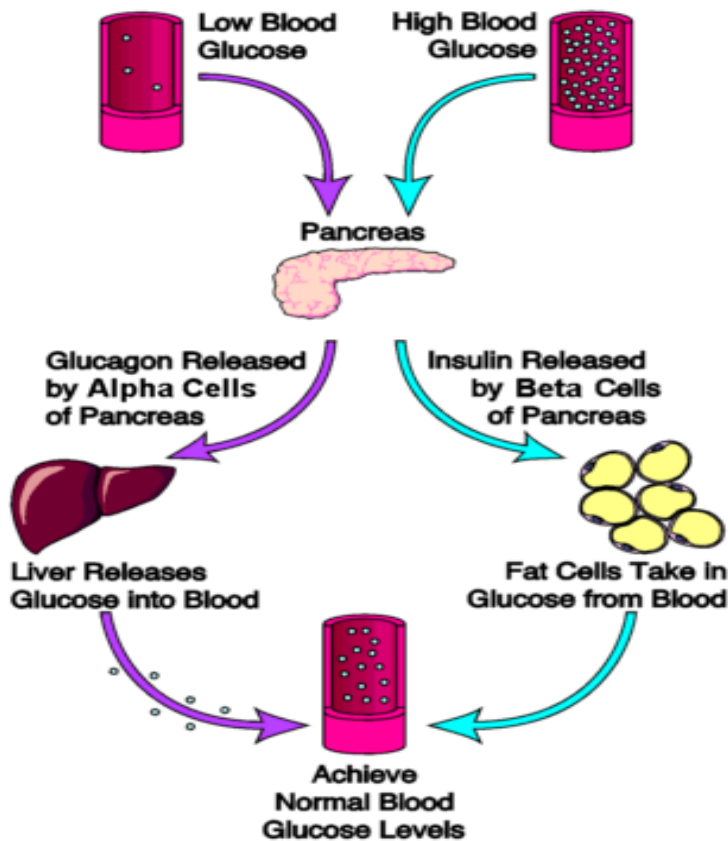
Figure 1.2: Normal glucose metabolisms by insulin and glucagon hormones. (Adapted from, Endocrine disorders and endocrine Surgery). (http://www.endocrineweb.com/insulin.html)

During the fasting state, plasma glucose levels are lowered and the hormone glucagon is responsible for increasing them to desirable levels by facilitating conversion of stored glucose into available glucose. This process is known as glycogenolysis (Braunwald, Fauci, Kasper, Hauser, Longo, & Jameson, 2001:2138). Glucagon is synthesized by the alpha-cell of Langerhans in the pancreas and is the primary hormone responsible for increasing glucose levels by either glycogenolysis or gluconeogenesis.

Figure 1.2. gluconeogenesis is a metabolic process that results in the generation of glucose from non-carbohydrate carbon substrates such as pyruvate, lactate, glycerol, and glucogenic amino acids. Gluconeogenesis takes place mainly in the liver and, to a smaller extent, in the cortex of kidneys (Le Roith *et al.*, 2004:423). This process normally occurs during periods of fasting, starvation, or intense exercise and also in insulin secretory and action deficient states such as diabetes (Basu, Chandramouli, Dicke, Landau & Rizza, 2005). Gluconeogenesis is associated with ketosis which is why it is

common in type 1 diabetes. Similarly, the hormone glucagon stimulates the process of glycogenolysis. Glycogenolysis transpires in the muscle and liver tissue, where glycogen is stored, and occurs as a result of hormonal response to glucagon. Glucagon is a pancreatic peptide triggered by low blood glucose concentrations and is produced in the Alpha cells of the Islets of Langerhans (Braunwald *et al.*, 2004:2116). Proteolysis and lipolysis are processes through which proteins and fat cells are broken down to provide fuel for the body. Like the rest of the above processes, lipolysis and proteolysis occur during starvation but also in insulin action defective states such as diabetes, (Braunwald *et al.*, 2001:2116). Lipolysis is associated with increased circulating ketone bodies (ketosis).

Besides enabling glucose utilization, insulin also inhibits glycogenolysis, gluconeogenesis, lipolysis and proteolysis. The above processes result in increased circulating blood glucose and free fatty acids. These processes are inhibited by the continuous insulin secretion which is believed to occur at certain regular intervals referred to as basal secretion. Continuous secretion of insulin is also believed to maintain the insulin receptor sensitivity (Braunwald *et al.*, 2001:2139).

1.2.2 Insulin insensitivity/resistance and its mechanisms

Insulin action is initiated by the binding of insulin molecules to its specific cell surface receptor know as insulin receptor substrates (IRS), and further involves numerous intracellular processes so as to cause a response (Braunwald *et al.*, 2001:2112). As discussed above, the role of insulin in glucose metabolism is to facilitate its utilization by the target cells or tissues of the body. Insulin resistance is described as the inability of insulin to promote adequate glucose utilization by the target tissues or the impaired ability of insulin to control hepatic glucose production and to enhance glucose clearance in target tissues (Le Roith *et al.*, 2004:422). It is characterized by an insensitivity of the peripheral tissue, for example, muscle, liver, adipose tissue to the effects of insulin. This leads to the impairment of other biological actions of insulin, including its effect on lipid and protein metabolism, vascular endothelial function as well as gene expression (Luana, Isa, Fisberg, & Martini, 2008). Such impairment can result in a reduced rate of glucose uptake into fat and skeletal muscle, and instead increase the release of glucose from the liver and of free fatty acids from fat (Matfin, 2008). Consequently, the cellular demand for insulin increases as cells become more insulin resistant. The body can overcome this

demand by secreting more insulin from the pancreatic beta cells and by reducing hepatic clearance of insulin resulting in 'hyperinsulinaemia'. This increased demand on the beta cells may lead to progressive loss of beta cell function, secondary to exhaustion of their secretory capacity. This combination of insulin resistance and beta cell dysfunction leads to a state of hyperglycemia and eventually type 2 diabetes mellitus, (Stumvoll, Goldstein & Haeften, 2005).

1.3 Diabetes Mellitus

1.3.1. Classification of Diabetes

Although all the described forms of diabetes mellitus are characterized by hyperglycaemia, the mechanism by which they develop differs. For example, while some forms are due to absolute lack or secondary to genetic defect of pancreatic beta cells, others may result from insulin resistance. It is in this context that the classification of diabetes has been based. Two main clinical types of diabetes have been identified, viz type1 and type 2 diabetes mellitus. Type 1 Diabetes Mellitus sometimes known as Juvenile Diabetes Mellitus or Insulin Dependent Diabetes Mellitus (IDDM) commonly occurs amongst children. The term juvenile is thought to be misleading since about 50% of type 1 diabetics are diagnosed after the age of 20 years. Kunnamo, (2005:716) also adds that in 10-15 % of type 1 diabetics, the illness appears at a later stage. Type 1 diabetes generaly accounts for about 5% of total diabetics. The other form of diabetes is type 2 Diabetes Mellitus also known as Non Insulin Diabetes Mellitus (NIDDM) which normally occurs during adulthood. It accounts for more than 80% of the diabetics (ADA, 2004). Although type 2 diabetes has been associated with adult onset, various studies have shown that the age of onset for type 2 diabetes is reducing (Song, and Hardisty, 2007; Kreiera, Kalsbeek, Sauerwein, Fliers, Romijn & Buijs, 2007). The reduction in the age of onset of type 2 diabetes is due to the increased incidence of childhood obesity (Alberti, Zimmet, Shaw, Bloomgarden, Kaufman & Silink, 2004). Classification of diabetes based on Insulin dependency e.g. IDDM or NIDDM has been controversial. For instance some authors argue that it is not correct to classify an individual as NIDDM yet he/she is on insulin therapy to control the blood glucose levels (Mayfield, 1998).

1.3.2 Type 1 Diabetes Mellitus

In type 1 diabetes mellitus, there is complete lack of insulin secretion and it is thought to result from autoimmune destruction of the pancreatic beta cells (Harrison, Honeyman,

Morahan, Wentworth, Elkassaby, Colman & Fourlanos, 2008). It is not clear what is responsible for this autoimmune destruction, but associations have been made with viral infections which result in the body's immune system attacking and destroying the beta cells of the pancreas. A genetic defect in which the pancreatic beta cells do not secrete adequate or completely no insulin has also been suggested (Knip and Siljander, 2008). This theory is further supported by Fakhfakh, Hadouk, Hamida, Kamoun, Ayed, Hachicha & Masmoudi, (2008), where 78% of eighty six children recruited into their study tested positive for pancreatic auto antibodies. Harrison *et al.*, (2008) is of the view that although genetic factors are responsible for type 1 diabetes, exposure to environmental factors such as infections, composition and amount of food intake partly account for the development of type 1 diabetes. Harrison *et al.*, (2008), further argues that the present change in environments predisposes children to autoimmune reactions more than was observed previously in terms of diet, exercise, infectious diseases, pharmaceutical product consumption, and insufficient exposure to vitamin-D. Regardless of the cause, the result is insufficient or lack of insulin secretion leading to episodes of hyperglycaemia. Type 1 diabetes mellitus is found mainly in younger individuals, under the age of 30 (Harmel & Mathur, 2004:12).

Generally, type 1 DM account for only 5-10% of the total diabetic patients (CDC, 2005). Type 1 diabetics are prone to metabolic emergencies such as diabetic ketoacidosis (DKA). This is a life threatening metabolic state in which the body fails to adequately regulate ketone production due to lack of circulating insulin. This causes a severe accumulation of keto acids which lower the pH of blood hence acidifying it. A pH below 6.7 is believed to be incompatible with life, (Souhami & Moxham, 1994:764). Although ketoacidosis occurs mainly in type 1 diabetic, type 2 diabetics requiring insulin therapy for diabetic control can also develop DKA.

1.3.3 Type 2 Diabetes Mellitus

Type 2 diabetes mellitus is characterized by hyperglycemia due to resistance to insulin. This resistance results in a relative, but not an absolute insulin deficiency. It constitutes the majority (~ 95%) of the diabetes cases (CDC, 2005). However, the ADA, (2004) reports this classification of diabetes to account for 80%. The disorder is preceded by Impaired Fasting Glucose (IFG) and Impaired Glucose Tolerance (IGT) (Nichols, Hillier & Brown, 2007). Impaired Glucose Tolerance, also called pre-diabetes is defined by WHO

(1999) as being a stage in the natural history of disordered carbohydrate metabolism. Doyle, Purnami, Koduah, Jagdeep, Mazen & King (2007) also state that IGT is an intermediate state between normal glucose homeostasis and diabetes. IGT is determined by subjecting an individual to a standard amount of glucose solution. Blood is then drawn after 2 hours to measure the glucose values which are normally raised but not high enough for diabetic diagnosis. On the other hand, IFG occurs in fasting states following a fasting glucose measurement where the individual's blood glucose levels are raised, but not enough to be classified as diabetic. Basing on the ADA criteria, the diagnostic values for IFG are 5.6mmol/L (Romero & Moran, 2006). The criteria for diagnosing IGT as suggested by the WHO, 1999 is ≥ 7.0 mmol/L and < 11.0mmol/L following an oral glucose tolerance test. Whilst IFG and IGT can lead to full blown diabetes, early intervention strategies such as change in dietary habits and physical activity can reverse this process (Franz, 2001).

1.3.4 Other types of diabetes are Gestational Diabetes mellitus (GDM) and Maturity Onset Diabetes of the Young (MODY)

The other types of diabetes are gestational and Maturity Onset Diabetes of the Young (MODY). Gestational diabetes mellitus (GDM) is diabetes occurring during pregnancy in mothers who have previously not been diabetic. The prevalence of gestational diabetes mellitus (GDM) varies in direct proportion with the prevalence of type 2 diabetes in a given population or ethnic group and is said to occur in 1-3% of the total pregnancies, (Dabelea, Snell-Bergeon, Hartsfield, Bischoff, Hamman & McDuffie, 2005). The incidence of GDM seems to vary with ethnicity and has been found to be higher in Asian women compared to the black and Filipino women (Nahum and Huffaker, 1993). Although the cause of GDM is said to be due to the diabetogenic effect of the pregnancy hormones such as placental lactogen, oestrogen and cortisal, whose effect counteracts that of insulin, there is also an association between gestational GDM and obesity (Chu, Callaghan, Kim, Lau, England & Dietz, 2007). The risk of developing hyperglycaemia decreases as delivery approaches. Although this may not significantly affect the mother immediately, she stands a risk of developing diabetes later in life, (Diabetes and Metabolic Syndrome review, 2008). On the other hand, the foetus is also at risk of developing macrosomia and obesity during growth (Clinical Research Reviews, 2008). It is crucial to carefully screen all mothers during the antenatal period as early detection

and adequate glycaemic control improve the outcome of the pregnancy (Abourawi, 2006).

Maturity onset diabetes of the Young (MODY) is a much rarer form of diabetes that accounts for about 2% of type 2 diabetics, (Hwang, Shin, Yang, Jung & Hu, 2006). MODY affects individuals less than 25 years of age and has a tendency to run in families, suggesting that it is a genetic disorder. Individuals with MODY do not need insulin for survival since their pancreas is able to secrete some insulin, although not in adequate amounts. This differitiates it different from type 1 and type 2 where in the former there an absolute lack of insulin secretion while in the latter there is insulin secretion but unable to act due to insulin resistance.

1.4 Epidemiology of Diabetes

The international Diabetes Federation (IDF) states that 246 million people were classified with Diabetes Mellitus in 2007 (International Diabetes Federation Atlas, 2007). It is further estimated that there will be 325 million diabetics by the year 2025, and 366 million by the year 2030, (WHO, 2007; Wild, Roglic, Green, Sicree & King, 2004). Figures 1.3 shows the prevalence of diabetes and the predicted prevalence by 2030. The most affected will be the low to middle income countries, (World Diabetes Foundation, 2007). The rising rates have been attributed to the global obesity epidemic, (Colagiuri, Yach & Pramming, 2006). It is important to note that Africa as a continent has not been spared this escalating trend in the diabetes epidemic. Studies carried out in Africa suggest that prevalence rates vary with different population groups. In Sub-Saharan Africa, population based epidemiological studies conducted from 1985 to 1999 showed higher rates for South Africa (7.7%) followed by Cameroon (1.4%) and Tanzania with 1.1%. Since these studies were conducted about a decade ago, assumptions are that the prevalence rates may have increased.
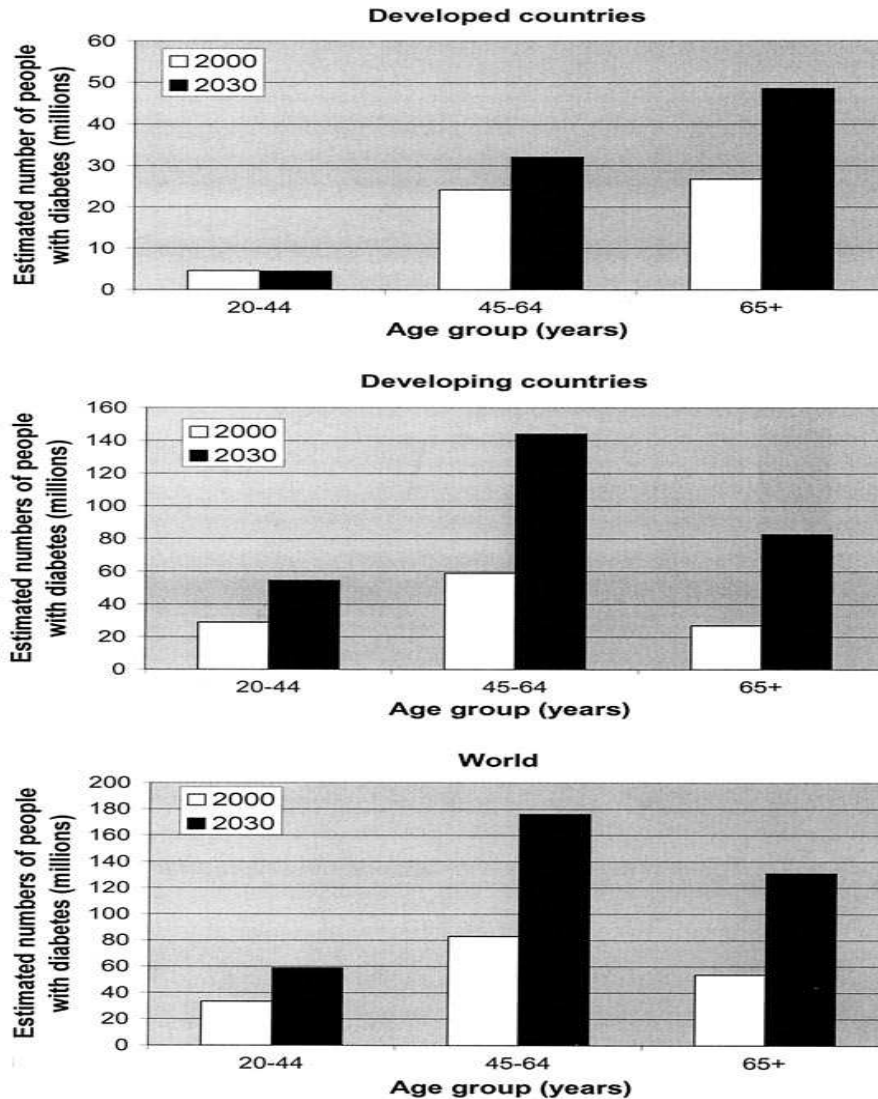
Figure 1.3: Global 2030 estimates of Diabetes. (Adapted from, Wild *et al*., 2004)

1.4.1 Diabetes in South Africa

The prevalence of diabetes in South Africa varies from province to province and within different population groups. This variation is not an uncommon phenomenon as such variations have been described by many researchers amongst various population groups of the world (Schulz, Bennet, Ravussin, Kidd, Kidd, Esparza & Mauro, 2006; Ramachandran, Snehalatha, Latha, Vijay, & Viswanathan, 1997). Following a study on the chronic diseases of lifestyle in South Africa, the prevalence of diabetes was found to be highest among the Asian Indian community with 8.5% and 11.5% for men and women respectively, (Goedecke, Jennings & Lambert, 2005). This was followed by the

coloured community whose prevalence was 3.1% and 5.8% for men and women respectively (South African Demographic and Household Survey, Medical Research Council Technical Report, 2005:110) SeeTable 1.1. The prevalence was also observed to be higher among the urban population compared to the rural population. The prevalence also varied according to provinces where the highest rate was amongst the Kwazulu Natal women while it was lowest amongst the North West and Limpopo men. The Mamre study conducted by Levitt, Steyn, Lambert, Reagon, Lombard, Fourie, Rossouw & Hoffmann (1999) in a mixed ancestry (coloured) community in the Western Cape region of South Africa have indicated a prevalence of 10.8%. In another study, Levitt, Katzellenbogen, Bradshaw, Hoffman & Bonnici, (1993) reported a prevalence rate 8.0% amongst black Africans.

A separate study conducted by Charlton, Levitt and Lombard (1997) amongst elderly coloured South Africans in Cape Town found a prevalence of 28.7%. However, this high prevalence can be justified on the basis of age since the survey focused on subjects aged 65 or older.

Table 1.1 The prevalence of diabetes amongst males and females in the different provinces of South Africa (Adapted from SAHDS, 2005)

Province	Women	Men
Western Cape	4.9%	3.2%
Eastern Cape	3.5%	2.7%
Northern Cape	2.9%	2.1%
Free State	2.3%	1.3%
KwaZulu-Natal	5.9%	3.1%
North West	1.1%	0.9%
Gauteng	4.3%	3.3%
Mpumalanga	2.8%	2.0%
Limpopo	1.2%	0.9%

1.4.2 Ethnic and racial variations in diabetes prevalence in the United States of America (USA)

The prevalence of diabetes varies considerably amongst population and ethnic groups reflecting both environmental influences and genetic susceptibility. For example, a high prevalence of diabetes has been reported amongst the Pima Indians. The Pima Indians who reside in the Arizona desert of North America are reported to have the worlds' highest prevalence of type 2 diabetes (Schulz *et al*., 2006). The Pima Indians in Arizona belong to the same linguistic group as the Mexican Indian counter parts who live in a remote part of central America. To elucidate the impact of environmental influence on type 2 diabetes, a comparative study was carried out to determine the prevalence amongst the two groups. The prevalence amongst Mexican Pima Indians was found to be lower (Schulz *et al*., 2006; Ramachandran *et al*., 1997). Although it is not very clear why ethnic disparities occur in type 2 diabetes prevalence, it has been suggested that genetic and dietary factors do play a role, since diabetes tends to run in families. Another theory is based on the urbanization principle where ethnic groups of people living in urbanized areas feed on a diet rich in fat yet exercise less in contrast to the rural populations whose dietary lifestyle is basically high fibre with greater involvement in labour intensive activities. However, it is important to note that urbanization is independently associated with factors that promote development of diabetes regardless of ethnicity. This is because urbanization brings with it factors that promote obesity such as physical inactivity and consumption of high fat diet. This evidence is provided by Schulze, *et al*. (2006) who found a lower level of obesity and diabetes prevalence amongst Pima Indians in Mexico who live in a more traditional rural environment than that of the U.S. Pima population living in a Westernized environment yet the two communities share a similar genetic background.

1.4.2.1 Ethnic and racial variations in South Africa

In South Africa, population based studies have reported varying rates amongst different racial groups. For example a study by Erasmus, Blanco, Okesina, Arana, Gqweta & Matsha (2001a) amongst the black population in Umthatha region of the Eastern Cape, found a prevalence of 2.4 for diabetes and 2.7 for IGT while the Mamre study by Levitt *et al*., (1999), amongst the coloured (mixed ancestry) population found a DM prevalence rate of 10.8%.

