Cardiovascular disease prevention in the slums of Kenya

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CHAPTER 4

The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya: results from a cross-sectional survey

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ABSTRACT

Objectives
This study assesses the prevalence, awareness, treatment and control of diabetes in the slums of Nairobi, Kenya. Additionally, we examine the relationship of obesity with raised blood glucose in the same setting.

Methods
We use data from a cross-sectional population-based survey, conducted in 2008-2009, involving a random sample of 5190 (2794 males and 2396 females) adults aged ≥18 years living in two slums – Korogocho and Viwandani – in Nairobi.

Results
The prevalence (weighted by sampling and response rates) of diabetes was 4.8% (95%CI 4.0-5.7) in females and 4.0% (95%CI 3.3-4.7) in males. Less than a quarter of those found to have diabetes were aware of their condition among which just over half of males and three-quarters of females reported being on any treatment in the 12 months preceding the survey. Overall, less than 5% of all people with diabetes had their blood sugar under control. Obesity and overweight were significantly associated with increased odds (1.7, 95%CI 1.1-2.6) of raised blood glucose only among females while adjusting for important covariates.

Conclusion
The prevalence of diabetes in this impoverished population is moderately high while the levels of awareness, treatment and control are quite low. In this population, obesity is an important risk factor for raised blood glucose particularly among females. Prevention and control strategies that target modifiable risk factors for diabetes and increase access to treatment and control in such disadvantaged settings are urgently needed.
BACKGROUND

In many low- and middle- income countries (LMICs), especially those in sub-Saharan Africa (SSA), there is an upsurge in the burden of non-communicable diseases (NCDs) such as diabetes, stroke and cancers[1]. This upsurge is believed to be largely driven by rapid urbanization and the attendant adoption of so-called western lifestyles—such as consumption of high-calorie diets and reduced physical activity—especially in the urban centres of LMICs [1]. As a result of their already high burden of infectious diseases such as HIV/AIDS and malaria, as well as weak health care systems, many countries are facing the prospects of the so-called ‘double burden of disease’ [2]. At least 80 per cent of deaths from NCDs occur in LMIC [1]. Moreover, NCDs generally tend to occur among younger and economically active populations in LMICs in comparison to their high-income countries’ counterparts [1]. This implies that economic development in such countries will be negatively impacted by an uncontrolled NCD epidemic.

Available evidence suggests that diabetes mellitus (mostly type 2) will be a key contributor to the rise of NCDs in LMICs [1]. For instance, the number of people affected by diabetes mellitus (DM) in SSA alone is projected to double from 12 to 24 million within the next two decades [3]. This increase will be driven in part by the rise in the prevalence of risk factors for DM in these settings. Specifically, several studies from SSA have shown that excessive body weight and obesity are independent risk factors for DM [4]. Obesity is reaching epidemic proportions globally—hence the coining of the term globesity and the SSA region has not been spared. Although data on trends in obesity in the SSA region are limited, a study that reviewed Demographic and Health Survey (DHS) data from seven African countries over a ten year period, revealed rising trends in overweight and obesity among urban women [5]. Specifically, in the studied countries, the prevalence of being overweight or obese had increased by about 35% in the period between 1992 and 2005 when the DHS surveys were con-
ducted. Even more worrying, the increase in overweight or obesity among the poorest urban women was about seven times higher than the richest urban women [5].

Overall therefore, upward trends in the levels of excessive body weight and obesity in SSA could contribute to an increasing prevalence of DM. Consequently, an increasing burden of DM will place further strain on the already overburdened health systems of LMICs. Patients with DM in SSA are faced with huge challenges in accessing basic health care including, but not limited to, a lack of steady access to diabetes medication, particularly insulin, at an affordable cost [3, 6]. Therefore patients with diabetes in SSA are often undertreated, resulting in poor glycaemic control, and at risk of developing avoidable complications and premature death [6]. At the population level, DM remains under-diagnosed as screening/detection opportunities are few, and levels of awareness about the disease are low [3, 6]. In general, increasing levels of an important risk factor for DM such as obesity combined with low levels of awareness, treatment and control poses an ominous scenario in low resource settings.

