Diabetes diagnosis and care in sub-Saharan Africa: pooled analysis of individual data from 12 countries

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Summary

Background Despite widespread recognition that the burden of diabetes is rapidly growing in many countries in sub-Saharan Africa, nationally representative estimates of unmet need for diabetes diagnosis and care are in short supply for the region. We use national population-based survey data to quantify diabetes prevalence and met and unmet need for diabetes diagnosis and care in 12 countries in sub-Saharan Africa. We further estimate demographic and economic gradients of met need for diabetes diagnosis and care.

Methods We did a pooled analysis of individual-level data from nationally representative population-based surveys that met the following inclusion criteria: the data were collected during 2005–15; the data were made available at the individual level; a biomarker for diabetes was available in the dataset; and the dataset included information on use of core health services for diabetes diagnosis and care. We first quantified the population in need of diabetes diagnosis and care by estimating the prevalence of diabetes across the surveys; we also quantified the prevalence of overweight and obesity, as a major risk factor for diabetes and an indicator of need for diabetes screening. Second, we determined the level of met need for diabetes diagnosis, preventive counselling, and treatment in both the diabetic and the overweight and obese population. Finally, we did survey fixed-effects regressions to establish the demographic and economic gradients of met need for diabetes diagnosis, counselling, and treatment.

Findings We pooled data from 12 nationally representative population-based surveys in sub-Saharan Africa, representing 38 311 individuals with a biomarker measurement for diabetes. Across the surveys, the median prevalence of diabetes was 5% (range 2–14) and the median prevalence of overweight or obesity was 27% (range 16–68). We estimated seven measures of met need for diabetes-related care across the 12 surveys: (1) percentage of the overweight or obese population who received a blood glucose measurement (median 22% [IQR 11–37]); and percentage of the diabetic population who reported that they (2) had ever received a blood glucose measurement (median 36% [IQR 27–63]); (3) had ever been told that they had diabetes (median 27% [IQR 22–51]); (4) had ever been counselled to lose weight (median 15% [IQR 13–23]); (5) had ever been counselled to exercise (median 15% [IQR 11–30]); (6) were using oral diabetes drugs (median 25% [IQR 18–42]); and (7) were using insulin (median 11% [IQR 6–13]). Compared with those aged 15–39 years, the adjusted odds of met need for diabetes diagnosis (measures 1–3) were 2·22 to 3·53 (40–54 years) and 3·82 to 5·01 (≥55 years) times higher. The adjusted odds of met need for diabetes diagnosis also increased consistently with educational attainment and were between 3·07 and 4·56 higher for the group with 8 years or more of education than for the group with less than 1 year of education. Finally, need for diabetes care was significantly more likely to be met (measures 4–7) in the oldest age and highest educational groups.

Interpretation Diabetes has already reached high levels of prevalence in several countries in sub-Saharan Africa. Large proportions of need for diabetes diagnosis and care in the region remain unmet, but the patterns of unmet need vary widely across the countries in our sample. Novel health policies and programmes are urgently needed to increase awareness of diabetes and to expand coverage of preventive counselling, diagnosis, and linkage to diabetes care. Because the probability of met need for diabetes diagnosis and care consistently increases with age and educational attainment, policy makers should pay particular attention to improved access to diabetes services for young adults and people with low educational attainment.

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Introduction

Increasing longevity, economic development, and changes in lifestyle and diet have produced an epidemiological transition that has resulted in a rapid rise in the burden of diabetes in sub-Saharan Africa.[1–3]

Although empirical data on the prevalence of diabetes in sub-Saharan Africa remain scarce,[4] a review[5] of 41 studies done in countries in sub-Saharan Africa between 2000 and 2015 showed an overall diabetes prevalence of 13·7% in adults older than 55 years.

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See **Online** for appendix

Research in context

Evidence before this study

We systematically searched MEDLINE for articles published in English between database inception and Aug 1, 2016, using the search terms "access" (and "need") and "diabetes." We searched separately for "Africa" and each of the 50 individual countries in sub-Saharan Africa. We further systematically screened the STEPS country reports. Our search did not identify a single published study that quantified unmet need for diabetes diagnosis or care at the national or the regional level in sub-Saharan Africa.

Added value of this study

Median prevalence of diabetes was 5% (range 2–14) across 12 surveys using biomarker-based diagnostic criteria. Our results show for the first time a very large unmet need for diabetes screening, diagnosis, awareness, preventive counselling, and treatment. Additionally, we show that access to diabetes diagnosis and care increases consistently and strongly with age and education.

Implications of all the available evidence

Although diabetes is highly prevalent in sub-Saharan Africa, most of the need for diabetes diagnosis and care remains unmet. Policies are urgently needed to increase awareness of diabetes diagnosis and to expand coverage of preventive counselling and diabetes treatment. Because of the positive age and education gradients of met need for diabetes services, such policies should particularly target younger and less educated populations.

Moreover, the International Diabetes Federation has estimated that the prevalence of diabetes in sub-Saharan Africa is likely to more than double by 2035.[6] Despite data limitations, the burden of diabetes in sub-Saharan Africa is clearly large and growing.[7]

Improved diabetes control through education and lifestyle modification programmes, along with effective treatment, can produce large reductions in both diabetes morbidity and mortality.[8–13] However, with the exception of a few single-country studies on access to diabetes diagnosis and insulin,[14,15] the level of unmet need for diabetes-related care in sub-Saharan Africa is not known. The scarcity of population-level data on unmet need for diabetes care is a substantial barrier to the development of effective policies and to the assessment of policy and intervention performance. Furthermore, the lack of data presents a challenge to the achievement of universal health coverage.[16,17]

In this study, we quantify diabetes prevalence and met and unmet need for diabetes diagnosis and care in 12 countries in sub-Saharan Africa using nationally representative population-based surveys. We then estimate demographic and economic gradients of met need for diabetes diagnosis and care.