A prospective study carried out on the Indian population in Natal revealed a 9.8% prevalence of type 2 diabetes. (Motala, Pirie, Gous, Amod & Omar, 2003). Similarly, Hertz, Unger and Carlos (2006) reported that type 2 Diabetes was more prevalent among Mexican whites at 11.2% compared to the Hispanics with 7.4%. The authors attributed these differences to the health care and awareness inequalities to which the Mexican whites have less access (Hertz *et al.,* 2006). Population disparities in diabetic prevalence have also been associated with environmental factors and westernization of life style. Nicola and Manisha (2003); Zaini, (2000), provide epidemiological evidence to support this by quoting different ethnic studies on diabetes. Many ethnic groups that migrated and settled in USA exhibit high prevalence of type 2 diabetes compared to the indigenous groups from their places of origin. According to a study conducted by Laina and Richard (1999), African-Americans have one of the highest prevalence rates of type 2 diabetes in the USA. Araneta, Mouton, Lina, Grandinetti, Lim, Healani, Barretti, Rodriguez and Wingard (2006), reported that obesity and type 2 diabetes were most prevalent amongst immigrant females of Asian, Filipinos, Japanese and Hawaiian origin living in USA and UK.

1.4.3 Age attributes to IGT and diabetes prevalence

Historically, it was thought that type 2 diabetes develops only during adulthood. However there is increasing evidence that type 2 diabetes is being diagnosed at an earlier age as individuals between 5-15 years of age are being diagnosed with type 2 diabetes (Betsy, Desmond, Cheng, Cowie, Gregg, Geiss, Engelgau, Narayan & Imperatore, 2005; Pavkov, Hanson, Knowler, Bennett, Krakoff & Nelson, 2007). Betsy *et al.*, (2005), also found that about 7.1 % American youths of mean age 15.3 years exhibited IGT and diabetes mellitus and of these, the highest prevalence was amongst the Mexican American youths. In a separate study, (Kreiera *et al.*, 2007; Alberti *et al.*, 2004), also reported an increasing number of adolescent subjects developing type 2 diabetes.

1.5 Aetiology of Diabetes Mellitus.

Diabetes is a result of genetic predisposition and an inter play of environmental factors. For example Adeghate, Schattner and Dunn (2006) argues that although an individual has a genetic predisposition to type 2 diabetes, genetic factors may have to be modified by environmental factors for diabetes mellitus to become overt. The environmental factors thought to lead to the development of type 2 diabetes mellitus include physical

inactivity, obesity, drug toxicity, infections and location (Misra & Ganda, 2006; Sano, Terasaki, Tsutsumi, Imagawa & Hanafusa, 2008). See figure 1.4. In rare cases, benign and malignant tumors of the endocrine glands such as insulinomas and glucagonomas can cause increased plasma glucose levels.
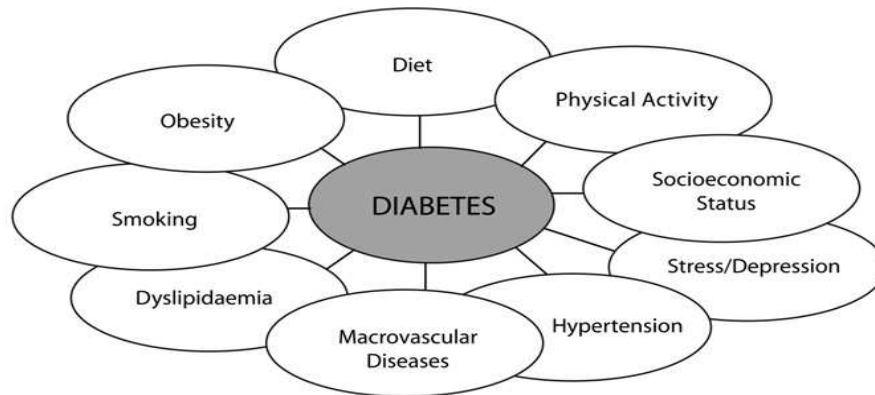
Figure 1.4: The risk factors for the development of type 2 diabetes mellittus. (Adapted from Colagiuri, *et al.*, 2006)

1.5.1 Diet and obesity

Diet is a crucial environmental factor in the development of obesity. Obesity is a condition in which there is accumulation of excess body fat to an extent that health may be adversely affected, (WHO). According to the WHO classification of body weight, an individual whose body mass index (BMI) exceeds 30kg/m^2 is considered obese, (WHO, 2003). Central abdominal obesity in particular (See figure 1.5) is stated to be the major cause of insulin resistance (Aboul-Seoud 1 & Aboul-Seoud 2, 2001) and has been implicated as a risk factor for type 2 diabetes (Mansour & Meelad, 2007; Jain & Saraf, 2008). It has also been observed that obese subjects with normal glucose tolerance have higher rates of progression to diabetes mellitus than non-obese subjects (Gary, Juliana, Chun-Chung, Yeung, Wing-Bunchan & Clive, 2004). Consumption of excessive amounts of refined sugars such as those found in sweetened juices and processed carbohydrates as well as consumption of high fat diet and alcohol have all been associated with numerous adverse effects that promote abnormalities in the glucose/Insulin system (Meira, 1998). Similar findings have also been noted by Wissow, (2006), who states that a high fat diet is likely to predispose to glucose intolerance.

Globally, it is estimated that there are currently about 300 million adults who are classified as obese. In South Africa, more than 29% men and 56% women are classified as obese, (Goedecke *et al.*, 2005). Over eating in combination with low physical activity is the main cause for the obesity epidemic rapidly spreading in the modern world (Loktionov, 2003). The high rates of obesity in South Africans reflect the effect of industrialization which is the primary driving force. There is a replacement of traditional diets with diets which are rich in animal fats and low in complex carbohydrates. Steyn, Kazenellenbogen, Lombard & Bourne (1997), reported that people who spent most of their lives in the urbanized environment tended to have an unhealthier lifestyle compared to their counter parts living in rural settings. From an African traditional perspective, being overweight is a sign of well-being and happiness whereas being underweight can be equated with being HIV positive (Puoane, Fourie, Shapiro, Rosling, Tshaka & Oelefse, 2005).

Figure 1.5: Central abdominal obesity, a risk factor for insulin resistance and type 2 diabetes. (Adapted from, Diabetes Voice, 2003)

Certain diets are also linked to the low prevalence of diabetes in some communities. For example the Raica community of north western Rajasthan in India, has an almost zero prevalence of diabetes, (Agrawal, 2006). This is attributed to high consumption of camel milk, though the protective effects are not known (Agrawal, Budania, Sharma, Gupta, Kochar, Panwar & Sahani, 2006). Other lifestyle factors such as increased physical activity due to the mobility of this population could partially explain the rates observed.

1.5.2 Physical Activity

There is a strong link between the development of type 2 diabetes and physical activity levels of an individual. Overweight, but especially central obesity, as well as physical inactivity, have been found to be a powerful predictor for development of type 2 diabetes. Wandell, De Faire and Hellenius (2006) state that about 90% of type 2 diabetic cases can be prevented if one adopts a prudent diet, avoidance of overweight and obesity, engagement in moderate to vigorous physical activity, non-smoking and moderate alcohol consumption. Only 30 minutes of physical exercise daily is required to prevent or delay the onset of type 2 diabetes (Franz, 2001). Physical exercise stimulates muscle uptake of circulating glucose and also promotes weight loss particularly in overweight individuals. A study carried out in Cape Town, South Africa found that 30-40% of adults are physically inactive (Lambert, Steyn, Kolbe, Bohlmann & Puoane, 2001).

Social affluence can be viewed as a double edged sword. While on one hand life is made more convenient than ever because of the advances in technology, on the other hand, the incidence of type 2 diabetes is increasing at an alarming rate due to social affluence. Television viewing and modern transport are the current technologies thought to be encouraging the lack of physical activity. Urban dwellers expend less energy because of the available means of transport as well as their respective occupations. Most individuals prefer to use lifts and escalators to move from office or to the different departments at their work places with most of the other time being spent working on computers (Myron, 2001). These habits promote physical inactivity. On the other hand, rural populations are involved in manual activities which result in high energy expenditure. This reduces obesity which otherwise would have resulted in insulin resistance and subsequently type 2 diabetes mellitus. Myron, (2001) reports that in the USA, an individual spends up to 29 hours per week watching television which is more

associated with weight gain than any other sedentary lifestyles such as driving, sewing and playing board games. He further states that television viewing is associated with a parallel intake of high energy rich calorie diets.

1.5.3 Cigarette Smoking

Apart from being a risk factor for lung, cancer tobacco consumption has been identified as one of the leading risk factors associated with cardiovascular disease and glucose metabolism disorders (Berlin, 2008; Bjorn, 2003). Following a study by Beziaud, Halimi, Lecomte, Vol and Tichet (2004), it was reported that current and past smokers stand a greater risk of developing type 2 diabetes. Furthermore, cigarette smoking is also a major risk factor for vascular complications amongst diabetics (Houston, Sharina, Pletcher, Kiang, Iribarren & Kief, 2006). Tobacco smoking affects both smokers and non smokers. Results from a ten year cohort study carried out by Barclay and Vega (2006) reported an equal risk of developing glucose intolerance in passive and active smokers. It is estimated that 4.9 million people die each year due to tobacco related diseases. Audera and Vera (2005), argue that this number is likely to double if the current tobacco consumption trends continue. Tobacco is consumed by people of all socio-economic status. However, it is thought that globally the largest number of smokers live in middle or low income countries (Pampel, 2008; Prabhat, Ranson, Nguyen & Yatch, 2002; Stenstrom & Anderson, 2000). Tobacco consumption prevalence varies from nation to nation. A study by Pampel (2008) revealed that cigarette smoking prevalence ranges between 8.0% in Nigeria to 27% in Madagascar. In South Africa, of whom Bellville South community is part of, the prevalence of tobacco consumption is 27% (Wallbeek, 2002) and is thought to account for 8% of adult deaths (Sitas, Urban, Bradshaw, Bah & Peto, 2004). The prevalence of cigarette smoking is thought to have decreased due to the introduction of tobacco legislation.

1.5.4 Alcohol Consumption

It is estimated that 2 billion people globally consume alcohol as a social drink annually. The WHO global report on alcohol estimates that 3.2% of the world's total deaths annually are attributed to alcohol consumption (WHO, 1999). While moderate alcohol consumption has been shown to be healthy, in terms of reducing the risk of diabetes onset and also in preventing other cardiovascular diseases, there are conflicting reports that link excessive alcohol consumption to glucose intolerance (Young-Lee, 2005).

Consumption of small quantities of alcohol can be beneficial with respect to delayed onset or prevention of type 2 diabetes, while consumption of excessive quantities can potentially predispose an individual to IGT or type 2 diabetes. Henk (2007) observed that individuals who consumed less than 48g of alcohol had a low risk of developing diabetes while, Wandell *et al.*, (2006); Mackenzie, Blair and Gerry (2005), reported that consumption of more than four drinks (48g) a day was associated with a high risk of developing type 2 diabetes. Although epidemiological studies have substantial evidence regarding the association between alcohol and cardiovascular diseases as well as its protective effects, the possible mechanism through which its consumption can both be beneficial and harmful regarding glucose metabolism is not clearly understood. However, Henk (2007) suggests that increased insulin sensitivity resulting from modulation of endocrine functioning of tissues as well as increased plasma adiponectin levels are responsible for the positive effects of alcohol in preventing diabetes. On the other hand, inflammation of adipose tissue which is highly associated with excessive alcohol consumption results in insulin resistance which is likely to predispose one to type 2 diabetes. Although Klatsky (2007) also provides evidence on the negative effects of alcohol consumption, he attempts to give an explanation of the protective effects of light alcohol consumption (less than three drinks). According to Klatsky, (2007), the protective effects of alcohol consumption are via reduction in blood lipid levels such as the low density lipoproteins (LDL) which are also referred to as harmful cholesterol. This is mediated by the increase in high density lipoproteins (HDL) levels also referred to as good cholesterol which is thought to have a cardiovascular protective effect. Other mechanisms as suggested by Klatsky (2007), are through its antithrombotic effects. Of all the alcoholic drinks, red wine offers the most protective effect in comparison to liquors and beer (Klatsky, 2007).

A study carried out in Nigeria by Nyenwe, Odia, Ihekwaba, Ojule and Babatunde (2003) reported a positive association between alcohol consumption and type 2 diabetes. In their study, consumption of more than 21 units (more than five 750ml bottles of alcohol) per week was associated with diabetes. In the South African context, 21 units of alcohol is equivalent to consumption of an average of 750ml beer with 4.0% alcohol content per day for one week. Apart from predisposing one to glucose intolerance, excessive alcohol consumption has also been linked to other health effects such as liver damage, pancreatitis, physical injuries, social and psychological effects and fetal alcohol

syndrome (FAS) which manifests in the new born of an alcoholic mother. Blackhurst and Marais (2005), state that South Africa has the highest number of foetal alcohol syndrome born babies, with the highest prevalence occurring in the Western Cape Province due to heavy alcohol consumption by the mother.

Although alcohol may be consumed at any time of the week, there is evidence that most drinking sprees occur over the weekends when people engage in what is referred to as "Binge Drinking" (Rotaemane, S. & Rotaemane, L., 2006). Binge drinking is defined as having five or more alcoholic drinks on one occasion. This form of risky alcohol consumption is not only practiced by adults but also by teenagers some of whom are underage. The WHO, (2004) global status report on alcohol, noted that high school learners from Cape Town had been involved in binge drinking. Binge drinking is not only a risk factor for IGT and liver diseases but also culminates in unwanted social behaviors such as domestic violence, perpetuation of crime, unsafe sex, absenteeism from work and road accidents, (WHO, 2004).

1.5.5 Genetic Factors

The association between family history and development of diabetes is indicative of a genetic role in the disease. Many studies have provided evidence that glucose intolerance and diabetes can occur in members of the same family (Ramachandran, Snehalatha & Vijay, 2002). It is mainly found within the first degree relatives such as children and their respective biological parents. A positive link between diabetes and second degree relatives such as grandparents has also been observed (Ramachandran *et al., 2002*). The association between diabetes and family history in African diabetics from South Africa has also been reported by Erasmus *et al.* (2001b). Out of 1,111 type 2 diabetic patients identified, 27% reported at least one diabetic family member. Of the subjects with a family history of diabetes, 87.8% had a first degree relative with diabetes. Diabetes also occurred in 10.5% and 5.9% of the second and third degree relatives of these patients. Various studies carried out to evaluate the role of genes in the development of type 2 diabetes have shown a positive association. For instance, Ohshiro, Ueda, Nishi, Ishigame, Wakasaki, Kawashima, Furuta, Sasaki, Sanke, Takasu and Nanjo (2000); Stephens, Hurel, Lowe, Rumley and Humphries (2006); Yanchun, Yang, Jin, Sun, Feng, Tang, Zhang, Zhu, Shi, Sun, Wange and Wanga (2008) report that genes have a role in the development of diabetes. In particular, IL-6(interleukin-6)

and the LEPR (leptin receptor) 25CAG allele genes have a role in the development of obesity which is a known risk factor for type 2 diabetes (Yanchun, 2008).

1.6 Diagnosis of Diabetes Mellitus

In most cases, an individual with diabetes will present with characteristic clinical symptoms such as polyuria (frequent desire and urge to pass large volumes of urine), polyphagia, (desire to eat frequently), polydipsia, (desire to drink large amounts of water) and loss of weight. For diagnosis these symptoms are not sufficient as they are not specific for diabetes. Diabetes mellitus is diagnosed by measuring circulating blood glucose levels. The diagnostic values have been developed by the American Diabetes Association (ADA)(2004) and WHO (1999). Though these two bodies have harmonized their diagnostic criteria, WHO (1999) further states that the diagnosis of diabetes in an asymptomatic subject should never be made on the basis of a single abnormal blood glucose value. For the asymptomatic person, at least one additional plasma/blood glucose test result with a value in the diabetic range is essential, either fasting, from a random (casual) sample, or from the oral glucose tolerance test (OGTT).

Laboratory examination of blood serves as confirmatory test for individuals with diabetes. Usually in clinical settings, a patient will not be subjected to OGTT but instead have fasting blood samples analysed for diabetes. The diagnostic values for diabetes by both the ADA and the WHO using the fasting blood specimen are ≥ 7.0mmol/L. Where an OGTT is performed, as is the case with WHO (1999) diabetes is diagnosed if the 2 hour values are ≥ 11.1mmol/L. The criteria for IFG, IGT and diabetes are summarized in table 1.2 below, (WHO, 1999).

Table 1.2: The ADA and WHO diagnostic criteria for diabetes. (Adapted from WHO, 1999)

	ADA	WHO
Diabetes	Fasting plasma glucose ≥ 7.0 mmol/L	Fasting plasma glucose ≥ 7.0 mmol/L **and /or** 2 hr post glucose load ≥ 11.1 mmol/L or both
IGT	Not Applicable	Fasting plasma glucose < 7.0 mmol/L **and** 2 hr post glucose load ≥7.8 and <11.1 mmol/L
IFG	Fasting plasma glucose ≥ 5.6 mmol/L	Fasting ≥ 6.1 mmol/dl **and/ or** (If measured) 2 hr post glucose load <7.8mmol/L

1.6.1 Oral Glucose Tolerance Test (OGTT)

Oral Glucose Tolerance Test is a test performed on an individual in order to determine how quickly glucose is cleared from the blood. In this test, the body is challenged with a standard glucose load over a period of two hours. This test has been used widely and is believed to provide more reliable results in terms of diabetes diagnosis. This is also a preferred test of choice in determining diabetes prevalence within communities (WHO, 1999). In this test, subjects are asked to fast for 10-14 hours preferably during the night. After the over night fast, a solution of glucose equivalent to 75 grams is given orally. Prior to the administration of the glucose solution, a venous blood sample is taken. After 120 minutes, another venous blood is drawn. This means that blood is drawn at time 0 and 120 minutes. Glucose values are then read from the two samples to provide fasting and 2 hour post glucose challenge results. Normal fasting blood glucose values range from between 4.0 to 5.5mmol/L. Fasting levels of ≥6.1 to <7.0 mmol/L are suggestive of Impaired Fasting Glucose while a diagnosis of diabetes is made if these values are over 7.0mmol/L. Post glucose challenge blood glucose levels over or equal to 11.1 mmol/L are diagnostic for diabetes, while values of between 7.8 and 11.0 are indicative of impaired glucose tolerance.

1.7 Complications of Diabetes Mellitus

As a result of long standing uncontrolled high plasma glucose levels, diabetes leaves numerous structural changes in the body. This is worsened by the co-existence of other cardiovascular risk factors such as hypertension, dyslipidaemia, obesity and smoking (Mundet *et al.,* 2008). The damage is not only confined to blood vessels but also to other organs. Some of the target organs damaged by diabetes are the eyes, kidneys, nerves, skin and the cardiovascular system. A brief description of the effects of this disease on each organ is provided below.

1.7.1 Cardiovascular System

Diabetes is an important risk factor for the development of cardiovascular disease. This is due to the gradual pathological changes that affect different blood vessels. Both large and small blood vessels undergo atherosclerosis affecting their integrity and compromising their vessel dilation and constriction abilities (Fowler, 2008). As a result of coronary atherosclerosis, blood supply to the myocardial tissue is diminished leading to death of heart muscle cells, a condition known as myocardial infarction (Widmaier, Raff,

& Strang, 2006:455). This is presumed to be the leading cause of death amongst diabetic patients. Following progressive vascular insufficiency, there is occlusion of cerebral blood vessels leading to death of brain cells.

Hyaline arteriolar sclerosis is thought to occur in small arterial vessels, while thickening has been observed on the basement of capillaries, (Widmaier, 2006).

1.7.2 Diabetic Nephropathy

The kidney is an important organ whose function among others is to regulate body water volume and electrolytes or salts. Other than hypertension and autoimmune disorders, diabetes is the most single common cause of end stage renal disease (Bin, Song, Dong, Yang, Zhang, Wen, Yiming, Zhou, Zhao, Zhu & Renming, 2007; ADA, 2004). Diabetic nephropathy is a progressive kidney disease resulting from long standing diabetes. Thickening of the glomerulus's basement membrane results into glomerulosclerosis, (figure 1.6). The presence of nodular glomerulosclerosis is thought to be pathognomonic (diagnostic) of diabetes. Renal vascular lesions have been thought to cause renal ischemia affecting mainly the efferent and afferent glomerular arterioles (Braunwald *et al.*, 2001). A higher proportion of individuals with type 2 diabetes are found to have microalbuminuria and overt nephropathy shortly after diagnosis as the diabetic state may have been present for many years prior to the diagnosis (ADA, 2003).

In uncontrolled diabetes, renal glycogen infiltration has been found in tubular cells while fatty changes are occasionally found in the proximal convoluted tubules.
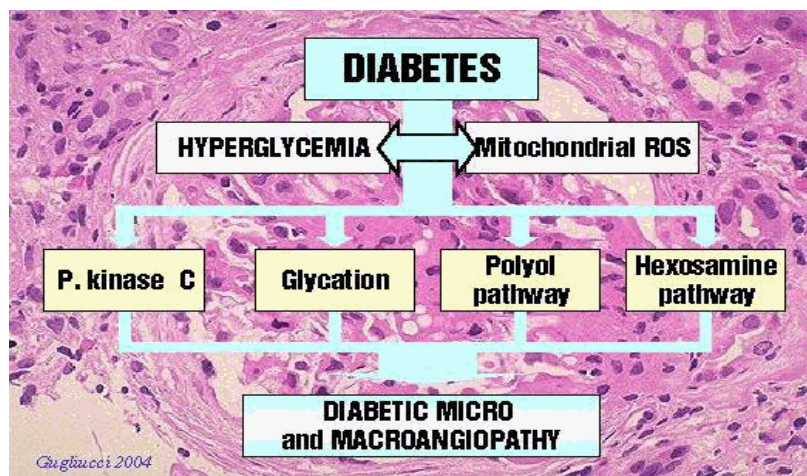
Figure 1.6: Destructive processes due to hyperglycaemia in a diabetic kidney (Adapted from Warwick Medical School, 2008. web publication)

1.7.3 Skin Infections

Recurrent skin infections amongst diabetic patients as seen in figure 1.7 have been attributed to poor blood supply to the skin. This is based on the understanding that small blood vessels undergo changes referred to as microangiopathy as well as atherosclerosis which compromises the blood supply to the skin (Souhami, 1994:770). During these changes, the walls of the affected blood vessels are damaged and lose their integrity. This makes it difficult for antibodies that help to fight infection to reach the skin.

Figure 1.7: Clinical manifestation of diabetic skin infections (Adapted from, Hurtley, 1995).

