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HAS DIABETES MELLITUS GLYCAEMIC CONTROL IMPROVED WITH INTRODUCTION OF POINT OF CARE GLYCATED HAEMOGLOBIN A_{1C}?

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment for the degree of Masters in Medicine -Internal Medicine

Declaration

I, Constance Sandra Adams declare that this research report is my own work. It is being submitted for the degree of Masters in Medicine –Internal Medicine in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

…….
19 December 2018

Abstract

Background: Diabetes mellitus has long been a cause for local and international concern; in Sub-Saharan Africa the mortality rate from diabetes related complications surpassed that of HIV/AIDS, tuberculosis and malaria combined. Point-of-care (POC) glycated haemoglobin (HbA1c) has been in routine use at a tertiary hospital's diabetic clinic in Johannesburg, South Africa. The investigator set out to determine if having a readily available result on the day of consultation has had a positive effect on improving glycaemic control.

Objectives: The aim of this study was to determine if an immediately available POC HbA1c would result in improved target HbA1c and improved glycaemic control.

Methods: 195 Adult attendees of the diabetic clinic who had been attending since before the advent of the POC HbA1c test were recruited. The laboratory HbA1c was compared to the current POC HbA1c to determine if there was any improvement in glycaemic control.

Results: The mean HbA1c before the POC test was 8.8% (SD 1.9) and the current POC HbA1c was 8.9% (SD 1.94). There was no statistically significant improvement in glycaemic control.

Conclusion: The POC test for HbA1c at a tertiary hospital's diabetic clinic has not resulted in improved glycaemic control. This important study has shown that the introduction of new technology is not the answer to better diabetic care. Comprehensive diabetic care is multifactorial and relies on intensive efforts of a multidisciplinary team including physician and diabetic nurse educator with active patient participation to ensure optimal glycaemic control.

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Abbreviations

HIV	human immunodeficiency virus
AIDS	Acquired immunodeficiency syndrome
SEMDSA	Society of Endocrinology, Metabolism and Diabetes of South Africa
DM	Diabetes mellitus
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
HbA1c	glycated haemoglobin
UKPDS	United Kingdom prospective diabetes study
DCCT	Diabetes control and complications trial
ACCORD	Action to control cardiovascular risk in diabetes
VADT	Veteran affairs diabetes trial
CMJAH	Charlotte Maxeke Johannesburg academic hospital
POC	Point-of-care-test
NGSP	National glycohemoglobin standardisation program
EDTA	Ethylenediaminetetraacetic acid
NHLS	National health laboratory service
UK	United Kingdom
ZAR	South African rand
HOPE	Health opportunities for people everywhere
IFCC	International federation of clinical chemistry and laboratory medicine
BMI	Body mass index
CVD	Cardiovascular disease
CEO	Chief executive officer
HOD	Head of department
SBP	Systolic blood pressure
DBP	Diastolic blood pressure

1. Introduction

Diabetes mellitus has long been a cause for local and international concern and has now reached pandemic proportions. As of 2017, 425 million people in the 20-79-year age group worldwide have diabetes mellitus, and the International Diabetes Federation predicts that by 2045, 629 million people will have diabetes.[1] Three quarters of these diabetics live in low- and middle-income countries. In South Africa in particular, which is considered to be a upper middle income country by the World Health Organization, it is estimated that there are approximately 2,2 million adults living with diabetes, at least half of which are undiagnosed.[1] According to the World Health Organization diabetes country profile of 2016, diabetes accounts for 6% of total deaths across all ages.[2] Statistics South Africa counts diabetes as one of the leading causes of non-communicable disease deaths in South Africa in 2010.[3]

In 2012, the estimated prevalence of diabetes in persons older than 15 years in South Africa was 9.5%, and 45% of these individuals are undiagnosed. In Sub-Saharan Africa the mortality rate from diabetes related complications surpassed that of HIV/AIDS, tuberculosis and malaria combined.

It comes as no surprise that 12% of global health expenditure is spent on managing diabetes and its complications.[3] This makes early detection and management of diabetes of global concern.

Diabetes mellitus is a metabolic disorder with heterogeneous aetiologies, caused by defective insulin secretion, action or both; which leads to chronic hyperglycaemia and disturbances in carbohydrate, fat and protein metabolism.[4,8] The most common type being type 2 diabetes mellitus which results from a relative insulin deficiency and insulin resistance. It is associated with a broader metabolic syndrome which encompasses obesity, sedentary lifestyle, hypertension and dyslipidaemia as pertinent features which need to be addressed in the comprehensive care of diabetes mellitus. The relatively specific long-term effects of diabetes mellitus are microvascular complications including retinopathy, nephropathy and neuropathy. Macrovascular complications associated with diabetes are coronary artery, cerebrovascular and peripheral arterial disease. The acute metabolic derangements that accompany hyperglycaemia are responsible for many hospital admissions and add to the healthcare burden. Controlling diabetes mellitus is of paramount importance in our healthcare setting in order to reduce the cost of treating the complications.[5,6,7]

The Society of Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA), [8] defines the following criteria to diagnose diabetes mellitus (DM). In the symptomatic patient when any of the following are met:

- the fasting plasma glucose is ≥ 7 mmol/l;
- the plasma glucose taken 2 hours after a standardized oral glucose tolerance test is ≥ 11,1 mmol/l;
- a random plasma glucose is ≥ 11,1 mmol/l or
- a glycated haemoglobin (HbA1c) level of ≥ 6,5%

From these parameters, glycaemic control is the cornerstone of a rational diabetic treatment strategy. Type 2 DM is associated with obesity, hypertension and dyslipidaemia; therefore it is important to treat these conditions when striving for 'comprehensive diabetic care'.[5,6,7]

Chronic hyperglycaemia is responsible for many of the complications associated with diabetes. Blood glucose measurements play a role in diagnosing, controlling and eventually monitoring response to treatment strategies. HbA1c is a measure of chronic hyperglycaemia that has made it possible to conduct meaningful research with clear and reproducible endpoints that assist the clinician in managing individual patients and risk stratify in a more precise manner. The United Kingdom Prospective Diabetes Study (UKPDS) showed that correcting chronic hyperglycaemia decreased the macro- and microvascular complications associated with type 2 DM.[9] Notably; there was a 35% reduction in complications for every percentage point decrease in HbA1c. The Diabetes Control and Complications Trial (DCCT) which ran prospectively from 1982-1993, targeted an HbA1c of 7% to demonstrate that early intensive glycaemic control reduced and delayed the onset of the microvascular complications associated with Type 1 DM.[10]

HbA1c has become an internationally accepted and validated method of diagnosing and managing diabetes. HbA1c shows average glycaemic control over the preceding 2-3 months. It is a more robust measurement than a fasting or random blood glucose measurement because it is unaffected by sudden fluctuations in glycaemia caused by stress and acute illness. It can also be taken at any time regardless of fasting state.[11]

Haemoglobin is normally exposed to glucose in the blood. Persistently high levels of glucose lead to increased glycation of haemoglobin, this reaction is irreversible and because the average lifespan of erythrocytes is 2-3 months, HbA1c serves as a marker of average

glycaemia over the lifespan of the erythrocyte. This glycation of erythrocytes is expressed as a percentage. This value can therefore be used to diagnose, treat and monitor response to treatment at follow-up visits. This is then used in conjunction with the patient's self-monitored blood glucose measurement trends to assess overall glycaemic control and devise an appropriate care plan for the individual patient. This combination is far superior in managing diabetes than a single blood glucose measurement taken at the time of consultation.[9,10]

HbA1c has become the primary tool in devising pharmacologic treatment strategies as well as monitoring long term glycaemic control. HbA1c is a weighted average that reflects the turnover of erythrocytes in the circulation. But as older erythrocytes become senescent, the HbA1c value will be affected by recent changes in glycaemia, so the value will favour glucose levels reflecting the most recent 6 weeks.[11] There are factors that affect the accuracy of the HbA1c measurement. False increases in HbA1c can be caused by any condition that increases the lifespan of the erythrocyte or reduces its turnover. Conditions such as uraemia, hyperbilirubinemia, hypertriglyceridemia, iron deficiency and B_{12} deficiency anaemia as well as asplenia will lead to falsely elevated HbA1c levels.[12]

Conversely any condition which decreases the lifespan or increases the breakdown of the erythrocyte leads to less exposure of the haemoglobin to glycation and will result in a falsely low HbA1c reading. Conditions of note are haemoglobinopathies, haemolytic anaemia and decreased erythropoietin production in chronic renal failure.[12]

The recommended target HbA1c is 7% but this is further individualized to specific patient profiles as shown in the Action to control cardiovascular risk in diabetes (ACCORD) trial where more stringent HbA1c targets showed higher rates of death from any cause.[13] Some patient groups like the elderly did not benefit from such tight control, the Veteran affairs diabetes (VADT) trial demonstrated that there was no added benefit to strict HbA1c targets for elderly people and the physician can accept an HbA1c of closer to 8%.[14] Whereas in younger patients; particularly type 1 diabetes mellitus (T1 DM) patients, much more stringent control is advised as shown in the Diabetes control and complications (DCCT) trial. We aim to approach as close to normal HbA1c as possible i.e. 6.5% to avoid the retinopathy and other microvascular complications associated with hyperglycaemia. These are targets that health care providers aim to achieve in their setting, and South Africa has local comprehensive guidelines set out in the 2017 SEMDSA guidelines for the management of type 2 diabetes.[8]

These guidelines cover comprehensive diabetes care with the resources at our disposal. It is with this backdrop that we aim to see how we can improve diabetic care in our setting.

Literature review

Two local cross-sectional studies conducted at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) addressed the lack of comprehensive diabetic care in treating the accompanying cardiovascular risk factors related to diabetes. These local audits showed an average HbA1c of 8,8% (Pinchevsky et al 2013)[15] and 8,7% (Klisiewicz et al 2009)[16] both published in the Journal of Endocrinology, Metabolism and Diabetes of South Africa (JEMDSA). With very little change in the average HbA1c in the 4-year period between the audits, and with no new treatment options available in the public sector, the only new development was the introduction of the POC HbA1c. The POC test enables patient and physician to get an HbA1c result at first contact without the delay associated with sending a phlebotomy specimen to the laboratory.

