Examination of Mortality Due to Diabetes and Assessment of Diabetes-Related Healthcare Services in Rural Western Kenya

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Abstract

Background

The prevalence of diabetes is increasing in low-and middle- income countries, due to the adoption of a western diet and decreased physical activity. Diabetes is often underdiagnosed, and the management of the disease is resource intensive. In this paper, we examine the burden of diabetes on a rural population in western, Kenya and assess the ability of the health care system to diagnose, manage, and treat diabetes.

Methods

We utilized verbal autopsies from the Kombewa Health and Demographic Surveillance Site in rural western Kenya from 2011-2018 to measure the burden of diabetes among the deceased. We classified deaths as either primarily caused by diabetes according to verbal autopsy or as a death of any cause that reported having a previous diagnosis of diabetes. We also conducted a survey of health facilities to measure the capacity of the health system to prevent, diagnose, and manage diabetes.

Results

From 2011-2018, 85 people died with diabetes as the verbal autopsy reported primary cause in the region (1.8% of verbal autopsies). An additional 4.6% of verbal autopsies indicated the deceased had a previous known diagnosis of diabetes. Deaths with diabetes as the primary cause of death increased with age and were more likely among men than women. Of the 23 surveyed health facilities, 26% regularly screened for diabetes and 39% managed diabetes in their patients. We found a lack of screening and resources to consistently treat patients with diabetes. All facilities reported not having the full range of medications indicated by the Kenya Essential Medication List to treat diabetes.

Conclusions

Our results suggest that the undetected burden of diabetes may be greater in rural Western Kenya than previous country-wide studies suggested. Additionally, our results demonstrate that most health facilities in the region do not have the capacity to screen for diabetes nor do they have stocks of the medications to treat diabetes. This lack of care results in patients being referred to larger hospitals for treatment. As the prevalence of diabetes increases in Kenya, and other low- and middle-income countries, improved detection and treatment of diabetes will be important to limiting the deleterious chronic damage caused by undiagnosed and uncontrolled diabetes.

Background

Diabetes mellitus is a non-communicable disease involving elevated blood glucose levels due to dysregulation of insulin and insulin receptors. Damage to tissue and organs occurs when blood glucose levels remain elevated for extended periods of time which results in non-enzymatic glycosylation of molecules and changes in fluid osmotic pressure [1]. Symptoms of diabetes include polyuria (frequent

urination), polydipsia (thirst), and fatigue. Untreated or poorly managed diabetes can result in microvascular (nephropathy, retinopathy, neuropathy) and macrovascular (myocardial infarction, stroke) damage, which all can lead to severe disability [2]. Uncontrolled hyperglycemia also impairs the immune system and increases the risk of infectious complications. These complications all result in premature death.

There are an estimated 463 million adults living with diabetes and 368 million (80%) of these individuals live in lower and middle-income countries (LMIC) [3]. The total number of disability-adjusted life years lost due to diabetes has more than doubled since 1999 [4], and the prevalence of diabetes is increasing at a greater rate in LMICs compared to wealthier nations [5]. The increasing diabetes prevalence in LMICs has been attributed to increased availability of calorie-dense food and decreased physical activity [6]. Additionally, diabetes in adulthood is associated with poor antenatal and child nutrition which is theorized to cause epigenetic changes in “thrifty” genes in adulthood [6]. Both an increase in westernized diets and epigenetic changes result in populations becoming more obese, which is correlated with an increase in the prevalence of diabetes [7].

As rates of diabetes rise in LMICs, more research is required to understand the burden, epidemiology, and management of diabetes in lower resource settings. Risk factors for diabetes traditionally include obesity, urban residency, advanced age, inactivity, and family history of diabetes. However, populations in LMICs tend to have weaker correlations between risk factors identified in higher income countries and the development of diabetes [8]. Clinical features of diabetes amidst the stressors of poverty (ie. food insecurity, medical insecurity) are likely to demonstrate a different pattern of presentation and prognosis disease [9]. In addition, diabetes has traditionally been treated with lifestyle modifications, pharmacotherapy, clinical monitoring, and regular interactions with the healthcare system. Diabetes related health care costs are predicted to rise to \$2.48 trillion by 2030 based on past trends and the greatest burden of these costs is predicted to fall on LMICs [10].