1.7.4 Diabetic foot and the recommended care

Diabetic foot complications are one of the commonest complications amongst diabetic patients (ADA). They also contribute to the bulk of hospital admissions, yet if screened early enough, can be prevented. According to Souhami (1994:772), four factors are implicated in the diabetic foot which commonly coexist to reinforce each other in causing this condition. They are neuropathy (death of nerves), ischaemia (lack of blood supply), trauma and infection. The effect of neuropathy in the diabetic foot is a lack of sensation in the foot which results in injuries being unnoticed while ischaemia leads to reduced blood supply to the foot leading to tissue necrosis. Souhami (1994:772) further states that trauma caused by pressure from shoes or foreign bodies in the shoes result in callus formation and eventually ulcers that don't heal (figure 1.8). These ulcers are at risk of infection by gas forming organisms that might result in gangrene leading to amputation of either the toes or foot.

Anon, (2004) suggests the following measures in caring for diabetic feet:

- The feet should be cleaned daily, using warm—not hot—water and a mild soap. One should avoid soaking his/her feet. The feet should be dried with a soft towel paying particular attention to the web space (between the toes).
- Inspect the feet and toes every day for cuts, blisters, redness, swelling, calluses, or other problems. Use a mirror—laying a mirror on the floor works well—or get help from someone else if you cannot see the bottoms of the feet. Notify a health care provider of any problems.
- Moisturize feet with lotion, but avoid getting the lotion between the toes.
- After a bath or shower, file corns and calluses gently with a pumice stone.
- Each week or when needed, cut your toenails to the shape of your toes and file the edges with an emery board.
- Always wear shoes or slippers to protect feet from injuries. Prevent skin irritation by wearing thick, soft, seamless socks.
- Wear shoes that fit well and allow toes to move. Break in new shoes gradually by first wearing them for only an hour at a time.
- Before putting on shoes inspect them carefully and feel the insides to make sure they have no tears, sharp edges, or objects in them that might injure your feet.
- If help is needed taking care of your feet, make an appointment to see a podiatrist.

Figure 1.8: Clinical manifestation of diabetic feet (Adapted from Hurtley, 1995).

1.7.5 Diabetes and Pregnancy

Diabetes can occur during pregnancy in women who were previously non diabetic. This is referred to as gestational diabetes mellitus (GDM). Pregnancy can also occur in known diabetics. A woman with established diabetes can experience multiple problems at different stages of the pregnancy. These problems can affect both the mother and the unborn child (Sadikot, 2008). Hormones that maintain pregnancy (placental lactogen) increase the risk of developing hyperglycaemia which can worsen during the last six months of pregnancy. These mothers are also said to be at risk of developing hypertension and fits during pregnancy. For mothers that already have kidney and eye problems secondary to diabetes, these problems can worsen. It is also common for these mothers to deliver big babies (macrosomic) which may lead to obstructive labour (Sadikot, 2008). Macrosomic babies typically weigh more than 4500grams at birth as seen in figure 1.9. High mortality rates for diabetic mothers have previously been reported, though this has reduced.

Figure 1.9: Microsomic baby: Note the weight of the baby.(6.4kg)(Nationmaster.com, 2005)

Just like the mother, the foetus of a diabetic mother is also at risk of developing diabetes related complications (Sadikot, 2008). The organs of the body are formed during a process referred to as organogenesis in the first ten to twelve weeks of foetal life. During this period of pregnancy, diabetes may potentially affect the process of organ formation

resulting in a deformed baby (Mills, Knopp, Simpson, Jovanovic, Metzger, Holmes, Aarons, Brown, Reed & Bieber, 1988; Souhami, 1994: 759). Although some pregnant mothers can deliver big babies, the incidence is increased by 7% in diabetic pregnancies (Souhami, 1994:759). Macrosomia, a condition where the new born has an increased body size is also a common complication amongst pregnant diabetic mothers. Macrosomia has been linked to glucose crossing the placenta. A high level of glucose in the placenta stimulates the foetal beta cells leading to increased insulin secretion. A high level of plasma insulin induces growth hormones which result in an increased body size of the foetus. After birth, the babies are prone to hypoglycaemia because their pancreatic beta cells are still actively secreting large amounts of insulin.

1.7.6 Neuropathy

Neuropathy refers to damage caused to the nerves by diabetes. Nerve damage in diabetes involves both afferent and efferent nerves (Boon, Colledge, Walker & Hunter 2006:843). When these are damaged, their morphology /status change leading to episodes of pains of varying degrees and types. Boon *et al.* (2006:843) states that diabetic nerve damage is caused by increased plasma glucose levels. Prolonged hyperglycaemic states are thought to have a destructive effect on nerve tissue through diffusion of glucose into them resulting in over activity of the nerves while destruction of blood vessels that supply specific nerves leads to reduced or complete lack of blood supply to the nerve. This results in partial or complete nerve tissue necrosis. Patients with such complications experience localized lack of sensation or pain. The danger of such complications is that patients may sustain injuries without being aware of them and may become infected. According to Parry, Godfrey, Mabey & Gill (2004:754), other effects of diabetic neuropathy are:

- Sexual dysfunction including erection problems due to nerve damage
- Gastrointestinal motility disturbance leading to vomiting and diarrhea especially at night.
- Neuropathic bladder includes incomplete emptying, continuous urine flow and being at risk of infections.
- Postural hypotension occurs as a result of failure of blood vessels to return or maintain size in different positions.
- Abnormal sweating.

1.7.7 Diabetic Retinopathy

Several destructive structural changes occur in the eyes of a diabetic person with or without adequate control (Harmel, 2004:190). The primary causes are increased plasma glucose concentrations. For the eye lens to maintain its integrity and perform its function accurately there must be equilibrium in the glucose levels between the lens and the aqueous fluid. This therefore means that any change in glucose concentration between the two mediums will result in fluid movement either into the lens or out of the lens. Near sightedness occurs if fluid moves out of the lens, and far sightedness if there is fluid movement into the lens material, Harmel, (2004:190). A diabetic lens is more prone to cataracts which is a clouding of the natural eye lens leading to reduced vision. Cataracts also occur with advancing age (Esteves, Pizzol, Sccoco, Roggia, Milano, Amaral, Rodrigues & Canani, 2008)
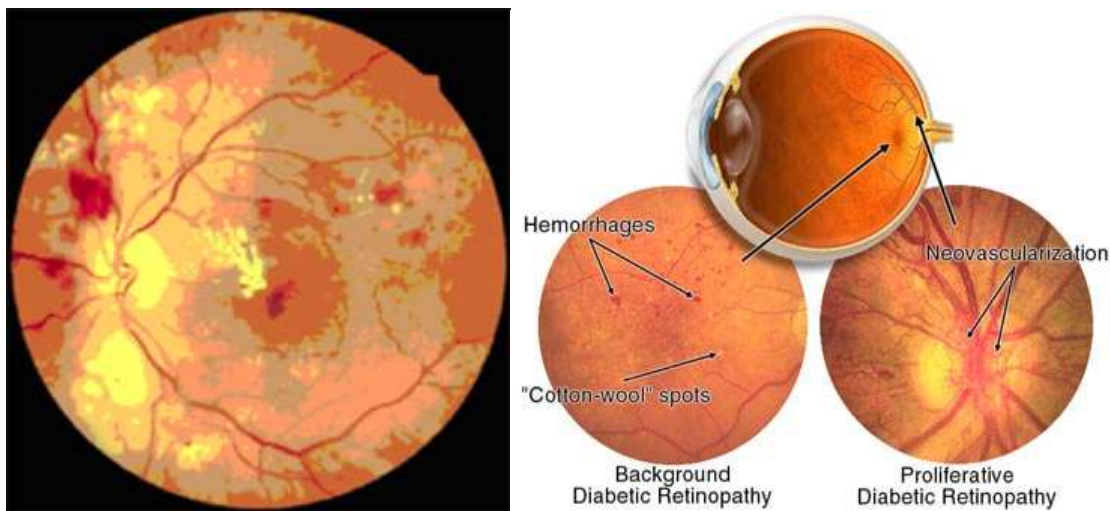
Figure 1.10: Vascular changes in a diabetic eye (Diabetes Research and Clinical practice, 2007, 78(3):S51-S58), Retinal Changes in the eyes of a diabetic.

Over a period of time, diabetics develop a condition called retinopathy. Diabetic retinopathy has been thought to be the most common diabetic eye disease and a leading cause of blindness amongst diabetics (Fong, Aiello, Gardner, King, Blankenship, Cavallerano, Ferris & Klein, 2003). It is caused by changes in the blood vessels of the retina which swell and leak fluid into the eye (see figure 1.10). Eventually these blood vessels break, leading to intraocular haemorrhage. Scar formation within the retinal tissue following bleeding leads to retinal detachment which further impairs sight or leads to complete blindness, (Souhami, 1994:766). The incidence of blindness due to diabetic

retinopathy is believed to be on the rise. Boehm, Sosna, Lund-Anderson and Porta (2007) note that globally, every 90 minutes, a person develops blindness due to diabetic retinopathy.

One of the major risk factors for the development and progression of diabetic retinopathy is the duration of the disease and how adequately the diabetes is controlled (Fong *et al.*, 2003; Florkowski, Scott, Coope, Graham & Moir, 2000). Thus, it is important that Primary Health Care professionals are equipped with skills to detect such changes at an early stage for appropriate referral. Good diabetic control also needs to be encouraged amongst diabetic patients in order to prevent or delay onset of retinopathy. Education is also essential as many patients have been found to be ignorant regarding the association between blindness and diabetes (Clarke-Farr, Nel & Wilkinson, 2006). Findings from the Diabetic Control and Complications Trial (DCCT), (1993) show that up to 75% or more cases of retinopathy can be prevented if good glycaemic control is instituted, (ADA, 2003). Adequate high blood pressure control is also vital in reducing the risk or progress of the disease (Weatherall, Ledingham & Warell, 1996:1492).

1.7.8 Diabetic Emergencies

Diabetic patients can develop acute and life threatening emergencies. These emergencies tend to occur during persistent hyperglycemic states, although may also arise due to hypoglycaemic states (Parry *et al.*, 2004:759) . For both type 1 and 2, these emergencies occur in the absence of insulin. However, other factors such as acute illnesses play a role if there is inadequate glycaemic control. Boon *et al.* (2006:820) states that during acute illnesses, there is an increase in stress hormones such as cortisol, which antagonize the effect of insulin, hence the need for increasing the drug doses. Often, new diabetic patients have been diagnosed following or during coma. This is common amongst type 1 diabetics who are unaware that they are diabetic and need insulin to control their plasma glucose. While early clinical presentations of both type 1 and 2 may differ, patients may go into coma if early and appropriate management is not instituted. Diabetic ketoacidosis (DKA) is a term used to describe the metabolic emergency seen in Type 1 diabetic patients with uncontrolled diabetes. Although the mechanism of DKA follows a complex process, the major reason is absolute lack of insulin (Parry *et al.*, 2004). The lack of insulin results into lipolysis, gluconeogenesis and glycogenolysis. The effect is increased fat metabolism leading to the release of fatty

acids into the blood as well as increased blood glucose levels which result from conversion of liver glycogen into glucose and also from other non carbohydrate sources. A combination of these processes results in elevated ketone bodies which causes severe acidosis. The breath of a DKA patient smells of acetone. Other signs and symptoms are dehydration due to vomiting and excessive passing of urine, increased respiration and eventually coma (Parry *et al.*759).

In type 2 diabetics, hyperosmolar non ketotic coma is the typical metabolic emergency. Since these individuals have some amounts of insulin to counter-regulate lipolysis but not sufficient to prevent glucose production by the liver, ketosis is not observed. Souhami (1994:763) states that confusion, drowsiness and coma are more common in these patients than those observed in type 1 diabetes. Earlier symptoms are excessive or intense thirst, passing large amounts of urine, weight loss and poor vision.

Considering the severity of these emergencies, primary health care workers need to be adequately trained in order to be able to identify them and provide appropriate management.

1.8 Management of diabetes

Good glycaemic control is the main objective of diabetes management, (Norris, Engelgau & Narayan, 2001). The goal of diabetes management should be to achieve as near to normal blood glucose levels as possible without risking the danger of hypoglycemia or hyperglycaemia. Adequate glycaemic control reduces the risk of complications due to hyperglycaemia. In order to achieve this, the patient has to be committed regarding the time schedules of taking the medications or any other form of management suggested by the physician. This calls for appropriate education and professional guidance from the physician (Harmel, 2004:259). Because of the differences in the pathogenesis of the two major forms of diabetes, different forms of management have been suggested. For example patients with type 1 diabetes might require insulin for survival, while those with type 2 diabetes may be advised on dietary change and exercise as a mode of management, although they may also require anti diabetics if the former measures are not effective. Since type 2 diabetes is mostly associated with obesity, weight loss is paramount. Exercise and weight reduction are thought to be beneficial to type 2 diabetics as it promotes insulin sensitivity and improve cardiovascular functioning (Harmel, 2004:278).

1.8.1 Treatment of Diabetes

Once diagnosed as a diabetic, appropriate management needs to be instituted. As mentioned above, the goal should be maintaining blood sugar levels to normal levels. For type 1 diabetes, insulin is the drug of choice. Different preparations of insulin are available depending on the patients need for the drug and the goals of treatment. A mixture of short and long acting preparations can be made especially at bed time. Oral anti diabetics are suggested for type 2 diabetes treatment if dietary and lifestyle interventions are not successful.

1.8.2 Control of diabetes mellitus

In order for diabetic patients to be compliant with the management schedule, they need to learn about their disease and this should be part of the overall strategy in addition to drug administration. The patient must take responsibility for his/her condition. This includes personal discipline for scheduling a regular exercise program and weight maintenance or reduction targets. Diabetes control also demands prioritization in terms of available financial resources. This is especially important if a patient is to make a decision about purchasing an item other than that which will help him/her with his/her disease treatment. When diabetic patients are well sensitized about their condition, they may set goals for themselves. A study conducted by Morrow, Haidet, Skinner and Naik (2008) found that most diabetic patients have set goals regarding self management of the disease. This study confirms that good diabetic education can lead to good glycaemic control thereby preventing brittle diabetes (poorly controlled diabetes) (Souhami, 1994:751). Diabetic patients need to be encouraged and also taught to monitor their glucose levels at home (Bonora, Calcaterra, Lombardi, Bonfante, Formentini, Bonadonna & Muggeo, 2001) since plasma glucose level fluctuations before and after meals result in poor glucose control. However, the cost of consumable products such as glucose strips should be borne in mind when suggesting this management strategy. For patients who cannot afford such facilities, regular and more frequent visits to the clinic are recommended.

1.8.3 HbA1c Test

HbA1c is the ratio of glycosylated haemoglobin in relation to the total hemoglobin in circulation. This test assesses the glycaemic control over the previous three months. HbA1c levels in normal non diabetic subjects ranges between 3.5% to 6.0%, (Bonora, *et*

al, 2001). This value is elevated in diabetics. Therefore, diabetic patients with HbA1c values less than 6.5% are thought to have good glycaemic control. This assessment is based on life span of the red blood cell (RBC) which is about 120 days (3 months) (Souhami, 1994:1049). The relevance of this test to diabetes is that, during the lifespan of an RBC, glucose molecules bind to the hemoglobin molecules during a process known as glycosylation. This process occurs gradually and is influenced by the concentration of glucose in the blood such that the more glucose there is in the blood, the more will be bound to the hemoglobin molecule. If hemoglobin is separated from the blood, the degree of glycosylation can be measured indicating how much glucose has been in the blood during the lifespan of the molecule. Persistent raised plasma glucose levels increase glycosylation of haemoglobin within these cells. Therefore this test reflects the average or level of diabetic control over a period of about 3 months.

1.8.4 Cost implication of diabetes care

The chronic nature of diabetes requires that once it is diagnosed, some form of management should be instituted. During its early stages, exercise and diet may be recommended as modes of management in the case of type 2 diabetes. However, when these interventions can no longer control the blood sugar, there is need for therapeutic intervention in which oral or injectable antidiabetic agents are prescribed. These have to be taken on a regular basis usually indefinitely, and are a significant burden either to the patient or to the state. In Africa, many people die of diabetes related complications because they can not access basic care. It is estimated that globally, a person dies of diabetes related complications every 10 seconds (World Diabetes Foundation, 2007). It is also estimated that between 215-375 billion US dollars (USD) is spent globally on diabetes care (World Diabetes Foundation, 2007). This cost is expected to double corresponding with the projected increase in diabetes prevalence by 2025. The most affected will be the low and middle income countries, since they have highest prevalence of the disease. Educating the diabetic patient can result in significant cost savings.

In the developing world the cost of educating a person with diabetes on how to take care of his feet is about USD 3, whereas the cost of treating a non-healing foot ulcer is about USD 450. The cost of amputation when treatment fails is estimated to be over USD 550 while the cost of buying foot prosthesis exceeds USD 650. "While Health care systems may fund emergency amputation surgery, they typically do not invest in providing

education and training to patients in order to prevent the ulcers and amputations" (WDF Summit, Nairobi, 2005).

1.8.5 Type 2 Diabetes Prevention

Considering the escalating diabetes prevalence both globally and locally, it is crucial that the existing preventive measures are re-emphasized. Some of the suggested preventive measures include the consumption of a low fat diet as well as increasing physical activity. The ADA (2003) recommends that reducing body weight by 5-7% and exercising for 150 minutes in a week can help reduce the risk of developing diabetes by 58%. Studies implementing lifestyle modification approaches provide compelling evidence regarding the prevention of diabetes (Brekke, Lenner, Taskinen, Mansson, Funahashi, Mustuzawa & Jansson, 2005; Diabetes Prevention Program Research Group, 2004). Those at risk of developing diabetes can be advised to take up preventive measures that are affordable. As it is the case with majority of the African population, not every one has access to the gymnasium where different types of exercise equipment are found. It is therefore important that alternative forms of exercises are suggested as a measure of reducing weight. As for the rural African population who habitually engage in farm work on a daily basis, other aspects of lifestyle change should be emphasized such as low fat intake. Such measures may also be applied to those who are genetically at risk of developing diabetes. Song, Nam-Goomg, Han, Kim, Lee, Yoon, and Park (2008) have observed that the enormous increase in the diabetes prevalence is due to pronounced changes in the environment and lifestyle of humans. An earlier study conducted by Tuomilehto, Lindstrom, Eriksson, Timo, Hamalainen, Ilanne-Parikka, Kiukaanniemi, Laakso, Louheranta, Rastas, Salminen, Aunola, Cepaitis, Moltchanov, Hakumaki, Mannelin, Martikkala, Sundvall and Uusitupa (2001) has provided strong evidence that improvement in lifestyle habits greatly reduces the risk of developing type 2 diabetes. In the above study, subjects at risk of developing the disease were subjected to intervention measures which included changes in dietary habits, participating in a physical exercise program with the objective of losing weight. They were monitored against a control group over a period of three years. Marked improvements were observed regarding progression from IGT to diabetes. Thus changes in life style habits are the main form of prevention in the development of type 2 Diabetes (Wandell, 2006).

1.9 Rationale and significance of this study

The prevalence of diabetes in South Africa is not well documented, and few studies have been conducted since 1994. Type 2 diabetes makes up the majority of the total diabetic population and many of these patients are unknown to the health service and often undiagnosed. Few studies have been carried out in the Western Cape with the only community based study reported more than a decade ago in the Mamre area along the Cape West Coast, which can be considered a peri-urban area. Bellville South represents a relatively stable urban community. It is situated in the northern suburbs of Cape Town.

Considering the global epidemic of obesity and lifestyle changes that are primarily associated with urbanization, it is assumed that there will be a concomitant increase in the prevalence of diabetes in South Africa. It is against this background that this study investigated the prevalence of impaired glucose tolerance and diabetes in this community.

This study therefore provides baseline information about the health status of the residents of Bellville South with regards to diabetes highlighting the possible risk factors to developing diabetes. The findings of this community-based study will provide valuable information about the estimated prevalence of IGT and type 2 diabetes, which could significantly influence the planning of future health service and prevention strategies by the provincial and national Health Department(s).

1.10 Aims and objectives

The aim of this investigation was to determine the prevalence of impaired glucose tolerance (IGT) and diabetes mellitus within the community of Bellville South, in Cape Town and to examine some of the predisposing factors in terms of:

1.10.1 Objectives

This study had three main objectives.

1. To establish the prevalence of impaired glucose tolerance and diabetes within the community of Bellville South.
2. To examine the relationship between previous family history of IGT and diabetes in order to identify the risk of respondents.

3. To investigate the relationship between lifestyle factors such as alcohol consumption and cigarette smoking in order to explain their role in the aetiology of IGT and diabetes.

4. To analyze the association between high fat diet with IGT and diabetes in reference to (BMI).

CHAPTER TWO
MATERIALS AND METHODS

2.1 Ethical Issues

This research protocol was approved by the Research and Ethics Committee of Cape Peninsula University of Technology, upon which permission was granted with Reference Number: CPUT/HW-REC 2008/002 (a copy of which is attached in the appendix L). Permission was also sought from other relevant authorities such as the city and community authorities. These authorities granted permission to operate in the community and also to make use of designated places such as community halls and sample collecting venues.

2.1.1 Informed consent and Information sheet

Participants recruited to participate in the study were informed of the aims and objectives of the study through the circulation of information sheets, (Appendix I). All procedures and implications were explained to the participants. Participation was entirely voluntary and participants were free to withdraw at any time with no obligations. All the relevant information was contained in the information sheet which was handed to the participants a day prior to participation. The consent form was signed on arrival at the participation venue. A copy of the consent form appears in appendix A.

2.2 Research Design

This was a cross sectional quantitative study aimed at determining the prevalence of diabetes mellitus in the community of Bellville South. Both dependent and independent variables were obtained. Dependent data such as personal demographic information were collected by means of a structured questionnaire whilst independent variables such as blood urine anthropometric data were obtained through participant measurements.

2.3 Study setting

Bellville South is a traditionally Coloured town-ship formed in the late 1950s. In the South African context, the term township usually refers to the (often underdeveloped) urban living areas that, under Apartheid, were reserved for non-whites (principally black Africans and Coloureds, but also working class Indians). Bellville South is located within the northern suburbs of Cape Town in the Tygerberg sub-district, (See figure 2.1 and

2.2). According to the 2001 population census, its population stands at approximately 24,000. About 46% are males while females represent 54% (City of Cape Town Census, 2001) of which the target population was 24.6 % (35-65 years). Although English and other African languages such as Xhosa are spoken, the predominant language in this community is Afrikaans. Most of the residents of this community have lived there for over five years while others have been there for their entire lives.

