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ABSTRACT

Background: The prevalence of diabetes is rising globally, and Sub-Saharan Africa is no exception. With diverse health challenges, health authorities in Sub-Saharan Africa and international donors need good data on the epidemiology and public health implications of diabetes in order to plan and prioritise their health programmes.

Methods: We conducted a systematic literature review of papers published on diabetes in Sub-Saharan Africa 1999-2010 providing data on diabetes prevalence, diabetes outcomes (chronic diabetes complications, infections, and case-fatality), access to diabetes diagnosis and care, and economic burden caused by diabetes.

Results: Type II diabetes accounts for well over 90% of diabetes in Sub-Saharan Africa, and prevalence proportions range from 1% of the population in rural Cameroon to 18% in
Mauritius. Reported type I diabetes prevalence is low and ranged from 4 per 100,000 in Mozambique to 12 per 100,000 in Zambia. Gestational diabetes prevalence varied from 0% in Tanzania to 9% in Ethiopia. Recorded proportions with diabetic complications among patients ranged from 7-63% for retinopathy, 27-66% for neuropathy, and 10-83% for microalbuminuria. Diabetes is likely to increase the risk of several important infections in the region, including tuberculosis, pneumonia and sepsis. At the same time, HIV and its antiviral treatment increase the risk of obesity and insulin resistance. Observed diabetes case-fatality within five years varied from 4-57%. High proportions (>40%) with previously undiagnosed diabetes, and low levels of adequate glucose control among previously diagnosed diabetics were detected in screening studies. Several barriers to accessing diagnosis and treatment were identified, including a profound lack of diagnostic tools and glucose monitoring equipment and high price of diabetes treatment, especially insulin. The total annual cost of diabetes in the region is estimated at Int$25.51 billion, or $3363 per diabetic patient.

**Conclusion:** Diabetes exerts a significant burden in the region and this burden is expected to increase. Existing literature indicates that many diabetic patients face significant challenges accessing diagnosis and treatment, and that this fact contributes to the high case fatality and prevalence of complications observed. Associations between diabetes and important communicable diseases in the region such as tuberculosis, pneumonia and HIV need to be acknowledged.

**BACKGROUND**

Sub-Saharan Africa, like the rest of the world, is experiencing rising prevalence of diabetes alongside other non-communicable diseases [1]. In 2010 12.1 million people are estimated
to be living with diabetes in Africa, and this is projected to increase to 23.9 million by 2030 [2]. In Sub-Saharan Africa this trend is emerging in a region grappling with high rates of communicable diseases – including the highest global prevalence of HIV [3], Tuberculosis [4] and Malaria [5]. With this double burden of disease and limited resources, diabetes must compete for political attention and financial investment. Diabetes and other non-communicable diseases have yet to become a political priority in the region [6]. Policymakers need guidance from strong reviews of current information on trends and public health impact. This review expands on recent reviews of diabetes in the region [7-12], providing greater consideration of the diabetes prevalence, access to diabetes diagnosis and care, clinical outcomes following diabetes (chronic diabetes complications, infections and case-fatality), and economic costs.

METHODS

We conducted a systematic review of all papers published on diabetes in Sub-Saharan Africa between January 1999 and September 2010 and available on PubMed. A combined keyword search on PubMed identified 1102 papers. See Annex 1 for a description of the review and Annex 2 for the keywords used. The references of included articles were scanned to identify additional articles of interest published before January 1999. Grey literature, from sources including the websites of the World Bank, World Health Organisation and International Diabetes Federation was also reviewed.

RESULTS

The prevalence of diabetes in Sub-Saharan Africa
Type II diabetes accounts for over 90% of diabetes cases in Sub-Saharan Africa [7], whilst Type I diabetes, gestational diabetes, and variant forms such as atypical ‘ketosis-prone’ diabetes and malnutrition-related diabetes constitute the remainder.