Kenya is an LMIC located in East Africa. In 2015, the Kenyan Ministry of Health estimated 2% of the adult population had diabetes (defined as plasma glucose ≥ 7.0 mmol/L or were currently taking medications for diabetes) and 3% of the adult population had impaired fasting glycemia [11]. Worryingly, the prevalence of diabetes is projected to increase in Kenya due to an aging population, increasing inactivity, and increasing obesity [11]. To combat these trends Kenya has developed guidelines to standardize diabetes diagnosis and care (Table 1) [12]. However, the country has had difficulties in implementing the policies at the clinical practice level due to limited resources and lapses in health care governance [13].

Table 1

Guidelines for screening, diagnosis, management, and pharmaceutical treatment of diabetes in Kenya [12] and International Diabetes Federation [30].

	Kenya	International Diabetes Federation
Guidelines for Diabetes Screening	<p>Screen any individual with Risk Factors:</p> <ol style="list-style-type: none"> 1. First Degree Relative with diabetes 2. Women with previously diagnosed Gestational diabetes 3. History of Cardiovascular disease 4. Hypertension 5. Women with Polycystic Ovarian Syndrome 6. Diets low in fiber content, high in refined sugar and low in fruits and vegetables <p>Screen the General Population by these cutoffs:</p> <ol style="list-style-type: none"> 1. BMI ≥ 25 2. Women delivering a baby $\geq 4\text{Kg}$ 3. Blood Pressure $\geq 140/90$ mmHg 4. Blood Lipids: HDL ≤ 35 mg/dl, Triglycerides ≥ 250 mg/dl, LDL ≤ 100 mg/dl 5. ≤ 150 minutes of physical activity per week 	<p>Screening should be offered to high risk individuals</p> <p>Universal Screening is not recommended</p>

	Kenya	International Diabetes Federation
Guidelines for Diabetes Diagnosis	<p>A diagnosis of diabetes is made if:</p> <ol style="list-style-type: none"> 1. Fasting Glucose ≥ 7.0 mmol/L 2. 2-hour glucose following ingestion of 75 g glucose load ≥ 11.1 mmol/L 3. Random Glucose in symptomatic patient ≥ 11.1 mmol/L 4. HbA1c $\geq 6.5\%$ 	<p>A diagnosis of diabetes is made if:</p> <ol style="list-style-type: none"> 1. Fasting Glucose ≥ 7 mmol/l 2. 2 hour glucose following ingestion of 75 g glucose tolerance test ≥ 11.1 mmol/l 3. Random Glucose in symptomatic patient ≥ 11.1 mmol 4. HbA1c $\geq 6.5\%$ <p>An individual with an abnormal test should have a repeat test confirm diagnosis.</p> <p>Use of HbA1c requires stringent quality assurance.</p> <p>In low resource settings:</p> <ol style="list-style-type: none"> 1. Diagnosis can be made on a singular fasting glucose 2. If no blood glucose can be obtained, symptoms are enough for diagnosis
Guidelines for Diabetes Management	<p>Regular Appointments at 3–6 month intervals with blood glucose or HgA1c testing.</p> <p>Annual Physical Assessment including:</p> <ol style="list-style-type: none"> 1. Weight 2. Waist Circumference 3. Cardiac Exam 4. Blood Pressure 5. Foot Examination 6. Mouth Examination 7. Eye Examination 8. Blood Lipid Panel 9. Kidney Function <p>Life Style Modifications:</p> <ol style="list-style-type: none"> 1. Incorporate moderately intense physical activity into daily life 3 days a 	<p>Patients with detected diabetes should be offered treatment.</p> <p>Encourage collaborative relationships between providers and patients to provide patient centered care.</p> <p>Annual Surveillance for Complications of Diabetes:</p> <ol style="list-style-type: none"> 1. Psychological assessment 2. Self-Monitoring Skills 3. Body Weight 4. Blood Glucose Levels 5. Blood Pressure 6. Blood Lipid Panel 7. Cardiac Exam 8. Screen for Erectile Dysfunction 9. Peripheral Neuropathy