We set out to determine if such a scenario exists in the urban slums of Kenya. A recent study in Nairobi, the capital city of Kenya, suggests that DM is a major problem in one slum [7] and that obesity and overweight are important correlates for DM. Our study goes the extra mile to assess the prevalence, awareness, treatment and control of diabetes, in addition to examining the relationship of obesity with DM in a large population-based cohort in two urban slums in Nairobi-Kenya, established in 2002 as part of a demographic and health surveillance system [8].

METHODS

Study design
The study was a population-based cross-sectional survey of two slums—Viwandani and Korogocho in Nairobi, Kenya. Large sections of these slums are covered by the Nairobi Urban Health and De-
mographic Surveillance System (NUHDSS). The NUHDSS is operated by the African Population and Health Research Center (APHRC) – a regional research institution, headquartered in Nairobi. Details of the operation of the NUHDSS have been published elsewhere [8]. In brief, the NUHDSS covers approximately 71,000 individuals residing in about 28,500 households in both slums. Every four months, demographic data including birth, death and migration status of every resident of the NUHDSS is updated. The NUHDSS therefore provides an up to date sampling frame for in-depth studies on various health and other social outcomes such as ours.

**Sampling technique**

Our study utilized the sampling frame of adults (≥18 years) known to be resident in the NUHDSS area at the preceding round of data collection (about three months prior to the beginning of the survey). We conducted stratified random sampling based on the WHO STEPwise protocol for chronic disease risk factor surveillance [9]. The STEPwise approach focuses on collecting core data on the established behavioral and physiological risk factors for NCDs that determine the major chronic disease burden. These risk factors include but are not limited to diabetes and elevated blood glucose, as well as measures of excessive body weight and obesity. Based on the STEPwise protocol, a target of 250 respondents in each of the following strata: sex (male and female), age group (18-29, 30-39, 40-49, 50-59, 60 years and over), slum of residence (Korogocho and Viwandani), was required. Therefore, in each stratum, a sampling frame was generated from the NUHDSS database and a computer based program (STATA® statistical software) used to randomly select eligible individuals.

**Data collection**

Details of the data collection methods have been described in detail elsewhere[10]. In summary, trained interviewers conducted interviews with study participants using a structured questionnaire that was translated into Kiswahili – the main local language in the study.
The field interviewers were trained in interviewing techniques, basic research ethics as well as in taking anthropometric and clinical measurements in accordance with the WHO STEPwise protocol [11]. Measurements were taken using WHO recommended and validated equipment (see Table 1). Overall, we considered several socio-demographic, behavioural and physiological risk factors for DM based on the framework developed by Wong et al [12]. Diabetes, our main outcome, is defined as random capillary blood glucose ≥11.1mmol/L or previously diagnosed by a health professional or confirmed by Oral Glucose Tolerance Test (OGTT) in accordance with WHO criteria [13]. Prediabetes is defined as two-hour (post 75g oral glucose load ingestion) blood glucose of between 7 and 11.0mmol/L [13]. See Table 2 for full definition of variables.

Statistics

Data were analysed using STATA 12 (StataCorp. 2011. College Station, TX: StataCorp LP). All estimates were weighted for sampling probability (using the size of the stratum in the NUHDSS database as denominator) and for response probability (using the total number sampled per stratum as denominator). A composite weight, taking both weights into account, was then applied to all estimates. Study participants’ socio-demographic, behavioural, and physiological risk factors by BMI (normal versus overweight/ BMI) were presented descriptively using Chi-square and ANOVA tests for significance at \( p \) less than 0.05. The awareness, treatment and control levels for DM by gender are also presented (see Table 2 for definitions).
To examine the relationship between diabetes and obesity, we performed a univariate random effects logistic regression analysis of the outcome variable over BMI stratified by gender and controlling for key covariates. In order to improve the power of our analysis, we collapsed certain sub-categories within selected variables. Specifically, within the BMI variable, overweight and obesity are combined into one sub-category while pre-diabetes and diabetes are combined into one category: raised blood glucose. Factors significant at $p \lessdot 0.20$ were then included in an adjusted analysis. All analyses were stratified by gender since it is expected that some associations might differ between females and males. Also, all analyses considered the outcome variable in its weighted form.