Though a significant number of the inhabitants are civil servants employed in the public sector or retired civil servants, Bellville South has a relatively high rate of unemployment. Sixty three percent of the population can be classified as working class as they are engaged in paid economic activities. Records from Bellville South Community Health Centre which serves as the only public community health facility in the area indicates a rapid rise in the number of patients diagnosed with diabetes year by year (personal communication).

Figure 2.1: Map of Cape Town. Map edited to show the location of Bellville. (Googlemaps.com, 2009).
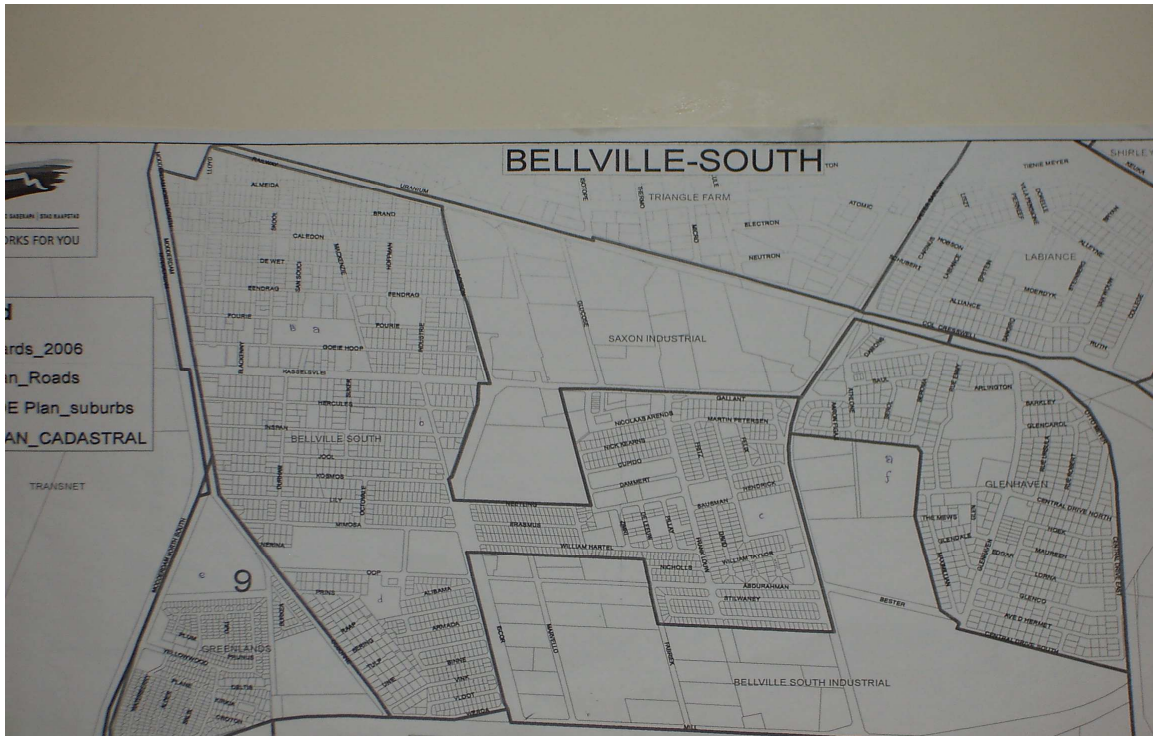
Figure 2.2: Map of Bellville South, (Bellville Municipality, Cape Town, 2007).

2.3.1 The study population

The study population comprised of adults resident in Bellville South ranging between the ages 35 -65 years.

The following were exclusion criteria for participants.

- Those under the age of 35 and over 65 years.
- Those that did not voluntarily consent to participate in the study.
- Pregnant females
- Acutely ill people

2.4 Sampling Technique

The sample size of this study was determined by obtaining the population size of the community. The total population of the community was about 24,000. This figure was obtained from the Bellville South Partnership Project Information Pack Compiled by Theresia Daniels whose figures were based on the 2001 population census. From the above source, individuals that were within the 35-65 years age group were 6150 (24.6%) individuals. Therefore, an adequate sample size for the study was calculated   by a

statistician at 1,000 based on the power of 80%. Basing on the power of 80%, it was expected that atleast 800 subjects would form the study sample.

In order to effectively carry out the above strategy, a map of Bellville South was obtained from Kasselsvlei library. A Multistaged stratified random sampling approach was used to recruite subjects into this study. For purposes of the study, the area was therefore divided into six strata. The purpose of stratification was for easier participant identification and also to be able to work on a smaller area at a time.

From a list of streets of the area, the streets were then classified as short, medium and long streets. These classifications were based on the number of houses per street. Streets were classified as short if they had between 0-22 houses, while medium streets had between 23-40 houses. A street with 41 houses and above was classified as a long street. A total of 16 short streets representing approximately 190 houses, 15 medium streets representing approximately 410 and 12 long streets representing approximately 400 houses were randomly selected accross the different strata. Thus each of the six strata had short, medium and long streets.

Each strata was visited individualy where the randomly selected streets were identified. From the selected streets, all household members meeting the selection criteria as described on page 41 were invited to participate in the study. After one stratum was delt with, the field team moved on to another stratum in which sampled streets were also identified and participants reminded about participation in the study. All the strata were re-visited to give participants either a second or third chance for partipation.

2.4.1 Recruitment and marketing
Information regarding the project was disseminated to the local residents through the local radio station (Radio Tygerberg), community news paper, (The Tyger) and brochures and fliers, the latter bearing information about the project and distributed through school children and taxis to the local residents. The aim of social marketing was to sensitize the community the community of Bellville South about the importance of such a study. However, only participants who were living in the randomly selected streets were recruited into the study.

Other forms of communication included the street advertisement campaign (See appendix J). Figure 2.3 below shows the researcher with the recruitment team after a street advertisement.

Figure 2.3: The diabetes research team after a road show. Information leaflets concerning the project details were distributed to the residents. (Field Photograph, 2008).

This strategy compared well with the one used by Amoah, Owusua & Adjeic (2002) in Ghana in which a similar social marketing strategy was used to sensitize the community.

2.4.2 Pre-participation counseling

Recruited subjects were visited by the recruitment team the evening before participation and reminded of all the survey instructions. These instructions included overnight fasting for 10-14 hours prior to the taking of the blood samples. They were also asked to refrain from smoking and drinking alcohol as these would interfere with the serological measurements on the following day. Since the study also required the collection of early morning urine samples, subjects were reminded to bring the early morning urine sample, for which a container was provided. The protocol for urine collection was explained to them so as to ensure quality of the specimen. (See page 55 for validation of smoking).

2.5 Pilot study to assess potential problems

Before embarking on the main study, a pilot study was conducted in a neighboring community but with similar demographics. The objective was to evaluate the reliability, validity, data collection as well as data analysis.

2.6 Data collection

Prior to collection of data, all procedures were explained to the participants by the researcher and informed consent obtained. Measurements were carried out according to the standard operational procedures by qualified health professionals who had previously been trained in questionnaire administration. Personal demographic data was collected using a questionnaire (Appendix M) administered by the staff whilst anthropometric data was obtained by measurement of the subjects. A questionnaire took averagely ten minutes to complete. Blood was drawn by trained health professionals. The following measurements were obtained: height, weight, hip and waist circumferences, body fat measurements and blood pressure. Participants were asked to provide urine. Fasting and post prandial blood samples for estimation of glucose levels, serum insulin, urine creatinine, HbA1c, cholesterol, triglycerides, gamma glutamyl transferase enzyme and cotinine was obtained. All participants except the self reported diabetic subjects underwent oral glucose tolerance test (OGTT) as explained below.

2.6.1 The Questionnaire

The questionnaire was designed to obtain information on personal demographics such as age, gender and previous medical history of diabetes, dietary as well as life style aspects. It consisted of four components and these were personal demographics, family health history, diet, cigarette smoking and alcohol consumption. The questionnaire was adapted from several existing standard and recognized sources. Among these sources are: The South African Demographic and Health Survey Report by the Medical Research Council (Chronic Diseases of Lifestyle in South Africa, 2006). This survey focused on chronic and lifestyle diseases and its questionnaire addressed the nutritional status, diabetes, hypertension and physical activity of the subjects. Questions related to alcohol use were adopted from the CAGE questionnaire (Ewing, J.A. 1984). The CAGE questionnaire is an internationally accepted tool used in alcohol related studies. These questions were used during the pilot study but omitted during the main study since they did not prove very significant in answering the research question. The questionnaire was

also adopted from a previous study conducted to determine the prevalence of obesity amongst learners attending school in Belhar, Mfuleni and Delft (Somers, Rusford, Hassan & Erasmus, 2006). The questionnaire used in this study also addressed among other areas food types and consumption frequencies (Dietary History Interview). After consultation of the above sources, a modified questionnaire was then developed to suit and answer the research question. The dietary component of the questionnaire was developed in conjunction with a qualified dietician from the University of the Western Cape (UWC). The dietary component of the questionnaire enquired about the details of participants dietary fat intake from different types of foods consumed.

The family health history questionnaire covered the presence or previous treatment of family related diseases up to third degree relatives. The dietary questionnaire focused on the types of food eaten as well as their frequency (Quantity Frequency Questionnaire), (Koppes, Twisk, Snel & Kemper, 2002).

The questionnaire on cigarette and alcohol consumption focused on:

   (a) The habit, (b) Duration of the habit, (c) quantity consumed and when the habit was given up.

Following the pilot study, the questionnaire was further modified in which the cage questionnaire was omitted since information obtained would not be appropriate for the study.

2.7 Anthropometric Measurements

These measurements were carried out by the researcher and other members of the research group who had been trained in anthropometric measurements. This was performed in community halls or in class rooms for which permission was obtained. Participant privacy was maintained throughout the process.

2.7.1 Height Measurement

Height was measured using a portable stadiometer. Without shoes on, a participant was asked to stand on the flat surface of the stadiometer at right angles to the vertical sliding lever of the stadiometer. The head was placed in the Frankfort plane with hands at the sides. The scapular and buttocks were to be close to the vertical sliding metallic bar. The subject was asked to maintain a fully erect position in order to achieve the required accuracy. The sliding metallic bar was then gently allowed to rest on the subjects head.

Readings were recorded in (centimeters). If the participant was taller than the investigator, a plat form was used to correctly read the height.

Figure 2.4: Height Measurement (Field photograph, 2008)

2.7.2 Weight Measurement

Weight was measured using an electronic calibrated scale. Participants were weighed in light clothing. Weight was taken for all participants except the wheel chair bound persons and anybody with postural imbalances. The subject stood on the middle of the flat surface of the scale after it had been set to zero. The hands were placed on his/her sides. After it was ensured that the subject's weight was evenly distributed, the reading was then taken in (kg) (Figure 2.5). Weight was recorded to the nearest kilograms. Measurements less than 0.5 kg were rounded off to the nearest lower level while those greater than 0.5 were rounded off to the nearest higher weight.
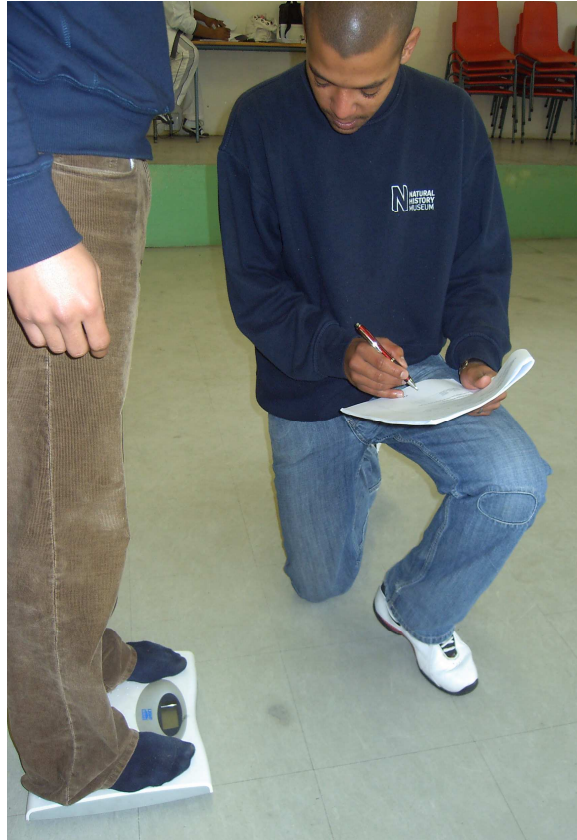
Figure 2.5: Weight measurements (field photograph, 2008**)**

2.7.3. Waist Circumference measurements

Waist circumference was measured using a commercial tape that had been inspected for calibrations and stretch. The waist measurements were taken with subjects in the erect position with hands placed on the sides and the feet together with the abdominal muscles relaxed. Measurements were taken with the investigator facing the participant and placing the measuring tape at the level of the natural waist which is the narrowest part of the torso as seen in figure 2.6 below from the anterior view. As it may be difficult to see the narrowing of the waist in obese subjects, the narrowest circumference between the ribs and the iliac crest should be measured. In such subjects, readings were only taken at the end of normal expiration, (European Health Risk Monitoring, 2002).

Figure 2.6: Positions of Waist circumference (Field Picture, 2008)

2.7.4 Hip Circumference

Hip circumferences were measured as the maximal circumference over the buttocks. With the investigator squatted before the fully extended subject, the tape was placed around the buttocks over the widest area in the horizontal plane without pressing tightly against the skin and the measurement taken. Where the hip circumference exceeds the tape, the measurement was not taken but noted, (European Health Risk Monitoring, 2002).

Figure 2.7: Hip Circumferences, Note the reflection in the mirror (Adapted from European Health Risk Monitoring, 2002)

2.7.5 Skin Fold measurements

This is a measure of skin thickness and the underlying subcutaneous adipose/fat tissue, Moreno, Mesana, Gonzalez, Gil, Fleta, Warnberg, Ruiz, Sarria, Marcos & Bueno, 2006). The four sites that were measured were triceps, biceps, sub-scapular and supra-iliac areas. It was preferred to take all measurements on the right side of the participant for the convenience of the researcher.

2.7.5.1 Procedure and measurement sites

- A skin fold and the underlying subcutaneous tissue were grasped between the thumb and the forefinger about 1cm above the site of measurement. The skin fold elevation was taken by placing the fingers 8cm apart on a line perpendicular to the long axis of the fold.
- The thumb and index fingers were drawn towards each other and the skin fold grasped firmly but without hurting the participant.
- The thicker the adipose (fat) tissue layer, the more separation was needed between the thumb and the index finger when the measurer elevated the skin fold.

- The fold was pulled away from the underlying muscle and the jaws of the caliper were placed on the other side of the site at a depth of approximately one centimeter. The skin fold was held firmly through the application. The calipers were applied perpendicular to the fold at all times.
- The measurement was taken about 4 seconds after the pressure was released. This process applied to all the measurement sites as mentioned below.

2.7.5.2 Obese subjects

As elevation of skin in the obese subjects may be difficult using one hand, a two handed technique was used in such cases. In this technique, one measurer lifts the skin fold using both hands and another measures the skin fold.

2.7.5.3 Measurement sites

(i)Triceps

This was measured from the back on the posterior surface of the arm mid way between the top of the shoulder (acromion process) and the posterior aspect of the elbow (olecrenion process).

It was ensured that the upper limb hung loosely by the subjects' side with the subject in standing position.

(ii) Biceps

The measurement was done on the anterior (front) surface of the arm midway between the top of the shoulder (acromion process) and the front of the elbow (anterior surface of the cubital fossa) with the subject in a standing position.

(iii) Sub-Scapular

The measurement was taken about 20 mm just below the inferior (lower) angle of the scapular with the fold in an oblique plane of the descending outwards and downwards at an angle of approximately 45 degrees the horizontal plane.

(iv) Supra-Iliac

The measurement was taken about 20mm above the iliac crest in the axillary line with the fold in the oblique plane descending medially and downwards at an angle of 45^0 to the horizontal plane. The subject remained in an erect position with upper limbs by the side and the abdominal muscles relaxed.

Figure 2.8: Skin folds (Calipers) Measurements, Note: Abdominal fat (Central Obesity) a risk factor for type 2 diabetes (Field Photograph, 2008)

Figure 2.9: A Blood drawing Station during the data collection of the project (Field photograph, 2008)

2.8 Oral Glucose Tolerance Test

Oral glucose tolerance test is a test performed to assess the ability of the body to metabolize glucose. This test has been used widely to diagnose diabetes. In this test, subjects are asked to fast for 10-14 hours preferably during the night and then challenged by a standard glucose load (WHO, 1999).

In this study, an oral glucose tolerance test (OGTT) was performed on fasting participants using a 75gram glucose load on the morning after the fasting state. A written instruction as well as a detailed explanation of the procedure was conveyed to each participant. Known diabetics were excluded from this test.

The following steps were followed.

- Confirm that participant is fasting.
- A blood sample for glucose analysis was taken before administering
- 75 grams of glucose anhydrous dissolved in 250-300mls of water which was drank within 3-5 minutes and the time recorded.
- A second blood sample for glucose was drawn 2 hours after drinking the glucose solution.

2.9 Specimen collection, Transport and analysis

A total of five blood tubes were collected per subject, three fasting and two for post prandial blood. One grey top tube, one red top tube and one purple top tube for fasting blood samples. The gray top tube was used for fasting glucose, while the red top tube was used for serological tests such as serum cotinine. The purple tube was used for HbA1c and blood lipid tests (serum sample). The 2 hour blood tubes were 1 grey top for post prandial blood glucose, while the other was a red top for insulin determination. All the blood samples were labeled with the participants details, then placed in plastic bags before being packed in a cooler box which was later collected by laboratory staff. Upon receiving the blood and urine specimen, the laboratory staff signed a specimen collection sheet on which all samples collected for each participant had been entered. The details on the sample collection sheet included name, date of birth, date of sample collection, time of sample collection, specifications of blood tubes used, for example if all tubes required for each participant had been taken (Red, Purple and Grey tubes). The sheet also indicated whether fasting and the 2 hour blood samples had been taken (Appendix H). All this information was only accessible to the researcher in order to maintain participant confidentiality.

At the laboratory, blood specimens were analyzed using the routine laboratory procedures and equipment by an accredited pathology laboratory under the supervision of an experienced chemical pathologist.

2.9.1 Biochemical Analyses

The following biochemical tests were performed at the Laboratory using routine chemistry analysis techniques; blood glucose, cotinine, gamma glutamyltransferase, high density lipoproteins(HDL), low density Lipoproteins(LDL), cholesterol and triglyceride levels.

2.10 Blood pressure Measurements

Blood pressure is described as the force of circulating blood on the walls of the arteries.
It is measured to determine the resistance generated against the arteries by the circulating blood in an individual. According to Leung, Tran, Tan, and Caughey (2004), blood pressure can also be described by the following equation "BP=Cardiac Output multiplied by the systemic resistance". (BP=CO X SVR). Its units are given in millimeters of mercury (mmHg). Normal blood pressure value ranges are 100 to 120 mmHg for systolic phase and it ranges between 60 and 80 for the diastolic phase. An elevated blood pressure also known as hypertension is a risk factor for cardiovascular disease (Chiong, 2008).

As smoking and caffeine containing drinks have been found to have a vaso-constrictive effect on the vascular system, subjects were asked to refrain from taking these substances thirty minutes prior to blood pressure measurements (Takashi, Ueda, Nishioka, Hidaka,Takemoto, Nakamura, Jitsuiki, Soga, Goto, Kazuaki, Yoshizumi & Yukihito, 2006). Blood pressure readings were taken with the subject in a relaxed sitting position with the back supported by the chair backrest.

Figure 2.10: Taking a participant's blood pressure. Note the participant's relaxed position (Field photograph, 2008)

Their arms were exposed and rested on the table at the level of the heart. Blood pressure readings were performed using a calibrated baumanometer (Rossamax). The correct adult cuff size was placed 2 cm above the elbow joint in order to ensure accurate readings, (Pickering, Hall, Apple, Falkner, Graves, Hill, Jones, Kurtz, Sheps & Roccella, 2004). Efforts were made to perform five readings at one minute intervals before recording the last three. The lowest reading of the three values was then taken as the participant's final blood pressure. During the procedure, the participants were asked not to speak as this has been found to affect the readings. This technique has been used by Adams, Burke, Beilin, (2002); Panchon, Lobato and Sanchez (2004).

In this study, high blood pressure was defined as Systolic Blood Pressure(SBP) greater than 140mmHg over Diastolic Blood Pressure(DBP) greater than 90mmHg. (Asmatullah, Haq, Pervez, Saleheen, Frossard, Ishaq, Hakeem, Hamza and Ahmad, 2008; Gary, Chan & Cockram, 1999). A participant who reported being diagnosed by professional medical personnel as hypertensive or was on antihypertensive treatment was considered a self reported hypertensive.

2.11 Quality control procedures

A standard operating procedure manual was developed and issued to all research team assistants. In the manual, details of all measurements were clearly explained. Whoever needed clarification about a particular procedure was free to ask for further explanation. One of the quality control measures employed in this study was the use of standardized operational procedures (SOP). All the equipment was calibrated routinely or on daily basis depending on the manufacturer's instructions. All field staff were pre-trained on questionnaire administration as well as carrying out measurements before embarking on the study. Measurements carried out were traceable to individual measurers since they were required to sign against the measurements they performed. Spot field checks to verify accuracy of measurements by the project supervisors also enhanced quality control (Adams *et al.*, 2002). In order to avoid false measurements due to staff fatigue, work load was kept within acceptable limits as had earlier been agreed.

2.11.1 Questionnaire

Although the interviewer or researcher effect is avoided in self administered questionnaires, it is also likely that some errors could occur due to unclear questions leading to inappropriate responses. This can impact negatively on the quality of the data. Considering the fact that some respondents could have some form of impairments such as visual or literacy levels thus rendering the questionnaire understanding difficult, the research team therefore individually administered the questionnaires in order to avoid inaccuracies due to the above effects. During questionnaire administration, the exact answer given by the respondent was then indicated. Participants were asked to indicate when a question was not clear for clarification by the interviewer.

