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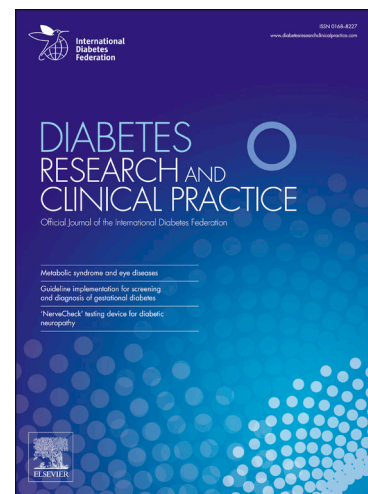
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Type 2 diabetes mellitus management among Ghanaian migrants resident in three European countries and their compatriots in rural and urban Ghana – The RODAM Study***Authors and affiliations***

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Abstract

Aims: To compare Type 2 Diabetes Mellitus (T2DM) awareness, treatment and control between Ghanaians resident in Ghana and Europe.

Methods: Comparisons were made for the 530 participants of the Research on Obesity and Diabetes among African Migrants (RODAM) study with T2DM (25-70 years) living in Amsterdam, Berlin, London, urban Ghana and rural Ghana. We used logistic regression to assess disparities with adjustment for age, sex and education.

Results: T2DM awareness was 51% in rural Ghana. This was lower than levels in Europe ranging from 73% in London (age-sex adjusted odds ratio (OR)=2.7; 95%CI=1.2-6.0) to 79% in Amsterdam (OR=4.7; 95%CI=2.3-9.6). T2DM treatment was also lower in rural Ghana (37%) than in urban Ghana (56%; OR=2.6; 95%CI=1.3-5.3) and European sites ranging from 67% in London (OR=3.4; 95%CI=1.5-7.5) to 73% in Berlin (OR=6.9; 95%CI=2.9-16.4). In contrast, T2DM control in rural Ghana (63%) was comparable to Amsterdam and Berlin, but higher than in London (40%; OR=0.4; 95%CI=0.2-0.9) and urban Ghana (28%; OR=0.3; 95%CI=0.1-0.6).

Conclusions: Our findings suggest that improved detection and treatment of T2DM in rural Ghana, and improved control for people with diagnosed T2DM in London and urban Ghana warrant prioritization. Further work is needed to understand the factors driving the differences.

Keywords

Type 2 diabetes mellitus, ethnic minority groups, migrants, Ghana, sub-Saharan Africans, RODAM study

1. Introduction

Type 2 Diabetes Mellitus (T2DM) is a global burden, and low- and middle-income countries (LMIC) are particularly affected compared to high-income countries [1]. The current projections indicate that the gap in T2DM burden between high-income countries and LMIC will further widen in the coming decades. Sub-Saharan Africa (SSA) is expected to experience the fastest increase globally in the number of people living with T2DM in the next two decades [1].

Migrant populations in high-income countries are disproportionately affected by T2DM compared with the local host populations. A recent meta-analysis indicates that SSA migrants are among those most affected by T2DM with the prevalence being nearly 3 times higher than in European host populations [2]. Migrant populations also tend to develop T2DM at a younger age and have more diabetes-related complications such as cardiovascular disease than local populations [3].

Despite the high levels of T2DM and related complications among migrant populations, evidence on T2DM awareness, treatment and control rates among SSA migrants in Europe is lacking and limited for the SSA region. Sobngwi et al. reported low proportion of T2DM control in the SSA region (29%), but this study was conducted among patients in specialized centers, and thus does not provide us with population-based information [4]. Moreover, it is unclear how this is distributed across rural and urban SSA sites and whether the levels of T2DM management outcomes (i.e. T2DM awareness, treatment, and control) among SSA migrants vary across European countries. Adequate T2DM management is crucial for prevention of T2DM related complications.