### Role of funding source

The study sponsors had no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication. The corresponding author declares that he had access to all the data in
the study and had final responsibility for the decision to submit for publication.

**Ethical approval**
The study protocol was approved by the Kenya Medical Research Institute (KEMRI)/National Ethical Review Committee.

**RESULTS**

A total of 5190 adults aged 18 years and older were successfully interviewed. This constitutes overall response rates of 94% in Korocho and 95% in Viwandani. Of those interviewed, 2396 (46%) were females and 2794 (54%) were males.

Table 3 shows the background characteristics of the study population by gender and diabetes status. Among both females and males, raised fasting glucose varied significantly by age, ethnicity, waist-hip ratio, waist-circumference and hypertension status. Among males only, raised fasting glucose varied significantly by study site.

Table 4 shows the distribution of prevalence, awareness, treatment and control of DM by gender. A quarter of females with DM were aware of their condition as compared to 16% of males. Two-thirds of females and about half of males who were aware of having DM were on treatment. Less than a third of those on treatment, of either gender, had their blood sugar levels under control.

Table 5 shows the distribution of respondent characteristics and prevalence of raised blood glucose stratified by BMI categories. The prevalence of raised blood glucose did not differ significantly by gender, education, smoking status, fruit/vegetable intake, physical activity or waist circumference across either BMI category. However the prevalence of raised blood glucose increased significantly with age among both BMI categories. The prevalence of raised blood glucose was significantly higher among current smokers if they had a normal BMI. Hypertensives had a significantly higher prevalence of raised blood glucose whether they had normal weight or were overweight/obese.
Table 3: Background characteristics for females and males by diabetes status and gender

<table>
<thead>
<tr>
<th></th>
<th>Females (N = 2396)</th>
<th>Males (N = 2794)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal n (%)</td>
<td>Prediabetes n (%)</td>
<td>Diabetes n (%)</td>
</tr>
<tr>
<td></td>
<td>Normal n (%)</td>
<td>Prediabetes n (%)</td>
<td>Diabetes n (%)</td>
</tr>
<tr>
<td>Study site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korean</td>
<td>1123 (99.7)</td>
<td>62 (2.5)</td>
<td>40 (1.6)</td>
</tr>
<tr>
<td>Vietnamese</td>
<td>1007 (98.7)</td>
<td>54 (4.6)</td>
<td>8 (0.65)</td>
</tr>
<tr>
<td>Age (in years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>1171 (93.3)</td>
<td>36 (2.9)</td>
<td>47 (3.8)</td>
</tr>
<tr>
<td>30-39</td>
<td>375 (90.6)</td>
<td>32 (8.4)</td>
<td>18 (4.6)</td>
</tr>
<tr>
<td>40-49</td>
<td>267 (90.0)</td>
<td>17 (5.6)</td>
<td>18 (5.8)</td>
</tr>
<tr>
<td>50-59</td>
<td>100 (90.6)</td>
<td>7 (6.1)</td>
<td>8 (7.1)</td>
</tr>
<tr>
<td>60-69</td>
<td>71 (76.5)</td>
<td>7 (7.6)</td>
<td>15 (15.7)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No school</td>
<td>186 (90.6)</td>
<td>8 (4.5)</td>
<td>13 (6.8)</td>
</tr>
<tr>
<td>Rural primary school</td>
<td>454 (91.2)</td>
<td>17 (3.5)</td>
<td>27 (5.4)</td>
</tr>
<tr>
<td>Secondary school &amp; higher</td>
<td>1044 (95.6)</td>
<td>54 (4.6)</td>
<td>55 (4.8)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kamba</td>
<td>434 (87.8)</td>
<td>27 (5.5)</td>
<td>33 (6.7)</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>413 (99.3)</td>
<td>47 (11.6)</td>
<td>51 (12.6)</td>
</tr>
<tr>
<td>Luhya</td>
<td>262 (99.1)</td>
<td>9 (3.3)</td>
<td>8 (2.8)</td>
</tr>
<tr>
<td>Luo</td>
<td>246 (95.6)</td>
<td>8 (3.2)</td>
<td>11 (4.7)</td>
</tr>
<tr>
<td>Others</td>
<td>407 (95.5)</td>
<td>9 (2.1)</td>
<td>12 (2.9)</td>
</tr>
<tr>
<td>Current smoking</td>
<td>No</td>
<td>216 (91.6)</td>
<td>115 (5.8)</td>
</tr>
<tr>
<td>Current drinking</td>
<td>No</td>
<td>212 (91.1)</td>
<td>113 (4.8)</td>
</tr>
<tr>
<td>Insufficient fruit and vegetable intake</td>
<td>No</td>
<td>61 (95.5)</td>
<td>4 (6.1)</td>
</tr>
<tr>
<td>Adequate physical activity</td>
<td>No</td>
<td>842 (97.6)</td>
<td>37 (3.8)</td>
</tr>
<tr>
<td>Adequate physical activity</td>
<td>Yes</td>
<td>1339 (97.1)</td>
<td>63 (4.8)</td>
</tr>
<tr>
<td>Water-hydrated ratio</td>
<td>Normal</td>
<td>565 (98.6)</td>
<td>27 (4.2)</td>
</tr>
<tr>
<td>Water-hydrated ratio</td>
<td>Normal</td>
<td>1456 (95.6)</td>
<td>73 (4.8)</td>
</tr>
<tr>
<td>Water consumption</td>
<td>Normal</td>
<td>1672 (92.3)</td>
<td>76 (4.2)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>Normal</td>
<td>195 (94.4)</td>
<td>35 (1.6)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>Normal</td>
<td>1267 (98.8)</td>
<td>64 (4.5)</td>
</tr>
<tr>
<td>Obesity</td>
<td>N/A</td>
<td>1440 (97.4)</td>
<td>44 (2.9)</td>
</tr>
<tr>
<td>Obesity</td>
<td>N/A</td>
<td>155 (93.5)</td>
<td>25 (4.1)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>No</td>
<td>205 (82.3)</td>
<td>30 (12.3)</td>
</tr>
</tbody>
</table>
| Missing data: smoking 1, inadequate physical activity 3, body mass index 116, water-hydrated ratio 326, waist circumference 3. P-value are derived from chi-square test.