To establish consistency between different laboratory HbA1c values, the National Glycohemoglobin Standardisation Program (NGSP) resolved in 1996 to have a reproducible method of analysis that laboratories could use to yield consistent results that could be benchmarked against the landmark UKPDS and DCCT trials in order to assist clinicians in diabetic care. This would enable comparability and consistency and produce standardized targets of HbA1c.[17] The setting of our study, CMJAH, uses an internationally validated technique endorsed by the NGSP. The laboratory HbA1c will be the reference method. This uses venous EDTA-anticoagulated blood processed by the National Health Laboratory Service (NHLS) using the analyser Roche Hitachi 917. (Boehringer Mannheim, Switzerland) This is a high-performance liquid chromatography (HPLC) method which adheres to the standards set out by the NGSP reference assays.[18]

POC HbA1c has not replaced laboratory HbA1c in defining glycaemic targets. The Diabetes Care Journal (2012) suggests at least an annual laboratory HbA1c to still be done in centres that primarily use POC .[19] These POC devices were intended for primary care settings with resource and personnel constraints, to improve non-urban areas access to healthcare. Many trials have studied their validity in relation to the reference method; in our setting we currently use the DCA Vantage (Siemens) for POC testing, and the Hitachi Roche 917 laboratory analyser for formal HbA1c.

A 2014 study showed that 3 out of 7 POC devices did not meet standard NGSP criteria when matched against a laboratory analyser. The DCA Vantage was specifically shown to be reliable and valid when compared to the laboratory HbA1c using the NHLS analyser. It uses the latex agglutination inhibition immunoassay method with has been shown to meet NGSP criteria as well as correlating closely with laboratory HbA1c. This result is reproducible even when using different reagents and lot numbers.[20]

A study published in 2016 looked at the long-term performance of the DCA Vantage by following measurements over a 3-year period at a diabetic clinic. The investigators were concerned about the long-term reliability. The study found the DCA Vantage to be one of 2 most reliable POC methods when compared to the stringent NGSP criteria. It had a strong linear correlation throughout the HbA1c range when compared to 2 commonly used HPLC laboratory analysers. However there was variability throughout the time frame and it was found that there was no consistency between POC and laboratory HbA1c. At times the POC would record higher and other times it would record lower than the laboratory HbA1c. The study did not elaborate on the patient profile nor comment on whether treatment intensification occurred or whether it was the same cohort followed up over the 3 years.[21]

A South African study published in 2015 compared the DCA Vantage POC against the locally used laboratory analyser, the Hitachi 917. The population group studied were diabetic patients attending the diabetic clinic at Chris Hani Baragwanath Academic hospital in Soweto, Johannesburg. This study also showed a good correlation between the POC test compared to laboratory HbA1c.[22] For the purpose of this study, the DCA Vantage POC is considered to be an appropriate, valid method of monitoring patients' glycaemic control.

The POC HbA1c taken at time of consultation is available immediately for interpretation. A laboratory HbA1c would require the patient to have a blood test done prior to the scheduled doctor's visit or it would mean contact with the doctor after the consultation when the result is available in order to make necessary treatment adjustments. Having a readily available POC result could potentially provide better interaction and care between doctor and patient. Even though in our setting the POC test was initially designed to improve primary health care clinics access to better care, it is now in common use at tertiary hospitals throughout South Africa. Studies have confirmed POC validity and ease of access. This development can

potentially lead to improved glycaemic control because of more immediate responses and treatment intensification during consultations. Patients could also potentially save on travel and time costs by reducing the number of visits for phlebotomy and checking of results.

A meta-analysis from Clinical Chemistry in 2011 did a systematic review of 7 randomized controlled trials to determine if POC improved diabetic patient outcomes. With the main outcome being the overall mean reduction in HbA1c, they showed a nonsignificant overall reduction of 0.09% (95% CI -0.21 to 0.02). There was no apparent improvement in glycaemic control. It was difficult for the meta-analysis to draw other conclusions because of the variations in methodology between the trials and lack of details regarding treatment intensifications and follow-up. It did not improve patient satisfaction either. This could be attributed to health care providers not discussing the results with patients.[23]

A prospective randomized controlled trial followed 8 practices in the UK. They compared POC to laboratory HbA1c. Their primary outcomes were cost to patient and improved glycaemic control. The investigators found no significant reduction in diabetes related costs over a period of a year when compared to the control group which received 'usual care' using laboratory HbA1c with routine follow-up.[24]
The total cost of diabetes related care in control and intervention arms were 390 British pounds and 370 pounds per patient respectively. This was not statistically significant. This outcome may seem surprising but the actual cost per unit of POC was found to exceed actual per patient cost of formal HbA1c. A similar number of tests were still being done and furthermore the investigators found that follow-up schedules remained unchanged from the usual routine so did not translate into less visits for the patients and thus no money saved on travel costs. The investigators were quite thorough in accumulating all relevant costs including cost of actual test, consumables, travel cost of patient and time off work, cost of medications, and contact with healthcare providers including telephonic follow-ups and home visits. The study found that the proportion of patients at target HbA1c of 7% at 1-year follow-up between the intervention and control groups were very similar at a proportion of 0.37 and 0.38 respectively. No real difference in glycaemic control was observed.

A prospective randomized controlled trial published in 2016 looked at the Cape Town community health centres in South Africa.[25] The investigators determined to see if introducing POC would reduce direct costs of diabetic care including staff costs, test and

consumables, as well as transport and time costs for patients. And improve glycaemic control with treatment intensification and patient education. The control arm was usual care with an annual laboratory HbA1c. This study failed to show that POC HbA1c improved test coverage, treatment intensification, counselling or glycaemic control. In fact, there was an added cost of ZAR 2110.00 per 100 tests performed. The investigators found that despite the availability of a functional POC device and consumables, testing was not ordered more frequently even with trained technologists on site. There was no significant increase in mean dose of medications or additions of medications. There was also no difference in counselling and patient education during consultations. These findings were evident even with the health centre staff knowing about the trial and having open access to the POC test. The intrinsic methodology makes it difficult to run a double-blind trial as it will always be apparent in a real-life setting whether the test result is laboratory or POC HbA1c. It is apparent from this study that primary health care needs to be strengthened with good clinical practice and guidelines to provide better care. Despite the advantages of an immediately available result, they were simply not using the POC test.

It can be argued that even though POC HbA1c may have increased costs at the time; timeous achievement of glycaemic targets may delay the long term complications of diabetes and ultimately reduce cost of health care expenditure at a national level.

A seemingly more favourable study was carried out through an international non-government organization (NGO) called Project HOPE. This NGO runs the Hope centre in a burgeoning largely poor semi urban developing settlement on the fringe of Johannesburg called Zandspruit.[26]This is a community with poor resources and limited access to basic health care. Project HOPE aims to improve screening and provide essential primary health care treatment for non-communicable diseases. Health education and health promotion programs are emphasized to prevent non-communicable diseases by various self-empowerment initiatives including exercise and subsistence farming strategies.

Their study was published in Primary Care Diabetes in 2017 and was carried out during years 2012-2014.[27] Of the 332 people who had POC HbA1c done, 211 were classified as having DM. This initial POC result formed the baseline HbA1c and would be compared to the final HbA1c taken at end of study after treatment was initiated. 131 patients returned for repeat HbA1c and there was an average of 2-5 tests done over the study period, with the last HbA1c

done an average of 15 months later. The clinic had access only to oral hypoglycaemic agents and non-pharmacological strategies like lifestyle, exercise and dietary advice. The baseline average HbA1c was 9.7% and improved to 8.4% at end of study. There was an increase of 125% in the total number of patients achieving the glycaemic target of 7% (from 28 to 63 people). 63 (45%) people improved, 47 (36%) remained stable and 21 (16%) worsened.

However, the study design was not similar to other studies purporting to show the value of POC HbA1c. They screened the general population who were potentially newly diagnosed diabetics that were asymptomatic. The SEMDSA guidelines emphasize the diagnosis of DM to include typical symptoms associated with biochemical parameters. If the patient is asymptomatic, the HbA1c should be repeated within a 2-week period. This was not a cohort of established diabetics within defined criteria. This may explain why of the 211 people classified as having diabetes, 40% (80 people) did not return for follow-up and treatment. They were possibly not symptomatic and had inadequate insight into this unexpected diagnosis. It is not clear how participants were selected to participate in the screening process. No mention is made about how many had pre-existing diabetes and whether they were on treatment prior to the study. This was potentially a population of newly diagnosed diabetics and this makes it difficult to draw comparisons with a usual cohort of a diabetic population who are already on treatment. This study highlights the importance of POC HbA1c as a screening and diagnostic tool to provide non-urban and primary health care facilities better access to health care. The latest IDF estimates in 2015 showed that in South Africa, 61.1% of people aged 15 and above with diabetes remain undiagnosed.[1]

A much older randomized controlled trial published in 1999 in Diabetes Care studied 201 type I and II diabetics on insulin treated at an academic diabetes centre.[28] HbA1c levels decreased significantly at 6, and 12-month follow-up in the POC group. This was largely due to treatment intensification by clinicians. There were no added hypoglycaemic events or differences in use of healthcare resources. These results have not been reproduced in later trials and as noted previously, it would be difficult to perform a double blind randomized controlled trial because treating doctors would be aware of which study arm utilized POC and which used laboratory HbA1c. If a similar trial design was used, arguably the results could be misleading because of bias. The treating clinician may intensify treatment because they are not blinded to the objectives of the trial.

It seems intuitive that an immediately available value will result in appropriate changes in pharmacological strategies as well as non-pharmacological interventions like patient education and counselling. With updated and readily available guidelines in South Africa, glycaemic control and comprehensive diabetic care seems possible, and the realization of reduced long term micro- and macro- vascular complications a near reality. The investigator in this study asserts that POC HbA1c in a diabetic clinic at a tertiary hospital may lead to improved glycaemic control presumably through expeditious treatment intensification.

This point of care test can assist the physician with treatment intensification and therefore improved glycaemic control. The result is immediately available and should help the physician in deciding about adjusting medication without the delay associated with waiting for a laboratory result. POC HbA1c was envisioned for primary health care where there is no readily available access to a laboratory HbA1c. The ease of use and rapid turnaround time seems to have enticed the larger health centres who already have access to laboratory HbA1c. POC seems to have gained favour due to these supposed advantages and has literally become the point of care. The supposed benefit to patients has made it popular at outpatient clinic settings even at an academic hospital like CMJAH in Johannesburg. There is a logistical hurdle with obtaining a laboratory HbA1c. The patient will either be required to draw blood before the visit so that the result is available at the consultation; or return sooner to receive the result and effect the necessary alterations in treatment. However, the 2 previously discussed studies showed no cost benefit to patient in terms of time and money when utilizing POC. A point of care result should intuitively improve glycaemic control because treatment would be intensified at the time of consultation. Even though so many studies have shown minimal improvement in glycaemic targets when using POC in their setting, the aim of the study was to investigate if clinicians at a tertiary hospital in Johannesburg are reacting to the POC result by titrating/changing medications, intensifying follow-up and increasing health care facility access in order to achieve targets of glycaemia.