**Type II Diabetes**

Just ten countries in the region have conducted type II diabetes (T2DM) prevalence surveys in the last decade (see table 1). Four of these countries have conducted population surveys with the assistance of the World Health Organisation’s ‘STEPwise Approach to Chronic Disease Surveillance Management’. Prevalence in the general population of T2DM recorded in these studies ranged from 0.8% in rural Cameroon [13] to 17.9% in Mauritius [14]. A low to medium prevalence (0-7%) was recorded in Cameroon, Ghana, Guinea, Kenya, Nigeria and South Africa and a very high prevalence (>10%) was recorded in Zimbabwe, the Seychelles and Mauritius (table 1).

Variation in prevalence recorded within countries was common. Prevalence estimates varied considerably between different studies for some countries, with estimates for rural South Africa ranging from 3.9% [15] to 8.8% [16]. Variation between urban and rural populations was frequently observed, with a higher prevalence recorded in urban populations [13, 16-20]. Prevalence recorded in Christensen’s Kenyan survey ranged from 2% in rural areas to 12% in urban areas [19].

One recent study investigated the incidence of type II diabetes in Kinshasa among a cohort of 807 people, aged over 40 at baseline [21]. 93 participants developed T2DM during the
study period (December 2004 to September 2008), corresponding to an incidence rate of 29 (95% CI 15–43) per 1,000 person-years.

**Insert table 1: Prevalence of type II diabetes in cross-sectional surveys in Sub-Saharan Africa 1999-2010.**

Type I Diabetes

Five studies estimating the prevalence and/or incidence of type I diabetes in the region were published since 1990 [22-26] (see table 2). Observed prevalence ranged from 3.5 per 100,000 persons in Mozambique[24], to 12 per 100,000 persons in Zambia[24]. Recorded incidence ranged from 1.5 per 100,000 persons per year in Tanzania[25] to 2.1 per 100,000 persons per year in Ethiopia[23].

**Insert Table 2: Prevalence and Incidence of Type I Diabetes in Sub-Saharan Africa 1990-2010**

Gestational diabetes mellitus

The literature review identified two studies on the prevalence of gestational diabetes in Sub-Saharan Africa 1999-present, one in Ethiopia [27] and one in South Africa [28] (see table 3). Three other relatively recent studies, published before January 1999, were identified [29-31]. The range of prevalence recorded in these five studies is considerable, from 0% among pregnant women in Tanzania to 9% in Ethiopia.

**Insert Table 3: Prevalence of Gestational Diabetes in Sub-Saharan Africa**
Other Types of Diabetes

Several reviews describing diabetes trends in Africa report the occurrence of other forms of diabetes, namely ‘Atypical African diabetes’ or ‘Ketosis-prone atypical diabetes mellitus’ and ‘Malnutrition-related diabetes’ or ‘Tropical Diabetes’ [7, 9, 11]. However, beyond describing their existence and aetiology, no studies investigating the population prevalence of these forms of diabetes in the region were identified.

Outcomes of diabetes

Case-fatality of diabetes

Three studies investigated case-fatality following diabetes in the region, two of which were conducted almost twenty years ago (Table 4). These studies revealed high case fatality proportions, with 5-year mortality ranging from 4% - 57% [32-34]. A 5-year mortality of 41% among persons with Insulin-Dependent Diabetes Mellitus (IDDM) was recorded in Tanzania, and half of these deaths were attributed to ketoacidosis [34]. Infection was another important cause of mortality, accounting for 48% of deaths in indeterminate diabetes cases, 32% in IDDM and 23% in Non-Insulin Dependent Diabetics (NIDDM) in the Tanzanian survey [34].

Insert Table 4: Diabetes case fatality studies in Africa from 1990

The prevalence of chronic diabetes complications among persons with diabetes

Twenty-four studies on the prevalence of chronic complications of diabetes among persons with diabetes published from 1999-2010 were reviewed. The recorded prevalence of
retinopathy ranged from 7% in Kenya\cite{35}, to 63% in South Africa\cite{36}, neuropathy ranged from 27% in Cameroon \cite{37} to 66% in Sudan \cite{38}, and the prevalence of microalbuminuria ranged from 10% in Tanzania \cite{39} to 83% in Nigeria \cite{40}. Some national variation was suggested, with recorded retinopathy rates ranging from 7% to 22% in Kenya \cite{35, 41}.