Table 4: Prevalence, awareness, treatment and control of diabetes and gender

<table>
<thead>
<tr>
<th></th>
<th>Has diabetes (%)</th>
<th>Aware* (%)</th>
<th>Treat%(c)</th>
<th>Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females (n)</td>
<td></td>
<td>n = 162</td>
<td>n = 44</td>
<td>n = 48</td>
</tr>
<tr>
<td>As a % of N (5190)</td>
<td>4.81 (3.55-6.67)</td>
<td>1.10 (0.75-1.62)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>As a % of (a)</td>
<td>NA</td>
<td>248 (17.9-33.3)</td>
<td>19.1 (12.9-21.2)</td>
<td>5.01 (1.62-8.40)</td>
</tr>
<tr>
<td>As a % of (b)</td>
<td>NA</td>
<td>NA</td>
<td>77.8 (67.0-88.8)</td>
<td>28.4 (18.2-38.5)</td>
</tr>
<tr>
<td>As a % of (c)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>26.3 (13.4-39.2)</td>
</tr>
<tr>
<td>Males (n)</td>
<td></td>
<td>n = 136</td>
<td>n = 37</td>
<td>n = 24</td>
</tr>
<tr>
<td>As a % of N (5190)</td>
<td>3.99 (3.2-4.72)</td>
<td>0.63 (0.13-3.92)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>As a % of (a)</td>
<td>NA</td>
<td>157 (9.5-21.9)</td>
<td>8.48 (3.7-15.2)</td>
<td>39.9 (20.9-77.8)</td>
</tr>
<tr>
<td>As a % of (b)</td>
<td>NA</td>
<td>NA</td>
<td>53.6 (16.8-70.6)</td>
<td>25.3 (18.4-40.1)</td>
</tr>
<tr>
<td>As a % of (c)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>28.2 (17.9-47.6)</td>
</tr>
</tbody>
</table>

*Awareness of diabetes among those who were found to have diabetes.
†Treatment for diabetes among those who were aware of their condition.
‡Control of diabetes among those who reported receiving treatment.
Estimates weighted for sampling probability and response rate.
In the logistic regression analyses for females (Table 6), the odds of raised blood glucose were significantly increased in the overweight/obese, oldest age group (60 years and older), and among hypertensives while controlling for other factors. Females belonging to “other” ethnicities had lower odds of raised blood glucose compared with the reference group (Kamba). Among males, BMI and all other factors were not significantly associated with raised blood glucose except hypertension. Male hypertensives had twice the odds of raised blood glucose compared to non-hypertensives after controlling for all other factors.