Rationale for study

The DCA Vantage was initially piloted at CMJAH in September 2011 and is now fully operational as the preferred method of HbA1c monitoring at the diabetic clinic of this large tertiary care hospital in South Africa. Without any recent literature showing the clear, uncontested value of POC HbA1c in attaining glycaemic targets, this study aimed to evaluate the impact that POC HbA1c has had on diabetic care.

Therefore, this study aimed to see if the addition of an immediately available result would have an effect on HbA1c targets and result in improved glycaemic control.

Problem statement

There has been no improvement in glycaemic control over several years at a specialist diabetic clinic located at a tertiary hospital. The proportion of patients at target HbA1c has declined and the average HbA1c of the diabetic clinic attendees has worsened.

Hypothesis

POC HbA1c will improve overall glycaemic control and increase the proportion of patients achieving target HbA1c in a tertiary healthcare setting.

Null hypothesis

There is no statistically significant difference in using the POC in comparison to the laboratory HbA1c in monitoring glycaemic control and response to therapy in diabetic patients over several years.

Objectives

The primary objectives:

- To ascertain change in HbA1c from baseline. The baseline HbA1c will be the laboratory HbA1c taken prior to implementation of POC HbA1c. This will be compared to the POC HbA1c taken in the preceding 12 months to see if the treatment changes made in the interim have led to improved glycaemic control and reduction in mean HbA1c.
- To assess proportion of patients achieving target HbA1c since POC.
- To assess the number of patients that have improved HbA1c.

The secondary objectives were to assess if physicians are reacting to abnormal HbA1c results:

- if treatment is being changed/intensified by physicians
- are follow-up intervals being adjusted

2. Methods

2.1. Design:

A Retrospective cross-sectional analysis at CMJAH outpatient diabetic clinic.

2.2 Setting

2.2.1 Hospital

Charlotte Maxeke Johannesburg Academic Hospital is a provincial hospital situated in Parktown, Johannesburg, which provides tertiary level of care. It is also a teaching hospital for the University of the Witwatersrand, Faculty of Health Sciences. It is a referral hospital for a number of hospitals in its chain of referral including hospitals in surrounding provinces.

2.2.2 Clinic information

The diabetic clinic runs twice weekly on Monday and Thursday, between 50-70 patients are usually seen on each day. Medical officers, registrars and consultants are responsible for attending to patients. Referrals are received from local primary health care, other hospitals in the referral chain, post discharge patients who require follow-up, as well as referrals from other departments at the hospital. Type 1 diabetic patients are usually seen on a Monday and type II/other on a Thursday. Follow-up appointments are made ranging between 1-6 months and sometimes within a month if necessary. These appointments are scheduled in advance in the booking book and electronic system; but walk-in patients are seen if required. Adult patients are seen aged 15 and above. Patient files are kept at the clinic record room and the patient leaves with a page containing the prescription and short summary with a duplicate kept in their clinic file. Insulin in its short, intermediate and long acting form is available as well as oral hypoglycaemic agents. The clinic also sees other types of diabetes (other) related to alcoholic pancreatitis, post-pancreatectomy etc.

2.3. Analyser information

The point of care device being used, the DCA Vantage Analyser (Siemens Health, Pennsylvania) is operated by a trained, certified technologist from the National Health Laboratory Service. It is NGSP and IFCC certified.[29] This point of care device was piloted in 2011 and came into routine use in 2013. There are usually 1-2 technologists allocated on each day that are trained to operate the device as per manufacturer's instructions. The measurement is routinely taken every 6 months but also on request by the attending doctor. The point of care analyser requires a finger prick where 1 microliter of whole blood is

collected into the test cartridge and inserted into the analyser, a printout is then generated. No blood preparation is needed and no pre-treatment is required. The result is automatically generated and the resulting printout is stapled into patient file to reduce transcription errors. The result is available in 6 minutes, and the range is an HBA1c of 2,5%- 14%.[29] The laboratory analyser is situated at the NHLS and runs automated tests using whole blood specimens collected in an EDTA tube. The analyser range is 4.2%-20.1%. The results are automated and require no post analytic review. They are then electronically uploaded onto the results application to be checked by the treating doctor.

2.4 Objectives

The primary objective of this study was to determine if there was a statistically significant difference in the mean HbA1c since the introduction of POC in comparison to the laboratory HbA1c. To determine if there was an increase in the proportion of patients at target Hba1c, and to assess the overall number of patients with an improvement in glycaemic control (i.e. a reduction in HbA1c).

The secondary objective was to see if health care workers were reacting to abnormal values as guided by SEMDSA guidelines and intensifying treatment appropriately. SEMDSA recommends 3 monthly testing of HbA1c whenever medication is changed or HbA1c is not on target.

2.5. Population group

The participants were 195 male and female adult attendees of the clinic diagnosed with diabetes who are on oral hypoglycaemic medications and/or insulin. They must have been attending for at least 5 years in order to have had a baseline HbA1c done preceding POC. Exclusions were patients under age 18, patients with no HbA1c done in previous year, and patients who had defaulted follow-up appointments or medications in the previous 12 months. Patients with comorbidities that may affect the HbA1c were included as they were the same cohort being followed up over a period. Haemoglobinopathies are not common in this population group and patients with anaemia and those who had progressed to end stage renal disease were also excluded.

2.6 Data collection

2.6.1 Method

Data was mined from patient files that were kept at records department at the clinic. Patient records were perused after their consultation and before the files were archived. This ensured that only patients seen on that day were recorded and did not account for those booked patients who did not attend their appointment. Data was collected on a data collection sheet which was anonymous and listed patients merely in numerical order. However a confidential record that matched allocated subject number to their name and hospital number was kept to eliminate duplication of patients who may have returned within the collection period. This confidential record was transcribed on a separate page and was only available to cross-reference and exclude patients already recorded. Collection occurred over a 3 month period during May – July 2017.

2.6.2 Patient demographics

The age, gender, ethnicity, weight in kilograms (kg), height in meters (m), body mass index (BMI) in kg/m^2, history of hypertension and the current blood pressure in mmHg, and HbA1c measurements at baseline and current year POC HbA1c was recorded from information obtained from the patient file. Cardiovascular disease (CVD) including peripheral arterial disease, coronary artery disease and cerebrovascular disease was documented from the records. Treatment intensification was defined as a hospital admission, a change in dose or diabetic medication or follow-up within 1 month.

2.6.3 Data capturing

The subject number for each entry was recorded in a numerical fashion, with no identifying information recorded onto the collection sheet. Demographic information including age, gender, race (classified broadly as black, white, indian or coloured) was recorded to describe the cohort. Weight and height were also required to calculate the body mass index (BMI). The type of diabetes: type 1 DM or type 2 DM, length of disease, type of medication including oral and insulin was recorded as well as length of attendance at the facility.

Relevant comorbidities were recorded:

- hypertension (including specific systolic and diastolic readings on the day of data capturing)

- vascular disease (stroke, coronary artery disease and peripheral arterial disease)
- dyslipidaemia (this was defined as anybody on lipid lowering therapy)

Exclusions were:

- end stage renal disease (estimated glomerular filtration rate of <20ml/min/m^2)
- patients who did not have a baseline HbA1c prior to POC or that have not attended clinic long enough to have a baseline POC.
- patients with no HbA1c in past 12 months
- patients who had defaulted follow-up or medications in past 12 months

The primary outcome was to determine if there had been an improvement in glycaemic control defined as a statistically significant reduction in HbA1c from an average of the past 12 months values when compared to the same patient's laboratory HbA1c recorded prior to introduction of POC ; three HbA1c values were transcribed from the year preceding the POC, the precise timing differed for patients, most were from year 2012-2013.

The past 12 months POC HbA1c were recorded, there were on average 2-4 results noted in patient files. SEMDSA recommends 6 monthly HbA1c if at target and 3 monthly if not at target or if treatment has been modified. The investigator used an average of the last 12 months HbA1c to make it representative of the patients control instead of using 1 reading that may be skewed due to acute illness or transient indiscretions.

The secondary outcomes were:

1. Related to treatment intensification:
   - change in medication
   - dose adjustment
   - change in follow-up interval (recorded in months)
   - admission on day of visit

Patient counselling was not considered to be treatment intensification as it should be reinforced at every visit.

2. Using the current POC mean HbA1c obtained as a descriptive audit to
   - Evaluate current glycaemic control in the population group and compare it to other centres, previous audits at the hospital, and international levels of glycaemic control.
   - This average HbA1c could also be used in future audits to assess changes in glycaemic control when a new intervention is being introduced.

- This HbA1c value could also assist in predicting the risk of diabetes related complications and costs of future healthcare.

2.7 Data analysis

This was a cross-sectional retrospective analysis and data was collected from the patient records from patients seen at clinic on that day. The raw data was put into an excel spreadsheet and then imported into a statistical program using Statistica version 13.0 licensed through the University of the Witwatersrand. The raw data was cleaned and duplications and errors were removed. The raw data was reviewed for transcribing errors. Assistance from statisticians allocated to assist with postgraduate research was obtained throughout the data analysis process to verify, check the statistical analysis and assist with the more difficult derivations. The data variables were tested for normality using the Shapiro-Wilk test of normality. The mean, median, standard deviation, range, 25th and 75th quartiles were obtained through basic descriptive statistics on the Statistica program for the continuous variables. The categorical variables were grouped into histograms and frequency tables to obtain percentages and proportions. The mean of the laboratory HbA1c taken at baseline was the average of the last 3 laboratory HbA1c results before POC was introduced. This was usually results from year 2013. The HbA1c recorded at a first visit was not included as this was likely to skew the results as it was taken before treatment initiation and would be disproportionately elevated. The final average was entered onto the spreadsheet as the pre-POC or laboratory HbA1c. At the time of data collection, all the HbA1c's taken in previous 12 months were averaged and entered as a single value on the spread sheet. The baseline HbA1c (laboratory HbA1c) was compared to the POC HbA1c in the current year using the paired students t test for the 2 related samples taken approximately 4-5 years apart (p value < 0.05; 95% confidence interval). Other than the average HbA1c values, all other variables were from the actual clinic visit on day of data collection.

The HbA1c were grouped into categories to classify subjects as being

- at target i.e. HbA1c $\leq 7\%$
- controlled i.e. HbA1c $\leq 8\%$
- poorly controlled i.e. HbA1c $\geq 10\%$

These values were then reported using frequency tables and histograms to determine proportion of affected subjects in each category.

The change in HbA1c was determined by calculating the % change between pre-/post POC (POC HbA1c minus baseline Hba1c divided by baseline HbA1c) to determine the percentage change in HbA1c.