Methods

Data sources

We did a pooled analysis of individual-level data from nationally representative population-based surveys. Most of the surveys included in our analysis used the WHO's Stepwise Approach to Surveillance (STEPS) survey method. The STEPS survey is a standardised instrument for collecting and disseminating data about non-communicable diseases in adults living in WHO member countries.[18]

The STEPS survey data was obtained through a systematic request process. In brief, WHO maintains a list of all STEPS surveys.[19] We approached WHO but were not provided access to the STEPS survey data through a centralised, WHO-led process. We thus identified the responsible contacts for each survey via the WHO STEPS website, complemented by information obtained through international diabetes experts and electronic searches. In addition, we reviewed the 2013 Namibia Demographic and Health Survey (DHS) and other nationally representative surveys for diabetes biomarkers and diabetes diagnosis and care questions.

The requirements for inclusion of a country survey in this study were that the data were collected between 2005 and 2015; the data were made available at the individual level; a biomarker for diabetes (namely, fasting glucose or HbA_{1c}) was available in the dataset; and the dataset included a suite of questions that assessed access to a core and comparable group of health services for diabetes diagnosis, prevention counselling, and treatment.

Of the 40 STEPS surveys listed by WHO, 27 met our inclusion criteria. Of the 27 countries with an eligible STEPS survey, 17 were not included in our study because the STEPS investigators did not respond to our request for data (eight surveys), the investigators refused to participate in this study (one survey), or we were not able to identify valid contact information for the STEPS investigators (eight surveys).[20]

To the dataset of the ten eligible STEPS surveys that we gained access to, we added data from two nationally representative population-based surveys that also met all of our inclusion criteria: the 2012 SANHANES, which was done by the South African Human Sciences Research Council,[21] and the 2013 Namibia DHS.[22,23] The STEPS data included in this analysis are from Benin, Comoros, Guinea, Kenya, Liberia, Mozambique, Seychelles, Tanzania, Togo, and Uganda.[24–32]

Most of the surveys used two-stage cluster random sampling designs; several surveys used stratified sampling approaches (eg, according to region or urban versus rural location). The sampling designs are described in detail in the appendix.

Data analysis

We first analysed individual-level data from the surveys to define the population in need of diabetes care by estimating the prevalence of diabetes in the different surveys. We further estimated the prevalence of the major diabetes risk factors overweight and obesity. Diabetes was defined on the basis of the present WHO and American Diabetes Association diagnostic criteria as any of the following: a fasting plasma glucose of 7·0 mmol/L (126 mg/dL) or higher; a 2 h plasma glucose of 11·1 mmol/L (200 mg/dL) or higher; or an HbA_{1c} measurement of 6·5% or higher.[33,34] This definition represents the present international gold-standard for clinical diagnosis of diabetes.[35] Individuals reporting use of drugs for diabetes were also classified as diabetic, irrespective of the biomarker values. Respondents who self-reported a diagnosis of diabetes but were not on drug treatment and did not meet the diagnostic criteria were not classified as diabetic.

In view of previous evidence suggesting that capillary glucose often underestimates plasma-based glucose measurements and on the basis of published guidelines,[36] we adjusted fasting capillary glucose values by 1·1% for the relevant STEPS surveys (Benin, Comoros, Guinea, Kenya, Mozambique, Tanzania, Togo, and Uganda).[2,36,37] Instead of this adjustment, several STEPS investigator teams used an alternate definition for interpreting the fasting capillary glucose measurements in published reports about the surveys (diabetes defined as fasting capillary glucose of 6·1 mmol/L or higher).[19,23,29,38] These two alternative approaches result in slight differences in estimates of diabetes prevalence (appendix). Additionally, all surveys measured height and weight, which we used to calculate BMI.[2] We defined the overweight or obese population as all respondents with a BMI of 25 kg/m² or higher.

The STEPS surveys, 2012 South African National Health and Nutrition Examination Survey (SANHANES), and 2013 Namibia DHS are designed to be representative at the national level for their eligible populations. In the descriptive analyses of prevalence, we adjusted for the various complex survey sampling designs of the different surveys and calculated age and sex stratified prevalence values for the age groups 25–39 years, 40–54 years, and 55–64 years, as well as the overall prevalence estimates across all age groups.[39] We report median and IQR to summarise the distributions of diabetes prevalence and overweight and obesity prevalence across 12 surveys. Detailed summaries of survey and sampling designs are provided in the appendix.

We used self-reported data from the surveys to quantify met and unmet need for screening and diagnosis of diabetes. We defined three measures: (1) ever having received a blood glucose measurement among the overweight or obese population (Ever sugar: overweight or obese); (2) ever having received a blood glucose measurement among all individuals defined as having diabetes (Ever sugar: diabetic); and (3) having been told by a health-care provider about diabetes diagnosis (Told diagnosis), as a measure of awareness of diagnosis among all respondents with diabetes. Next, in all respondents who were categorised as diabetic, we quantified met need for four dimensions of diabetes care: (1) ever having received counselling from a health-care provider to lose weight (Counselled to lose weight); (2) ever having received counselling from a health-care provider to exercise (Counselled to exercise); (3) use of oral drugs for diabetes management (Oral diabetes drugs); and (4) use of insulin for treating diabetes (Insulin). Measures 1 and 2 capture preventive lifestyle counselling and measures 3 and 4 capture diabetes treatment. We report the median and IQR for each of the met need measures across the 12 surveys.