Table 5: Description of study participants and prevalence of raised blood pressure by BMI

<table>
<thead>
<tr>
<th>BMI ≥25</th>
<th>BMI ≥25</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (%)</td>
<td>Prevalence (95%CI)</td>
</tr>
<tr>
<td>Gender</td>
<td>P = 0.073</td>
</tr>
<tr>
<td>Female</td>
<td>1227 (15.8)</td>
</tr>
<tr>
<td>Male</td>
<td>2179 (44.2)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>P = 0.006</td>
</tr>
<tr>
<td>18-29</td>
<td>1645 (46.3)</td>
</tr>
<tr>
<td>30-39</td>
<td>768 (26.8)</td>
</tr>
<tr>
<td>40-49</td>
<td>476 (19.0)</td>
</tr>
<tr>
<td>50-59</td>
<td>269 (6.2)</td>
</tr>
<tr>
<td>60 or age</td>
<td>101 (5.0)</td>
</tr>
<tr>
<td>Education</td>
<td>P = 0.284</td>
</tr>
<tr>
<td>No formal schooling</td>
<td>195 (1.7)</td>
</tr>
<tr>
<td>Did not finish primary school</td>
<td>568 (16.7)</td>
</tr>
<tr>
<td>Completed Primary school</td>
<td>1662 (49.0)</td>
</tr>
<tr>
<td>Secondary school or higher</td>
<td>971 (28.6)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>P = 0.018</td>
</tr>
<tr>
<td>Kamba</td>
<td>845 (24.9)</td>
</tr>
<tr>
<td>Khoja</td>
<td>1062 (13.3)</td>
</tr>
<tr>
<td>Loidha</td>
<td>436 (12.9)</td>
</tr>
<tr>
<td>Luo</td>
<td>409 (14.8)</td>
</tr>
<tr>
<td>Others</td>
<td>562 (16.6)</td>
</tr>
<tr>
<td>Current smoker</td>
<td>P = 0.493</td>
</tr>
<tr>
<td>No</td>
<td>2933 (86.4)</td>
</tr>
<tr>
<td>Yes</td>
<td>461 (13.6)</td>
</tr>
<tr>
<td>Current daily drinking</td>
<td>P = 0.018</td>
</tr>
<tr>
<td>No</td>
<td>3059 (89.5)</td>
</tr>
<tr>
<td>Yes</td>
<td>351 (10.5)</td>
</tr>
<tr>
<td>Insufficient fruit and vegetable intake</td>
<td>P = 0.981</td>
</tr>
<tr>
<td>No</td>
<td>1618 (47.7)</td>
</tr>
<tr>
<td>Yes</td>
<td>1777 (52.3)</td>
</tr>
<tr>
<td>Adequate physical activity</td>
<td>P = 0.626</td>
</tr>
<tr>
<td>No</td>
<td>463 (13.7)</td>
</tr>
<tr>
<td>Yes</td>
<td>2930 (86.3)</td>
</tr>
<tr>
<td>Waist hip ratio</td>
<td>P = 0.015</td>
</tr>
<tr>
<td>Normal</td>
<td>2250 (66.3)</td>
</tr>
<tr>
<td>≥49 (male) (≥80 female)</td>
<td>1156 (33.5)</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>P = 0.074</td>
</tr>
<tr>
<td>Normal</td>
<td>2851 (84.0)</td>
</tr>
<tr>
<td>≥94 cm (male) (≥80 cm female)</td>
<td>544 (16.0)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>P = 0.003</td>
</tr>
<tr>
<td>Yes</td>
<td>817 (23.6)</td>
</tr>
<tr>
<td>No</td>
<td>318 (9.4)</td>
</tr>
</tbody>
</table>