Kenya	International Diabetes Federation
<p>week for 20–30 minutes</p> <p>2. Modify diet to increase consumption of fruits, vegetables, complex carbohydrates, and water while avoiding sweeteners and alcohol</p> <p>Diabetes Education including sessions that are held at regular intervals and individualized plans to reduce blood sugar levels.</p>	<p>10. Eye Exam</p> <p>11. Kidney Function</p> <p>Schedule routine visits between annual reviews.</p> <p>Provide urgent access to unforeseen diabetes related health care problems.</p> <p>Provide telephone contact between clinical visits.</p> <p>Compile a list of local people with diabetes.</p> <p>Use appropriately trained health-care professionals to provide Diabetes care.</p> <p>Life Style Modifications:</p> <p>1. Advise on reducing energy intake and limit food with added sugar, fats, or alcohol</p> <p>2. Provide advice on using food to prevent hypoglycemia</p> <p>3. Introduce physical activity gradually, aiming for 30–45 minutes of exercise 3–5 days a week of moderate-intensity activity</p> <p>Diabetes Education provided to all individuals by an appropriately skilled clinician.</p>
<p>Guidelines for Pharmaceutical Treatment of Diabetes</p>	<p>Recommendations made depending on HgA1c:</p> <p>1. $\geq 7\%$- life style modification</p> <p>2. 7%-8%- Metformin treatment</p> <p>3. 8%- 9.9%- Combine Metformin with second line drug therapy</p> <p>4. $\geq 10\%$- Consider adding Insulin therapy to medications</p> <p>Begin oral glucose lowering medication when life style modifications do not lower HbA1c to $\geq 7\%$.</p> <p>Continue lifestyle modifications with medications.</p> <p>First line Therapy: Metformin (unless impaired renal function).</p> <p>If target blood glucose levels are not achieved, add a second line therapy: sulfonylureas.</p> <p>If target blood glucose levels are not achieved, being insulin therapy. Aim for premeal glucose levels of ≤ 6.5 mmol/l.</p>

Objectives

Herein we estimate the burden of diabetes in the area covered by the Kombewa HDSS (Seme sub-county and a portion of Kisumu West sub-county), a rural area in western Kenya. In addition, we assess the ability of the local health system to diagnose, manage, and treat diabetes.

Methods

Study design

We estimated the burden of diabetes in western Kenya by assessing diabetes-related mortality from the health and demographic surveillance system (HDSS) from 2011–2018. Additionally, we carried out a cross-sectional survey of health facilities in the HDSS area between July and August 2019 to assess the health system's ability to prevent, diagnose, and treat diabetes.

Setting

The Kombewa HDSS is a prospective population-based surveillance platform that tracks health and demographic dynamics of the geographically defined area over time. The HDSS is located along the shore of Lake Victoria, 40 km west of Kisumu, Kenya and covers an area of 369 rural km² across two sub counties (Seme sub-county and a portion of Kisumu West sub-county) (Fig. 1) [14]. Details of the Kombewa HDSS are described elsewhere[15] but in brief, the Kombewa HDSS site conducts bi-annual demographic surveillance of residents within the defined, enumerated catchment population. Each round of surveys captures key population changes such as births, deaths, and migrations. A Verbal Autopsy (VA) is additionally performed for all reported deaths to ascertain probable cause of death. The site uses a WHO validated tool that contains standardized questions regarding circumstances leading up to death and the cause of death is coded using the InterVA4_03 software [16].

At the time of the health facility survey, the HDSS had a total of 24 Ministry of Health (MOH) health facilities ranging from dispensaries (level 2 – basic medical services, n = 16), health centers (level 3 – some inpatient services and laboratory testing, n = 7), and a district hospital (level 4 – more comprehensive care, n = 1) [15].

Participants

A dynamic cohort of over 150,000 residents drawn from 40,000 households forms the HDSS surveillance population. The burden of diabetes was assessed among registered deaths within the HDSS population as determined by the VAs. The survey to assess ability of the local health system to diagnose, manage, and treat diabetes was conducted in 23 MOH health facilities within the HDSS area. The survey was administered to 15 nurses-in-charge and 8 clinical officers-in-charge of the facilities.