Additionally, we estimated the gradients of met need for diabetes diagnosis and care along several key demographic and economic factors. We used logistic regressions with survey fixed effects. We ran seven regressions, using each of the three outcome measures of met need for diabetes diagnosis and each of the four outcome measures for met need for diabetes care as separate independent variables. All regressions included age, sex, educational attainment,

	Respondents (N=38 311)	Response rate	Mean age (years)	Female	Male	GDP per capita*	Health expenditure per capita*
Benin STEPS 2008	3821	99·0%	43·4	1967 (52%)	1852 (48%)	1785	66·4
Comoros STEPS 2011	2564	96·5%	41·7	1331 (54%)	1114 (46%)	1348	85·1
Guinea STEPS 2009	2445	98·8%	34·6	1357 (59%)	960 (41%)	1180	44·0
Kenya STEPS 2015	4180	92·0%	37·5	1926 (58%)	1367 (42%)	2818	169·0
Liberia STEPS 2011	2322	87·1%	42·2	709 (57%)	531 (43%)	733	81·9
Mozambique STEPS 2005	2557	98·4%	39·9	1954 (53%)	1764 (47%)	735	47·0
Namibia DHS 2013†	3293	96·9%	46·9	1925 (75%)	636 (25%)	9143	802·2
Seychelles STEPS 2013	1240	72·9%	45·7	1524 (60%)	1033 (40%)	24 805	865·9
SANHANES 2012‡	3564	92·6%	44·5	2323 (65%)	1241 (35%)	12 375	1097·4
Tanzania STEPS 2012	4915	94·7%	41·9	2637 (54%)	2278 (46%)	2248	127·1
Togo STEPS 2010	3718	91·0%	34·2	2529 (61%)	1651 (39%)	1230	64·7
Uganda STEPS 2014	3692	75·2%	35·4	2224 (60%)	1468 (40%)	1689	132·6

GDP=gross domestic product. STEPS=Stepwise Approach to Surveillance. DHS=Demographic and Health Survey. SANHANES=South African National Health and Nutrition Examination Survey. *GDP and health expenditure per capita data were compiled for each country and respective survey year from the World Bank's World Development Indicators database and converted to 2011 international dollars. †For all surveys, the response rate refers to the published survey response rate; in the case of the 2013 Namibia DHS the response rate is the overall household response rate. ‡The SANHANES response rate refers to the overall individual interview response rate.

Table 1: **Summary of population-based surveys and health system characteristics**

	Population
Age (years), n=34 776	
Median	39
15–39	17 470 (50%)
40–54	11 136 (32%)
≥55	6170 (18%)
Sex, n=38 301	
Female	22 406 (58%)
Male	15 895 (42%)
Education (years), n=38 146	
<1	11 234 (29%)
1–4	5519 (14%)
5	9322 (24%)
6–7	6091 (16%)
≥8	5980 (16%)
Currently working, n=38 231	21 659 (57%)
BMI, n=37 553	
Mean	23·9
Overweight*	7680 (20%)
Obese*	5177 (14%)
Diabetic, n=38 311	2156 (6%)

*Overweight or obese defined as BMI ≥25 kg/m².

Table 2: **Baseline characteristics**

and present employment status as independent variables. We adjusted the standard errors for clustering at the level of the primary sampling unit in the analysis of those surveys that used a two-stage cluster random sampling design. To test the robustness of our results, we also ran this set of regressions without the Seychelles, because the Seychelles are an outlier with respect to gross domestic product per capita and total public and private health expenditures per capita.

The independent variables were available across all datasets and represent key demographic and economic indicators, allowing analyses of gradients of access to diabetes diagnosis and care. The number of observations across these regression analyses varied slightly because of small differences in the indicators included in each survey. In particular, South Africa was excluded from the regression analyses for counselling outcomes because the data was not disaggregated by type of counselling, and Namibia was excluded from regression analyses of oral diabetes drug use because indicators for use of oral drugs and insulin were not disaggregated. The appendix provides additional details about the data and analytical methods. These analyses were done in Stata version 13.1.

Role of the funding source

This study was done without any involvement by a funding source. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

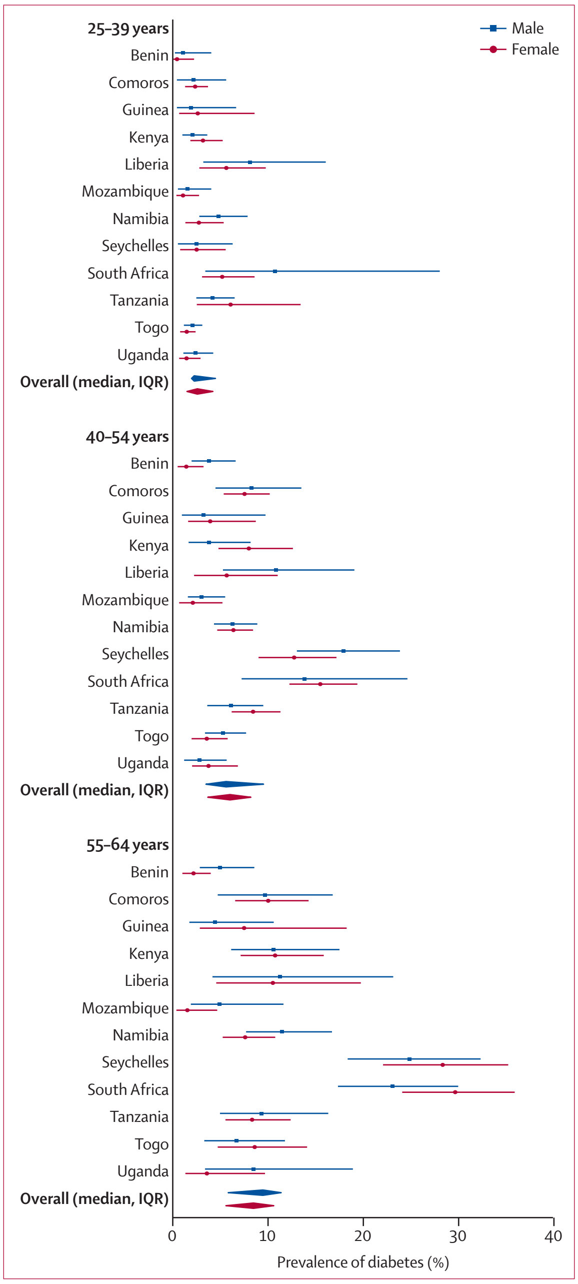

Figure 1: **Age–sex stratified prevalence of diabetes in 12 countries**
Prevalence and 95% CIs for diabetes (or obesity) by age and sex in each of the 12 countries. The overall row in each section shows the median and IQR of the prevalence values across surveys.