Mising data: smoking (1), adequate physical activity (3), body mass index (116), waist hip ratio (126), waist circumference (3). 95% CI - 95% confidence interval. All P-values derived using chi-square test.
We set out to determine the magnitude (prevalence, awareness, treatment and control) of diabetes, and to examine the relationship of obesity with raised blood glucose in a random population of adult slum dwellers. Overall, the weighted prevalence of diabetes was about 4% and this did not differ significantly by gender. Overall levels of awareness, treatment and control for diabetics were quite low among males and females, though females fared slightly better than males. Four out of ten females in our study 

Table 6: Odds ratios for the association between raised blood glucose and BMI controlling for other risk characteristics, among females and males

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th></th>
<th></th>
<th>Males</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>OR</td>
<td>95%CI</td>
<td>Adjusted</td>
<td>OR</td>
<td>95%CI</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Overweight (BMI &gt; 29)</td>
<td>2.13***</td>
<td>1.48-3.07</td>
<td>1.67**</td>
<td>1.07-2.59</td>
<td>1.39**</td>
<td>0.98-1.96</td>
</tr>
<tr>
<td>Age (in years)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30-39</td>
<td>1.45**</td>
<td>0.95-2.27</td>
<td>1.35</td>
<td>0.82-2.21</td>
<td>0.58</td>
<td>0.31-1.16</td>
</tr>
<tr>
<td>40-49</td>
<td>1.80**</td>
<td>1.18-2.75</td>
<td>1.46</td>
<td>0.90-2.46</td>
<td>1.49</td>
<td>0.96-2.32</td>
</tr>
<tr>
<td>50-59</td>
<td>2.17***</td>
<td>1.39-3.40</td>
<td>1.32</td>
<td>0.77-2.88</td>
<td>1.88**</td>
<td>1.15-2.96</td>
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<tr>
<td>60 or older</td>
<td>4.30***</td>
<td>2.82-6.55</td>
<td>2.50*</td>
<td>1.34-4.77</td>
<td>1.90**</td>
<td>1.26-2.82</td>
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<td>Education</td>
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<tr>
<td>Did not finish primary school</td>
<td>0.94</td>
<td>0.62-1.42</td>
<td>1.03</td>
<td>0.56-1.97</td>
<td>1.10</td>
<td>0.51-2.29</td>
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<tr>
<td>Completed Primary school</td>
<td>1.01</td>
<td>0.68-1.48</td>
<td>0.96</td>
<td>0.53-1.73</td>
<td>1.22</td>
<td>0.67-2.13</td>
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<td>Secondary school higher</td>
<td>0.82</td>
<td>0.49-1.36</td>
<td>1.22</td>
<td>0.67-2.23</td>
<td>1.48</td>
<td>0.81-2.64</td>
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<tr>
<td>Khatra</td>
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<td>Lahia</td>
<td>0.87</td>
<td>0.57-1.31</td>
<td>1.04</td>
<td>0.62-1.73</td>
<td>1.27</td>
<td>0.86-1.88</td>
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<tr>
<td>Luva</td>
<td>0.46*</td>
<td>0.24-0.85</td>
<td>0.67</td>
<td>0.34-1.37</td>
<td>1.15</td>
<td>0.67-1.89</td>
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<tr>
<td>Others</td>
<td>0.50*</td>
<td>0.26-0.97</td>
<td>0.67</td>
<td>0.32-1.41</td>
<td>0.45*</td>
<td>0.24-0.84</td>
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<tr>
<td>Current smoker</td>
<td>0.38**</td>
<td>0.20-0.72</td>
<td>0.43*</td>
<td>0.21-0.89</td>
<td>1.10</td>
<td>0.66-1.82</td>
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<tr>
<td>Current daily drinking</td>
<td>0.74</td>
<td>0.26-2.12</td>
<td>0.9</td>
<td>0.54-1.44</td>
<td>0.9</td>
<td>0.54-1.44</td>
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<td>Insufficient fruit and vegetable intake</td>
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<tr>
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<td>1.07</td>
<td>1.00-2.83</td>
<td>1.04</td>
<td>1.00-2.94</td>
<td>1.34</td>
<td>0.84-2.09</td>
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<td>Adequate physical activity</td>
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<td>0.82</td>
<td>0.59-1.14</td>
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<td>0.79</td>
<td>0.53-1.14</td>
<td>0.94</td>
<td>0.61-1.45</td>
<td>0.82</td>
<td>0.53-1.32</td>
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<td>Waist-height ratio</td>
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<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>29 cm (males)/28 cm (females)</td>
<td>1.32</td>
<td>0.79-2.22</td>
<td>1.32</td>
<td>0.62-2.03</td>
<td>1.31</td>
<td>0.59-2.32</td>
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<tr>
<td>Waist circumference</td>
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<td></td>
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<td>Normal</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>29 cm (males)/28 cm (females)</td>
<td>1.67***</td>
<td>1.09-2.51</td>
<td>1.67</td>
<td>0.94-3.00</td>
<td>1.88**</td>
<td>1.15-3.00</td>
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<tr>
<td>Hypertension</td>
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<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>1.35***</td>
<td>1.28-4.71</td>
<td>3.30***</td>
<td>2.14-6.90</td>
<td>2.13***</td>
<td>1.52-3.00</td>
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95%CI, 95% confidence interval; OR, odds ratio.
1P ≤ 0.20, ••P ≤ 0.05, **P ≤ 0.001, ***P ≤ 0.0001.