Outcomes

We assessed two separate outcomes in considering the burden of diabetes in western Kenya. First, we estimated diabetes as the primary cause of death as analyzed by the VA (InterVA-4_03). Second, we calculated a measure of the prevalence of diabetes at death by including any reported previous diagnosis of diabetes in the VA among those who died.

In addition to the burden of diabetes, we also assessed the capacity to prevent and care for diabetes in this area. Along those lines, we estimated for each facility the ability to screen and test for diabetes, the ability to manage diabetes, the availability of diabetes medication, and the availability of diabetes education (Additional file 1).

Data sources / measurement

Households participating in the HDSS are visited bi-annually to monitor migration, fertility, and mortality. In addition to the routine house visits, a team of dedicated 'village reporters,' largely drawn from a pool of Ministry of Health (MOH) trained Community Health Volunteers (CHVs), provide death notification within 7 days of an event. The notified events are thereafter verified and registered into the database by a team of HDSS field staff. Recorded deaths are followed up with a standardized VA interview by specially trained interviewers to record events surrounding death. At the time of the VA, additional questions are asked about any chronic diseases that the deceased was diagnosed with prior to their death, including diabetes.

To assess the level of diabetes prevention and care at health facilities in the HDSS, we modified the diabetes questions from the Kenya Service Availability and Readiness Assessment and Mapping survey [17] and the Kenya Essential Medication List.

Potential sources of bias

Verbal autopsy data are known to have challenges, including potential recall error and bias. Verbal autopsies are collected three to six months following each death, allowing for a respectful mourning period. The passage of time between the death and the data collection could exacerbate recall errors. Furthermore, in past studies, the InterVA4 software, under predicted diabetes as the cause of death as compared to diagnostic symptom classification [18].

We expect three additional sources of bias could be present. First, the estimate of diabetes prevalence at death is likely underreported. Diabetes may go undiagnosed, and access to diabetes care in this population is limited. Furthermore, family members may not have known all the medical conditions a person had been diagnosed with before death. Second, there are many conditions that are secondary to diabetes which the InterVA-4_03 may not have been able to differentiate between, such as renal failure. This may have biased the causes of death due to diabetes downward. Finally, only 54% of reported deaths were followed up with a valid VA, therefore the sample of people in which the VAs were carried out may not be representative of the population.

In regard to the cross-sectional health facility survey, there could be reporter bias in the survey responses due to clinicians giving favorable answers to questions about diabetes care in order to present themselves better to the field supervisor.

Study size

Between 2011–2018 there were 7,916 deaths in the HDSS area of which 4,306 (54.3%) VAs were conducted. The facility survey was conducted in 23 of the 24 (95.8%) health facilities. The final health facility was not surveyed due to time limitations in the field.

Quantitative variables

A diabetes-caused death was defined by the InterVA4_03 assigning diabetes mellitus as the highest probability cause of death based on the collected VA. A previous diagnosis of diabetes was defined as the answer “YES” to the question of a surviving relative about a previous diagnosis of diabetes in the VA. Sex was defined as male or female based on the VA. We categorized age into different stages of adulthood based on the age at death as recorded in the VA: early adulthood (ages 22–34), early middle adulthood (ages 35–44), late middle adulthood (ages 45–64), and late adulthood (aged 65+).

We defined a facility’s ability to screen and test for diabetes by whether the facility routinely screened for diabetes, had the capacity to screen for diabetes, if the facility had a functional glucometer, if the facility had test strips for the glucometer, and the method used for blood glucose testing (Appendix). We defined a facility’s ability to manage diabetes based on whether diabetes management was done on site or referred to a larger hospital. We defined the availability of diabetes medication based on the survey respondents report of the five diabetes medications on the Kenya Essential Medication list. And we defined the availability of diabetes education for patients based on the survey response to the availability of preventive and nutritional education.

Statistical methods

We stratified by age and gender the deaths due to diabetes mellitus as well as the prevalence of diabetes at death. We estimated the proportion of facilities to prevent, diagnose, and care for diabetes. We used Microsoft Excel for all analyses.