\textbf{Insert Table 5: Cross-sectional studies on chronic complications of diabetes in Sub-Saharan Africa 1999-2010}

\textbf{Important infections and diabetes}

Diabetes is a component cause of several other important and often lethal diseases, both non-communicable diseases such as cardiovascular disease \cite{42} and renal disease \cite{43}, and communicable diseases such as pneumonia \cite{44}, bacteraemia \cite{45, 46} and tuberculosis \cite{47}, which have considerable impacts on morbidity and mortality in the region \cite{48-53}.

A recent meta-analysis of thirteen studies found that diabetes was associated with a 3.1 times elevated risk of tuberculosis \cite{47}, and a systematic review of 9 studies found that this increased risk varied from 1.5 to 7.8 \cite{54}. Newer results suggest that any tuberculosis risk increase from diabetes is lower in highly developed countries \cite{55, 56} and that tuberculosis risk is mainly increased by poor glycemic control\cite{57, 58}. Unfortunately, proper epidemiological studies of the diabetes-tuberculosis association from Africa are sparse\cite{59}. It is currently not clear if diabetes makes individuals more susceptible to initial tuberculosis infection or increases the development of active tuberculosis from latent infection \cite{59}. Diabetes may also affect the nature and severity of tuberculosis, including infectivity \cite{54} and responsiveness to treatment \cite{54, 60, 61}. It has also been suggested that tuberculosis
increases the risk of incident diabetes [62]. One study found an eight-fold increased risk of multi-drug resistant tuberculosis among diabetics [63], but this association remains uncertain [54, 59, 62].

There is evidence that type 2 diabetes is associated with a 25-75% increase in the risk of pneumonia leading to hospitalisation [64-69]. Longer duration of diabetes, diabetes complications, and poor long-term glycemic control increases the risk for pneumonia, and the relative risk impact of diabetes is greatest in young adults with diabetes [66, 70]. Diabetes and acute hyperglycemia also predict increased case-fatality following pneumonia[71]). This knowledge underscores the potential value of influenza and improved pneumococcal immunizations in this risk group, and the general importance of improved glycemic control.

There is a 2.5 times increased risk for hospitalization with sepsis in diabetic individuals compared to the general population[68], and the standardized mortality ratio for septicaemia as cause of death in the developed world is 4 times higher than in the general population [72]. Patients with diabetes mellitus are at increased risk in particular for bacteremia and sepsis originating from the urinary tract with relative risks of 2 to 3 compared with other persons [73]. Bacteremia risk due to hemolytic streptococci and staphylococci is also increased 2 to 3 times or more in diabetes[74-76], often originating from wound infections which are an important health problem in the region[11]. Among 11 patients newly admitted with type 1 diabetes at a teaching hospital in Nigeria, 9 (82%) presented with urinary tract infection, malaria, or recurrent boils [77]. Risk increases for
pneumococcal bacteremia are in line with the approximately 1.5 times increased risk for pneumonia [70].

Both HIV and its antiretroviral therapy (ART) are associated with an increased risk of developing the metabolic syndrome, which predisposes individuals to develop type II diabetes and cardiovascular disease [62]. A range of metabolic changes have been associated with both untreated HIV and ART, such as increased central obesity [62], increased insulin resistance [78], lipodystrophy [79], and dislipidemia [80], although greater changes have been associated with ART [78]. One review found that prevalence of metabolic syndrome among patients on ART ranged between 18 and 33% [81].

**Access to diabetes diagnosis and treatment**

All of the type II prevalence surveys which recorded proportions of previously undiagnosed diabetes among participants who attended screening programmes found very high levels (≥40%). Proportions exceeded 50% in five surveys, and reached 100% in rural Guinea [14, 16, 18, 19, 82-85].