Results

Our complete pooled dataset included 38 311 individuals across 12 countries during 2005–15.

We summarise the survey characteristics, per-capita gross domestic product, and total health expenditures for all of the country-years included in the analysis (table 1). The individual country survey sizes ranged from 1240 to 4915 respondents (table 1) and reported survey response rates varied from 73% to 99%.

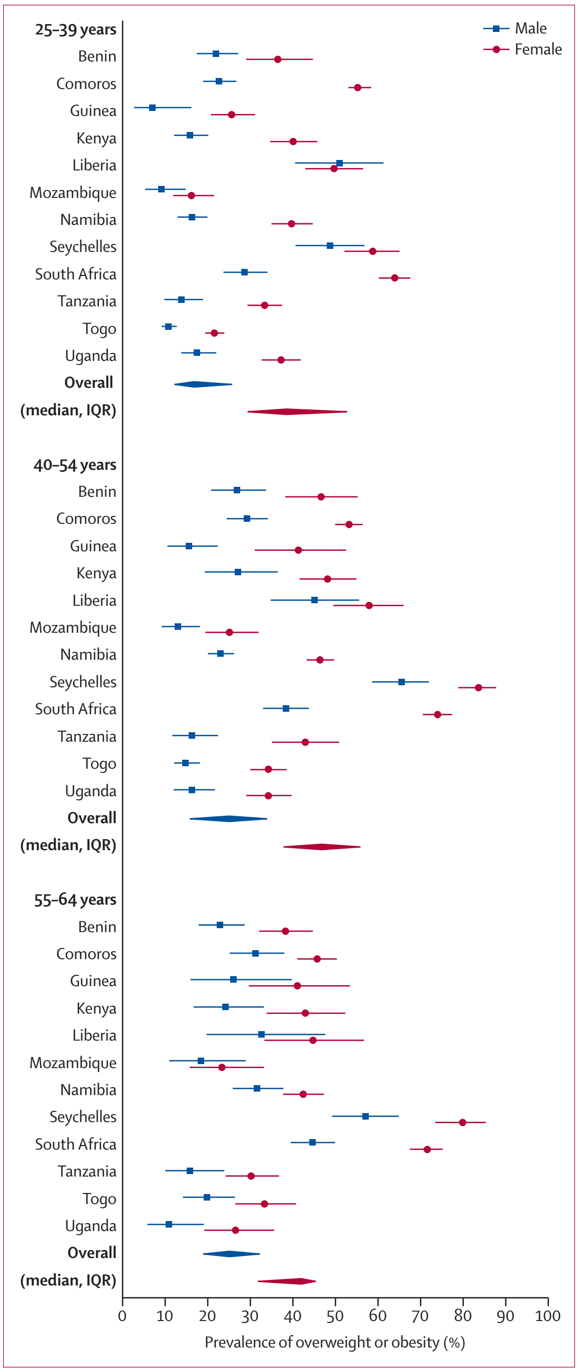

Figure 2: **Age–sex stratified prevalence of overweight or obesity in 12 countries**
Prevalence and 95% CIs for obesity by age and sex in each of the 12 countries. The overall row in each section shows the median and IQR of the prevalence values across surveys.

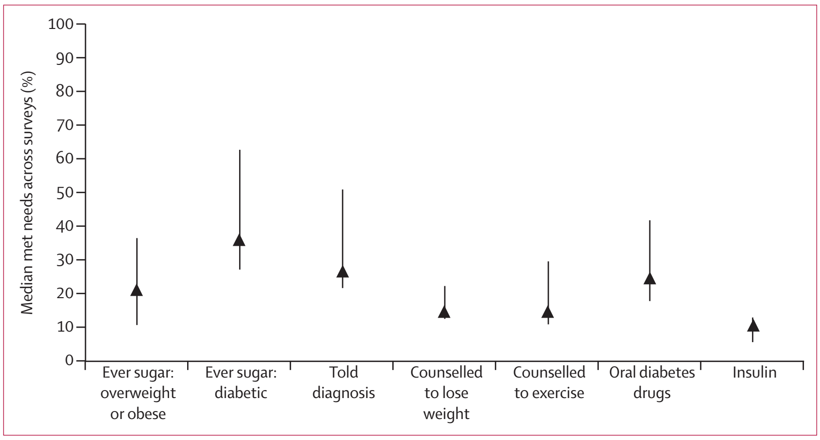

Figure 3: **Met need for diabetes diagnosis and care**
This figure displays the median and IQR for met need for diabetes diagnosis and care across surveys. The denominator for Ever sugar: overweight or obese is the overweight or obese population; the denominator for all of the other indicators of met need is the diabetic population.

The median age in the overall sample was 39 years; 22 406 (58%) of the respondents were female and 21 659 (57%) of the sample were currently employed (table 2). The pooled dataset of overweight or obese respondents included 12 857 (34%) individuals, with a median age of 42 years and of whom 9366 (73%) were female. The subset of participants with diabetes included 2156 (6%) individuals whose median age was 51 years and among whom 1263 (59%) were female.