Results

Descriptive data

The Kombewa HDSS had 7,916 deaths between 2011–2018. From those deaths, 4,306 (54.4%) VAs were collected and assigned a cause of death by the InterVA-4_03. Diabetes was the probable cause of death for 1.8% ($n = 85$) of mortality with a VA. Including those probably dying from diabetes, the prevalence of diabetes was 4.6% ($n = 196$) among deaths in the HDSS with a completed VA.

Data was collected from 23 out of the 24 (96%) of the health facilities. Of the surveyed health facilities in the HDSS, 26% (n = 6) of health facilities in the HDSS regularly screened for diabetes and 39% (n = 9) of facilities managed diabetes in their patients.

Main Results

Diabetes as a primary cause of death was greatest for males in late middle adulthood (aged 45–64) 17.6% and late adulthood (65+) 37.6%, as well as females in late adulthood, 38.8% (Fig. 2). Younger age groups represented 6% of the deaths with diabetes as the primary cause.

A previous diagnosis of diabetes before death was higher for adults > 43 years of (Fig. 3). Younger age groups represented 4.1% of previous diagnosis of diabetes before death.

The diabetes health facility survey indicated that 26% of facilities routinely screened for diabetes, 61% had the capacity to test for diabetes, and 48% referred patients for diabetes testing at other facilities (Fig. 4). There were 60.8% of facilities that had a functional glucometer and functional glucometer test strips (Table 2). Of the facilities that had the ability to test for diabetes, 86% use random blood sugar testing, 57% use fasting blood sugar testing and no facilities used Hemoglobin A1c for testing (Table 2).

Table 2

Proportions of clinics that provided diabetes related services in August 2019. Diabetes service surveys developed by SUNY Upstate and USAMRU-Kenya physicians were distributed to the health centers in Kombewa county and administered by Field Supervisors. The survey asked questions on Diabetes screening, testing, management, medications, and patient education.

Facility Demographics	Number of Facilities	Proportion
Facilities in the HDSS Interviewed	23	0.96
Facilities offering Inpatient Services	5	0.22
Facilities funded by the Kenyan Government	22	0.96
Dispensary	16	0.69
Basic Health Center	5	0.22
Primary Care Hospital	2	0.09
Diabetes Screening and Testing		
Facilities that Routinely Screen for Diabetes	6	0.26
Facilities with Capacity for Diabetes Testing	14	0.608
Facilities that Refer for Diabetes Testing	11	0.48
Facilities that Refer to Kombewa	7	0.64
Facilities that Refer to Chulaimbo	4	0.36
Facilities with a Functional Glucometer	14	0.608
Facilities with Glucometer Test Strips	14	0.608
Facilities that use Random Blood Sugar Testing	12	0.86
Facilities that use Fasting Blood Sugar Testing	8	0.57
Facilities that use Hemoglobin A1C for testing	0	0.00
Diabetes Management		
Facilities that Manage Diabetes	9	0.39
Facilities that Refer for Diabetes Management	14	0.608
Facilities that Refer to Kombewa	7	0.50
Facilities that Refer to Chulaimbo	5	0.36
Facilities that Refer to Kisumu	2	0.14
Diabetes Medication		
Insulin, Soluble	2	0.09

Facility Demographics	Number of Facilities	Proportion
Insulin, Intermediate Acting	0	0.00
Metformin	12	0.52
Glibenclamide	10	0.43
Gliclazide	0	0.00
Diabetes Patient Education		
Patient Education of Prevention of Diabetes	21	0.91
Patient Education on Nutrition and Diabetes	20	0.87

The facilities used various patient demographics to screen patients for diabetes. Of the clinics that were designated as dispensaries, 25% use clinical symptoms, 81% use preexisting medical conditions associated with diabetes, none use age, and 69% use family history as a screening indicator for diabetes (Table 3). Of the level 3 clinics designated within the HDSS as basic health centers, 40% use clinical symptoms, 60% use preexisting medical conditions associated with diabetes, 40% use age, and 80% use family history of diabetes as screening indicators for diabetes (Table 3). Of the level 3 facilities designated within the HDSS as a primary care hospital, 100% use clinical symptoms, 50% use preexisting medical conditions associated with diabetes, 50% used age, none use family history as screening indicators for diabetes (Table 3).