Beran et al surveyed the availability of diagnostic testing tools in a sample of healthcare settings in three countries, and found that in Mozambique urine glucose strips were available in just 18% of health facilities surveyed, ketone testing strips in 8% and blood glucose metres in 21%, whilst availability in Mali was 54%, 43% and 13% and in Zambia 61%, 54%, 49% [24, 86].
Low levels of adequate glucose control in diagnosed diabetics were reported in several prevalence studies [83, 87]. Only 25% of diagnosed type II diabetics receiving treatment in the Seychelles study and 27% in the Cameroon study had adequately controlled glucose levels [83, 85]. Of 99 type I diabetics in the Tanzanian survey, only one person achieved good glucose control [87]. None of the 99 type I diabetics had the ability to monitor their glucose levels at home, and hospitals were unable to routinely do this [87]. A regular supply of insulin was unaffordable for many diabetics, with one month’s insulin supply costing 19.6 days wages in Malawi [88] and 25% of the minimum wage in Tanzania [89]. One Sudanese study found that 65% of a families’ annual household expenditure on health was spent on caring for a diabetic child [90]. Beran and Yudkin found that state interventions affected insulin price, reporting that an annual supply of insulin cost 5% of GDP in Mozambique, where it was subsidised by the government, whereas it cost 25% of GDP in Mali without subsidies [86]. One study investigated Insulin availability and reported that one of five hospitals and none of six health centres surveyed had a regular insulin supply[24].

**ECONOMIC COSTS OF DIABETES**

Few studies were identified which investigated the cost of diabetes in the region. Kiriga et al (2009) estimated that the total economic cost (direct and indirect) of diabetes in the WHO’s Africa region in 2000 was Int$25.51 billion, or $3363 per person with diabetes per year [91]. Kiriga also estimated that the direct cost of treating diabetes in 2000 ranged from Int$876 to Int$1220.6 per person.
One study into the cost of caring for children with T1DM in Sudan found that the mean annual expenditure on diabetes care was US$283 per diabetic child, 36% of which was spent on insulin [90]. A Tanzanian study estimated that in 1989-1990 the total cost of outpatient care for all diabetic patients was US$2.7million, of which insulin accounted for two-thirds of the expenditure, and total in-patient cost was US$1.25million [92]. As diabetes care in Tanzania was provided free of charge to users this total cost of US$4million was paid from the government health budget and accounted for 8% of the government’s total health expenditure 1989-1990. A South Africa study investigated the cost of hyperglycaemic emergency admissions in South Africa over a two month period in 2005 and reported an average cost R5309, equivalent to US$712, per admission [93].

**DISCUSSION**

**Prevalence of diabetes**

**Prevalence of type 2 diabetes**

The prevalence of T2DM appears to have increased considerably from that recorded in earlier (pre-1985) surveys conducted in the region, which found the prevalence in Sub-Saharan Africa was typically below 1%, with the exception of studies in South Africa (3.6%)[94] and the Ivory Coast (5.7% (Zmirou, D. 1979 thesis, reported in McLarty et al 1990 and Motala et al 2003)) [10, 95]. However, many of these early studies may have underestimated prevalence, due to use of low sensitivity screening methods and non-standardised diagnostic criteria [16, 85, 96]. Impaired Glucose Tolerance (IGT) and Impaired Fasting Glucose (IFG) are predictors of incident T2DM [97]. Thus, a high IGT prevalence alongside a low T2DM prevalence may indicate the early stage of a diabetes epidemic [8]. IGT prevalence suggests that the T2DM prevalence is likely to increase further in several
countries in the region, including Cameroon, Ghana, Guinea and the Seychelles (Table 1) [85], whereas the decreasing prevalence of IGT in Mauritius alongside a stable prevalence of T2DM, may indicate that the epidemic has reached a plateau and is more mature [14, 98].