Fasting plasma glucose was used as a clinical biomarker of diabetes in 11 of the 12 surveys, and HbA_{1c} was used in one survey. Across the 12 surveys analysed, the single-country prevalence of diabetes ranged from 2% in Mozambique to 14% in the Seychelles, with a median prevalence of 5%. For each country, we calculated age-stratified and sex-stratified prevalence of diabetes (figure 1) and age-stratified and sex-stratified estimates for the prevalence of overweight or obesity (figure 2). In particular, in the 55–64 year old group, the median prevalence of diabetes was 9% (IQR 6–11%) across surveys. Notably, an additional 237 respondents self-reported a diagnosis of diabetes, but did not meet the diagnostic criteria for diabetes (biomarker values indicating diabetes or diabetes treatment).

A median of 27% (range 16–68) of the survey sample were overweight or obese (BMI ≥25 kg/m²). Notably, 1277 (60%) of 2125 individuals who were diabetic were also either overweight or obese (the remaining 31 of the 2156 diabetic people did not have a BMI recorded). A summary of the met need for diabetes diagnosis and care is shown in figure 3. Among individuals who were overweight or obese, a median of 22% (IQR 11–37) of individuals self-reported receiving a blood glucose test. In the diabetic population surveyed, a median of 36% of respondents (IQR 27–63) self-reported receiving a blood glucose test. A median of 27% (IQR 27–63) reported being told of their diabetes diagnosis (told diagnosis).

We assessed four major components of met need for care in the diabetic population (figure 3). First, a median of 15% (IQR 13–23) of respondents with diabetes across surveys reported that they had ever been counselled by a health-care provider to lose weight. Second, a median of

15% (IQR 11–30) reported that they had been advised to exercise. Third, a median of 25% (IQR 18–42) of survey respondents reported use of oral drugs and a median of 11% (IQR 6–13) reported use of insulin. Figures 4 and 5 show the met need estimates by country. Lastly, we found substantial overlap in the receipt of the various types of care across the diabetic population. Of the 360 survey participants with diabetes who reported using oral diabetes drugs, most also reported that they received counselling to exercise (197 [55%]) or to lose weight (182 [51%]), whereas only a minority of participants with diabetes who did not report concurrently using an oral diabetes drug (n=1009) reported that they had received counselling to exercise (79 [8%]) or to lose weight (70 [7%]).

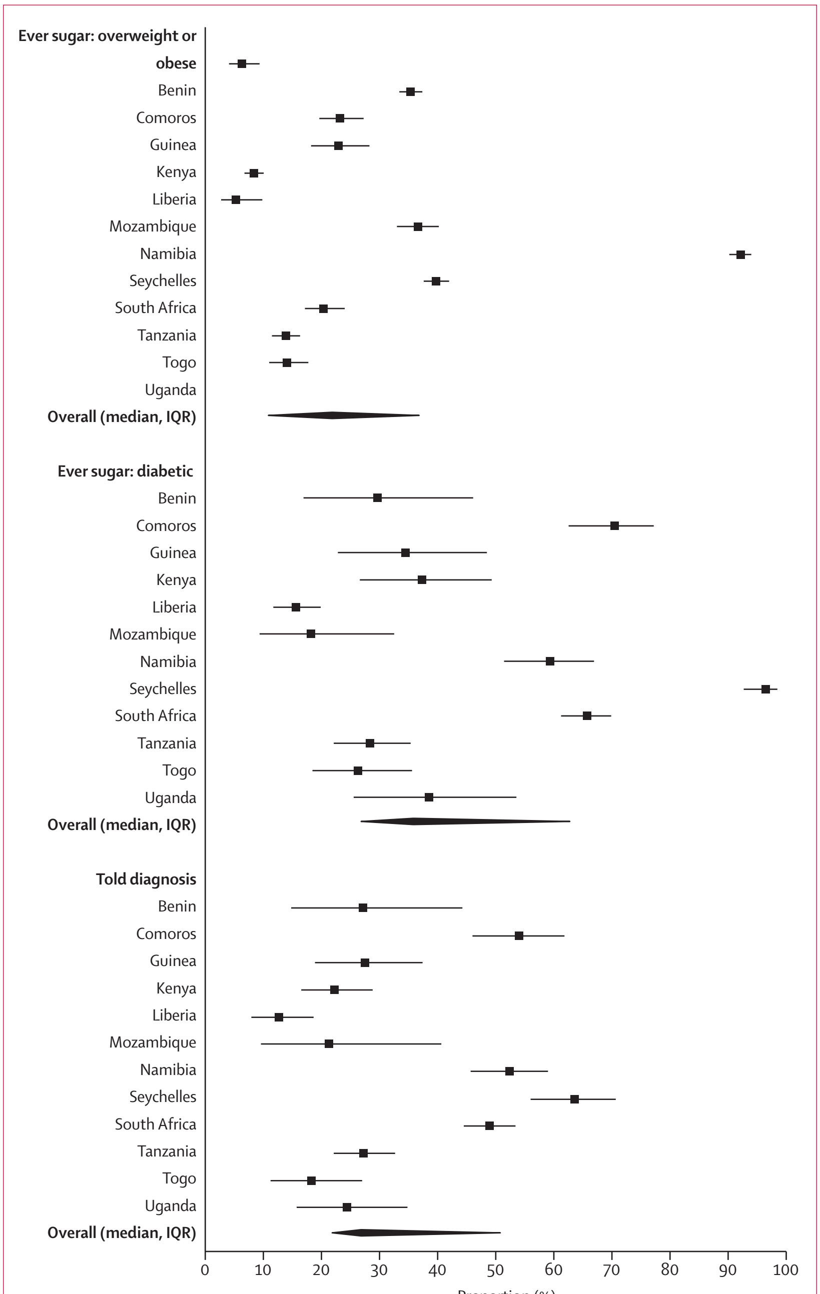

Figure 4: **Met need for diagnosis in the overweight or obese and diabetic populations**
Proportion of met need for diabetes diagnosis and the associated 95% CIs by country. The overall row in each section shows the median and IQR of the prevalence values across surveys.