Table 3

Proportion of clinicians that indicated reasons to screen or test for diabetes in August 2019. Diabetes service surveys developed by SUNY Upstate and USAMRU-Kenya physicians were distributed to the health centers in Kombewa county and administered by Field Supervisors. Based on the survey, the clinicians indicated that they screened or tested for diabetes based on clinical symptoms, pre-existing medical conditions associate with diabetes, age, and family history of diabetes.

Diabetes Screening Demographics	Number of Clinics	Proportion of Clinics
Number of Clinics		
Dispensary	16	0.69
Basic Health Center	5	0.22
Primary Care Hospital	2	0.09
Clinical Symptoms		
Dispensary	4	0.25
Basic Health Center	2	0.4
Primary Care Hospital	2	1.0
Pre-Existing Medical Condition Associated with Diabetes		
Dispensary	13	0.81
Basic Health Center	2	0.6
Primary Care Hospital	1	0.5
Age		
Dispensary	0	0.0
Basic Health Center	2	0.4
Primary Care Hospital	1	0.5
Family History of Diabetes		
Dispensary	11	0.69
Basic Health Center	4	0.8
Primary Care Hospital	0	0.0

Of the facilities that completed the diabetes survey, 39% manage diabetes on site (Table 2). A total of 60.8% facilities refer to other hospitals for diabetes management: half refer to Kombewa Hospital, 36% refer to Chulaimbo Hospital, 14% refer to Kisumu County Hospital (Table 2). As for availability of diabetes medications, 9% of facilities carry soluble insulin, no facilities carry intermediate acting insulin, 52% of facilities carry metformin, 43% of facilities carry glibenclamide, no facilities carry gliclazide (Table 2). As

for diabetes education, 91% of facilities provide patients with education on how to reduce their risk of developing diabetes and 87% of facilities provide patients with diabetes nutritional education (Table 2).

Discussion

Key results

For the Kombewa HDSS, diabetes as a cause of death increases with age and more men die of diabetes than women. The data also indicate that there are more people dying with a prior diagnosis of diabetes than is recognized in the mortality data, suggesting that diabetes may play a larger role driving mortality due to comorbidities like stroke, heart attack, blindness, kidney failure. There are more older adults and more males who have had a prior diagnosis of diabetes at the time of death.

The diabetes health facility surveys indicated that fewer than half of the health facilities in the Kombewa HDSS have the capacity to screen for diabetes. The health facilities at each level screen for diabetes based on clinical symptoms, preexisting medical conditions associated with diabetes, age, and family history. There were no health facilities that were stocked with all the five medications indicated by the Kenya Essential medication list for treating and managing diabetes. Without stock of essential medicines, management of patients with diabetes in the area will be challenging.

Limitations

Some limitations are present in estimating the burden of diabetes in this population. We did not access official medical records for the deceased, therefore there could be some cases of diabetes that were not reported upon verbal autopsy because the family members were unaware of their diagnosis. Additionally, only 54% of all reported deaths had a valid VA at the time of the study. Further, we were unable to assess if the primary cause of death due to kidney failure, myocardial infarction, or cerebral accident could be partially attributed to diabetes. It is likely that the estimate of diabetes diagnosis at death is underestimated.

This study assessed availability of diabetes care in only a small number of facilities in Kenya, and so generalization beyond the study site should be made carefully. The health facility survey was also based on report of diabetes care and we were not able to witness the care available at each of the surveys.

Interpretation

Our results suggest that there is an undetected burden of diabetes in rural western Kenya, perhaps greater than the 2–3% estimated in the country-wide survey [19]. The burden of diabetes in the Kombewa HDSS is likely to be higher than what our data determined due to the number people who are not diagnosed and the growing population of people living with diabetes that were not examined in our study. The national survey in Kenya show that > 50% of those testing positive for diabetes, via fasting blood glucose, in Kenya are unaware of their condition, making them unlikely to report this in a verbal autopsy interview [19].