2.11.2 Blood and midstream urine Sample collection

Blood and urine samples can either be contaminated by participants or inappropriately labeled by the researcher during surveys. Participants were therefore carefully informed of the instructions on urine collection. The males had to hold the penis and allow the first stream of the urine to pass down before directing the mid-stream in the container. The container was then to be tightly secured. The female subjects were asked to clean the vulva with a swab, separate the labia's with fingers of one hand and pass urine into the container held with the other hand. They were however also asked to pass the first stream away before collecting some into the container. By so doing, contamination was

minimized. A sticker bearing the participants names, reference number, date of interview as well as his/her date of birth were placed on the urine container.

With respect to blood samples, pink coloured stickers bearing the participants details as above were placed on vacutainer tubes for fasting blood samples while post prandial blood samples were marked with orange stickers. By so doing, fasting blood samples could easily be differentiated from postprandial samples.

Labelled blood sample tubes were put securely in plastic bags before being placed in special cooler boxes containing ice packs before and sent to the laboratory for analysis. At the storage site, the samples were stored at the recommended storage temperatures of -30 ^{o}C to -70°C in the freezer or cold rooms (EHRM, 2002)

2.11.3 Measurement of Glucose powder

The recommended weight of glucose to be administered for purposes of diabetes epidemiological surveys is 75g. In order to adhere to these requirements, strict measures were undertaken while measuring glucose since the original packaging was that of 100g. An electronic calibrated scale was used to accurately measure the quantity needed. After being calibrated to zero, only glucose powder was placed on the digital scale. A spoon was used either to add or remove the powder until the required weight was achieved. The final quantity was then put in a dry plastic tin and securely tightened. The tin was only opened and emptied into a glass to make a solution.

2.11.4 Anthropometric measurements

All the equipment used in anthropometric measurements were checked and calibrated before starting measurements according to the manufacturers' recommendations. Weight taking equipment was checked for accuracy by use of standard weights. Measurements were carried out in repeatedly after which the average was calculated. The correct size of blood pressure cuff was used for individual participants.

2.12 Classification of subjects' glucose metabolism status

Study participants were classified in different glucose metabolism status categories depending on their previous history of diabetes, fasting and post prandial glucose results. For example subjects were classified as known diabetics if they were already on antidiabetic treatment following diagnosis by a medical professional. These classifications were based on the WHO, 1999 revised criteria.

2.12.1 Impaired Glucose Tolerance (IGT)

A participant was classified as an IGT if his/her 2 hour OGTT values ranged between 7.8 and 11.1 mmol/L. He/she could also be classified as IGT if the fasting blood glucose values were less than 7.0mmol/L.

2.12.2 Impaired Fasting Glucose (IFG)

A participant met this classification if his/her fasting plasma glucose levels were greater or equal to 6.1 mmol/L and less than less than 7.0 mmol/dL and/or 2 hour post glucose challenge plasma value of <7.8mmol/L.

However, these classifications differ from that of the ADA as appears in the table below.

2.12.3 Normal/Euglycaemia

Participants whose fasting blood glucose profiles were below 5.6mmol/L and below 7.0mmol/L were classified as normal subjects.

2.13 Data Documentation and Transcription

2.13.1 Sub problem one with its data and measurements

This sub problem examined the relationship between family history of diabetes in order to identify the risk of respondents.

The information required for this sub problem was family health history with particular reference to diabetes. Other related family diseases with cardiovascular risk potential such as hypertension and high cholesterol levels amongst family members were also sought. This enquiry was based on assumption that genetic factors play a role in the etiology of diabetes. This means that if one of the parents suffered from diabetes, the off-spring or those that follow within the generation could possibly develop the disease. A detailed systematic inquiry by use of a simple structured questionnaire was used to obtain this data. The family health history of the respondents as well as that of their entire generation was obtained to determine whether the respondents biological or extended family members had diabetes. Such information was used to make associations with the participants' current health status in terms of glucose metabolism. For example, if some participants were found to be diabetic or impaired glucose tolerant against a history of their biological diabetic parents, associations could be made between their diabetic state and that of their parents. A participant was said to have a

positive family history of a disease as evidenced by the presence of that particular disease in a parent or sibling as suggested by Schachinger, Britten, Elsner, Walter, Scharrer and Zeiher (1999). In this case, a participant had a positive family history of diabetes if his/her biological parents or siblings were diagnosed with diabetes.

2.13.2 Sub problem two with its Data and Measurements

This sub problem investigated the relationship between lifestyle factors such as alcohol consumption and cigarette smoking in order to explain their role in the etiology of Impaired glucose tolerance and diabetes.

Data required for this sub problem was the lifestyle habits of the participants. Of particular interest was alcohol consumption and cigarette smoking.

2.13.2.1 Alcohol Consumption

In order to obtain this data, a questionnaire designed with multiple relevant questions on alcohol was used. A participant was required to indicate the type of alcohol he/she drunk, quantity, frequency and duration.

Information generated on the questionnaire was thereafter coded and entered into an excel data capture sheet. Every question bore a different code so as to differentiate them. The average alcohol intake per day was calculated in grams. By so doing, it was possible to determine the amount of alcohol consumed regardless of brand. The calculations were based on the alcohol concentration in that particular drink per every 100mls. For example a drink whose alcohol concentration is 5.2 % was calculated as 5.2 multiplied by the volume of the drink and divided by 100ml (5.2x750mls)/100=39grams. The average alcohol content for most of the South African alcoholic drinks is 5.0, 12 and 15-40% for beers, wines and spirits respectively. Three categories of drinking were classified as light, moderate, and heavy drinker. Light drinkers were subjects that drank between 0.1-10g, while the moderate drinkers consumed between 10.1-30g, (Wandell *et al.*, 2006). Subjects consuming more than 30g of alcohol per day were classified as heavy drinkers. Subjects falling in these categories were then correlated with diabetes to see if any category was a risk factor for diabetes.

2.13.2.2 Validation of alcohol consumption data

The alcohol data was validated by measuring the gamma glutamyl transferase (GGT) enzyme levels. Gamma glutamyl transferase is an enzyme found on cell surfaces but whose concentrations are highest in the liver. Normal serum GGT levels range between 0-50 IU/L. Serum levels of GGT are thought to be raised due to certain medical conditions among which are increased alcohol consumption. Gamma glutamyl transferase has been used widely as a biochemical marker for determining or conforming alcohol consumption (Hietala, Puukka, Koivisto, Anttila and Niemela, 2005). Other factors to consider in elevated GGT are liver diseases and use of drugs that are toxic to the liver as noted by (Lee, Evans, Robins, Wilson, Albano, Fox, Wang, Benjamin, D'Agostino & Vasan, 2006). In this study, GGT as determined on the fasting blood sample was used to validate the alcohol consumption status of participants as indicated in the questionnaire.

2.13.2.3 Cigarette Smoking

Data regarding cigarette smoking was also obtained using a structured questionnaire. Questions inquiring into a participants smoking pattern were developed and incorporated into the general questionnaire. The questions asked were whether the participant smoked, the quantity, the frequency and the duration of smoking. Such information was used to classify subjects as current, previous or non-smokers. After coding and entering the data on the excel database in their respective columns, the amount of cigarettes were then calculated per day per individual. Three categories of cigarette smoking were generated for purposes of being able to correlate subjects falling under each of these categories to see if any of the categories was a risk factor for diabetes. The following categories were generated, current smoker, previous smoker and non-smoker.

2.13.2.4 Validation of smoking data

Validation of smoking data was performed by measuring urine cotinine levels of the participants. Cotinine is a substance that is found in tobacco and can be detected in urine or blood of an individual. People who smoke cigarette could retain cotinine in the blood. Although non smokers could also have some levels of cotinine in their blood, especially if they stay in a smoking environment, high levels of urine cotinine do signify tobacco smoking (Wall, Johnson, Jacob & Benowitz, 1988)

2.13.3 Sub problem three with its Data and Measurements

This sub problem analyzed the association between high fat diet with IGT and diabetes with reference to the body mass index (BMI). Anthropometric measurements have been used in various studies and found to be a useful tool in determining the risk for developing type 2 diabetes. The location of fat on the body significantly determines the risk of developing type 2 diabetes. For example Allen, Allen, Boyd and Alston-Mills (2003) state that central obesity is associated with insulin resistance, which eventually results in hyperinsulinaemia. Over time, one develops IGT and diabetes mellitus.

2.13.3.1 Data required, how and where it was obtained

Data required for this sub problem was sought from both the questionnaire and anthropometric measurements. Different types of diets have been linked to an alteration in size or mass which eventually become a predisposing factor to the development of IGT and type 2 diabetes (Meira, 1998).

A dietary questionnaire developed by the dietetics department of the University of the Western Cape was used to obtain information regarding dietary lifestyle of participants. Although a dietary recall might not be very efficient in determining dietary lifestyle, it generally provides information on the average diet. In the dietary questionnaire, different types of foods were listed with different frequencies of possible consumption. A participant was then asked to indicate how frequently he/she ate a certain type of food. Emphasis was put on how often subjects ate foods with high fat content. The duration of consumption was also recorded.

2.13.3.2 Transcription of dietary data

Classifications for fat containing foods such as French fries, doughnuts, chips and high fat butter and margarine were created. This classification was based on the dietitians classification of the different foods. For example, the consumption of a certain food type on daily basis, or 1-4 times a week was classified as regular consumption, while consumption of the same food type for between 1-3 times in a month was classified as seldom. Those that never consumed that particular food type were classified as never. These classifications were then compared with the possible risk of developing diabetes.

2.14 Data analysis

All the data was captured in a data spread sheet, coded appropriately and later cleaned for any possible errors in a statistical package for social sciences (SPSS v.15). Analysis was performed using SPSS version 15. During data cleaning, more variables were created so as to facilitate association of variables. Clear values for various outcomes were determined before running frequency tests. Cross tabulation of variables was done to find any obvious associations. A multinomial regression analysis was performed to determine any risk factors for diabetes. Pearson chi square and Mann Whitney tests were performed to generate probability values for different associations. The data was presented as medians and percentages. All tests were performed at a 5% level significance, thus an association was significant if the value was less than 0.05 (P-value<0.05).

CHAPTER THREE
RESULTS

3.1 Characteristics of the study population
3.1.1 Demographic and anthropometric characteristics of participants

The study population was recruited randomly from Bellville South, Western Cape, South Africa as described in chapter two (materials and methods). Anthropometric measurements were performed by a trained health professional. The characteristics of the participants are summarized in table 3.1. In total 600 subjects (135 males and 465 females) had complete data with fully complete questionnaires, anthropometric measurements as well as blood and urine specimen examination, hence a response rate of 60% out of the expected 800(80%). Generally, the distribution of participants across age groups was similar, however female participation was significantly more prevalent than that of male, p< 0.01. Females had significantly higher BMI, waist and hip circumferences.

Table 3.1: Anthropometric characteristics of participants

| Characteristics | Age group | | | | | | | | |
| | 35-45 | | | 46-55 | | | 56-65 | | |
	Male	Female	P-value	Male	Female	P-value	Male	Female	P-value
Number (%)	41(20.8%)	156(79.%)	<0.001	43(21.7%)	155(78.3%)	<0.001	51(24.8%)	154 (75.2%)	<0.001
Weight (kg)	68.5(30.1)	75.3(31.3)	0.290	69(21.2)	78.7(23.3)	0.012	77.4(22.3)	73.4(22.2)	0.258
Height (m)	1.70(0.1)	1.56(0.08)	<0.001	1.69(0.1)	1.56(0.1)	<0.000	1.67(0.08)	1.56(0.09)	<0.000
BMI (kg/m^2)	24.4(11.6)	30.25(11)	<0.001	23.2(7.8)	31.2(9.1)	<0.000	27.8(7.3)	30.3(8.3)	0.002
Biceps (cm)	.60(1.17)	1.46(1.1)	<0.0001	0.58(0.4)	1.5(0.9)	<0.000	0.8(0.56)	1.4(1.05)	<0.000
Triceps (cm)	.80(0.94)	2.45(1.09)	<0.001	0.88(0.7)	2.5(1.2)	<0.000	1.05(0.9)	2.4(1.2)	<0.000
Subscapular (cm)	1.65(2.46)	2.94(2.0)	<0.001	1.6(1.2)	3.0(1.8)	<0.000	2.0(1.44)	2.9(1.9)	<0.000
Supra-Illiac (cm)	1.3(1.69)	2.59(1.78)	<0.0001	1.3(1.1)	2.5(1.5)	<0.000	2.0(1.3)	2.4(1.2)	<0.000
Waist Circumference (cm)	87.0(31)	97.0(25.0)	0.004	90.5(19)	100(19.7)	0.002	99(24)	97(18.5)	0.900
Hip cirmference (cm)	97.0(18)	111(22.6)	<0.000	98(11.8)	114(19.8)	<0.000	102.5(12)	110.7(19.2)	<0.000

3.1.2 Residence Duration, Education and Employment History

A validated questionnaire was used to collect the residence duration, education and employment data. As shown in table 3.2, most of the subjects have been living in this community for over five years, 574(95.7%). Majority of participants (86.5%) either do not have or have not completed high school education, and only 3.3% possessed post high school education (Table 3.3). Only 173 (28.8%) of the employable workforce had jobs with 3.9% of the participants being employed as professionals (Teachers, nurses and Engineers) (Table 3.4). Employable workforce was determined by subtracting pensioners (17.3%) and those who were reluctant to respond to this question (3.3%) from the total workforce 600(100%).

Table 3.2: Duration of Stay in Bellville South

Stay in Bellville	Frequency	Percent
Less than 6 months	18	3.0
Less than one year	4	0.7
Above five years	574	95.7
No answer	4	0.6
Total	**600**	**100.0**

Table 3.3 Highest Education obtained by participants

Education	Frequency	Percent
Primary school or less	208	34.7
High school (not completed)	311	51.8
High school graduate	50	8.3
College or Technical College(not completed)	3	0.5
College or Technical College graduate	11	1.8
University or Technikon(not completed)	5	0.8
University or Technikon graduate	9	1.5
No answer	3	0.5
Total	**600**	**100.0**

Table 3.4: Occupations of the study population

Occupation	Frequency	Percent
Non-Employable workforce		
Pensioners	104	17.3
No Answer	20	3.3
Total	**124**	**20.7**
Employable workforce		
Unemployed	307	64.5
Casual labourers	72	15.1
Professionals such as Teachers, Engineers, Nurses	19	3.9
Drivers	6	1.26
Students	5	1.05
Carpenters, Welders and Painters	8	1.68
Florists, Cell phone repairers, Shop Assistants	13	2.7
Self Employed	26	5.46
Clerks, Cashiers, Call centre Assistants,	20	4.2
Sub-Total	**476**	**79.3**
Total	**600**	**100**

3.1.3 Alcohol and Tobacco Consumption

Cigarette smoking was assessed by means of a questionnaire and validated by measuring urine cotinine levels of the respondents. Smoking status was classified according to whether an individual smoked or did not smoke. Past smokers were those that had stopped smoking, while non smokers were those that never smoked at all. On the other hand, alcohol classification was based on quantity of alcohol consumed per one sitting. Light drinkers were subjects that drank between 0.1-10g, while the moderate drinkers consumed between 10.1-30g, (Wandell *et al.*, 2006) Subjects consuming more than 30g of alcohol per day were classified as heavy drinkers.

Generally, males smoked more than females, p 0.001 and their cotinine levels were higher than those of their female counterpart across age groups. No significant differences were observed with regards to smoking and age category, however smoking showed a decreasing trend with increasing age (Table 3.4). Similarly, a biochemical test (GGT) was included to validate alcohol consumption data from questionnaires. Table 3.5 and figure 3.1 summarizes drinking patterns by gender and age, respectively. Heavy drinking though not significant, was more prevalent in females than males, $p < 0.052$. What is surprising though, is that GGT levels were significantly higher in males than females (Table 3.6). Furthermore, participants between the ages of 35 – 45 were shown to consume much more alcohol than the other age groups (Figure 3.1).

Table 3.5: Tobacco smoking status by gender and age category **Cotinine*** **Median and interquatile range values.**

	Age group in years					
	35-45		**46-55**		**56-65**	
	Male	Female	Male	Female	Male	Female
Current	26 (63.4%)	76(48.7%)	26(60.5%)	66(42.6%)	23(45.1%)	53(34.4%)
Stopped	3 (7.3%)	13 (8.3%)	5 (11.6%)	22(14.2%)	12(23.5%)	24(15.6%)
Not Smoking	12 (29.3%)	67(42.9%)	12(27.9%)	67(43.2%)	16(31.4%)	77(50.0%)
Cotinine*(ng/ml)	57.3(350.5)	38.1(36.2)	150.0(349.0)	9.0(374.0)	9.0(164.0)	9.0(233.7)
Total	**41**	**156**	**43**	**155**	**51**	**154**

Table 3.6: Level of alcohol consumption in males and females. **GGT*** **Median and interquatile range values.**

	Male	Female	P-value
GGT*(IU/L)	36.5(30.1)	26.1(23.8)	<0.0005
Heavy	53(39.3%)	76(16.3%)	**0.052**
Moderate	10(7.4%)	30(6.5%)	**0.002**
Light	2(1.5%)	6(1.3%)	0.289
Stopped	32(23.7%)	96(20.6%)	<0.0005
Non-drinker	38(28.1%)	257(55.3%)	<0.0005
Sub-total	**135(100%)**	**465(100%)**	
Total	**135(22.5%)**	**465(77.5%)**	
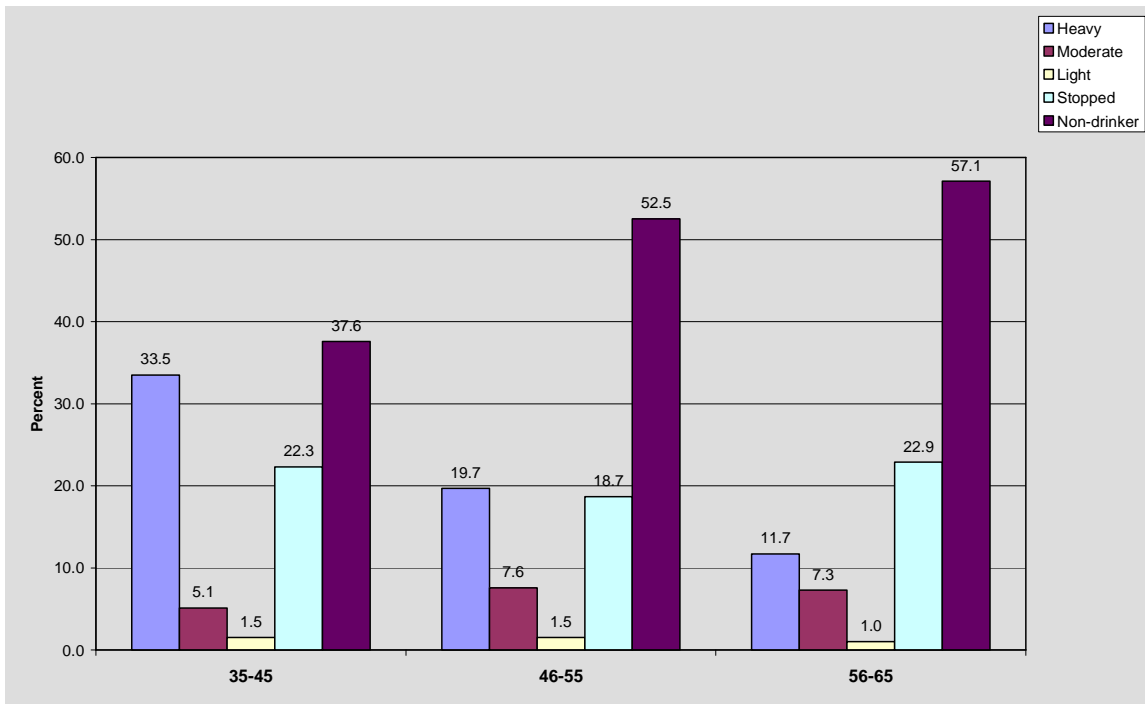
Figure 3.1: Level of alcohol consumption in different age groups. The participants were categorized according to the amount of alcohol consumed as described above. Drinking patterns between the age groups were investigated. Heavy drinking is higher in younger population group, ages 35-45.

3.1.4 Biochemical Assessment of participants

Table 3.7 shows the distribution of the respondents' biochemical characteristics in each age group across gender. Summary of the data is presented in terms of the median of the measurements of the respective characteristics and interquartile range being attached to describe the variability in the measurements. To test the equality of the distribution of the measurements for males and females in each age group, Mann-Whitney test was used and the corresponding p-value is provided. The insulin levels of females across age groups were significantly higher than that of males, $p < 0.05$. Females had higher total cholesterol in the 46-55 and 56-65 age group and lower HDL-C levels in the 35-45 and 46-55 age groups than males, but in the 56-65 age group, the HDL-C of females was significantly higher, $p < 0.05$.