Preventing obesity and low rates of physical activity is essential in preventing T2DM. Six T2DM surveys measured the prevalence of obesity among participants, which ranged from 0.2% among rural males in Tanzania[20] to 35% among females in the Seychelles [85]. Faeh et al estimated that almost half (49%) of diabetes in the Seychelles was attributable to obesity[85] , whilst the Ministry of Health study in Cameroon reported that controlling obesity and overweight levels would reduce diabetes by 15% in males and 13% in females [83]. The comparatively higher prevalence of T2DM recorded in urban areas was associated with a higher prevalence of obesity among the urban samples and a lower proportion reporting regular physical activity [17, 20]. The projections that by 2025 70% of Africans will live in cities, with a regional annual urban growth rate of 4.5% [99], suggest that levels of obesity and T2DM diabetes will continue to rise in the region [7].

**Prevalence of other types of diabetes**

As there is very limited data available on other forms of diabetes in the region it is difficult to describe trends. Given the small number and limitations of existing studies, it is not clear whether the very low incidence rates of T1DM of 1-2 per 100,000 are reliable. All the existing studies based their estimates on previously diagnosed cases rather than population screening, and misdiagnosis and high community mortality may leave many cases unknown [11, 23, 87]. This is supported by the observation that T1DM was often first diagnosed when patients presented at healthcare facilities with acute diabetic complications [32, 93].
Also concerning the prevalence of gestational diabetes, more studies are needed to determine whether the observed variations from 0-9% among pregnant women reflect true regional variation.

**Outcomes of diabetes**

The three studies investigating case fatality found high proportions, and these may have been underestimates or overestimates due to sampling only diagnosed diabetic patients accessing healthcare. More studies are needed to explore whether the varying diabetes complication proportions in different countries reflect true variation. Small samples sizes and hospital-based recruitment limit the generalisability of these studies. Only one study, in Mauritius, recruited a population-based sample [100].

The observed high case fatality and high prevalence of diabetes complications is likely to be a consequence of many late diagnosed and poorly controlled cases. Assessing the public health importance of diabetes demands an appreciation of the impact of diabetes on other diseases and population mortality, and in particular the benefits of well-controlled diabetes for averting costly cardiovascular and microvascular complications [43, 101]. The total cost of these complications is likely to far outweigh the cost of effective primary and secondary prevention.

The associations between diabetes important communicable diseases in the region, particularly tuberculosis and HIV, further complicate the pattern of increasing diabetes prevalence in Sub-Saharan Africa and the challenges posed on resource-constrained health systems. An increased prevalence of diabetes in the region may fuel a surge in
tuberculosis, in a region which already has the highest global incidence rate of tuberculosis [4]. Studies have found that 20% of smear-positive tuberculosis in India and 25% of tuberculosis in Mexico is attributable to diabetes [102, 103]. No similar studies have been conducted in Sub Saharan Africa for comparison. Meanwhile, the high prevalence of HIV and the roll-out of ART may increase the prevalence of diabetes risk factors and consequently diabetes incidence. Projections of future diabetes trends have not considered the potential impact of this association which could increase the future diabetes burden. Consideration of the associations between diabetes and the other major communicable diseases in the region has been notably absent from the literature – both peer reviewed and grey literature. It is vital that awareness of these associations is promoted so that complementary and integrated programmes in these disease areas can be planned.

Access to diagnosis and treatment

The high rates of undiagnosed and uncontrolled diabetes recorded highlight the presence of significant barriers to accessing diagnosis and treatment. The high rates of undiagnosed diabetes suggest that existing screening practices in the region are not effective. Given the reports that health centres lack the necessary diagnostic tools it is also likely that screening for diabetes is not routinely performed. It is notable that rates of undiagnosed diabetes are also substantial in the high prevalence and comparatively more developed islands of Mauritius and the Seychelles.

Several important challenges to accessing diagnosis and treatment have been identified in the literature: the high financial cost of treatment, particularly insulin; the limited availability of diagnostic tools, treatment and glucose monitoring equipment; and a low
awareness of diabetes among healthcare professionals which was reported by some authors[24]. Other important barriers may exist that have not yet been identified, as few studies have focused on this issue, and more information on the comparative importance of these factors is necessary to effectively target any interventions.