The Sign test was used to determine the actual number of subjects who had a reduction in HbA1c, by calculating the difference between POC and baseline HbA1c, all the negative values were a reduction in HbA1c (i.e. an improvement in glycaemic control) and vice versa.
The Pearson Chi^2 test was used to determine associations between the baseline and POC HbA1c. This helped determine the proportion of patients who initially had poor control and subsequently improved or worsened; and those who initially had good control and subsequently worsened.

Follow-up intervals were recorded in months, with follow-up within 1 month noted as an intervention even if treatment was not changed. This was expressed as a frequency table.

3. Ethics

Permission to conduct the study was obtained from the hospital CEO, the clinic HOD and ethical clearance was obtained by Wits Human Research Ethics Committee on 31/03/2017 clearance certificate no. M170260
Approval by the Postgraduate committee of the University of the Witwatersrand was obtained

4. Results

296 patient files were audited. 101 patients were excluded as they had not been attending the clinic prior to POC, had no baseline HbA1c or had a history of noncompliance.
The final cohort consisted of 195 subjects.

Characteristics of the study group:

Age

	N	Mean	Minimum	Maximum	Std.Dev.
Age	195	53.92	21.00	90.00	15.20

95% confidence interval (CI)

Table 4.1 Age in years

Type of diabetes mellitus (DM)

- 41 (21%) people with type 1 DM
- 153 (78.5%) with type II DM
- 1 person (0.5%) recorded as having diabetes related to alcoholic pancreatitis.

Gender

Males n= 78 40%

Females n=117 60%

Ethnicity

Black 124 63.6%

White 35 18%

Coloured 8 4%

Indian 28 14.4%

Duration of diabetes mellitus (DM)

	N	Mean	Minimum	Maximum	Std.Dev.
Duration	195	13.85	4.00	40.00	7.12

95% CI

Table 4.2 Duration of DM in years

Years attending this facility

	N	Mean	Minimum	Maximum	Std.Dev.
Years	195	10.28	4.00	25.00	5.01

95% CI

Table 4.3 Number of years attending facility

Weight distribution of cohort:

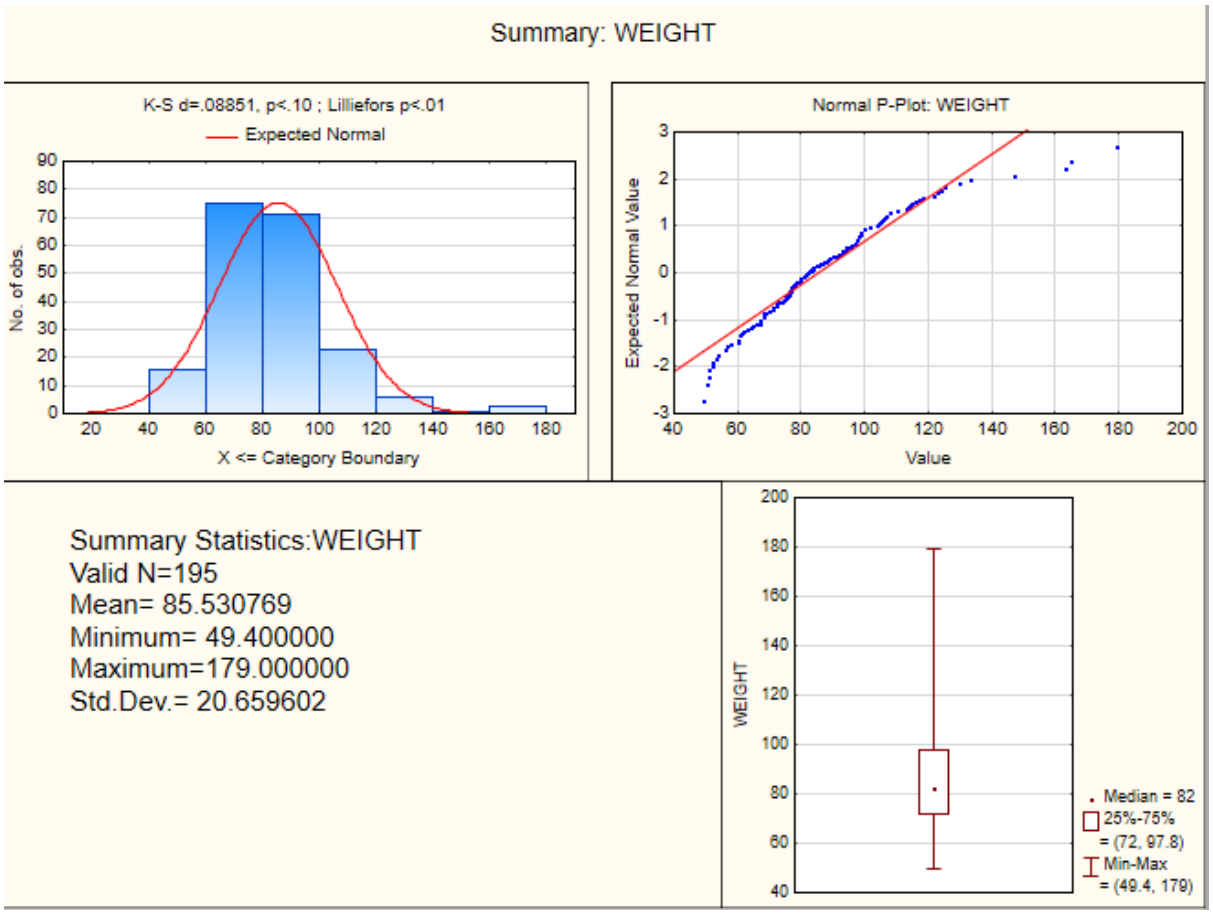

Figure 4.1 Weight in kilograms

Height

As height is not routinely recorded at the clinic, only 62 patients had height recorded; 62 body mass indexes (BMI) in kg/m^2 could be calculated:

	N	Mean	Minimum	Maximum	Std.Dev.
Height	62	1.62	1.48	1.88	0.10

95% CI

Table 4.4 height in metres

Body mass index summary (BMI):

	N	Mean	Minimum	Maximum	Std.Dev.
BMI	62	31.84	20.44	50.78	6.89

95% CI

Table 4.5 Body Mass Index in kg/m^2

Hypertension (HPT):

144 (74%) patients with HPT

Systolic blood pressure (SBP) descriptive statistics:

	N	Mean	Minimum	Maximum	Std.Dev.
SBP	194	140.77	89.00	194.00	22.04

95% CI

Table 4.6 Systolic blood pressure (SBP) in mmHg

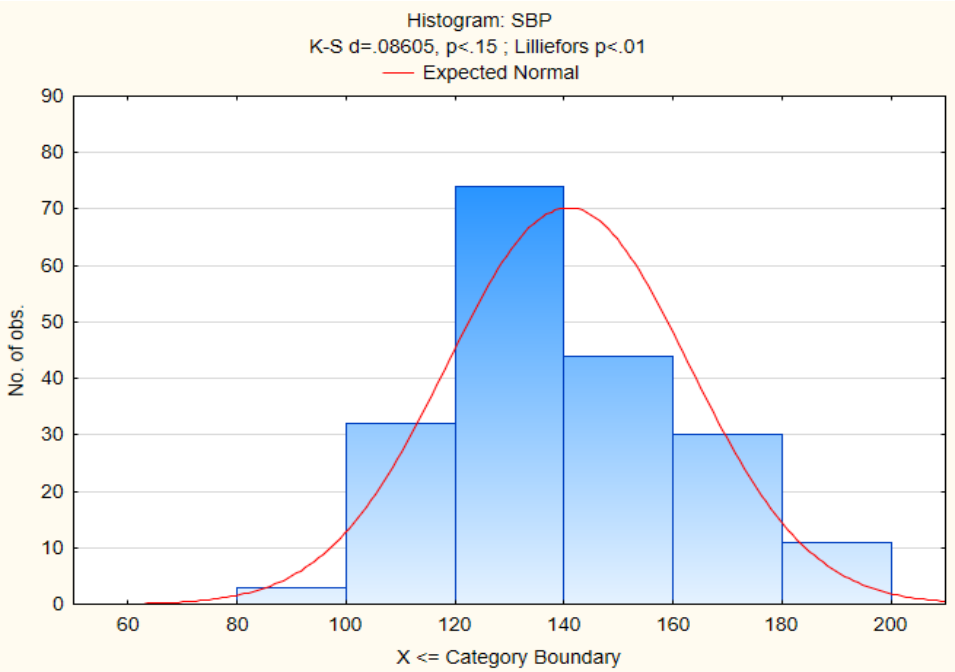

Figure 4.2 Systolic blood pressure graph X = SBP in mmHg

Diastolic blood pressure (DBP) descriptive statistics:

	N	M	M	M	SD
DBP	194	76.81	49.00	113.00	12.50

95% CI

Table 4.7 DBP in mmHg

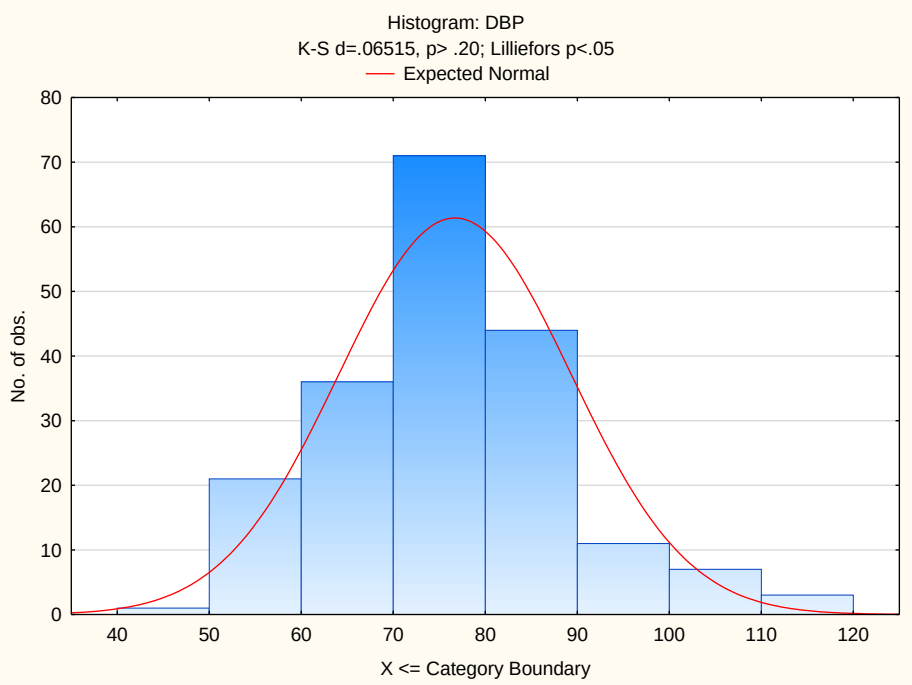

Figure 4.3 X category = DBP in mmHg

Related macrovascular complications/ CVD:

- peripheral vascular disease PVD,
- coronary artery disease CAD (anyone noted to have had a previous myocardial infarction, angina or a coronary angiogram noting significant disease),
- dyslipidaemia was anyone noted in file to have dyslipidaemia including any patient on lipid lowering therapy.
- Previous stroke (ischemic cerebral infarcts)

Cardiovascular disease frequency:

Related condition	N	%
Previous stroke	9	4.6 %
PVD	6	3.1%
CAD	18	9.2%
Dyslipidemia	154	79%

Table 4.8

Pharmacological treatment

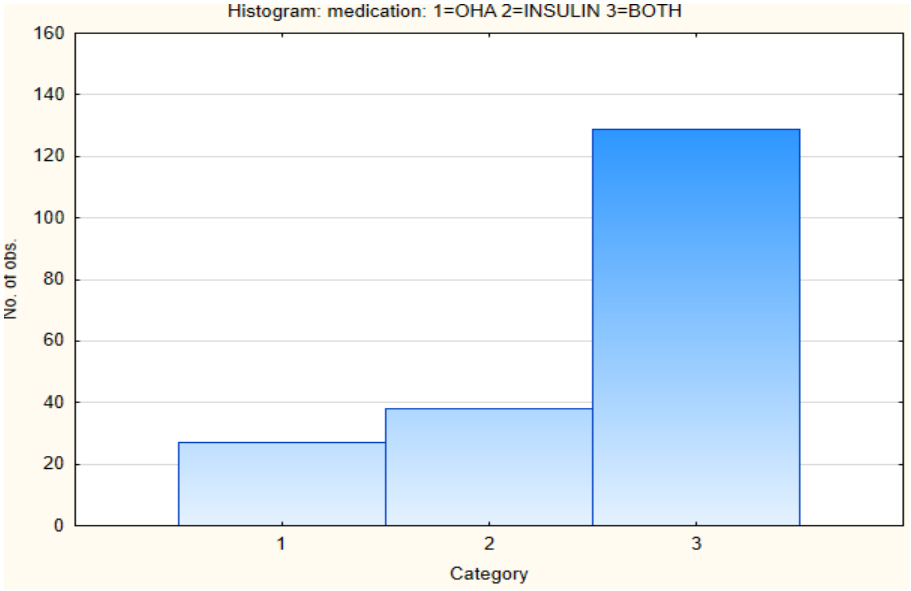

Figure 4.4

1. Patients on oral hypoglycaemic agents (OHA) only n= 27 (13.8%)
2. Patients using insulin only n= 38 (19.6%)
3. Patients on both insulin and OHA n= 130 (66.6%)

The pre-POC HbA1c:

Mean, minimum, maximum and standard deviation is presented below. The graph is normally distributed and the scatter plot demonstrates no extreme outliers:

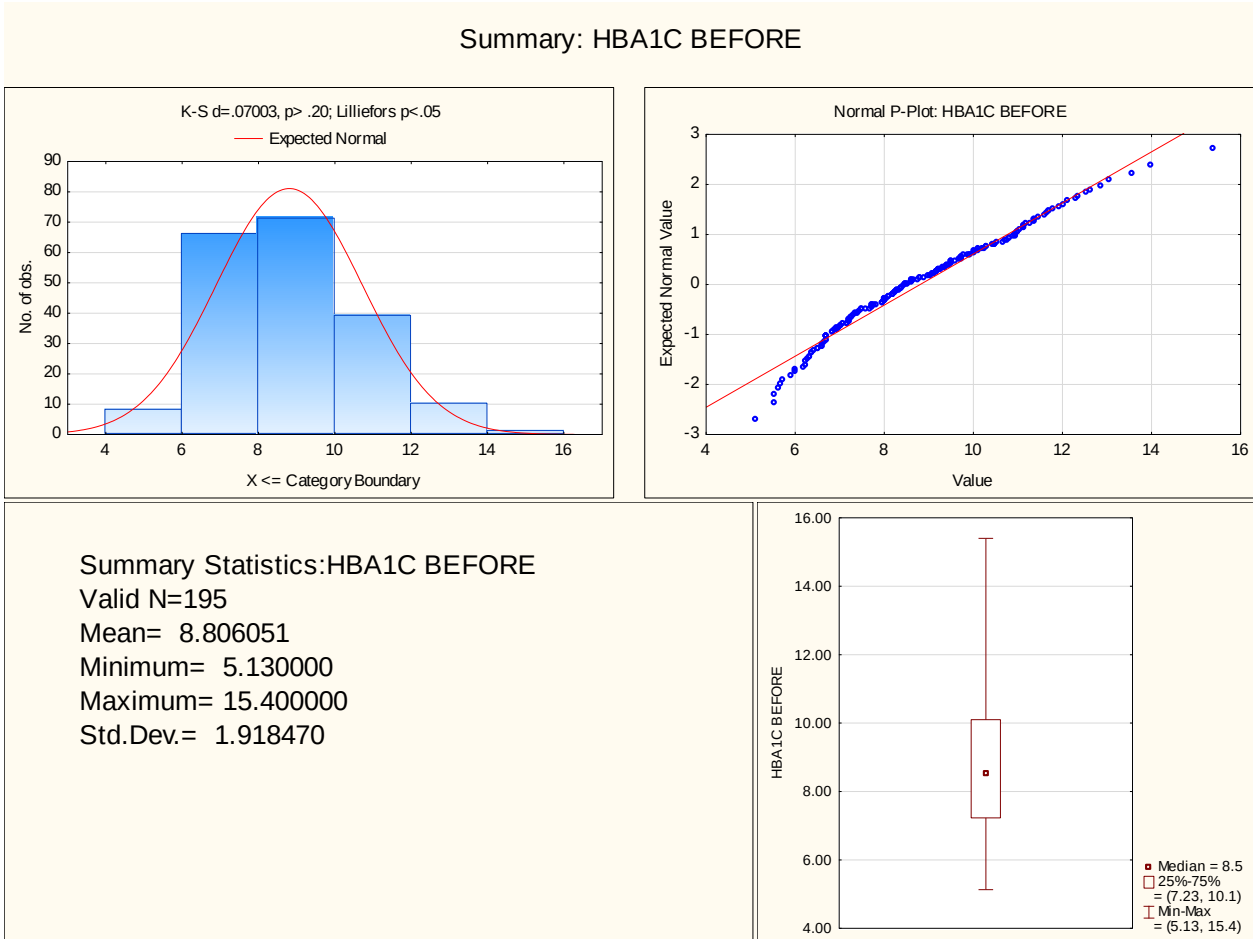

figure 4.5 x = HbA1c expressed as a percentage

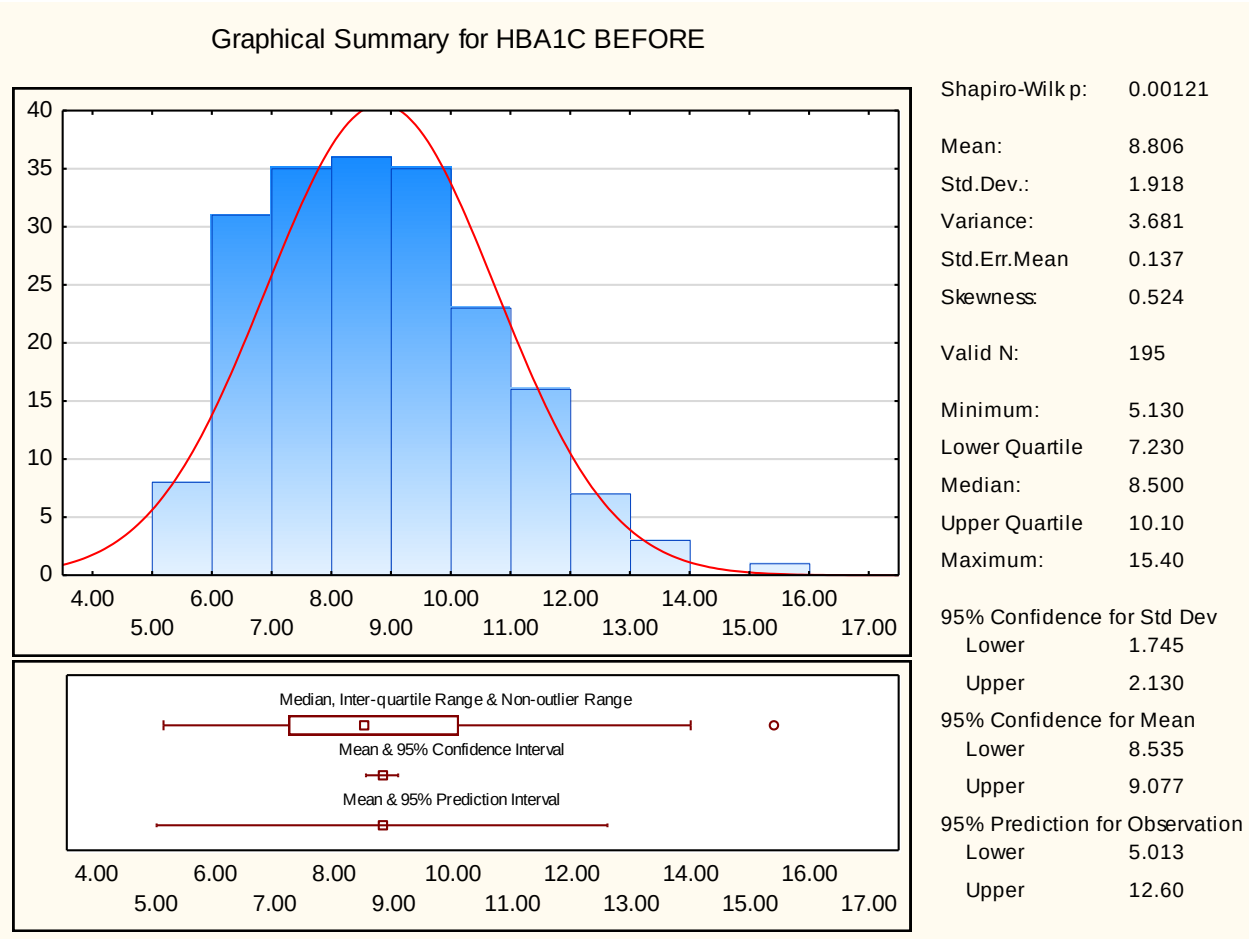

figure 4.6 X= HbA1c % Y= no of observations

39 (20%) people were at target HbA1c of 7% at baseline

<u>If the cut-off for controlled HbA1c is 8%</u>

How many were controlled 5 years ago? **71 (36.4%)**

How many were uncontrolled 5 years ago? **124 (63.6%)**

The following graphs express descriptive statistics of the average HbA1c result taken in the last 12 months from the patient. This is with the POC. It has been tested for normality using Lilliefors test and normal probability plot.