Table 3.7: Biochemical characteristics of participants

	Age group								
	35-45 years			**46-55 years**			**56-65 years**		
	Male	Female	P-value	Male	Female	P-value	Male	Female	P-value
FBG (mmol/L	5.3(1.35)	5.3(1.0)	0.79	5.2(2.7)	5.7(1.0)	0.300	5.9(4.82)	6.0(2.8)	0.547
FSI (mmol/L	3.9(9.3)	8.35(10.6)	**0.007**	5.0(6.8)	7.9(10.7)	**0.046**	6.6(7.5)	8.3(9.8)	**0.048**
HbA1c(%)	5.6(0.7)	5.6(0.6)	0.736	5.6(1.0)	5.7(1.0)	0.569	6.0(1.4)	6.0(0.8)	0.624
CHOL (mmol/L)	5.06(1.56)	5.2(1.4)	0.343	5.66(1.11)	5.6(1.42)	0.586	5.5(1.6)	6.06(1.76)	**0.003**
TG (mmol/L)	1.19(0.91)	1.12(0.74)	0.412	1.38(0.81)	1.3(1.07)	0.654	1.6(1.0)	1.36(0.94)	0.337
HDL(mmol/L)	1.22(0.6)	1.14(0.41)	0.453	1.1(0.43)	1.2(0.4)	0.314	1.0(0.25)	1.25(0.39)	**0.001**
LDL(mmol/L)	3.25(1.14)	3.4(1.2)	**0.046**	3.4(1.3)	3.7(1.2)	0.211	3.6(1.4)	4.0(1.5)	**0.002**
SBP (mmHg)	118(18.5)	115(24)	0.497	126(17)	118(22)	**0.021**	125(21)	124(26)	0.395
DBP (mmHg)	75(13.5)	76(18.75)	0.679	81(13)	73.5(16)	**0.010**	76(17)	73(15)	**0.070**
Cotinine (ng/ml)	57.3(350.5)	38.1(36.2)	0.570	150.0(349.0)	9.0(374.0)	0.479	9.0(164.0)	9.0(233.7)	0.742
GGT (IU/L)	39(38)	28(29.2)	**0.004**	38(30)	25(22)	**0.001**	32.5(21.7)	25(20.2)	**0.005**

FBG: fasting blood glucose; FSI Fasting serum insulin; CHOL: cholesterol; TG: triglycerides; HDL: HDL-cholesterol; LDL: LDL-cholesterol GGT: Gamma Glutamyl Transferase ; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

3.2 Prevalence of Diabetes Mellitus

The WHO and ADA criteria were used to classify subjects as being, IFG, IGT or Diabetic. The overall prevalence of diabetes is shown in figure 3.2. The prevalence of diabetes did not vary between the criteria used. Overall the prevalence of diabetes was 154 (25.6 %) of which 77 (12.8 %) were newly diagnosed and 77 (12.8%) were known diabetics. IGT was present in 4.0% whilst IFG was in 29.8% using the ADA criteria. Generally females were more affected than males and diabetic prevalence increased with age (Table 3.8)
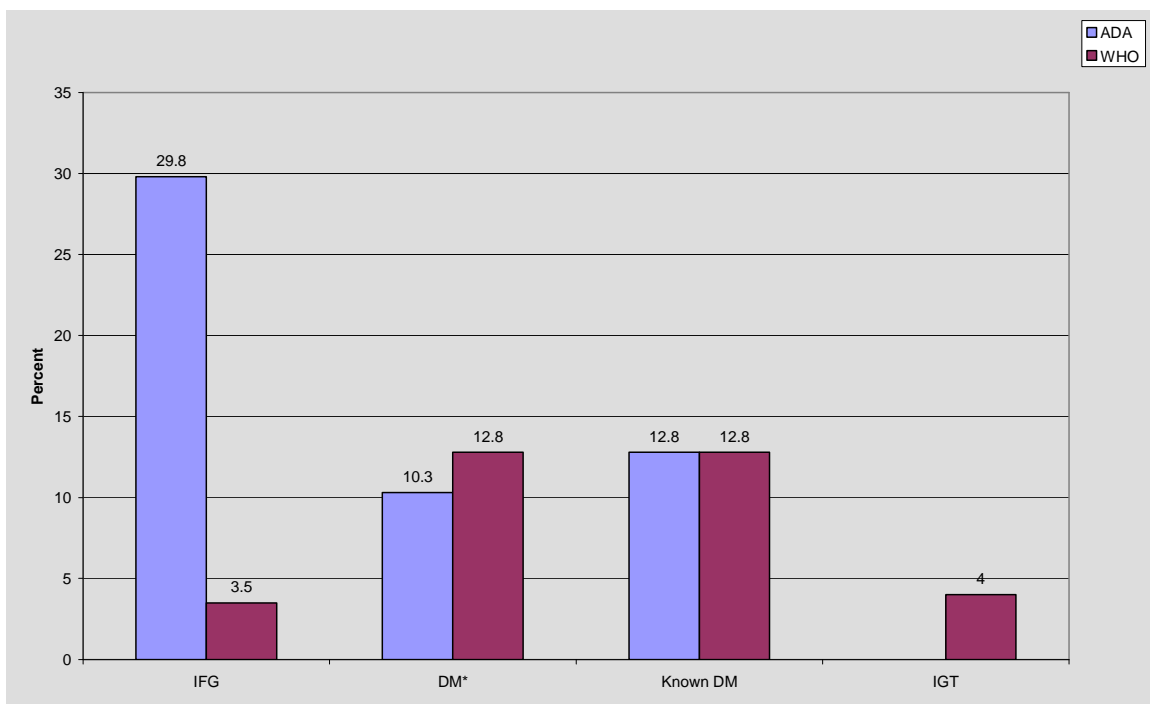
Figure 3.2: Prevalence of Impaired Fasting Glucose, Impaire Glucose Tolerance and Diabetes mellitus**.** The overall prevalence of diabetes was 25.6% and those diagnosed during the present study were 12.8%.

Table 3.8: Prevalence of diabetes by gender and age.

| | Age group | | | | | | |
| | 35-45 years | | 46-55 years | | 56-65 years | | |
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Total Prevalence**
WHO Criteria							
Impaired Fasting Glucose	1 (2.4%)	10 (6.4%)	1 (2.3%)	5 (3.2%)	0(0%)	4 (2.6%)	21 (3.5%)
Impaired Glucose Tolerance	0(0%)	6 (3.8%)	0(0%)	3 (1.9%)	3 (5.9%)	12 (7.8%)	24 (4.0%)
Newly diagnosed Diabetes Mellitus	4 (9.8%)	13 (8.3%)	5 (11.6%)	20 (12.9%)	3 (5.9%)	32 (20.8%)	77 (12.8%)
Known Diabetes Mellitus	6 (14.6%)	8 (5.1%)	8 (18.6%)	12 (7.7%)	16 (31.4%)	27 (17.5%)	77 (12.8%)
ADA Criteria							
Impaired Fasting Glucose	6 (14.6%)	49 (31.4%)	5 (11.6%)	55 (35.5%)	16 (31.4%)	48 (31.2%)	179 (29.8%)
Newly diagnosed Diabetes Mellitus	3 (7.3%)	10 (6.4%)	4 (9.3%)	15 (9.7%)	3 (5.9%)	27 (17.5%)	62 (10.3%)
Known Diabetes Mellitus	6 (14.6%)	8 (5.1%)	8 (18.6%)	12 (7.7%)	16 (31.4%)	27 (17.5%)	77 (12.8%)

3.3 Factors associated with the development of diabetes

3.3.1 Family History

Presence of a family history of diabetes was significantly associated with diabetes in the offspring, $p < 0.001$ as only 5.1% of individuals with a family history did not have either diabetes, IFG or IGT (Table 3.9). Also in this study, the family history of diabetes, hypertension and cardiovascular diseases (CVD) of participants' first and second degree relatives was assessed and the results are summarized in table 3.10. Family history of hypertension or CVD was not associated with diabetes, (Table 3.10).

Table 3.9: Cross tabulation of family history of diabetes in diabetic and normal subjects.

History DM	DM	IFG	IGT	Normal	Total
Yes Count % within History DM	74 (93.6%)	0 (0%)	1 (1.3%)	4 (5.1%)	79 (100.0%)
No Count % within History DM	75 (14.5%)	21 (4.0%)	23 (4.4%)	395 (76.1%)	519 (100.0%)
Total Count % within History DM	77 (12.9%)	21 (3.5%)	24 (4.0%)	399 (66.7%)	598 (100.0%)

Table 3.10: Family history of Diabetes, hypertension and cardiovascular disease amongst participant**s**

		DM	IFG	IGT	Normal	Total
History of Diabetes		No (%)	No (%)	No (%)	No (%)	No (%)
Father	Yes	25 (39.7%)	2(3.2%)	0(0%)	36(57.1%)	63 (100.0%)
	No	129(24.0%)	19(3.5%)	24(4.5%)	365(68.0%)	537(100.0%)
Mother	Yes	37(31.1%)	7(5.7%)	3(2.5%)	72(60.5%)	119(100.0%)
	No	117(24.3%)	14(2.9%)	21(4.4%)	328(68.3%)	480(100.0%)
Maternal-Grand Parents	Yes	19(45.3%)	2(4.8%)	0(0%)	21(50.0%)	42(100.0%)
	No	135(24.2%)	19(3.4%)	24(4.3%)	380(68.1%)	558(100.0%)
Paternal Grand Parents	Yes	9(28.2%)	0(0%)	0(0%)	23(71.9%)	32(100.0%)
	No	145(25.5%)	24(4.2%)	24(4.2%)	378(66.5%)	568(100.0%)
History of Hypertension						
Mother	Yes	56(24.9%)	10(4.4%)	8(3.6%)	151(67.1%)	225(100.0%)
	No	98(26.3%)	11(2.9%)	16(4.3%)	250(66.7%)	375(100.0%)
Father	Yes	26(29.2%)	2(2.2%)	2(2.2%)	59(66.3%)	89(100.0%)
	No	128(25.0%)	19(3.7%)	22(4.3%)	342(66.9%)	511(100.0%)
Grandparents	Yes	10(32.3%)	1(3.2%)	1(3.2%)	19(61.3%)	31(100.0%)
	No	144(25.3%)	20(3.5%)	23(4.0%)	382(67.1%)	569(100.0%)
History of CVD						
Mother	Yes	32(26.9%)	2(1.7%)	4(3.4%)	81(68.1%)	119(100.0%)
	No	122(25.4%)	19(4.0%)	20(4.2)	320(66.5%)	481(100.0%)
Father	Yes	29(25.3%)	2(2.7%)	1(1.3%)	53(70.7%)	75(100.0%)
	No	135(25.7%)	19(3.6%)	23(4.4%)	348(66.3%)	525(100.0%)
Grandparents	Yes	7(19.5%)	2(5.6%)	0(0.0%)	27(75.0%)	36(100.0%)
	No	147(26.1%)	19(3.4%)	24(4.3%)	374(66.3%)	564(100.0%)

3.3.2 Body Mass Index and diabetes

Body mass index (BMI) was calculated as weight (kg)/height (m^2). Participants' body weight classifications were based on the criteria described by the WHO, 2000 Body weight Classification. According to the WHO Body Weight classification, normal weight is BMI less than $25kg/m^2$; overweight is BMI $25kg/m^2$-$30kg/m^2$; while BMI > $30kg/m^2$ is obese. Although overweight did not differ significantly between males and females, females were significantly more obese than males across all age groups 35-45 years, 46-55 years and 56-65 years, P-values=0.002 and 0.000 and 0.031 respectively (figure 3.3). Fifty seven percent of diabetic individuals were obese whilst 27.6% were overweight (Table 3.11).
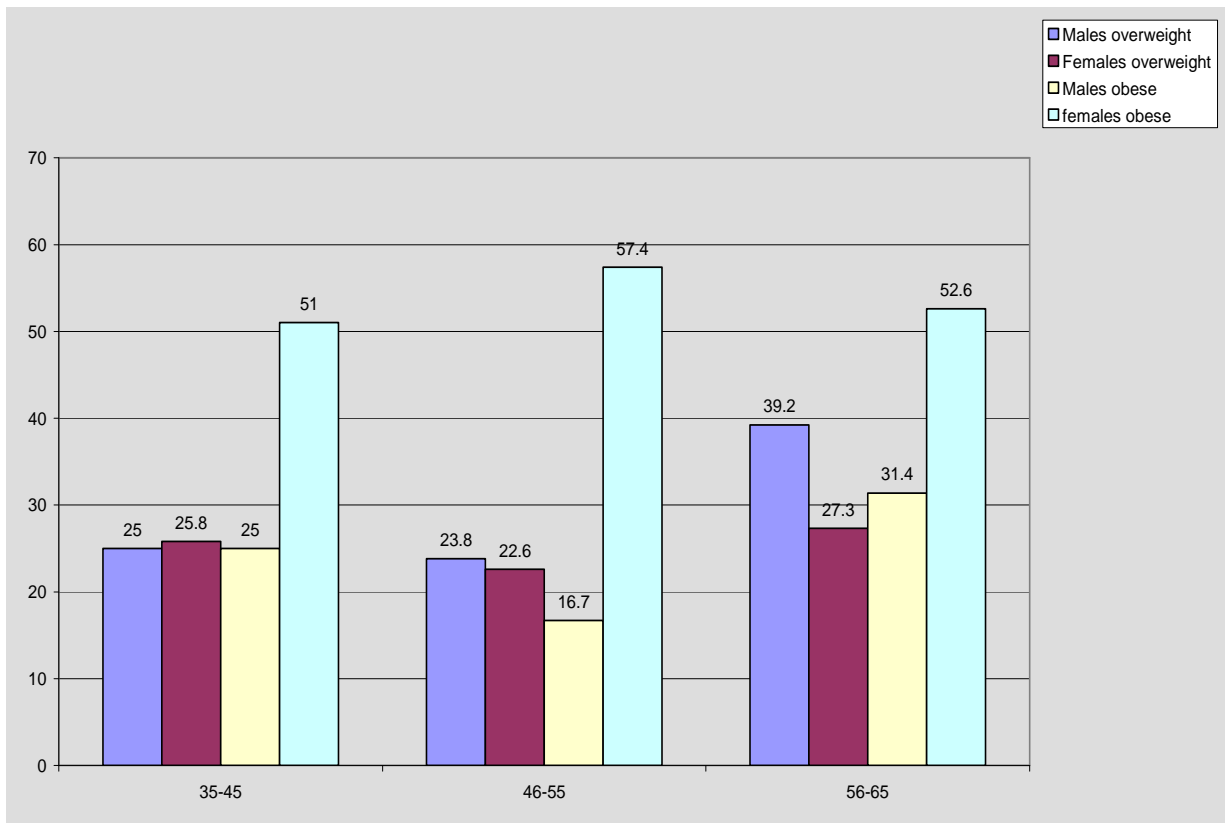
Figure 3.3: Distribution and classification of weight in the different age groups

Table 3.11: The weight status of the diabetic individuals

	35-45 years				46-55 years				56-65 years				Total	
	Male		Female		Male		Female		Male		Female			
	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)	No	(%)
Normal weight	1	(5%)	1	(2.8%)	4	(16%)	3	(9.7%)	4	(26.7%)	10	(32.3%)	23	(15.2%)
Overweight	4	(40%)	6	(15%)	3	(30%)	7	(20%)	7	(35%)	15	(35.7%)	42	(27.6%)
Obese	4	(40%)	14	(17.7%)	5	(69.5%)	22	(24.7%)	8	(50%)	34	(41.9%)	87	(57.2%)

3.3.3 Smoking and Alcohol Consumption

Cross tabulation of smoking and alcohol consumption showed no differences between those that do not smoke or drink and those that do. Table 3.12. Cross tabulation of alcohol consumption also showed no differences between those that drink and those that don't drink.

Table 3.12: Cross tabulation of smoking and development of diabetes

Age Group and Gender	Smoking status	Normal	DM	IFG/IGT	Total
35-45 Male	Currently Smoking	18(69.2)	7(26.9%)	1(3.8%)	26(100.0%)
	Stopped Smoking	2(66.7%)	1(33.3%)	0(0%)	3(100.0%)
	Non-Smoker	10(83.3%)	2(16.7%)	0(0%)	12(100.0%)
35-45 Female	Currently Smoking	59(77.3%)	11(14.5%)	6(7.9%)	76(100%)
	Stopped Smoking	9(69.2%)	2(15.4%)	2(15.4%)	13(100.0%)
	Non-Smoker	51(76.1%)	8(11.9%)	8(11.9%)	67(100.0%)
46-55 Males	Currently Smoking	19(73.1%)	7(26.9%)	0(0%)	26(100.0%)
	Stopped Smoking	4(80.0%)	1(20.0%)	0(0%)	5(100%)
	Non-Smoker	6(50.0%)	5(41.7%)	1(8.3%)	12(100.0%)
46-55 Females	Currently Smoking	52(78.8%)	13(19.7%)	1(1.5%)	66(100%)
	Stopped Smoking	18(81.8%)	3(13.6%)	1(4.5%)	22(100.0%)
	Non-Smoker	45(67.2%)	16(23.8%)	6(9.0%)	67(100.0%)
56-65 Males	Currently Smoking	15(65.2%)	7(30.4%)	1(4.3%)	23(100.0%)
	Stopped Smoking	5(41.7%)	6(50.0%)	1(8.3%)	12(100.0%)
	Non-Smoker	9(56.2%)	6(37.4%)	1(6.2%)	16(100.0%)
56-65 Females	Currently Smoking	30(56.6%	18(34.0%)	5(9.4%)	53(100.0%)
	Stopped Smoking	12(50.0%)	10(41.7%)	2(8.4%)	24(100.0%)
	Non-Smoker	37(48.1%)	31(40.3%)	9(11.2%)	77(100.0%)

Table 3.13: Alcohol Consumption and Diabetes Mellitus

Gender	Classification of Drinking	Normal	DM	IFG/IGT	Total
Male	Light Drinker	2(100.0%)	0(0%)	0(0%)	2(100.0%)
	Moderate Drinker	7(70.0%)	3(30.0%)	0(0%)	10(100.0%)
	Heavy Drinker	37(69.8%)	14(26.4%)	2(3.8%)	53(100.0%)
	Stopped Drinking	20(62.5%)	10(31.3%)	2(6.2%)	32(100.0%)
	Non- Drinker	22(57.9%)	15(39.5%)	1(2.6%)	38(100.0%)
Total		88(65.2%)	42(31.1%)	5(3.7%)	135(100.0%)
Female	Light Drinker	5(83.3%)	1(16.7%)	0(0%)	6(100.0%)
	Moderate Drinker	21(70.0%)	8(26.7%)	1(3.3%)	30(100.0%)
	Heavy Drinker	56(73.7%)	15(19.7%)	5(6.5%)	76(100.0%)
	Stopped Drinking	68(70.8%)	21(21.9%)	7(7.3%)	96(100.0%)
	Non- Drinking	163(63.4%)	67(26.1%)	27(10.5%)	257(100.0%)
Total		313(67.3%)	112(24.1%)	40(8.6%)	465(100.0%)

3.3.4 Relative risk for various factors associated with diabetes Mellitus

A multinomial regression analysis was used to determine the adjusted odds ratio for diabetes by adjusting for other factors such age, sex, family history of diabetes, cotinine and GGT levels, weight and lipid levels. The fathers family history of diabetes was associated with the development of diabetes (odds ratio = 2.092, 95% CI 1.109 – 3.949, p = 0.023) (Table 3.13). HDL cholesterol levels and younger age groups of 35-45 and 46-55 were negatively associated with diabetes, (0.320, 0.147-0.697, P-value=0.004 and 0.311, 0.176-0.548, P-value=0.000 and 0.430, 0.261-0.707, P-value=0.001) respectively.

Table 3.14: Relative risk as expressed by odds ratios for various factors associated with diabetes mellitus

Factor	Odds ratio	Confidence Interval (CI)	P value
WC (cm)	1.024	0.995 – 1.053	0.106
BMI	1.016	0.957 – 1.079	0.598
GGT(IUL)	1.002	0.998 – 1.006	0.303
Urine Cotinine(ng/mL)	1.000	0.999 – 1.001	0.801
TG(mmol/L)	1.156	0.945 – 1.413	0.158
HDL (mmol/L)	0.320	0.147 – 0.697	**0.004**
LDL (mmol/L)	1.032	0.838 – 1.272	0.765
Age 35 - 45	0.311	0.176 – 0.548	**0.000**
Age 46 - 55	0.430	0.261 – 0.707	**0.001**
Sex	1.215	0.702 – 2.103	0.486
Mother History DM	1.195	0.712 – 2.006	0.501
Father History DM	2.092	1.109 – 3.949	**0.023**

CHAPTER FOUR
DISCUSSION OF RESULTS

The objective of this research was to determine the prevalence of impaired glucose tolerance and diabetes and also to identify lifestyle risk factors that contribute to the development of diabetes mellitus.

In this project we provide evidence that the crude prevalence of diabetes is extremely high (25.6%) in the coloured population of Bellville South, Western Cape, South Africa. Although no data on the prevalence of diabetes is available on this community, a comparative association can be made with that of the Mamre community in Malmesbury, Cape Town since it is also a coloured and a hormogenous population although it is peri-urban. Results from this study found the prevalence be 10.8 % (Levitt *et al.*, 1999). Results from this study reveal the highest prevalence rates of diabetes in Africa amongst the middle aged population as previous epidemiological studies have only reported 1.1% in Tanzania, 1.4 in Cameroon, 6.8% in Nigeria and 7.7% in South Africa between 1985-2003. A study on the Cape Town coloured population that found higher prevalence than that in this survey was conducted by Charlton *et al.*, (1997) in which a prevalence of 28.7% was found. However, this study was conducted on the elderly population. Results from our study seem to agree with the predicted rise in the prevalence of diabetes as reported by the WHO and ADA. Other recent studies have also shown an increasing prevalence of diabetes. For example, (Hussain, *et al.*, 2007; Ramachandran, *et al.*, 2002) observed a rise in diabetes prevalence from 2.3% to 6.8% over a period of five years amongst the population of Bangladesh and Southern India.

The present prevalence indicates a more than two fold rise, from 10.8% in 1999 to 25.6% in 2008. From our results, this rise can be attributed to the genetic predisposition of the population to diabetes since off springs diabetic fathers were more likely to develop the disease, (Table 3.14). Another attributable factor is age since it was found that middle and advancing age were a risk factor for developing diabetes mellitus, (table 3.14). Although our odds ratio did not show BMI as a risk factor for development of diabetes, table 3.11 shows that 87(57.2%) of the diabetic participants were obese which could also explain the current diabetes prevalence. Other population based studies have further demonstrated a rise in the global trend of type 2 diabetes mellitus. Dunstan, Zimmet, Welborn, Courten, Cameron, Sicree, Dweyer, Colagiuri, Jolley, Knuiman,

Atkins, Shaw (2002) reported findings from an Australian population based study in which the prevalence of diabetes had more than doubled since 1981. Findings from this study reflected an overall diabetes prevalence of 7.4%. This prevalence can be comparable to that of South Africa which was 7.7% at the time (Chronic Diseases of Lifestyle in South Africa, 2005). In the USA, the Pima Indians who reside in Arizona have the highest prevalence of diabetes 38% (Schulz *et al.*, 2006). The association between findings made by Schulz *et al.*, (2006) and those in our study is that both have a strong family history linkage as well as the ageing factor. Considering the level of industrialization of the USA and that of South Africa, it can be argued that the prevalence rate of diabetes reported in this study is comparable to that of USA. However, what is of great contrast is the age of onset of diabetes. Whereas the age of onset of diabetes among the Pima Indians is much lower (5-19years) (Schulz *et al.*, 2006). In our study the youngest age group was 35 years.