For the overweight or obese population, our regression analysis shows strong and significant age, education, and employment gradients of diabetes diagnosis (table 3). Among the diabetic population, reports of access to counselling and treatment followed similar age and education, but not employment, gradients.

Respondents with 6–7 years and 8 years or more of education were significantly more likely to report having received counselling on weight loss and exercise than those with less than 1 year of education, and respondents with 8 years or more of education were significantly more likely to use oral diabetes drugs than those with lower levels of educational attainment. The regression results for met need in the diabetic population are shown in table 4. The results of the regression analyses were robust to the exclusion of the Seychelles.

Discussion

Our study is the first to provide national estimates of unmet need for diabetes diagnosis and care for sub-Saharan African countries. Our analysis of pooled individual-level data across 12 nationally representative population-based surveys shows strikingly high levels of unmet need across several key indicators of diabetes diagnosis and care. Taking the median of country means as a summary statistic, among all people with diabetes only a third reported having ever received a blood sugar measurement and only a third recalled being diagnosed as having diabetes. Similarly, only small proportions of overweight or obese people reported being screened for diabetes despite their high risk for the disease. Although the target population and cost-effectiveness of screening with blood glucose measurement for previously undetected diabetes in sub-Saharan Africa is under debate, the overweight or obese population certainly constitutes a key group for targeted diabetes screening interventions.[40]

These findings are important because they show that present health systems fail to identify the majority of patients with diabetes and that population screening needs to be strengthened (eg, through community mobilisation and home-based diabetes testing).

Moving along the so-called cascade of diabetes care, we find large unmet need for diabetes prevention counselling and treatment. Again, taking the median of country means as a summary statistic, only a fifth of the patients with diabetes reported having ever been counselled to lose weight and only a fifth reported having ever been counselled to exercise, whereas only a fourth reported using oral drugs for diabetes and only a tenth reported insulin use.

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While met need for diabetes diagnosis and care was overall very sparse from a cross-country perspective, countries with higher per-head incomes were generally found not only to have larger epidemics of both obesity and diabetes, but also greater access to diabetes diagnosis and care than countries with lower incomes.

Our regressions show that met need for diabetes diagnosis increases steeply with age and education in the overweight or obese population. Although an age gradient in diabetes screening is generally expected, in view of the clinical understanding that risk of diabetes increases with age, the particular age gradient in the overweight or obese population suggests that interventions to ensure comprehensive glucose testing in all age groups in this risk group would have substantial potential to identify people in need of diabetes care.[41] Overall, the consistent positive age gradients across all measures of access to diabetes diagnosis and care suggest that a focus on diabetes programmes that target younger population groups has the potential to substantially improve health-care coverage and health.

Similarly, our findings regarding the positive education gradients in access to diabetes care suggest that targeted diabetes programmes for population groups with low levels of educational attainment could be particularly beneficial. The positive education gradients in access, which we have shown here for the first time for diabetes diagnosis and care in sub-Saharan Africa, are not surprising. Across many settings and populations, health-care access has been found to increase with education.[42]

The education and the age gradients of access to diabetes diagnosis and care do not necessarily imply a direct causal association—for example, income and financial resources for health care are likely to increase with both factors. Furthermore, very distinct causal pathways could link education and age to diabetes diagnosis and care, including those mediated by health literacy, social support, and the provider–patient relationship. Although the strong and consistent education and age gradients warrant further causal investigation, the gradient data can already be useful in guiding the targeting of diabetes policies and programmes.