ECONOMIC IMPACTS OF DIABETES

Diabetes is an expensive disease, especially when the cost of complications, including the many diseases where diabetes is an underlying causal factor, is considered. Kiriga’s study highlighted the vast expense of treating diabetes in the WHO’s African region; however the cost of complications were excluded from the study, and therefore this is a significant underestimate of total cost of diabetes. Kiriga estimated that the direct cost of treating diabetes in 2000 ranged from Int$876 to Int$1220.6 per person. Even at this level of direct cost, there is a significant discrepancy between the cost and available expenditure, as the International Diabetes Federation (IDF) has estimated that in 2010 national funding for the healthcare of diabetics in Africa is just US$111 per person, which already amounts to 7% of national healthcare expenditure [104].

With limited national funding, individual patients and their families may have to spend significant proportions of their income on treatment for diabetes, a level of expenditure that may not be sustainable or affordable. The Sudanese study found that families spend an average of US$283 per year caring for their diabetic child, which amounted to 65% of the family’s annual expenditure on health. It is possible that in this scenario other health needs are overlooked in order to devote over 50% of annual health expenditure to the one member of the family with diabetes.
The burden of T2DM is disproportionately borne by people of working age[105], which is also the age-group most profoundly affected by HIV in this region. Reducing the economic activity of this group through disease and disability affects both household and national economies. Diabetes therefore not only imposes considerable costs of treatment on families, it also hinders their ability to pay for this treatment through the loss of income of the diabetic member. At a national level an increasing prevalence of diabetes among the economically active, and the high prevalence of diabetic complications and low survival rates, will negatively impact economic development, and in turn the health budget.

Information on the cost of diabetes, including the cost of the complications, is critical for policymakers to highlight the importance of introducing early and cost effective interventions for both primary and secondary prevention.

**CONCLUSION AND RECOMMENDATIONS**

With increasing prevalence and interactions with other diseases, including the major communicable diseases of the region, diabetes is becoming a pressing public health problem for Sub-Saharan Africa. If effective interventions are implemented in the near-future it may be possible to avert much of this burden, as primary prevention and treatment can reduce the incidence of both diabetes and a range of related diseases where diabetes is a causal factor. However, establishing timely and effective integrated diabetes programmes in the region requires a shift in current public health priorities, and this requires a much better evidence base – both to highlight the scale of the problem and the areas for intervention.
Below are a set of recommendations for necessary action in order to address some of the knowledge gaps identified in this article:

1. Conduct prevalence and incidence surveys to increase the number of countries and regions with available data.
2. Collect more data on mortality, morbidity, costs, and access to diagnosis and care.
3. Construct models of the public health impact of diabetes in relation to other important diseases.
4. Promote awareness of the interactions between diabetes and key communicable diseases in Sub-Saharan Africa, to inform the development of integrated and complimentary service delivery programmes and health policies.
5. Establish peer-learning and experience-sharing discussion forums to promote development of feasible and cost-effective strategies and solutions for management and control of diabetes in Sub-Saharan Africa.

**Competing interests:**

VH undertook this review as a consultant for Novo Nordisk A/S. NL and OH are both employees of Novo Nordisk A/S.