When measuring the burden of diabetes in the Kombewa HDSS, there may be deaths due to the many complications of diabetes that would not have diabetes assigned as the primary cause of death. Diabetes damage to the vascular (both micro- and macro-) and the immune systems contributes to the development of other communicable and noncommunicable diseases. Diabetes can contribute to the development of the primary cause of death by acute cardiac disease, unspecified cardiac disease, strokes, and renal disease due to vascular damage [20]. In previous studies of the Kombewa HDSS, acute cardiac disease was the primary cause of 1.9% of deaths, unspecified cardiac disease was the cause of 3.1% of deaths, stroke was the cause 5.2% of deaths, renal disease was the cause of 1.2% of deaths [14]. Additionally, diabetes weakens the immune system and makes people more susceptible to bacterial infections, such as lower respiratory infections, urinary tract infections, fungal infections, and tuberculosis [21, 22, 27]. In the Kombewa HDSS, acute respiratory infection (including pneumonia) was the cause of 10.1% of deaths, pulmonary tuberculosis was the cause of 4.9% of deaths, and sepsis was the cause of 0.2% of deaths. Further research should be done to determine the double burden of noncommunicable and communicable diseases in the population of the HDSS.

The International Federation for Diabetes estimates that 75% of all diabetes cases are undiagnosed in LMICs in Africa [23]. The diagnosis of diabetes is often missed because the health care systems have prioritized screening and treatment for infectious diseases rather than chronic noncommunicable diseases (NCDs) [15]. The majority of facilities in our survey did not screen for diabetes until there were symptoms of diabetes or complications of diabetes, both later stages of the disease attributed with greater morbidity from previous months to years of asymptomatic hyperglycemia. Diabetes diagnosis typically occurs late in the disease progression - there is an average of 10 years where a patient has elevated blood sugars prior to a diagnosis [24]. When caught earlier, diabetes is more easily managed and a great amount of damage to the vascular and immune systems can be avoided. The cost burden of managing diabetes is high to both the patient and the health system, but this cost decreases the earlier the condition is diagnosed [25].

Our results also suggest that there is a lack of resources for diabetes diagnosis and management in rural western Kenya. A review of the Kenyan National Clinical Guidelines for the Management of Diabetes (Table 3), indicates that the Kenyan Ministry of health has developed guidelines for clinicians that are like the International Diabetes Federation Global Guideline for Type 2 Diabetes. The lack of the translation of the guidelines to clinical practice can be attributed, in part, to the lack of resources available to treat diabetes. If the glucometers are unavailable in the dispensary clinics, then there is difficulty in screening for diabetes even when the clinician is following the guidelines. Additionally, if the clinic is not regularly stocked with diabetes medications, the clinicians are unable to provide the pharmacotherapy needed to manage diabetes.

The optimal management of diabetes is individualized, requires a team of health care professionals, and is time intensive [26]. The Kenyan National Clinical Guidelines for the Management of Diabetes recommends visits to the clinic every three months and that patients receive regular dietary counseling (Fig. 3). Many of the dispensaries in the Kombewa HDSS do not have the number of providers needed to

optimally provide care for diabetic patients. As a result, the patients must travel to larger health care centers to manage their diabetes, which increases barriers to accessing care (ie. Cost, time, transportation, etc).

Health systems serving populations where diabetes is increasing face the burden on their health care systems of both non-communicable and communicable diseases [27]. In the future, health systems in LMICs need to be restructured to accommodate both non-communicable and communicable disease to reduce the burden of both on the health system [28]. Long term noncommunicable disease management revolve around the same principles of healthy lifestyle changes, community involvement, and regular follow up [26]. Early detection and treatment of HIV has long proven to extend life and decrease costs to society, the same will prove true for diabetes if we are able to appropriately screen and manage diabetes from an early stage, the cost to the health system and life loss will be less burdensome to the society [29].

Generalizability

As seen in the Kombewa HDSS, the rate of diabetes is on the rise in LMICs [5]. While our study looked at a small geographic area in Kenya, other LMICs are dealing with the same challenges of increased western diet and decreasing physical activity [8]. While the health care structure poses challenges for diabetes diagnosis and management, we need to focus on the resources necessary for early detection, community education and support around management of diabetes prior to complications and death to avoid such a high burden on the health systems of LMICs [25].