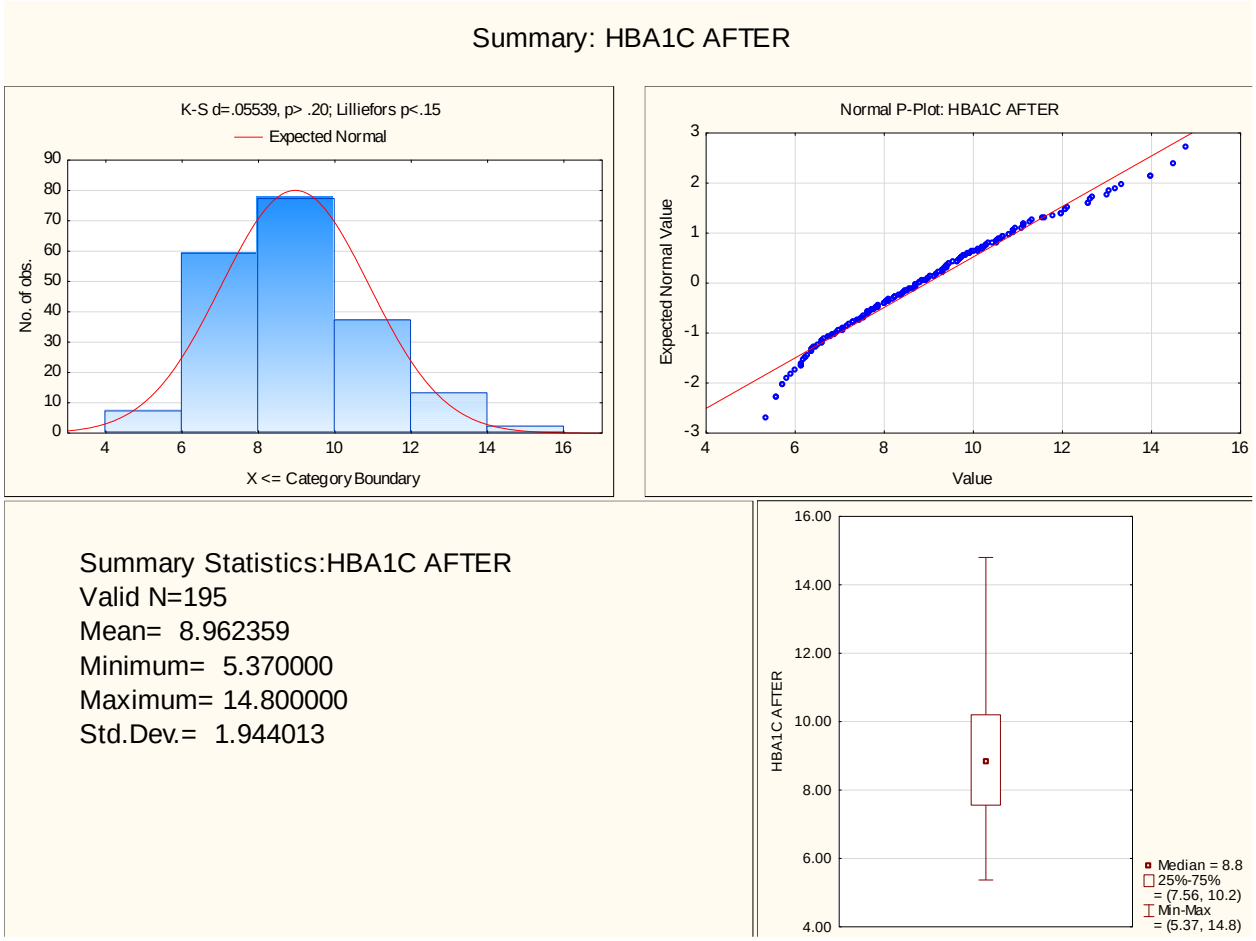

Figure 4.7 X= HbA1c

The POC HbA1c summary statistics are graphically represented below

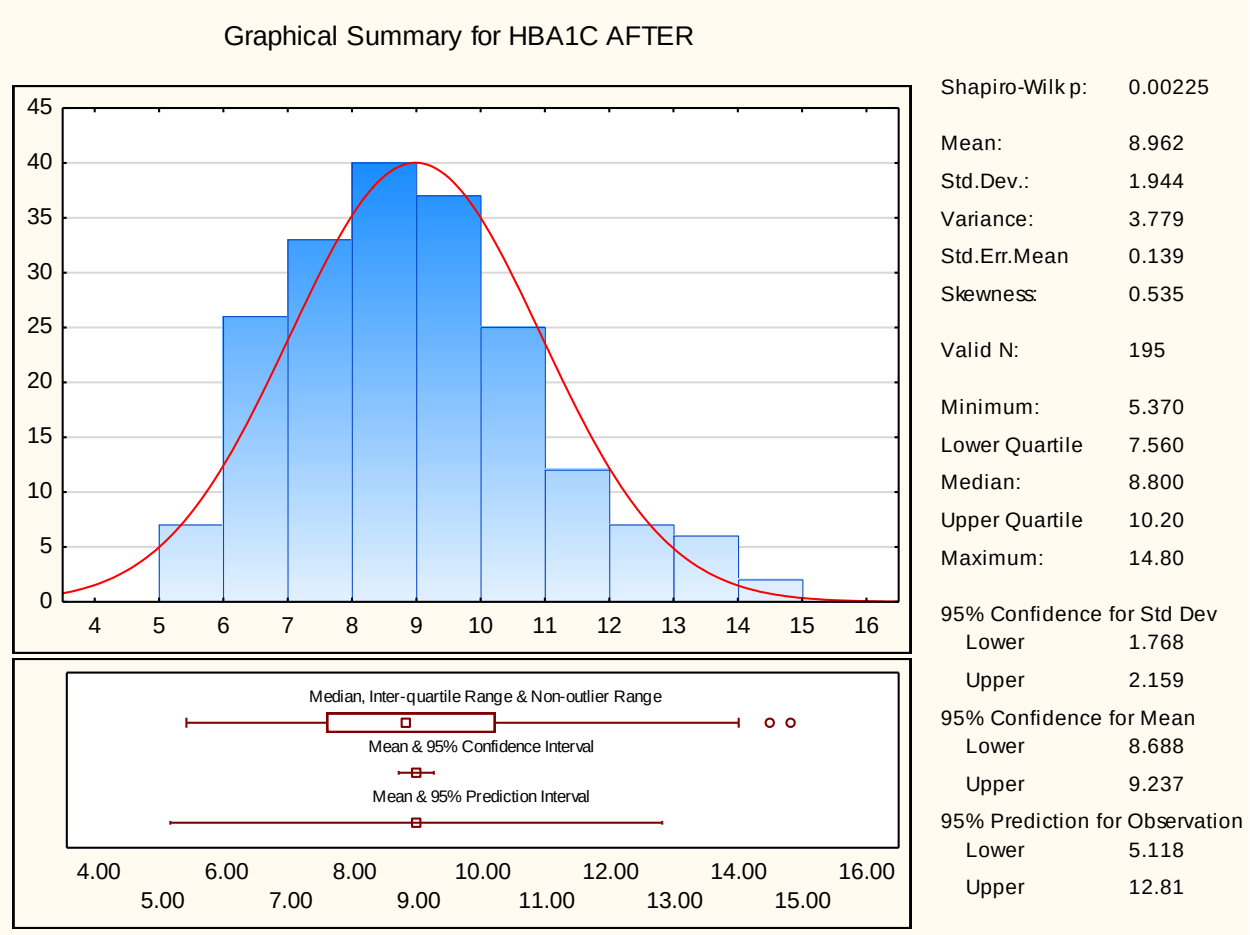

figure 4.8

33 (17%) at target HbA1c of 7%

How many are currently controlled in past year? (Hba1c < 8%) n=**64** (**32.8%)**

How many are uncontrolled in past year n=**131** (**67.2%)**

Data analysis to evaluate if the mean HbA1c after introduction of POC is statistically significant using the paired t test:

	Mean	SD	N	Diff	SD Diff	t	p	Confidence -95.00%	Confidence +95.00%
HbA1c before	8.80	1.92							
HbA1c after	8.96	1.94	195	-0.15	1.65	-1.32	0.19	-0.39	0.08

Table 4.9 T-test for dependent samples *p<0.05*

Percentage change in HbA1c = (POC – baseline)/baseline *100:

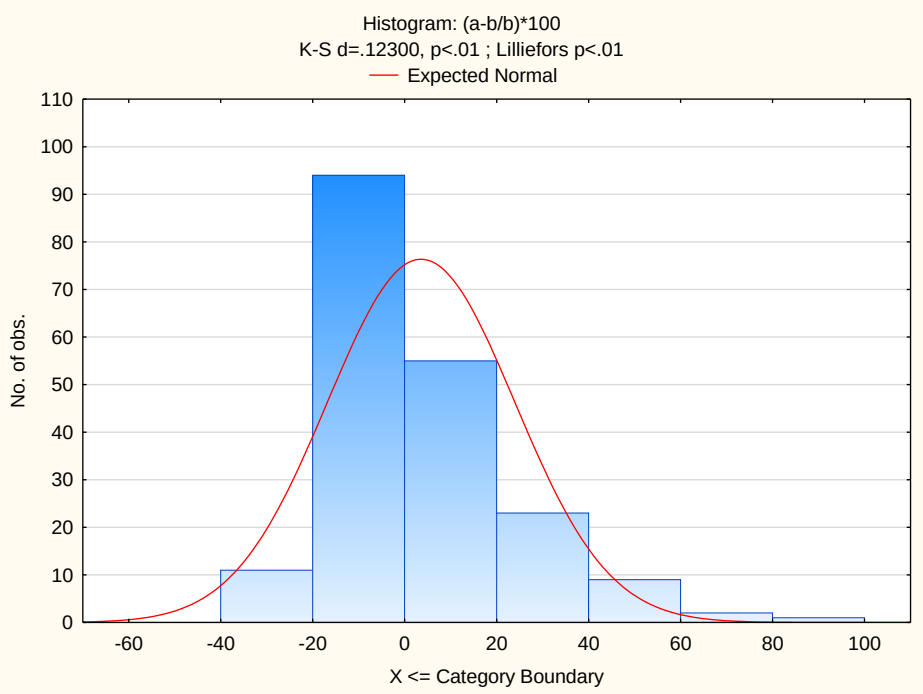

Figure 4.9 X = % change in HbA1c

Positive % change is the increase in HbA1c (worsened glycaemic control)

94 people had a 20% reduction in HbA1c, 11 people had between 20-40% reductions in HbA1c.