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**Author’s contributions:**

NL and OH conceived the study and wrote the analysis plan. VH conducted the literature review and analysis and wrote the first draft manuscript. NL, RWT and OH reviewed the draft manuscript, provided critical comments and suggested additional analyses. VH finalised the manuscript which was subsequently approved by all authors.
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<td>Rural &amp; urban</td>
<td>1459 (98.2)</td>
<td>≥17</td>
<td>FBG/OGGT (WHO 99)</td>
<td>4.5* (2.0-10.2)</td>
<td>4.2* (2.0-7.7)</td>
<td>4.2* (2.0-7.7)</td>
</tr>
</tbody>
</table>
Table 2: Prevalence and Incidence of Type I Diabetes in Sub-Saharan Africa 1990-2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Author</th>
<th>Sample</th>
<th>Age</th>
<th>Incidence per 100,000 persons (95% CI)</th>
<th>Prevalence per 100,000 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>Aleumu (2009) [23]</td>
<td>1029</td>
<td>-</td>
<td>2.1 (2.0 – 2.2)</td>
<td>-</td>
</tr>
<tr>
<td>Mauritius</td>
<td>Tuomilehto (1993)</td>
<td>-</td>
<td>0-19</td>
<td>1.9</td>
<td>-</td>
</tr>
<tr>
<td>South Africa</td>
<td>Ranchod (1991) [31]</td>
<td>1721</td>
<td>-</td>
<td>-</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Table 3: Prevalence of Gestational Diabetes in Sub-Saharan Africa 1990-2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Author</th>
<th>Sample size</th>
<th>Method</th>
<th>Prevalence GDM among women giving birth (%) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>Seyoum (1999) [27]</td>
<td>890</td>
<td>OGTT</td>
<td>3.7 (2.5 – 4.9)</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Hailu (1994) [29]</td>
<td>567</td>
<td>OGTT</td>
<td>9.2</td>
</tr>
<tr>
<td>South Africa</td>
<td>Mamabolo (2006) [28]</td>
<td>262</td>
<td>OGTT</td>
<td>1.5 (0.4 – 3.8)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Swai (1991) [30]</td>
<td>189</td>
<td>OGTT</td>
<td>0</td>
</tr>
<tr>
<td>South Africa</td>
<td>Ranchod (1991) [31]</td>
<td>1721</td>
<td>OGTT</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Table 4: Diabetes case fatality studies in Sub-Saharan Africa from 1990