DISCUSSION
were either overweight or obese compared with less than two out of ten males. The adjusted analysis show that among females, being overweight/obese, 60 years or older, and being hypertensive were associated with significantly increased odds of raised blood glucose. Among males, only being hypertensive was significantly associated with increased odds of raised blood glucose.

**Prevalence**

The overall prevalence of diabetes in our study is comparable to a previous study in Kenya that showed a prevalence of 4.2 - 5.3% [14]. Specifically, a recent study in another major slum in Nairobi showed a prevalence of 5.3% (95% CI 4.2-6.4) [7]. In comparison with studies from other settings in SSA, the prevalence of diabetes in our study was higher than a number of recent studies [15-18] and similar or lower than in others [19-25]. Overall, the prevalence of diabetes across the sub-continent ranged from 3% in Benin to as high as 14.5% in urban Democratic Republic of Congo [3, 6, 26]. Additionally, there is evidence of an increasing prevalence of diabetes in SSA over the past two or three decades [3].

**Figure 1:** Prevalence (%) of diabetes (DM) and raised blood glucose (RBG) by age-group and gender

It is noteworthy that the prevalence of prediabetes in our study was 5.3% and 5.7% among females and males, respectively. This is particularly significant because evidence suggests that up to 5-10% per year of people with prediabetes will develop diabetes [27]. This situation presents an opportunity for preventive interventions in the slum population barring which a further rise in the prevalence of diabetes will be unavoidable. Lifestyle modification is the cornerstone of diabetes prevention and could provide up to 70% relative risk reduction among people with prediabetes [27]. However, with the low levels of awareness, treatment and control in the study population, chances are that the majority of those with prediabetes will remain unidentified and untreated further aggravating the burden of diabetes in this population.

**Awareness, treatment and control**

In terms of awareness, our findings are comparable to other studies in SSA. Generally, the level of awareness of diabetes is usually less than 50% [6] – ours was only about 20%. One study in rural Guinea found that 100% of those surveyed and diagnosed with diabetes were previously unaware of their diagnosis [22]. An exception was a study in urban South Africa where more than 50% were aware of
However, with the exception of a recent study in one slum in Nairobi [7], the available evidence does not typically reflect the situation of diabetes in the slums of SSA as these studies focused on rural and/or urban populations in general rather than slums.