The people who worsened glycaemic control did so by much bigger % changes, with 12 people having > 40% increases in their baseline HbA1c.

Sign test showing proportion of positives and negatives:

(*Difference* between POC and baseline HbA1c)

Pair of variables	No. of non-ties	% v<V	Z	p-value
HbA1c before & POC	195	46.15	1.00	0.32

Table 4.10 v = baseline HbA1c V = POC HbA1c

v<V = means POC is > baseline so worsened glycaemic control

46.15% (n=90) had worsened HbA1c at POC

53.85% (n=105) had improved HbA1c values from baseline (p 0.316)

Scatterplot correlating baseline HbA1c (HbA1c before) with POC (HbA1c after)

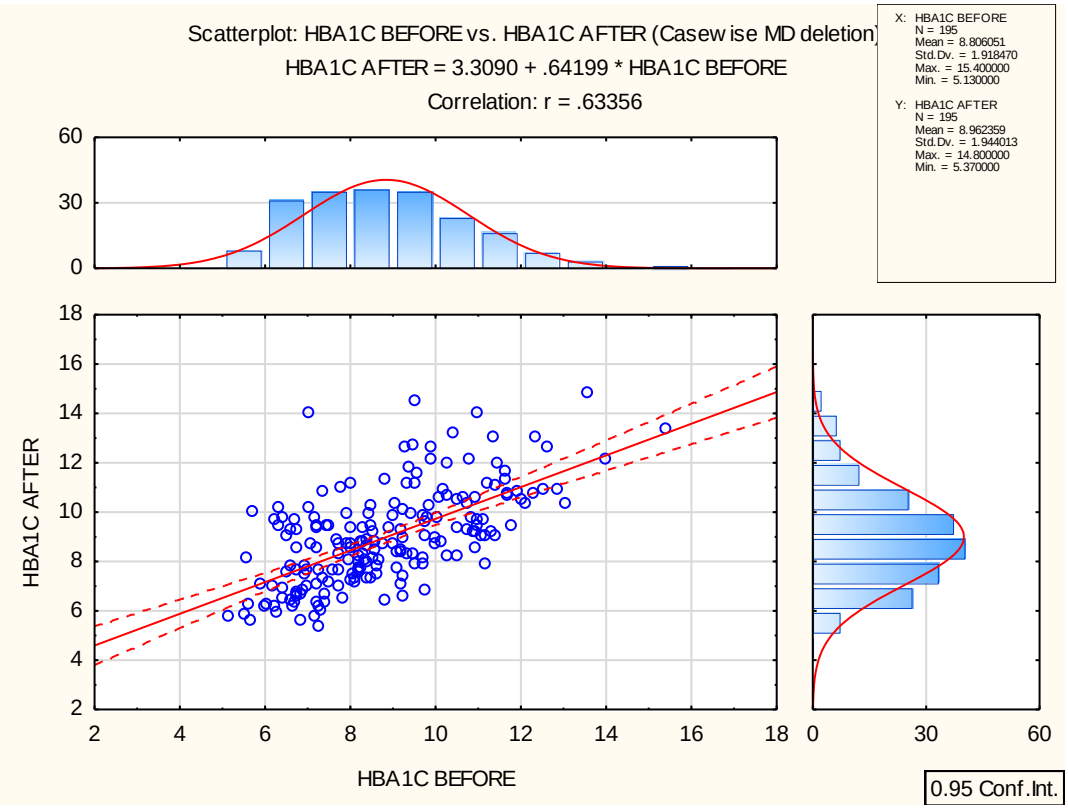

Figure 4.10

Pearson Chi^2 test showing association between baseline (HbA1c before) and POC (HbA1c after):

	HbA1c after		
HbA1c before	Controlled	Uncontrolled	Total
Uncontrolled	**21** 32.81%	**103** 78.63%	**124** 63.59%
Controlled	**43** 67.19%	**28** 21.37%	**71** 36.41%
Total	64 100%	131 100%	195 100%

Table 4.11 Pearson chi^2 = 38.9755 Pr = 0.000

Above tabulation outlines that the 124 patients who had an uncontrolled baseline HbA1c now 21 became controlled POC and 103 remained uncontrolled.

Of the 71 patients who were controlled before, 43 remained controlled and 28 became uncontrolled. I.e. HbA1c >8%

Healthcare provider responses during consultations

Follow-up interval

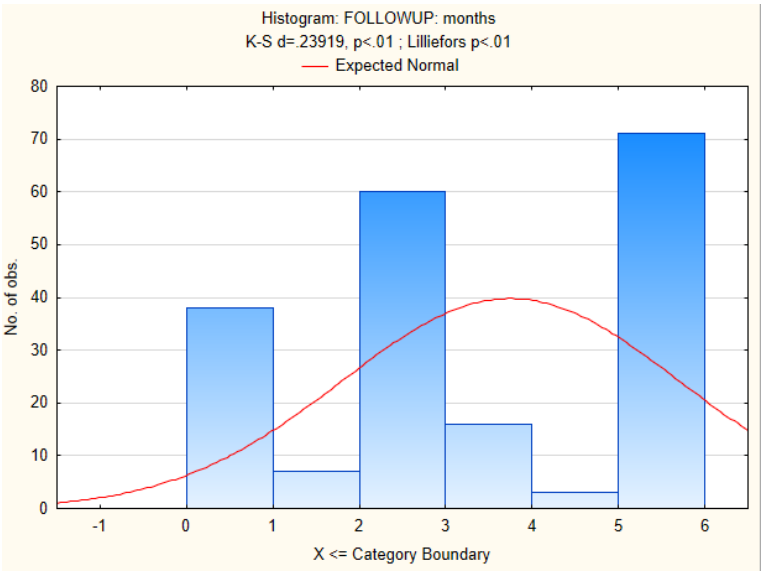

Figure 4.11 X= no of months

Patients asked to return within

- 1month n=38 19.5%
- 2 months n=7 3.6%
- 3 months n=60 30.8%
- 4 months n=16 8.2%
- 5 months n=3 1.5%
- 6 months n=71 36.4%

Treatment intensification

Treatment intensification referred to an increase in dose of insulin, oral hypoglycaemic agent, or introduction of insulin

46% n=90 of patients had their treatment intensified

54% n=105 of patients had no change at all to their antidiabetic medication.

Interventions including 1month follow-up:

Interventions include increase in medication, additional medication prescribed and follow-ups within 1 month. (Previous section on intervention did not include follow-up within 1 month) = 103

Nil intervention = 92

84 patients with HbA1c >8% at last visit had an intervention.

47 patients with HbA1c >8% had no change in management at last visit.

Discussion

Summary of results

Type II diabetics formed 80% of the patients attending the clinic. 129 patients (66%) were on both insulin and oral hypoglycaemic agents; and 13.8% were on oral hypoglycaemic agents alone. The mean age was 54 years (range 39-69) and there were more females than males: 60% and 40% respectively. The average BMI was 32 kg/m^2 but this was not representative as only 62 patients had a recorded height.

74% of patients had hypertension, the average SBP was 141mmHg (SD 22) with 109 (56%) had a SBP < 140mmHg. 41 patients (20%) had a SBP > 160mmHg and 11 (5.6%) had a SBP >180mmHg. 154 (80%) patients were on lipid lowering therapy. Macrovascular complications: CAD, CVA, PVD were present in 9%, 4.6% and 3% respectively.

The mean HbA1c before POC taken 5 years ago was 8.8% (SD 1.9)

The mean POC HbA1c using the average HbA1c readings in the past 12 months was 8.96% (SD 1.94). The paired t test for dependent variables comparing the pre/post POC HbA1c taken from the same patient 5 years apart showed no statistically significant improvement. The absolute difference was -0.16 (SD 1.65) (95% CI -0.389: 0.077) p value 0.188.

The pre/post POC HbA1c showed fair correlation on the scatterplot r= 0.633.

Patients remained on their trajectory, with no extreme deviations from their HbA1c taken before POC. The actual number of reductions in HbA1c after POC introduced was 105 (53.85%). 90 (46.15%) worsened after POC replaced laboratory HbA1c, when using the sign test p 0.3; Z 1.00.

At baseline, 39 (20%) people were at the target HbA1c of 7%. 71 (36.4%) had a controlled HbA1c of < 8% while 49 (25%) had a poorly controlled HbA1c of > 10%. Using the average HbA1c readings in the past 12 months 33 (17%) achieved the target HbA1c of 7%, while 64 (33%) were controlled with an HbA1c of < 8% and 52 (27%) were uncontrolled with an average HbA1c of > 10%.

Almost 80% of patients who were uncontrolled at baseline remained uncontrolled after POC, and approximately 70% of patients who were controlled at baseline remained controlled.

Treatment intensification

Changes in pharmacological treatment were noted in 90 people (46%). 64% of uncontrolled patients (HbA1c <8%) had an intervention (this includes follow-up within 1 month); and 36% of pts with an HbA1c >8% had no change to their treatment and no change in follow-up.

Increase in follow-up

19.5% of patients were asked to return within 1 month, 31% were to return in 3 months, and 36% were given follow-up dates for 6 months. There were no patients admitted on the day of their visit.

Discussion of results

There was no statistically significant change in glycaemic control since the implementation of POC HbA1c (from 8.8% to 8.96%) p 0,188 (95% CI -0,389:0,077). There was in fact an overall deterioration in average glycaemic control but this was not significant. 53.85% of people had a lower HbA1c when compared to their baseline HbA1c; i.e. nearly 54% of the cohort improved glycaemic control. However the magnitude of the uncontrolled results dilutes this finding; the number with improved glycaemic control did so by much smaller margins (% change) than those who deteriorated glycaemic control. The results followed a normal distribution using multiple tests so extreme outliers can't even account for these surprising findings. Perhaps those patients whose glycaemic control deteriorated had more room for large changes e.g. an HbA1c of 8% at baseline could potentially increase to 12%, this is a 50% increase. But patients who improved control only did so by smaller margins e.g. from 8% to 7% which was only a 12.5% reduction. It seems the large upward shifts hid the smaller improvements. (see graph on page 29)

Previous audits done at this facility found the average HbA1c to be 8.7% Kliesewicz et al (2009)[16] and 8.8% Pinchevsky et al (2013).[15] These were not different from our findings.