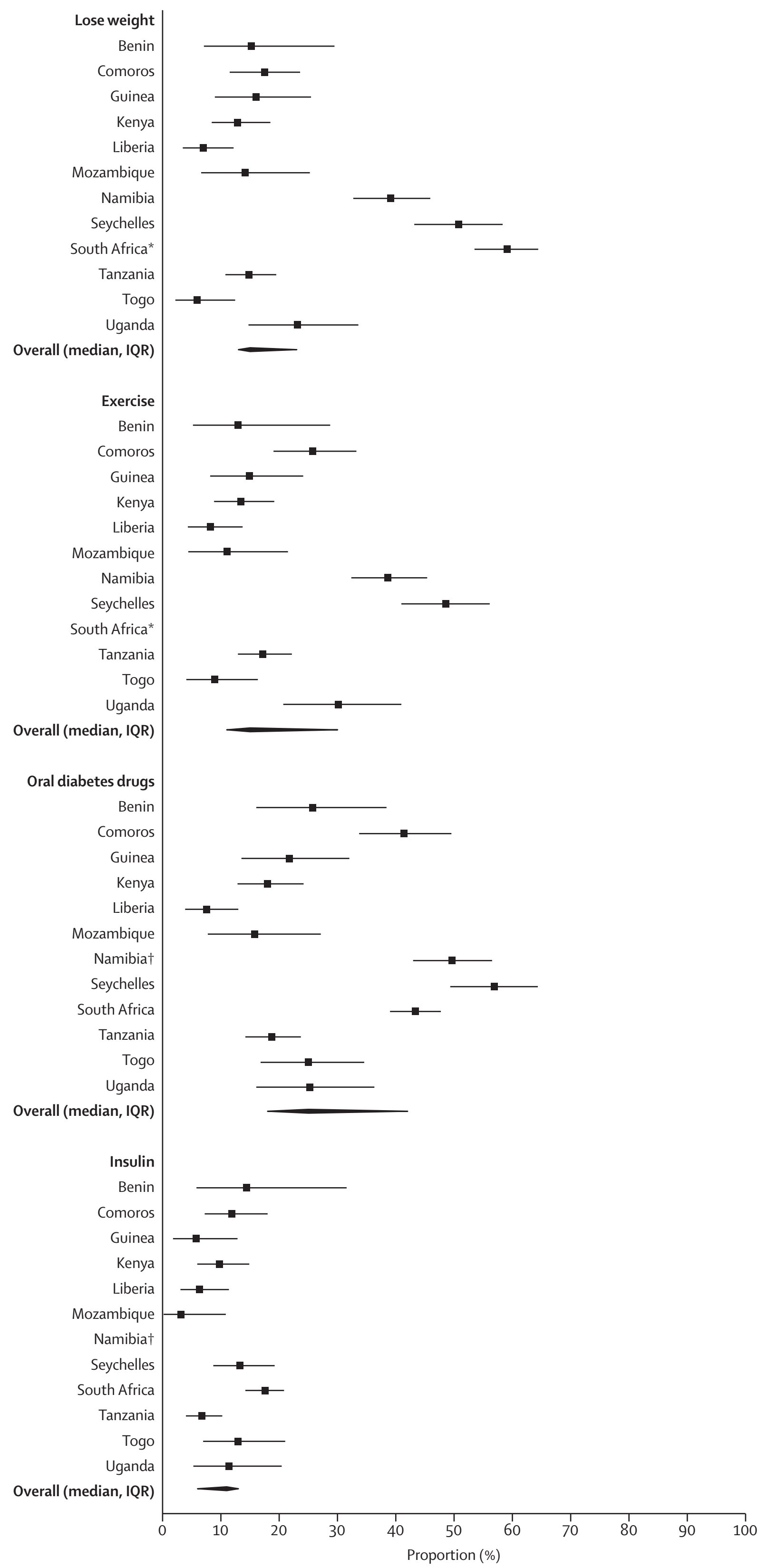

***Figure 5:* Met need for diabetes care in the diabetic population**
Proportion of met need for diabetes care and the associated 95% CIs by country. The overall row in each section shows the median and IQR of the prevalence values across surveys. *The 2012 SANHANES used a single question to measure whether respondents had received either weight loss or exercise counselling from a health-care provider; all other surveys included in this study used separate questions for weight loss and exercise counselling. The indicator value derived from the question on either weight loss or exercise counselling for South Africa is shown under the lose weight heading. †The 2013 Namibia Demographic and Health Survey used a single question to measure whether respondents had received any drugs to treat their diabetes; all other surveys included in this study used separate questions for oral drug and insulin treatment of diabetes. The indicator value derived from the question on any drug treatment for diabetes for Namibia is shown under the Oral diabetes drugs heading.

	Ever sugar: overweight or obese (n=12 631)*		Ever sugar: diabetic (n=1902)†		Told diagnosis (n=1905)‡	
	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value
Age 40–54 years§	2·22 (1·79–2·76)	<0·0001	3·53 (2·59–4·81)	<0·0001	3·27 (2·23–4·78)	<0·0001
Age ≥55 years§	3·82 (2·75–5·30)	<0·0001	5·01 (3·50–7·17)	<0·0001	4·85 (3·48–6·76)	<0·0001
Education 1–4 years¶	1·39 (1·18–1·65)	<0·0001	1·44 (0·87–2·40)	0·158	1·49 (0·98–2·26)	0·063
Education 5 years¶	2·08 (1·75–2·48)	<0·0001	1·97 (1·43–2·71)	<0·0001	1·65 (1·20–2·27)	0·002
Education 6–7 years¶	2·67 (2·20–3·24)	<0·0001	2·63 (1·86–3·72)	<0·0001	1·89 (1·32–2·72)	0·001
Education ≥8 years¶	4·56 (3·58–5·82)	<0·0001	3·73 (2·51–5·56)	<0·0001	3·07 (2·10–4·48)	<0·0001
Female||	1·13 (0·99–1·29)	0·076	1·15 (0·91–1·44)	0·237	1·20 (0·97–1·48)	0·095
Currently working**	1·20 (1·03–1·39)	0·022	0·96 (0·75–1·23)	0·744	0·99 (0·762–1·29)	0·941

AOR=adjusted odds ratio. *The sample for this regression consists of all individuals who were either overweight or obese. †The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurements or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they had ever received a blood sugar measurement. ‡The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurements or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they had ever been told that they had diabetes. §The reference group is age 15–39 years. ¶The reference group is less than 1 year of education. ||The reference group is male. **The reference group is currently working.

Table 3: **Demographic and economic gradients of met need for diabetes-related diagnoses**

	Counselled to lose weight (n=1383)*		Counselled to exercise (n=1383)†		Oral diabetes drugs (n=1662)‡		Insulin (n=1609)§	
	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value
Age 40–54 years¶	2·33 (1·44–3·79)	0·001	2·34 (1·52–3·60)	<0·0001	2·78 (1·89–4·10)	<0·0001	1·84 (1·15–2·95)	0·011
Age ≥55 years¶	2·99 (1·82–4·91)	<0·0001	3·13 (2·04–4·79)	<0·0001	4·16 (2·90–5·97)	<0·0001	2·57 (1·51–4·38)	<0·0001
Education 1–4 years||	1·56 (0·92–2·64)	0·101	1·28 (0·76–2·18)	0·356	1·52 (0·97–2·37)	0·065	1·50 (0·83–2·69)	0·176
Education 5 years||	1·69 (0·94–3·04)	0·079	1·92 (0·99–3·69)	0·051	1·41 (1·01–1·96)	0·043	1·10 (0·67–1·79)	0·705
Education 6–7 years||	2·22 (1·27–3·89)	0·005	2·52 (1·30–4·91)	0·007	1·25 (0·83–1·89)	0·293	1·20 (0·70–2·06)	0·507
Education ≥8 years||	4·81 (2·80–8·27)	<0·001	4·78 (2·58–8·85)	<0·0001	2·30 (1·50–3·54)	<0·0001	1·90 (1·04–3·47)	0·036
Female**	1·37 (1·01–1·88)	0·046	1·16 (0·84–1·60)	0·378	1·26 (0·96–1·67)	0·100	1·09 (0·78–1·53)	0·606
Currently working††	1·08 (0·74–1·57)	0·688	1·06 (0·74–1·52)	0·753	0·96 (0·74–1·25)	0·781	1·12 (0·72–1·73)	0·630

AOR=adjusted odds ratio. *The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurements or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they had ever been counselled to lose weight. †The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurements or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they had ever been counselled to exercise. ‡The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurement or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they were using oral diabetes drugs. §The sample for this regression consists of all individuals who were found to be diabetic on the basis of biomarker measurements or self-report of diabetes treatment in the surveys included in this study, and who had answered the question on whether they were using insulin. ¶The reference group is age 15–39 years. ||The reference group is less than 1 year of education. **The reference group is male. ††The reference group is currently working.