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Overall however, it is noteworthy that less than 5% of all people with diabetes in our study had their blood glucose under control. It is known that poor control of blood sugar is associated with high risk of complications that in turn lead to high morbidity and mortality. There is evidence that suggests that chronic vascular complications such as retinopathy, nephropathy and neuropathy are common in SSA and macrovascular complications such as stroke are also on the increase [6]. Reasons for low levels of awareness, treatment and control include lack of screening opportunities; high cost of treatment; stock-out of medication; late diagnoses; poor adherence; and preference of alternative medicines for the management of diabetes [3, 4, 6]. These reasons usually reflect a general lack of prioritization and investment of care for chronic NCDs and unresponsive health care systems across SSA [3, 4, 6]. The slum populations remain particularly disadvantaged and therefore extra attention is needed to prevent and control the diabetes epidemic in these populations.

**Obesity and raised blood glucose**

Our study found that a high BMI indicative of overweight/obesity was significantly associated with increased odds of raised blood glucose among females but not among males. There is evidence that obesity is increasing in SSA especially among females [5]. Further, studies from the sub-continent including Mali, Tanzania and Nigeria, also show that obesity typified by high BMI is associated with increasing risk of diabetes [4]. The reasons for the high rate of obesity among females in the slums may need further examination. However, there is evidence that suggests that socio-cultural perceptions of ideal body size may be a contributory factor. Specifically, some studies in African populations have shown that a large body size is perceived positively as a sign of wealth and good health as well as being attractive to the opposite sex [30]. As females come in contact with health service more frequently than males due to maternal and child health demands, there is an opportunity for health professionals to educate females about the health risks of obesity and overweight. Specifically, reproductive (family
planning) and maternal health services should be integrated with primary preventive strategies (such as screening and lifestyle counselling) for diabetes and related conditions.

Other risk factors
Our study found that the prevalence of diabetes increased with age among both males and females and was highest in the 60 plus age group. This is consistent with other studies from SSA [3, 6]. There were no significant gender differences in the prevalence of diabetes in our study population. This is in keeping with a few studies in SSA though other studies show gender differences [3, 6]. We also found that females in our study belonging to the broad group of “other” ethnicities were found to have a significantly lower risk of diabetes compared to the reference ethnic group. It is hard to explain this finding since this group is not homogeneous and comprises of over 30 other tribes in Kenya. One previous study in Kenya found that the ethnic group of Luos had the highest risk of diabetes owing to the higher total dietary energy intake (mostly from cereal grains) in that community [14]. However, in our study being Luo was not associated with increased odds of diabetes. Finally, we found that being hypertensive was significantly associated with increased odds of raised fasting glucose among both males and females. This finding is well established from previous studies across the world [31].

Our study is limited by the fact that some of our explanatory variables (such as smoking, physical inactivity) were based on self-reports which could have been misreported. However, self-reports remain useful and validated components of large surveys such as ours across the world. Additionally, the accuracy of BMI as a measure of obesity is limited though its use remains recommended [32, 33]. Our study was also limited by the fact that we did not measure or assess other important known risk factors of increased blood glucose such as underlying infection (HIV, TB) or medication (steroids, anti-retrovirals) [34-36]. We also did not collect objective information on type of or adherence to diabetes medication (e.g., HbA1c measurement) neither did we examine the respon-
dents for manifestations of microvascular and macrovascular complications of diabetes. The main strength of our study is that the sample size is large and is thus a good representation of the slum population for whom data are often unavailable.

CONCLUSIONS

In conclusion, we found that diabetes was moderately prevalent in the slum population in Nairobi. At the same time, the levels of awareness, treatment and control of diabetes are dismally low in the study setting. Further, obesity was significantly associated with increased odds of raised blood glucose especially among females. Again, we found that the presence of co-morbidities such as hypertension also increased the odds of having raised blood glucose. From the foregoing, it is imperative that health planners and policy makers in SSA pay attention to chronic NCDs such as diabetes especially in the often neglected but significant population of slum dwellers across the sub-continent.

Acknowledgements

We wish to acknowledge the contribution of APHRC’s dedicated field and data management teams as well as the study participants who shared their time with us. We acknowledge Prof. Joep M.A Lange and Dr. Gabriela G. Gomez for their academic support. We also acknowledge the Wellcome Trust UK and Academic Medical Center Foundation (through the Amsterdam Institute for Global Health and Development) for grant supports to the project and staff-time to write this paper, respectively.

Conflicts of interest

The authors declare that they have no conflict of interest.
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