<table>
<thead>
<tr>
<th>Country</th>
<th>Author (Year)</th>
<th>Diabetes Types</th>
<th>Sample (loss to follow up)</th>
<th>Mortality (%)</th>
<th>Mortality causes (deaths by cause /total deaths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Gill (2005)[32]</td>
<td>Type 1</td>
<td>88 (39)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>McLarty (1990) [34]</td>
<td>IDDM&lt;sup&gt;1&lt;/sup&gt;</td>
<td>272</td>
<td>40.5</td>
<td>Leading causes: IDDM: 50% Ketoacidosis; NIDDM: 24% Cardiovascular &amp; renal disease; Indeterminate: 48% infection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NIDDM&lt;sup&gt;2&lt;/sup&gt;</td>
<td>825</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indeterminate type</td>
<td>153</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup>IDDM: Insulin Dependent Diabetes Mellitus; <sup>2</sup>NIDDM: Non Insulin Dependent Diabetes Mellitus.
Table 5: Cross-sectional studies on chronic complications of diabetes in Sub-Saharan Africa 1999-2010
<table>
<thead>
<tr>
<th>Complication</th>
<th>Location</th>
<th>Author (year)</th>
<th>Sample</th>
<th>Setting</th>
<th>Type of diabetes</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurapthy</td>
<td>Cameroon</td>
<td>Ndip (2006) [37]</td>
<td>300</td>
<td>Hospital inpatient and outpatient clinics</td>
<td>N/A</td>
<td>27.3%</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>Oduesan (2008) [111]</td>
<td>108</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>Cardiac Autonomic Neuropathy: 34.2%</td>
</tr>
<tr>
<td></td>
<td>Sudan</td>
<td>Ahmed (2000) [38]</td>
<td>120</td>
<td>Hospital outpatient clinic</td>
<td>Type 1 &amp; 2</td>
<td>Cardiac Autonomic Neuropathy: 40% Peripheral: 66%</td>
</tr>
<tr>
<td>Foot ulcers</td>
<td>Cameroon</td>
<td>Ndip (2006) [37]</td>
<td>300</td>
<td>Hospital inpatient and outpatient clinics</td>
<td>N/A</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>Kengne (2010) [112]</td>
<td>1841</td>
<td>Hospital inpatients</td>
<td>N/A</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ogbera (2006) [113]</td>
<td>1500</td>
<td>Hospital inpatients &amp; outpatient clinic</td>
<td>Mixed</td>
<td>9.5%</td>
</tr>
<tr>
<td></td>
<td>Tanzania</td>
<td>Gulam-Abbas (2002) [114]</td>
<td>627</td>
<td>Hospital inpatients</td>
<td>Mixed</td>
<td>15%</td>
</tr>
<tr>
<td>Retinopathy</td>
<td>Botswana</td>
<td>Mengesha (2006) [115]</td>
<td>401</td>
<td>Outpatient clinics</td>
<td>Mixed</td>
<td>9.2%</td>
</tr>
<tr>
<td></td>
<td>Cameroon</td>
<td>Sobgnwi (1999) [116]</td>
<td>64</td>
<td>Hospital outpatient clinic</td>
<td>Mixed, non-proteinuric</td>
<td>37.5%</td>
</tr>
<tr>
<td></td>
<td>Ethiopia</td>
<td>Seyoum (2001) [117]</td>
<td>340</td>
<td>Hospital outpatient clinic</td>
<td>Type 1 &amp; 2</td>
<td>37.8%</td>
</tr>
<tr>
<td></td>
<td>Ghana &amp; Nigeria</td>
<td>Rotimi (2003) [118]</td>
<td>840</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>17.9%</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>Omolase 2010 [119]</td>
<td>100</td>
<td>Hospital outpatient clinic</td>
<td>Mixed</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
<td>Mwendwa (2005) [35]</td>
<td>100</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
<td>Mwale (2007) [41]</td>
<td>96</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Mauritius</td>
<td>Tapp (2006) [100]</td>
<td>528</td>
<td>Population</td>
<td>Mixed, including IGT</td>
<td>Incidence: 23.8%</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>Motala (2001) [120]</td>
<td>T1: 47 T2: 172</td>
<td>Hospital outpatient clinic</td>
<td>Type 1 &amp; 2</td>
<td>Type 1: 53.2%, Type 2: 64.5%</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>Read &amp; Cook (2007) [121]</td>
<td>248</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>32.3%</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>Mash (2007) [36]</td>
<td>400</td>
<td>Outpatient clinics</td>
<td>Mixed</td>
<td>63%</td>
</tr>
<tr>
<td></td>
<td>Tanzania</td>
<td>Majaliwa (2007)[87]</td>
<td>99</td>
<td>Hospital outpatient clinic</td>
<td>Type 1</td>
<td>22.68%</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>Unuigbe (2001) [124]</td>
<td>66</td>
<td>Hospital outpatient clinic</td>
<td>Type 1 &amp; 2</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Cameroon</td>
<td>Sobgnwi (1999) [116]</td>
<td>63</td>
<td>Hospital outpatient clinic</td>
<td>Mixed, non-proteinuric</td>
<td>53.1%</td>
</tr>
<tr>
<td></td>
<td>Ghana</td>
<td>Eghan (2007) [122]</td>
<td>109</td>
<td>Hospital outpatient clinic</td>
<td>Mixed</td>
<td>43.1%</td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
<td>Wanjoji (2002) [123]</td>
<td>100</td>
<td>Hospital outpatient clinic</td>
<td>Type 2</td>
<td>Albuminuria: 26%</td>
</tr>
</tbody>
</table>
Annex 1: Flow Diagram of Studies Reviewed

Please see attached document.

Annex 2: Keyword search terms

Please see attached document.
Additional files provided with this submission:

Additional file 1: Annex 1 Review Flow Diagram 06112010.docx, 19K
http://www.biomedcentral.com/imedia/6989952247725037/supp1.docx

Additional file 2: Annex 2 Keywords 06112010.docx, 11K
http://www.biomedcentral.com/imedia/2501954644772503/supp2.docx

Additional file 3: 2.1.1 - PRISMA 2009 Checklist.doc, 65K
http://www.biomedcentral.com/imedia/7713212464821174/supp3.doc