Conclusions

In summary, the study found that there was a higher than expected burden of diagnosed diabetes in the Kombewa HDSS population, and that diabetes in this area is likely not controlled. The prevalence of diabetes increased with age and was diagnosed more in males. The study also found that the health care facilities in the Kombewa HDSS do not have the resources to regularly screen for diabetes and manage diabetes. Despite clinician's knowledge of diabetes and national screening and treatment guidelines, the facilities lack screening tools and medications. With the larger than expected burden of diabetes on the community, the facilities need to be better stocked to screen and manage diabetes to avoid complications and premature death from diabetes.

Abbreviations

HDSS

health and demographic surveillance site

LMICS

lower and middle income countries

VA

Verbal Autopsy

Declarations

Ethics approval and consent to participate

This analysis was reviewed by ethical IRB through SUNY Upstate, WRAIR, and SERU and deemed to be non-human subjects research.

Consent for publication

Not applicable

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article. Files: HealthFacilitiesDataSet (Additional file 2) and VADataset (Additional file 3)

Competing interests

The authors declare that they have no competing interests

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Author's contributions

AP- survey development, data collection, data analysis, writing manuscript

PS- study design, survey development, edits of manuscript

LO- survey development

KO- data collection, data analysis

DL- study design, survey development, data analysis, editing of manuscript

AS- study design, survey development, editing of manuscript

All authors have read and approved the manuscript

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Disclaimer

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Figures

Figure 1

Map of the Kombewa Health Demographic Surveillance System (HDSS) site. The HDSS is located along the shore of Lake Victoria, 40 km west of Kisumu, Kenya and covers an area of 369 rural km² across two sub counties (Seme sub-county and a portion of Kisumu West sub-county). At the time of this survey, the

HDSS had a total of 24 Ministry of Health health facilities ranging from dispensaries (n=16), health centers (n = 7), and a district hospital (n = 1).

Figure 2

Proportion of verbal autopsies with diabetes as primary cause of death by age and gender. Verbal autopsies (VA) were collected by the field supervisors in the Kombewa HDSS area and analyzed by the InterVA-4_03. There were 85 total VAs with diabetes as the primary cause of death. Males in Early Adulthood (22-34 years) represented a proportion of 0.0352 and Females in Early Adulthood represented a proportion of 0.00 VAs with diabetes as the primary cause of death. Males in Early Middle Adulthood (35-44 years) represented a proportion of 0.0235 and Females in Early Middle Adulthood represented a proportion of 0.00 VAs with diabetes as the primary cause of death. Males in Late Middle Adulthood (44-64) represented a proportion of 0.1764 and Females in Late Middle Adulthood represented a proportion of 0.0471 VAs with diabetes as the primary cause of death. Males in Late Adulthood (65+) represented a proportion of 0.3763 and Females in Late Adulthood represented a proportion of 0.3882 VAs with diabetes as the primary cause of death.

Figure 3

Proportion of verbal autopsies with a known diagnosis of diabetes at time of death. Verbal autopsies (VA) were collected by the field supervisors in the Kombewa HDSS area and analyzed by the InterVA-4_03. There were 196 total VAs with a previous known diabetes diagnosis before death. Males in Early Adulthood (22-34 years) represented a proportion of 0.0153 and Females in Early Adulthood represented a proportion of 0.0051 VAs with a previous diabetes diagnosis. Males in Early Middle Adulthood (35-44 years) represented a proportion of 0.0102 and Females in Early Middle Adulthood represented a proportion of 0.0102 VAs with a previous diabetes diagnosis. Males in Late Middle Adulthood (44-64) represented a proportion of 0.1326 and Females in Late Middle Adulthood represented a proportion of 0.1122 VAs with a previous diagnosis of diabetes. Males in Late Adulthood (65+) represented a proportion of 0.4030 and Females in Late Adulthood represented a proportion of 0.3112 VAs with a previous diagnosis of diabetes.

Figure 4

Proportion of health facilities that offer diabetes related services in the Kombewa HDSS. Data collected from the health facility survey by the field supervisors in the Kombewa HDSS. There were 23 total facilities visited (95%). Of the facilities surveyed, 26% provided routine screening for diabetes, 61% had the capacity to test blood sugar levels, 39% managed patients with diabetes in the clinic, 52% of clinics had Metformin available for prescription, and 91% of facilities offered patient education on the prevention of diabetes.

Supplementary Files

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