Table 4: **Demographic and economic gradients of met need for diabetes care**

This study has several important limitations. First, the population-based surveys used in this analysis relied on two different biomarkers for the diagnosis of diabetes (namely, fasting glucose and HbA_{1c}). Furthermore, in several STEPS surveys, a capillary blood instead of plasma-based glucose measurement was used. This inconsistency in measurement approaches could have biased the rank order of diabetes prevalence across surveys,[38] although we applied a well established correction for surveys that used capillary-blood-based measurement to ensure comparability with surveys that used plasma-based measurements.[37] Notably, our empirical diabetes prevalence estimates fall within the range of the modelled diabetes prevalence estimates published in the present International Diabetes Federation's Diabetes Atlas.[6,37]

Second, several of our variables rely on self-reported data, which could be affected by misreporting that could in turn have introduced bias in the estimates of diabetes prevalence and unmet need for diabetes care. Third, although all surveys included in our study used a similar suite of questions on use of care for diabetes, two of the 12 surveys (the 2013 Namibia DHS and SANHANES) differed slightly from the other ten because they did not follow the WHO STEPS survey method. The Namibia DHS did not collect separate indicators for oral diabetes drugs and insulin use; SANHANES did not collect separate indicators regarding counselling to lose weight and counselling to exercise.

Fourth, all of the surveys included in this study were designed to be nationally representative. We investigated whether the surveys succeeded in achieving national representation by comparing the sex–age distribution of the samples to the sex–age distribution of the underlying country population as estimated by the UN Population

Division. This comparison revealed overall similar sex–age distributions but with a slight over-representation of women and young age groups in the surveys (appendix). Fifth, although this study assessed several basic measures of access to care for diabetes, several important dimensions of both diabetes care and outcomes exist that are not captured through these sources. In particular, information on comorbidities and clinical sequelae, including relevant biomarker data, were not available in the surveys included in this study, and neither were data on a range of diabetes-related services. Finally, we were unable to distinguish between type 1 and type 2 diabetes on the basis of the data provided. These data limitations could be overcome in the future through the collection of more detailed survey data directed at understanding several key facets of diabetes care.

Several important policy implications follow from the study findings. First, international and regional agencies and individual country governments in sub-Saharan Africa must urgently respond to the diabetes epidemic and the high unmet need for diabetes care by developing policies and programmes to address deficits in diabetes diagnosis, prevention, and treatment. Second, the low met need for diabetes care could present an important challenge to the achievement of the universal health coverage targets the world has committed to with the adoption of the Sustainable Development Goals.[43,44] Diagnosis, preventive counselling, and linkage to care should be a major focus of policies to address unmet need for diabetes care, coordinated with more general efforts to strengthen health systems to achieve universal health coverage. Third, the positive age and education gradients across all measures of access to diabetes diagnosis and care suggest that policy makers should consider intensifying diabetes programmes for younger adults and those with low educational attainment.

High quality data are crucial to monitor and effectively respond to the diabetes epidemic in sub-Saharan Africa. Our study provides a synthesis of the empirical data on access to diabetes care from those national studies in sub-Saharan Africa that are available to researchers worldwide. However, major challenges remain in relation to such analyses. The STEPS survey approach provides a standardised method for the collection of diabetes-related data worldwide, but gaining access to these datasets is difficult.[20] Unlike for other nationally representative population-based surveys, such as the DHS,[45] no central repository exists from which the individual-level STEPS survey data can be downloaded. STEPS survey data are not open-access and the survey datasets need to be separately obtained from individual investigator teams in the countries where the surveys were done. Moreover, variation in approaches to sampling and data capturing, control, and reporting constitute an impediment to pooled analysis and data synthesis that other survey infrastructures, such as the DHS, have successfully overcome through standardised reporting and data management processes. Finally, the scope of the STEPS questions regarding different aspects of diabetes-related health-care use (which, for example, do not include clinical sequelae and their treatment) limits the potential of STEPS data to inform health policy and programmatic planning for diabetes in sub-Saharan Africa.[20] Comprehensive, high-quality, national and cross-country studies, such as those done by independent research collaborations as part of the *Lancet Diabetes & Endocrinology* Commission[3] on diabetes in sub-Saharan Africa can provide valuable information to complement the available STEPS survey data.

The need for diabetes-related services in sub-Saharan Africa is high but largely unmet. Novel health policies and programmes are urgently needed to increase awareness of diabetes and to expand coverage of services. Because the probability of met need for diabetes diagnosis and care increases consistently and strongly with age and educational attainment, policy makers should pay particular attention to improved access to diabetes services for young adults and people with low educational attainment.

Contributors

JM-G, RA, and TB were responsible for the study design, data analysis, interpretation, and writing of the manuscript. AG provided assistance with data analysis, figure preparation, and writing. DH, CH, MMSH, BLM, ES, NB, JKM, GG, PWN, CSW, AD, NL, PB, DL, KZ, MM, GK, KR, KA, DG, SKB, GM, and NSL were responsible for data collection and assisted with data interpretation and writing. AS, DL, NSL, JAS, JSY, PG, and SV provided assistance with data interpretation and writing.

Declaration of interests

We declare no competing interests.

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