Some of the typical presenting signs and symptoms of diabetes are excessive thirst, passing of large volumes of urine and frequent desire to eat. It is on the basis of these and also by laboratory confirmation that most individuals are diagnosed. However, it is clear that diabetes may also present asymptomatically (Hodgson *et al.*, 1999; Costa *et al.*, 2007). This means that individuals may have undiagnosed diabetes which is harmful to their health. What is of greatest concern is that half of the crude prevalence of diabetes 77(12.8%) was only diagnosed during the project, while many of them had impaired glucose metabolism which is known to precede diabetes. This therefore supports the assumption that many individuals have undiagnosed diabetes. This is not the first study to find such high prevalence of undiagnosed diabetes. Hadaegh *et al.* (2008) found a high prevalence of undiagnosed diabetes amongst Iranian urban population. Hadaegh also found that the predicted prevalence of diabetes in that community for 2025 (6.8%) had far been surpassed before the time (8.1 in 2008). The WHO (2003) published a report in which it highlighted studies that had been conducted and found high prevalence rates of undiagnosed diabetes. Colagiuri, Dipdiet, Hussain, and Palu (2002) conducted a study in the Kingdom of Tonga which is found in the central Pacific. The overall prevalence of type 2 diabetes in this community was 15.1%, of which, only 2.1% had previously been diagnosed. Similarly, Hadaegh *et al.*, (1999) found a prevalence of undiagnosed diabetes in 10.4% compared to 21.7% of diagnosed diabetes. In view of the fact that individuals may have undiagnosed diabetes within their

communities, the WHO, (2003) recommended the implementation of policies at the different health care levels where screening of the population for diabetes would be encouraged. This is based on the understanding that there is a high prevalence of undiagnosed diabetes due to a latent asymptomatic period. The WHO also observed that a substantial proportion of newly diagnosed diabetic patients have evidence of microvascular complications.

The prevalence of diabetes in Bellville South community increased with age in both genders, but was more prevalent in the females. This phenomenon has already been described by several studies and clearly indicates that the older one becomes the higher the risk of developing type 2 diabetes, (Bonora, *et al.*, 2001; Charlton, *et al.*, 1997). This trend can be explained by the increase in BMI which also increase with age particularly amongst the males although females were more in number. For example 17.7% of females were obese in the 35-45 year age category whilst it had increased to 41.9% in the 56-65 year age category.

Epidemiological studies show that the development of type 2 diabetes takes place over a long period of time from the initial decline of insulin effectiveness ultimately progressing to frank diabetes when beta cell function collapses. The WHO published the new recommendations for diagnostic criteria for diabetes and included the categories of Impaired Glucose Tolerance (IGT) and Impaired Fasting Glucose (IFG). This classification was aimed at including subjects whose plasma glucose measurements were high but could not meet the criteria for diabetes, yet they had potential risk of progressing to diabetes. Studies reveal that the prevalence of IFG and IGT are increasing (Gokcel, 2003). What is strange in this study is that the prevalence of IGT was quite low (4.0%) although that of IFG was 29.8% (using the ADA criteria) which is in agreement with diabetes prevalence. It is possible that the IFG prevalence could have been influenced by participants not giving accurate information on their fasting status.

The global rise in the prevalence of diabetes is attributed to the worldwide rise in obesity. Obesity is one of the principal risk factors for type 2 diabetes. An excess of body fat, especially when concentrated within the abdomen, has a range of potentially harmful consequences, among which is inducing insulin resistance (WHO, 2003). In this study, more than 60% of the population studied were obese with the females exhibiting higher

rates compared to their male counterpart which is in agreement with findings by (Bonora *et al.*, 2004; Shera *et al.*, 1999). Further, obesity was significantly associated with diabetes which was also more prevalent amongst the females. (Table 3.11). This study therefore adds to the existing evidence that obesity is a risk factor for the development of diabetes and in particular to the population of Bellville South.

Obesity is the driving force of a condition known as metabolic syndrome. Metabolic syndrome is when several conditions occur together, including obesity, insulin resistance, diabetes or IGT, high blood pressure, and dyslipidaemia which is characterized by high total serum cholesterol, triglyceride, and low high density lipoproteins (HDL) and high low density lipoproteins (LDL). (Zimmet *et al.*, 2003). Several etiological mechanisms such as obesity, dyslipidemia, hypertension, microalbuminuria, and insulin resistance have been suggested to explain the clustering of metabolic syndrome. Metabolic syndrome is believed to contribute to cardiovascular disease as well as type 2 diabetes, (Ford *et al.*, 2002). HDL is synthesized in the liver and its role is to enable transportation of other lipids such as cholesterol and triglycerides within the water based blood stream to the liver for excretion. It is for this reason that it is referred to as "good cholesterol". According to the results, HDL was indeed negatively associated with diabetes (p.value=0.004). Generally the distribution of HDL cholesterol did not have a particular pattern amongst the different age groups though it was higher in females falling in the older age category (56-65) which is in line with results from other studies, (Campagna *et al.*, 1999) in which high HDL values were found to be protective for type 2 diabetes.

Insulin resistance and a positive family history have both been hypothesized to be significant risk factors in the development of type 2 diabetes. However, it is unclear whether these two factors serve as independent risk factors that may act through different pathways, or whether a positive family history increases risk through an effect on insulin resistance. Several studies have shown a link between family history with type 2 diabetes, an indication that genetic associations are possible, (Erasmus *et al.*, 2001; Arslanian *et al.*, 2005; Yanchun *et al.*, 2008). Results from this study also provide evidence of family history associations to type 2 diabetes. In particular, a positive history of diabetes in the fathers was significantly associated with type 2 diabetes as indicated by the odds ratio. Subjects that who had a positive history of diabetes in their mothers

and also maternal grandparents developed diabetes, P-values 0.030, and 0.004 respectively. These findings do agree with those made by Levitt *et al.*, (1999) in which a positive family history of diabetes was found to be significant risk factor for type 2 diabetes.

Socio-Economic factors are complex variables to consider when determining ones socio-economic status since several aspects are used. In this study, the level of education and occupation were used to consider socio-economic status. Data from the 2001 population census and statistics South Africa reveal that Bellville South is a low-middle income community with unemployment at 23.7%. In this study the rate of unemployment was more than 60%. Though SA unemployment is reported to be 23.2%, in this population it is actually higher. More than 80% of this population does not have a high school qualification, which limits chances of employment. From this observation, a possible association can be made between socio-economic status and diabetes. A possible explanation for this association is that low SES results in unemployment and consequently adoption of unhealthy eating habits such as consumption of high fat foods since they are found to be cheaper. The extremes of these lifestyles have been associated with poor glucose metabolism. In particular, consumption of high fat foods leads to obesity, which is a known risk factor for type 2 diabetes (Wandell *et al.*, 2006; Bjorn, 2003).

Additionally, low SES is associated with risky social behaviors such as smoking and drinking which have previously been linked to diabetes (Henk *et al.*, 2007; Will *et al.*, 2001). In this study, there was no statistical significance between alcohol intake and diabetes, p-value 0.303. More female heavy drinkers were found to be diabetic 15(19.7%) compared to the males, 14(26.4%). However what was of contrast was the higher GGT values exhibited by the males across all age groups as observed in table 3.7 suggesting that males were actually the heavy drinkers instead of females. Regarding smoking, males were more current smokers compared to the females across the three age groups. Generally more male current smokers were observed to be diabetics compared to the female. However, the odds ratio did not show smoking as a risk factor for the development of diabetes by measurement of urine cotinine (P=0.801). Results regarding the prevalence of smoking relate differently from those found by Wallbeek, (2002) in which the prevalence of cigarette smoking was 27% . The observed

rise in this study may be attributed to rise in population but could also be due to the high unemployment rate which could result in an adaptation of social habits like smoking and drinking. This notion is supported by findings from a study conducted by Montgomery, Cook, Bartley and Wadsworth (1998) in which smoking was associated with unemployment in participants. Our findings are also in agreement with the assumption that cigarette smoking is most prevalent amongst people of the mixed ancestry (coloured).

Similarly, results from our study also did not find any association between alcohol consumption and abnormal glucose homeostasis. While some studies including, Beulens, Stolk, Van Der Schouw, Grobbee, Hendriks & Bots (2005) and Young-Lee (2005) provide evidence regarding excessive alcohol consumption and its association with type 2 diabetes, low to moderate consumption has been associated with a protective effect (Scragg & Metcalf, 2005). However, other sources do acknowledge that despite the numerous studies on alcohol consumption, there still exists disparities in the association with diabetes (Kao, *et al*).

CHAPTER FIVE
CONCLUSION

5.1 Conclusion

The aim of this study was to determine the prevalence of impaired glucose tolerance and diabetes mellitus and the risk factors that predispose to its development amongst the middle aged population of Bellville South. According to the WHO, the prevalence of diabetes was predicted to increase with time and that the highest increase would be observed in the developing and resource poor countries. Epidemiological studies have shown that this is occuring. This study has revealed that the prevalence of diabetes mellitus has increased from 10.8% in Mamre which is a peri-urban community to 25.6% in Bellville South, an urban community within a period of about a decade amongst the Western Cape coloured community. However, this figure needs to be adjusted for global population so as to be comparable to the prevalence in mamre. In South Africa, people of Asian origin have been found to have the highest prevalence of type 2 diabetes. This is followed by the mixed ancestry population (coloured). This study was carried out on a coloured community and indeed shows a marked rise in the prevalence of type 2 diabetes.

Numerous studies have previously reported the role of family history and lifestyle factors as predisposing factors to the development of type 2 diabetes mellitus. Also urbanization which brings with it life style changes such as change in dietary consumption, cigarette smoking and alcohol consumption can increase the risk of developing diabetes. Sedentary habits that promote less energy expenditure but instead lead to obesity can result in impaired glucose metabolism and eventually diabetes. The aging population has also been reported to contribute to the global pandemic.

Our study has thus confirmed to the existing and increasing evidence that family history of diabetes particularly within the first degree relatives is a potential risk factor to the development of type 2 diabetes. The study also showed that age was a risk for the development of diabetes as more subjects became diabetic with advancing age.
Although no statistical significance was found between increased BMI and diabetes following odds ratio analysis, cross tabulation of weight and diabetes showed that more

obese subjects became diabetic as compared to the normal weight subjects particularly amongst the female gender who exhibited higher prevalence of obesity.

Diabetes mellitus poses a big economic burden on state resources not only in terms of finances but also manpower to care for the diabetic patients. The earlier the health policy makers are aware of the disease burden the better since it provides a basis for decision making regarding allocation of the necessary resources. This study has therefore served as an eye opener by bringing to light the fact that disease burden in South Africa needs to be reviewed routinely so as to correspond with the resource needs.

5.2 Limitations of the study

Results from this study gave valuable information regarding the diabetic prevalence in Bellville South. However, it was not without any limitations. One of the limitations in this study was the low participant response which resulted in a small sample size. According to the estimated sample size, one thousand participants were expected to turn up for the study. However, the response rate turned out to be 60 %(600 subjects).

Though the 80% power of the study was a sample of 1000 subjects, in this study, only 600 subjects met the randomization and inclusion criteria.

In this study, the volume of blood needed was high, which made it difficult for participants who were afraid of the needle prick.

Another limitation was the skewed gender representation. Female participants out numbered the males. Also, the major part of the study was conducted during the winter months. Therefore weather may have contributed to the low response rate as it was cold and rainy.

Age distribution of the participants was not even, leading to over representation of other age groups.

It was also observed that some participants did not observe the fasting instructions properly which was indicated by elevated values of the fasting blood glucose.

5.3 Areas of future work

Diabetes is associated with general systemic complications among which are cardiovascular disease. Data from this study also suggests a high mortality due to cardiovascular diseases specifically heart attacks. Areas of further exploration therefore are studies that will assess the status of both the newly diagnosed diabetic and the self reported individuals and also assess their risk for developing cardiovascular complications. By so doing, mortality and morbidity due to diabetes might be reduced.

The WHO considers IFG and IGT as being pre-diabetic states. Therefore, owing to the high prevalence of IFG amongst the 56-65 age group, there is a need for a follow-up study to evaluate the glucose metabolism status of these individuals. This is because IGT and IFG individuals are believed to progress into full blown diabetes years after diagnosis. The period within which this is likely to occur can not be ascertained. Such studies will not only estimate the period within which IGT subjects can progress to diabetes, but will also provide a guide on which intervention measures can be implemented to prevent progress of such individuals to full blown diabetes.

Furthermore the association between family history and diabetes strongly implicates a genetic role in diabetes development. Therefore, genetic studies that may identify sequence variations involved in diabetes are needed.

CHAPTER SIX
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APPENDICES

Appendix A: Survey Consent form

THE BELLVILLE SOUTH DIABETES SURVEY CONSENT FORM

Principal Investigators:	**Soita David Jonah**
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Contact Numbers:	**Mr DJ Soita – 072 555 8628** **Mr MS Hassan – 021 959 6274** **Prof Erasmus – 021 938 4107** **Dr Matsha – 021 460 3209**

Dear Participant,

You are being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff or doctor any questions about any part of this project that you do not fully understand.   It is very important that you are fully satisfied and that you clearly understand what this research entails and how you could be involved.   Also, your participation is entirely voluntary and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do initially agree to take part.

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This study has been approved by the Committee for Human Research at Cape University of Technology and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?

Worldwide new causes of certain diseases or conditions are continuously being discovered by research on the cells and molecules of the body. For research to be carried out on certain diseases it is necessary to first establish the incidence and prevalence of the disease. This project aims to determine the incidence and prevalence of diabetes and glucose intolerance. Additionally, this project aims to collect genetic material (blood) to analyze for certain variants and to store excess material for future research. When a large group of patients with similar diseases has been collected, meaningful research into the disease processes may become possible.

Why have you been invited to participate?

The prevalence of diabetes of diabetes in South Africa is not well documented and few studies have been conducted since 1994. Many subjects with diabetes are unknown to the health service, often because they are not yet diagnosed. In order to asses the magnitude of the problem, you have been approached to participate in this project to determine the incidence of diabetes amongst our adult population.

You have randomly been selected by means of a computer program to participate in the above-mentioned study. Adults of all races, gender, age (between ages 35 and 60 years) and weight will be approached as subjects.

What will your responsibilities be?

The participant will be requested to provide information about his/her medical history, family history and information on eating, drinking and smoking habits. Completion of the questionnaire will take no longer than 10 minutes. Measurement such as weight, height, waist and hip will be done. Fasting Venous Blood will be collected thereafter you will be

asked to drink a glucose solution (glucose content 75g). After two hours another venous blood will be collected. The blood will be used to determine whether you have diabetes or glucose intolerance. The other tests that will be determined from your blood sample are: Cholesterol and Triglycerides levels. The remainder of the blood sample will be used for genetic and future research studies. The DNA may be stored for several years until the technology for meaningful analysis becomes available. No pharmaceutical agent (medication) will be tested in the study.

Will you benefit from taking part in this research?

You will be notified of your glucose tolerance state or whether you are diabetic by the medical nurse or doctor. Thereafter, you will be referred to your local health centre or general practitioner for further investigations and treatment.

In the unlikely event that the research may lead to the development of commercial applications, the participant or the participant's heirs will not receive any compensation, but profits will be reinvested into supporting the cause of further research which may bring benefits to my/*the participant's family and to the community, such as health screening, medical treatment, educational promotions, etc.

Are there any risks involved in my taking part in this research?

A slight bruising might occur after blood has been drawn from the arm but this will heal quickly. After the administration of the glucose solution, you may feel nauseous and dizzy in which case you must notify the medical personnel. A medical nurse will be present on all occasions. In addition, the research team will be in contact with medical doctors should you need emergency care by a medical doctor.

Who will have access to your medical records?

The participant's identity will be kept confidential throughout. Information will not be associated with the participant's name. The research staff will use only a coded number, access will be limited to authorized scientists and any scientific publications, lectures or reports resulting from the study will not identify me/*the participant.

Some insurance companies may mistakenly assume that taking part in research indicates a higher risk for disease. Thus no information about you or your family will be shared with such companies.

Will you or your child be paid to take part in this study and are there any costs involved?

You will not be paid to take part in the study, but your transport, if required will be covered for each study visit. It is envisaged that you may be hungry since you would have come fasting, therefore, biscuits or fruit will be provided. There will be no costs involved for you if you take part in the project.

Is there any thing else that you should know or do?

You should inform your family practitioner or usual doctor that you are taking part in a research study.

You can contact *Prof Erasmus* **at Tel 938 4107 or rte@sun.ac.za** if you have any further queries or encounter any problems.

You can also contact the Committee for Human Research at **021 442 6162 or** engelhillssp@cput.ac.za

if you have any concerns or complaints that have not been adequately addressed by your study doctor.

You will receive a copy of this information and consent form for your own records if it is requested

DECLARATION BY PARTICIPANT:

I declare that:

I have read or had read to me this information and consent form and that it is written in a language with which I am fluent and comfortable.

I have had a chance to ask questions and all my questions have been adequately answered.

I understand that taking part in this study is voluntary and I have not been pressurized to take part.

I may choose to withdraw from the study at any time and will not be penalized or prejudiced in any way.

I may be asked to leave the study before it has finished if the study doctor or researcher feels it is in my best interests, or if I do not follow the study plan as agreed to.

I also consent that my blood may be:
- ♦ **Used and stored for future genetic research studies** ☐
- ♦ **Used and discarded** ☐

Signed at (*place*) ....…….......……………... on (*date*) …………....……….. 2007

Signature of participant------------------------------- Signature of witness-------------------

DECLARATION BY THE INVESTIGATOR

I *(name)* ………………..…………………………..……… declare that:

I explained the information in this document to (*Names of participant*)………………………………..………
I encouraged him/her to ask questions and took adequate time to answer them.
I am satisfied that he/she adequately understand all aspects of the research, as discussed above

Signed at (*place*) ....…….......……………... on (*date*) …………....……….. 2007.

Signature of investigator----------------------------- Signature of witness-------------------

Appendix B: List of Streets

1. Berol
2. Gershon
3. lorna
4. San Souci
5. Oop
6. Sousman
7. De Leeuw
8. Felix
9. Unie
10. Nicholas Arendse
11. Kirkia
12. Celtis
13. Cotton
14. Vloot
15. Sering
16. Rue Robert
17. Aaron Figaji
18. Hoek
19. Rue Ursula
20. Almeida
21. Mackenzie
22. Armada
23. Durham
24. Nicholls
25. Fritz
26. Martin Petersen
27. Prins
28. Kasselsvlei Road
29. Eendrag
30. Eendrag
31. Railway
32. Inspan
33. Kosmos
34. Mimosa
35. Erasmus
36. Stilwaney
37. David
38. William Taylor
39. Salix
40. Yellow wood
41. Plum
42. Waterberry
43. Caledon
44. De wet
45. Skool
46. Brand
47. Hercules
48. Jool
49. William Hartellaan
50. Hendrick Singel
51. Binne Singel
52. Croton Close
53. Arcadia
54. Ulmus
55. Iscor
56. Tulp
57. Rue Emmay
58. Otto Meyer
59. Fernwood
60. Maureen

61. Central drive(east west south north)
62. Glenhaven
63. Glen Carol Way
64. Vink
65. Plane
66. Lilac
67. Burkea
68. Nerina
69. Werda
70. Suker
71. Cupido
72. Prunus
73. Industrie
74. Tipo
75. Neethling
76. Raap
77. Dammert
78. Zimri
79. Herman Singel
80. Alder
81. Gallant
82. Lily/ Lelie
83. Nick Kearns
84. Pillay
85. Frank louw
86. Abdurahman

Appendix C: Invitation letter to participate in survey

**CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY**

**Faculty of Health and Wellness Sciences
Bellville South Diabetes Study**

From: Department of Chemical Pathology, Faculty of Health Sciences, University of Stellenbosch, Tygerberg Hospital,

P.O.Box 19113, Tygerberg, 7505

Department of Chemical Pathology, Tygerberg Hospital.

South Africa

Telephone number:

+27 21 938 4107

And Cape Peninsula University of Technology, Department of Health Sciences,

P.O.Box 1906 Bellville 7535, Cape Town

Telephone number:

+27 21 959 6274

Fax +27 21 959 6015

RE; INVITATION TO PARTICIPATE IN A RESEARCH SURVEY

The supervising team for the Impaired Glucose Tolerance and Diabetes study from the Cape Peninsula University of Technology and University of Stellenbosch do hereby invite you to participate in a Research Survey that will take place in Bellville South. As you may already be aware, the study targets individuals aged 40 years or older.

You will be expected to come to…………………………..……..on …..........at……..…which is the selected venue for participation.

You are requested to keep time and also observe the participation instructions as indicated on the consent form which you will be given later on.

Yours truly,

HOD

Appendix D: Letter of Introduction of research assistant to participant

**CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY**

**Faculty of Health and Wellness Sciences
Bellville South Diabetes Study**

From: Department of Chemical Pathology, Faculty of Health Sciences, University of Stellenbosch, Tygerberg Hospital,

P.O.Box 19113, Tygerberg, 7505

Department of Chemical Pathology, Tygerberg Hospital.

South Africa

Telephone number:

+27 21 938 4107

And Cape Peninsula University of Technology, Department of Health Sciences,

P.O.Box 1906 Bellville 7535, Cape Town

Telephone number:

+27 21 959 6274

Fax +27 21 959 6015

Date………………………………………….

RE; LETTER OF INTRODUCTION

The supervising team for the Impaired Glucose Tolerance and Diabetes study from the Cape Peninsula University of Technology and University of Stellenbosch do hereby introduce the bearer of this document Mr/Mrs/Ms/Sr……………………………..who is a bonafide staff working with the above mentioned research group.

He/She is currently involved in a research survey that is investigating the Prevalence of Diabetes in Bellville South.

Any assistance rendered to him during his duties will be highly appreciated.

Sincerely yours

HOD

Appendix E: Participant Referral Letter for further assessment

**CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY**

Bellville South Diabetes Baseline Study

Client Referral Note

Name…………………………………………….. Reference No………

Surname……………………………………………..