Kliesewicz et al 2009 did an audit at the 3 academic hospitals linked to the Wits University in Johannesburg. They found 30.7% of their cohort (46 people out of 150) to be achieving target HbA1c of <7% and 44.7% having an HbA1c < 8%. This data shows that glycaemic control has deteriorated; this study found only 17% to be at target. The 2009 study did not individually compare the 3 hospitals and it is difficult to say if a specific hospital had better glycaemic control. One of their objectives was to assess comprehensive diabetic care, which

was also found to be inadequate; clinicians were not expectantly managing associated cardiovascular disease.

Pinchevsky et al (2013) had a much larger cohort of 666 patients, they found 26.2% of patients to have achieved target HbA1c. And similar to the 2009 study, there was significant under treatment of cardiovascular risk factors.

Motta et al (2017)[27] achieved an average HbA1c of 8.4% (SD 2.4) 15 months from treatment initiation, although their cohort had different characteristics: their study screened the population for diabetes and initiated treatment at a community health centre. At the end of their study, 48.1% were at target glycaemia. This study is not comparable because it displays the excellent benefits of a well-functioning screening program using POC at primary care level. Patients referred to a tertiary hospital are usually uncontrolled diabetics who are potentially harder to treat.

Tanyanyiwa et al (2015)[22] conducted a study at a large tertiary hospital in Soweto, South Africa. The average HbA1c was found to be 12.84 (SD 4.36). These results were obtained from 104 subjects attending the diabetic clinic at Chris Hani Baragwanath hospital. The main objective of their study was to compare the DCA Vantage to the laboratory analyser and validate the POC for screening and managing diabetes in primary health care settings in South Africa. Nonetheless this poor glycaemic control reflects control at a tertiary diabetic clinic with comparable characteristics to our study setting.

An audit conducted at an academic hospital in Pretoria in 2004, showed an average HbA1c of 9.77% albeit using the laboratory analyser, but with similar clinic characteristics as this study. They examined the importance of improving physician education and providing practical tools to aid the consultation in order to achieve better care.[30]

Bubner et al (2009) conducted a multi-centre study covering general practices in the UK; this randomized controlled trial compared healthcare provider's response to POC vs delayed laboratory HbA1c. They assessed glycaemic control and treatment intensification. They found an average HbA1c of 6.91% and 64% of the subjects met target glycaemic control of <7%.[31]

Khunti et al (2006) used POC in their intervention arm of 290 participants, canvassing 8 general practices in the UK. At 12 month follow-up, the intervention arm utilising POC had an average HbA1c of 7.5% (SD 1.6) and 37% of this cohort achieved target glycaemic control of <7%. However the control arm which used delayed laboratory Hba1c had an average Hba1c of 7,7% (SD 1,6) and had 38% of their cohort at target Hba1c. There was no significant difference with POC .[24]

Reasons for poor control

A study conducted in KwaZulu-Natal (KZN), Okoroma et al (2013), surveyed 750 patient records at a regional hospital to evaluate the extent to which the diabetic department adhered to SEMDSA guidelines. The study found poor compliance with diabetic guidelines and poor glycaemic control, the average HbA1c was 9.7% and only 16.7% of the subjects were at target HbA1c of < 7%. Healthcare providers were simply not following guidelines, "processes of care" were neglected, and other components of comprehensive diabetic care were lacking.[32]

Mash et al (2016) suggested "clinical inertia" as a primary concern responsible for the lack of improvement in glycaemic control at health centres in the Western Cape. Despite feasible, easily implementable access to POC and readily available guidelines, there was no improvement in treatment intensification, no increase in POC usage, and no improved glycaemic control.[25]

Why did glycaemic control get worse??

Perhaps there are limitations inherent to institutions as suggested by Khunti et al. (2006) they found that follow-up dates for patients were fixed and did not depend on the outcome of the consultation. Practices were unable to reorganize return dates and patients attended in a manner that suited the booking system. In this study, 1, 3 and 6 month return dates were popular, there did not seem to be much flexibility in choosing an appropriate follow-up interval. Healthcare providers seemed to stick by their favoured norms. Medications were issued for 30 days at a time with repeats that are fetched monthly. If the facility has booked the maximum number of patients for that day; it becomes difficult to institute discordant return dates like 6 weeks or 8 weeks due to the risk of patients running out of medication.

Our population has a high unemployment rate and healthcare providers are recognizant of the financial strain that frequent visits impose on patients.

Anecdotal experience shows that many patients do not actually adhere to the insulin doses prescribed, they usually under-dose due to the fear of hypoglycaemia. This highlights the importance of self-monitored home glucose testing as part of diabetic care. Patient awareness of HbA1c is an important consideration in improving glycaemic control; the following study demonstrates the importance of patient education in achieving better diabetic care.

A large multi-centre study in the UK collated data from the UK National Diabetes Audit 2014-2015 to evaluate the determinants of improved glycaemic control. Data from 4050 general practices servicing 1.6 million patients with T2DM were evaluated to determine which characteristics led to improved glycaemic control. Overall, 67.2% had target glycaemic control at HbA1c <7.5% and 6.2% of the population had HbA1c of > 10% which was considered "higher glycaemic risk". They found that the practices that had better glycaemic control had patients aged > 65 years, spent less on prescribing sulfonylureas and insulin, prescribed more metformin and more glucose monitoring strips. Overall, they spent less on medication.

They also adhered to comprehensive diabetic care practices like patient education, blood pressure and cholesterol management. It is evident from this study that glycaemic control is achieved with better glucose monitoring and patient education and not necessarily more medication.[33]

Some patient characteristics associated with poorer glycaemic control have been investigated by Ali et al (2012) in the National Health and Nutrition Examination Survey in the Centre for Disease Control and Prevention morbidity and mortality report in the USA. They found that 12.9% of known diabetics had poor glycaemic control which was an HbA1c of > 9%. Poor control was least common in > 65-year age group, and most common in the 18-39-year group. The average age of our cohort was 54 years. There were racial disparities; the proportion of blacks with poor glycaemic control exceeded that of whites. Our study had 63.6% and 18% blacks and whites respectively. There were no consistent differences attributable to gender, education level and socioeconomic status. Patients who were using both insulin and oral hypoglycaemic agents had poorer control than those on oral treatment alone. However requiring insulin can be attributed to increased disease severity. Regrettably BMI and length of diagnosis was not considered in their study.[34]

Limitations of the study

Most patients had 2 HbA1c values in the preceding 12 months as the technologists routinely did the test 6 monthly. Perhaps doctors were not exercising their clinical judgement and requesting more frequent testing. The technologists may be deciding who gets tested and the doctors' work with the information in front of them. Technologists were only available in the morning and we assume that patients who came late missed out on testing and remained with their 6 monthly follow-up schedule.

We know that the HbA1c is a weighted average, even though it reflects glycaemic control over 3 months, an acute change in glycaemia over the past month will reflect as an increase overall. Therefore the average of all HbA1c's taken in 12 months was used.

Conditions that may affect the HbA1c readings were not readily documented in the patient records, e.g. anaemia and haemoglobinopathies. However this should not have affected many patients and is unlikely to have skewed the findings. The POC device had a maximum value of 14% but the laboratory test upper limit goes up to 18%, so it is still possible that the POC HbA1c could have been higher if the range was not restricted to 2.5%- 14%.

There seems to be underreporting of complications, this may be inherent to the subspecialist nature of the institution. Patients with coronary artery disease may be following up at cardiology. Patients who have recovered from a stroke may not have it documented in their diabetic file. Many patients assessed as having dyslipidaemia were done so based on the fact that they were on lipid lowering therapy, but they may have been on statins for secondary prevention of CVD, or as primary prevention of atherosclerotic cardiovascular disease due to the high-risk nature of diabetes.

Conclusion

The purpose of this study was not to compare the validity of point-of-care testing to its laboratory counterpart in terms of actual accuracy of the test result. However the hypothesis was that POC would lead to better glycaemic control because of the supposed immediate intensification of management. Perhaps the naïve premise was that quicker action and earlier titration of treatment coupled with enhanced patient education would lead to better glycaemic outcomes. The setting was, after all, a tertiary hospital. Perhaps patients referred here are harder to treat due to poorly modifiable patient characteristics. Clinicians are utilising POC testing without enough evidence to show patient benefit. The POC test turned out to be a sub-optimal addition to diabetic care. Other studies have also shown that it is not cost effective

and neither has it improved glycaemic control in its use for long term follow-up. This study likewise showed no improvement with patients following up over a 5-year period. When compared to the previous audits at this clinic, glycaemic control had actually deteriorated. With only 17% of diabetics at target, it seems that management of diabetes mellitus has become stagnant. Previous studies have shown that clinicians are not adhering to guidelines adequately. It seems they are not aggressively aiming to achieve target HbA1c levels and are satisfied with this pervasive hyperglycaemia. 36% of patients had no intensification of treatment despite having an HbA1c >8%. This chronic hyperglycaemia does not bode well for the development of diabetic complications.

Heald AH et al (2018) showed that improved glycaemic control stemmed not from prescribing more insulin, but from prescribing more testing strips. Diabetic nurse educators play a critical role in improving patients' competencies in managing the practical aspects of their diabetes; patients are encouraged to perform finger prick glucose monitoring and recording at home and self-titration of their insulin. This highlights the importance of patient involved care where patients are empowered with knowledge and skills to titrate their treatment in order to keep their postprandial glucose in the appropriate range. Diabetes care should not be a prescription that is only adjusted during contact with a health care provider. Home-based glucose monitoring and patient involvement seem to be underestimated strategies in improving glycaemic control.

Recommendations

Patient education and initiative are important in comprehensive diabetic care. Healthcare providers should make a point of communicating glycaemic targets with patients and encourage patients to self-monitor glucose, record the values and titrate their insulin accordingly; this diary should be brought to consultations for discussion and encouragement. Immediate discussion of results may improve patient enthusiasm and cooperation with prescribed treatment. Diabetic nurse educators are important in helping patients to manage their diabetes by providing encouragement, support and guidance to effect improved glycaemic control.

Healthcare providers need periodic reminders to remain committed to guideline-based care-plans. Frequent quality assurance audits may assist in keeping clinicians motivated to providing better care.

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R14/49 Dr Constance Adams

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170260

NAME: (Principal Investigator)	Dr Constance Adams
DEPARTMENT:	Internal Medicine, Endocrinology Charlotte Maxeke Johannesburg Academic Hospital Diabetic Clinic Outpatient Department
PROJECT TITLE:	Has Diabetes Mellitus Glycemic Control Improved with Introduction of Point of Care Glycated Haemoglobin A1c
DATE CONSIDERED:	24/02/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Frederick Raal
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	31/03/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in February and will therefore be due in the month of February each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date 31/03/2017

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