Date of Birth…………………………Address…………………………………

The following client is hereby referred to your facility for further investigation. He/she participated in the research study and his/her measurements were found to be as follows.

…………………………………………………………………………..
…..Fasting Glucose………………………….mmoL/L……………………
…..2 Hr OGTT Glucose………..……………mmoL/L…………………….
…………………………………………………………………………
…………………………………………………………………………

Attached also is a copy of his/her results

Your positive response will be highly appreciated

………………………….. ……………………

Prof. RT Erasmus Date of Referral

Tel. 021 938 4107

Appendix F: Letter of appreciation for participating in survey

**CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY**

Faculty of Health and Wellness Sciences

From: Department of Chemical Pathology, Faculty of Health Sciences, University of

Stellenbosch, Tygerberg Hospital,

P.O.Box 19113, Tygerberg, 7505

Department of Chemical Pathology, Tygerberg Hospital.

South Africa

Telephone number:

+27 21 938 4107

And Cape Peninsula University of Technology, Department of Health Sciences,

P.O.Box 1906 Bellville 7535, Cape Town

Telephone number:

+27 21 959 6274

Fax +27 21 959 6015

To: Participant No
………………… Avenue/Street, Bellville

Date:…………………………

RE; Appreciation for participation in Research Survey

The supervising team for the Impaired Glucose Tolerance and Diabetes study from the Cape Peninsula University of Technology and University of Stellenbosch do sincerely thank you for your participation in the above study.

Your participation was very important as it greatly contributed to the success of the study.

Thank you and regards

Yours truly,

HOD

Appendix G: Request for permission to release employee to participate in survey

**CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY**

**Faculty of Health and Wellness Sciences
Bellville South Diabetes Study**

From: Department of Chemical Pathology, Faculty of Health Sciences, University of

Stellenbosch, Tygerberg Hospital,

P.O.Box 19113, Tygerberg, 7505

Department of Chemical Pathology, Tygerberg Hospital.

South Africa

Telephone number:

+27 21 938 4107

And Cape Peninsula University of Technology, Department of Health Sciences,

P.O.Box 1906 Bellville 7535, Cape Town

Telephone number:

+27 21 959 6274

Fax +27 21 959 6015

To: …………………………..

Address…………………………………….

Date…………………………………….

**RE; REQUEST TO RELEASE YOUR STAFF TO PARTICIPATE IN A RESEARCH
SURVEY**

The supervising team for the Impaired Glucose Tolerance and Diabetes study from the
Cape Peninsula University of Technology and University of Stellenbosch do hereby
request you to allow your staff Mr./Mrs./Ms……………………………off duty
on……………He/She has been sampled as a participant in the up coming Diabetes
study due to take place between October 2007 to June 2008 in Bellville South. He/She
will be required to participate in the study for one day.

Your cooperation in this matter will be highly appreciated.

Sincerely Yours,

HOD

Appendix H: Specimen collection sheet

Day ……………………….. Date………………………...		BELLVILLE SOUTH DIABETES STUDY. SAMPLE COLLECTION RECORD SHEET							
Subjects Names	Ref. No	DOB	Time	Red Tube-Fasting	Grey Tube-Fasting	Purple Tube-Fasting	Urine Sample	Red Tube-2hr	Grey Tube-2hr

Appendix I: Participant information sheet

CAPE PENINSULA
UNIVERSITY OF TECHNOLOGY

BELLVILLE SOUTH DIABETES STUDY

INFORMATION SHEET

Invitation to participate in the study

We would like to invite members of the Bellville-South community who are aged 40 years or older, to participate in the above-mentioned research project conducted by the University of Stellenbosch, Cape Peninsula University of Technology and the University of the Western Cape.

What is the study about?

Diabetes, hypertension and cardiovascular diseases are increasingly common in our communities. Often people are not aware that they are at risk or that they might suffer from these conditions. The purpose of this research project is to provide an opportunity for early detection of people that are at risk and those who might already have the diseases. Furthermore this research project will then investigate various factors contributing to the development and management of these over a period of ten years. Diabetes is a health condition in which an individual's blood sugar is poorly controlled by the body because of various reasons. This results into increased blood sugar levels or occasionally reduced blood sugar levels which is dangerous for the body. Before one gets full blown diabetes, he/she develops signs suggesting that in future she/he might develop diabetes. This state is called Impaired Glucose Tolerance and can be identified early if routine screening is done to risky groups.

When some one develops diabetes, he/she is likely to get many complications such as;

➢ Kidney Diseases

➢ Eye diseases which could result into blindness

➢ Skin and foot infections

➢ Heart complications

Benefits of Participating in this Study

As one grows older, the chances of developing diabetes also increase. Since you are aged 40 years or older, it would be to your benefit since you would be informed whether you are at risk of developing Diabetes or not. You would also be advised by Professionals on lifestyle changes that would delay the onset and/or prevention of diabetes. For those who will be found to have undiagnosed diabetes, they will be referred for further examination and follow-up.

What will I need to do?

Should you be selected and agree to take part in the project:

- You will be asked to go to a central data collection site at ……………………… (between 7 – 9 am) of any day of the week (Monday – Friday) that is convenient to you.

- On the particular day of data collection that we will agree on, you should be fasting. That means that you should not eat or drink anything except water from 22:H00 the previous night.

- At the data collection site questions regarding general household information, family health history and health practices will be asked to you. This will take approximately ½ hour to complete.

- A nursing sister will then take your weight, height, measure the amount of fat in your body and take your blood pressure.

- A fasting blood sample will then be taken by health professionals using safe and sterile measures. If you have not previously been diagnosed as a diabetic, you will then be asked to drink a glucose solution and another blood sample will be taken after 2 hours to determine your body's reaction

to the glucose. This is called a glucose tolerance test. The blood samples will be used for tests linked to diabetes and its complications.

There is the possibility that you will be visited after the data collection by a dietician who will asked you questions about the food you usually eat and drink.

Over the next ten years we will interact with the Bellville South Community on a regular basis to repeat some of the measurements again (at least once a year). After ten years we will repeat the whole study and do all measurements again. At each and every time that we visit you again, you will have the choice to participate in the data collection or not.

Participation in this study will be voluntary and cost free, except for your time. All information will be confidential. Selection into the study will be on random basis. If you are not selected, but would also wish to have your health status determined, that will be arranged and your results will be communicated to you.

Do you have any questions?
If you need more information regarding the project, please feel free to contact the following people during office hours:

1. Sr. Irene ……Cell Phone 0827654163
2. Ms Bianca…..Cell Phone 0729581877
3. Mr. M.S Hassan… 021 9596274
4. Prof. R.T, Erasmus…021 938 4107
5. Mr D.J Soita..........Cell phone 0725558628

Appendix J: Other Social marketing strategies

The Community Health Centre

Kasselsvlei Community Health Centre is the public health facility offering health services to the population of Bellville South. Situated on one of the main roads, Kasselsvlei clinic is strategically located and thus easily accessible to many individuals living within Bellville South. For this reason, it was identified as one of the venues where the information regarding the study could be disseminated to the public.

The local Community Leaders

The existing community structural leadership was utilized in mobilizing the community for this project. Since they are constantly in contact as well as interacting with the community more easily, the local community leaders were able to pass on the information regarding the research project either during their meetings or any other time they had opportunity to speak to the people.

Religious and social Groups

The influence of all religious groups in delivering information about the Diabetes and Impaired Glucose Tolerance study was very important. With permission from the religous leaders, the information was passed on to the people during or after prayers highlighting key issues of the project. The aims and objectives of the study were further explained to the religious leaders for purposes of clarity in case the local community needed to know more during other prayer sessions.

Bellville South has several social groups with whom the local people identify with. Among these is the club of middle and elderly citizens who refer to themselves as the senior citizens. This club was vital in passing information from one person to another. Since members of this group were mainly senior citizens above the age of forty, it was assumed that they commanded great influence within the community enough to creat a positive impact regarding the project.

The street advertisement

The street advertisement popularly referred to as the "Road Show" is a social marketing strategy that was initiated in attempt to create diabetes awareness within the study population. On top of creating awareness, the road show was also intended to improve on the response rate by highlighting the objectives of the study. In this strategy, a highly

recognized member of the community was identified and invited to speak to the community members. By use of a public address system (megaphone) and on board a moving truck, the spokes person used brief but catching words to relay the message to the community members about diabetes. Such phrases as "You could be diabetic without knowing" and "Diabetes may lead to heart attack" were used to express the severity of diabetes. He was accompanied by the rest of the field team who alongside him issued fliers to the enthusiastic crowds that rushed to take a glimpse of the famous media actor. In this way, a big audience was able to be reached.

Appendix K: Procedure for Venipuncture

Phlebotomy

- Participants were identified by confirming their names and ages as indicated on their questionnaires.

- Upon determining the participant's physical characteristics, the necessary equipment was then assembled. For example a participant whose veins were clearly visible required use of a vacutainer needle and adopter for drawing blood instead of using a butterfly needle.

- With the participant sitting, the arm was appropriately exposed and the tourniquet applied 6-8 centimeters above the elbow joint of a fisted hand.

- The left hand was preferred.

- The area was cleaned with antiseptic and allowed to dry to avoid haemolysis.

- The vein was punctured using a vacutainer needle connected onto the adopter before inserting the vaccutainer tube.

- The vaccutainer tube was inserted and connected into the adopter and allowed blood to freely flow into it.

- The participant was asked to release the fist as soon as blood began flowing.

- After an adequate amount of blood was collected, the needle was drawn out and a cotton swab placed over the site and direct pressure applied to prevent bleeding.

- The needle was disposed off into the safety container.

Appendix L. Ethics approval Letter

Cape Peninsula University of Technology

14 January 2008
Ref: CPUT/HW-REC 2008/002

P.O. Box 1906 • Bellville 7535 South Africa •Tel: +27 21 442 6162 • Fax +27 21 447 2963
Symphony Road Bellville 7535

OFFICE OF THE CHAIRPERSON:
HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HW-REC)

At a meeting of the Health and Applied Sciences-REC on the 6 December 2007 ethics approval
was granted to David J Soita, for research activities related to the M Tech (............) at the Cape
Peninsula University of Technology, pending amendments which are now fulfilled.
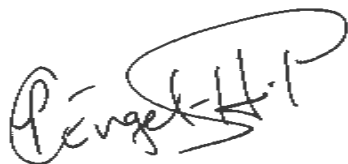
TITLE:
The prevalence of impaired glucose tolerance and diabetes amongst the middle aged population
residing in the Bellville South area of Cape Town.

Comment:
Research activities are restricted to those detailed in the ethics application submitted subsequent
to revisions requested on 6 December 2007. Ethics approval must be applied for anew should
further studies, utilizing the blood samples from participants in this study, be embarked on.

This ethics approval is granted to 31 December 2008. An extension must be applied for should
the study continue beyond this date.

Dr PENELOPE ENGEL-HILLS
CHAIRPERSON: HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE

e-mail: engelhillsp@cput.ac.za

Cape Peninsula
University of Technology

GLUCOSE INTOLERANCE AND DIABETES QUESTIONNIARE

Principal Investigator: **Soita David Jonah**

Name of Interviewer: **………………………….**

Date of Interview: **……./…..../…....**   **Ref No ……**

To the respondent:
Thank you very much for your willingness to participate in the completion of this questionnaire. The information obtained on this questionnaire will provide us with information on all the possible health, family, life style and dietary risk factors within your house hold that might influence the development of diabetes. This is because many health conditions develop slowly over time yet could be prevented if diagnosed early or if pre determined. This questionnaire therefore aims at getting information which may be used to determine the extent of diabetes and those likely to develop diabetes in the future. The questionnaire should not take long and we hope you find it interesting and enjoyable. All answers provided will be treated as confidential and anonymous.

Note
No special knowledge is needed to fill this questionnaire. Please feel free to ask for clarification if needed.

Postal Address: ---

Residential address: ---

Telephone OR
Cell phone Contacts: ---

A. PERSONAL DATA

Instructions:
Please complete the following general information about yourself by ticking in the box next to the appropriate answers. Please take your time and read through questions carefully.

1. What is your date of birth?

2. What is your gender?

Male ☐   Female ☐

3. What is your marital status?

Married ☐   Single ☐   Widowed ☐

Divorced ☐   Other ☐

4. How would you describe your self?

Black ☐   White ☐

Coloured ☐   Asian ☐

5. What is the highest level of education you have completed?
- (a) Primary School or less
- (b) High School (Not Completed)
- (c) High School graduate
- (d) College Or Technical College (Not Completed)
- (e) College or Technical College Graduate
- (f) University or technikon (Not Completed0
- (g) University or technikon graduate

6. What is your Profession/Occupation?
Please state………………………………………………………………………..

7 How long have you been living in Bellville South?

Less than 6 Months ☐   Less than 1 Year ☐

1-5 Years ☐   5 years and above ☐

B. FAMILY HEALTH HISTORY

Instructions:

The following questions will tell us about your family health history. Please complete all the questions by placing a tick next to the appropriate answer or writing in the answer.

8. Are you currently on any medication?   Yes ☐   No ☐   ☐

9. If Yes, Please list………………………………………………………………   ☐
………………………………………………………………………………
………………………………………………………………………………
………………………………………………………………………………

10. Have you ever been told that you have diabetes?

 Yes ☐   No ☐   ☐

11. Have any of the following in your family ever had or are being treated for   diabetes?

(a)Mother
           Yes ☐   No ☐   ☐

(b) Father
           Yes ☐   No ☐   ☐

(c) Sister(s)
           Yes ☐   No ☐   ☐

(d) Brother(s)
           Yes ☐   No ☐   ☐

(e) Husband/Wife
           Yes ☐   No ☐   ☐

(f) Children
           Yes ☐   No ☐   ☐

(g) Grandchildren
           Yes ☐   No ☐   ☐

12. Have any of the following extended family members ever suffered or are suffering from diabetes?

(a) Paternal (Fathers Side)
   (i) Uncles

   Yes ☐   No ☐   ☐

(ii) Aunties

   Yes ☐   No ☐   ☐

(iii) Grandparents

   Yes ☐   No ☐   ☐

(b) Maternal (mothers Side)
   (i) Uncles

   Yes ☐   No ☐   ☐

   (ii) Aunties
   Yes ☐   No ☐   ☐

   (iii) Grand Parents
   Yes ☐   No ☐   ☐

13. Have you or any of the following ever been treated for heart problems?

(a) Yourself
   Yes ☐   No ☐   ☐

(b) Spouse
   Yes ☐   No ☐   ☐

(c) Mother
   Yes ☐   No ☐   ☐

(d) Father
   Yes ☐   No ☐   ☐

(e) Children
   Yes ☐   No ☐   ☐

(f) Grandparents
   Yes ☐   No ☐   ☐

(g) Sisters
   Yes ☐   No ☐   ☐

(h) Brothers
   Yes ☐   No ☐   ☐

14. Have any of the following ever been treated for High Blood pressure?

(a) Yourself

Yes ☐   No ☐   ☐

(b) Spouse

Yes ☐   No ☐   ☐

(c) Mother

Yes ☐   No ☐   ☐

(d) Father

Yes ☐   No ☐   ☐

(e) Children

Yes ☐   No ☐   ☐

(f) Grandparents

Yes ☐   No ☐   ☐

(g) Sisters

Yes ☐   No ☐   ☐

(h) Brothers

Yes ☐   No ☐   ☐

15. Did either of your natural parents ever die of a heart attack?

(a) Before the age of 60?

Yes ☐   No ☐   ☐

(b) After the age of 60?

Yes ☐   No ☐   ☐

16. Have you or any of the following ever been treated for High Cholesterol?

(a) Yourself

Yes ☐   No ☐   ☐

(b) Spouse

Yes ☐   No ☐   ☐

(c) Mother

Yes ☐   No ☐   ☐

(d) Father

Yes ☐   No ☐   ☐

(e) Children

Yes ☐   No ☐   ☐

(f) Grandchildren

Yes ☐   No ☐   ☐

(g) Brother

Yes ☐   No ☐   ☐

(h) Sisters

Yes ☐   No ☐   ☐

C. DIETARY LIFESTYLE

17. Quick Food Scan to assess fat contribution (Source: U.S. National Cancer Institute)

Think about your eating habits over the past 12 months. About how often did you eat or drink each of the following foods? Remember breakfast, lunch, supper, snacks and eating out. When I mention a type of food, tell me if you never eat it, eat it less than once per month, eat it 1-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week, once every day, 2 or more times per day.

TYPE OF FOOD	Never	Less than once per month	1-3 times per month	1-2 times per week	3-4 times per week	5-6 times per week	1 time per day	2 or more times per day	
Cold cereal									___
Skim milk, on cereal or to drink									
Eggs, fried or scrambled in margarine, butter or oil									
Sausage or bacon, regular fat									
Margarine or butter on bread, rolls, pancakes									
Orange juice or grapefruit juice									
Fruit (not juices)									
Beef or pork hot dogs, regular fat									
Cheese or cheese spread, regular fat									
French fries, home fries, baked potatoes or hash brown potatoes									
Margarine or butter on vegetables, including potatoes									
Mayonnaise, regular fat									
Salad dressing, regular fat									
Rice									
Margarine, butter or oil on rice or pasta									

(mark only one option per food item)

18. Over the past 12 months, when you prepared foods with margarine or ate margarine, how often did you use reduced-fat margarine?

Didn't use margarine	Almost never	About ¼ of the time	About ½ of the time	About ¾ of the time	Almost always or always

19. Overall, when you think about the foods you ate over the past 12 months, would you say your diet was high, medium or low in fat?

High fat	Medium fat	Low fat

D. TOBACCO USE

20. Do you currently smoke any tobacco products such as cigarettes, cigars, Pipes or dagga?

(a)   Yes ☐   No ☐

(b) If yes, how often do you smoke now?

Daily ☐   Occasionally ☐   Not at all ☐

(c) If you smoke daily, on average, how many cigarettes, cigars or pipes do you smoke per day?

    Please state………….

(d) For how long have you been smoking?   (Please circle answer)

  1 Year ☐   2-3 Years ☐   >5 Years ☐   >10 Years ☐

(e) How old were you when you started smoking regularly atleast 3-4 cigarettes per week? Please state age………...

21. (a) If you have stopped smoking, did ever smoke on a daily basis in the past?

    Yes ☐   No ☐

(b) How old were you when you stopped smoking? Please state age…….

E. ALCOHOL USE

22. Have you ever consumed any alcoholic drinks (Wine, Beer, and Spirits)?

Yes ☐   No ☐   ☐

23. Do you still consume alcoholic drinks?

Yes ☐   No ☐   ☐

24. If you consume or consumed alcohol, how old were you when you first   started drinking?
Please state.   …………years   ☐

25. If you stopped, how old were you when you stopped drinking?
Please state.   ………   ☐

26. Which type of alcohol do you or did you drink?

Wine ☐   Beer ☐   Spirits ☐   ☐

☐   Others, please indicate………………………

27. When you drink or drank alcoholic drinks, how many drinks or glasses
do you or did you consume daily? Indicate the number…..   ☐

Wine…………..Beer…………..(Long Top/6 pack/Cans) Spirits..……..

28. How many days a week do you or did you consume alcohol?

1-2 ☐   3-4 ☐   5-6 ☐   every day ☐   ☐

29. For how long have you been drinking regularly? Please appropriate answer
1 Year ☐   2-4 Years ☐   >5 Years ☐   >10 Years ☐   ☐

F. BODY MEASUREMENTS.   Interviewers Name……………………
30. Weight and Height.

Body Weight (kg)			
Body height (cm)			
Body Mass Index			

31. **CALLIPERS MEASUREMENTS**

Biceps 1 (cm)		
Biceps 2 (cm)		
Biceps 3 (cm)		
Total		
Triceps 1 (cm)		
Triceps 2 (cm)		
Triceps 3 (cm)		
Total		
Sub-Scapular 1 (cm)		
Sub-Scapular 2 (cm)		
Sub-Scapular 3 (cm)		
Total		
Suprailiac 1 (cm)		
Supra-iliac 2 (cm)		
Supra- Iliac 3 (cm)		
Total		

32. CIRCUMFERENCE MEASUREMENTS

Waist Circumference 1 (cm)		
Waist Circumference 2 (cm)		
Waist Circumference 3 (cm)		
Total		

.

Hip Circumference (cm)		
Hip Circumference (cm)		
Hip Circumference (cm)		
Total (cm)		

33. BLOOD PRESSURE MEASUREMENTS. Interviewers Name………

Systolic Pressure 1 (mmHg)		
Systolic Pressure 2 (mmHg)		
Systolic Pressure 3 (mmHg)		

Diastolic Pressure 1 (mmHg)		
Diastolic Pressure 2 (mmHg)		
Diastolic Pressure 3 (mmHg)		

Pulse 1 (Beat per Minute)		
Pulse 2 (Beat per Minute)		
Pulse 3 (Beat per Minute)		

G. **BLOOD ANALYSIS.**   **Interviewers Name…………………..**

34. (a) Fasting State Measurements

(i) Did subject eat this morning?........... If yes state time…………..

(ii) When did subject eat the last meal last evening?.........................

(iii) Please indicate the time when fasting blood taken………………

(iv) Please indicate the time when Glucose was given..……………..

Glucose mmol/l		
Cholesterol mmol/l (L=1, N=2, H=3)		
Triglycerides mmol/l (L=1, N=2, H=3)		

(b) Post Prandial Measurements

Please indicate time when post pradial blood was taken…….

Glucose mmol/l		
Cholesterol mmol/l		
Triglycerides mmol/l		

39. **URINALYSIS**

Glucose (N=Negative, P= Positive)	P
Protein (N=Negative, P=Positive)	P

N
N

H. Researchers Check list.

Please make a tick or cross against each of the following questions

1. Were all personal data questions answered?   ☐

2. Were all Family Health History questions answered?   ☐

3. Were all questions on Tobacco use answered?   ☐

4. Were all questions on Alcohol use answered?   ☐

5. Were all dietary questions answered?   ☐

6. Were all body measurements carried out?   ☐

7 (a) Was fasting blood taken?   ☐

 (b) Was Glucose Given?   ☐

8. Was Post Pradial Blood taken?   ☐

9. Was blood pressure taken?   ☐