T2DM prevalence rates seem to be influenced by contextual factors in the country of residence [5, 6]. A higher T2DM prevalence was observed among Africans in the Netherlands compared to Africans in the United Kingdom, similar to the differences seen between host populations in these countries [5]. Possibly, contextual factors also result in cross-country differences in T2DM management outcomes. The Netherlands, Germany, the United Kingdom and Ghana differ in contextual factors that may affect T2DM awareness, treatment and control. These contextual factors entail among others different healthcare systems [7-10] including access to health care. No data are available about T2DM management among sub-Sahara Africans residing in these countries. Gaining insight into the differences in T2DM awareness, treatment and control among sub-Sahara Africans resident in multiple locations can help shape future management efforts in varying contexts.

Therefore, we aimed to assess differences in awareness, treatment and control of T2DM among a relatively homogeneous SSA population (i.e. Ghanaians stemming mainly from one region in Ghana) living in different European cities and in urban and rural Ghana.

2. Materials and methods

The rationale and design of the Research on Obesity and Diabetes among African Migrants (RODAM) study have been described in detail elsewhere [11, 12]. In brief, the RODAM study is a cross-sectional study that aims at understanding the reasons for the high prevalence of obesity and T2DM among SSA migrants.

2.1 Study population

Ghanaian (by country of birth criteria) adults were recruited for participation in the RODAM study in Amsterdam, Berlin, London, urban Ghana and rural Ghana. A total of 6385 Ghanaians participated. The participation rate was 76% in rural Ghana and 74% in urban Ghana. In London and Berlin, of those individuals that were in the various organization lists and were invited, 75% and 68% agreed to participate in the study. In Amsterdam, we received responses from 67% of those invited, while 53% agreed to participate.

From the total RODAM dataset a subset was selected for the current analysis. This subset comprised all RODAM participants with T2DM and aged 25 to 70. T2DM was defined according to WHO criteria: fasting glucose ≥ 7.0 mmol/l, glucose lowering medication use, or self-reporting of prior diagnosis of T2DM by a health care professional [13]. As previously described by Agyemang et al., the prevalence of T2DM among respectively males and females in the RODAM study was 12.8% and 9.9% in Amsterdam, 15.3% and 10.2% in Berlin, 10.4% and 8.4% in London, 10.3% and 9.2% in urban Ghana, and 3.6% and 5.5% in rural Ghana [6]. The selection of T2DM cases and participants aged 25 to 70 from the RODAM dataset resulted in a total of 530 individuals included in the current analysis: 172 in Amsterdam, 70 in Berlin, 102 in London, 135 in urban Ghana and 51 in rural Ghana.

2.2 Data collection and measurements

Data were collected between 2012 and 2015. Data collection comprised questionnaires, physical examination and collection of blood samples. Ethical approval was obtained from the medical ethical committees of the involved institutions in Ghana, the Netherlands, Germany and the UK before the start of data collection. We obtained written informed consent from each participant prior to enrolment into the study.

Information on demographic and socio-economic factors as well as self-reported T2DM and information on T2DM treatment were derived from the questionnaire, which was conducted face-to-face by a trained research assistant or self-administered, according to the preference of the participant. Height, weight and waist circumference were measured in duplicate and were averaged. Height was measured to the nearest millimeter without shoes using a portable stadiometer (SECA 217). Weight was measured in kilogram to the nearest decimal without shoes and in light clothes using a flat weighing scale (SECA 877). Waist circumference was measured to the nearest millimeter at the middle between the iliac crest and the rib cage using measuring tape. Furthermore, participants were asked to bring their medication to the research location in order to document the type of medication used. Blood samples were drawn by trained research assistants after a 10-14 hour fast to determine fasting plasma glucose in mmol/L (Horiba ABX Pentra 400), HbA1c in % and mmol/mol (HPLC) and insulin in mU/L (Mercodia ELISA). All blood samples were collected, handled, processed and stored according to standardized procedures and were analyzed in the same laboratory in Berlin (Charité) in order to avoid variability between laboratories.

2.3 Data analysis

Awareness was calculated as the proportion of self-reported T2DM cases among those with T2DM. Treatment was defined by documented use of hypoglycemic medication at the research location, or a positive reply in the questionnaire to being treated for T2DM in the past 12 months, use of oral T2DM medication or use of insulin injections. Treatment was calculated as the proportion of treated participants among those with T2DM. Control was calculated as the proportion of those having HbA1c levels $\leq 7.0\%$ (53 mmol/mol) [14] out of those with T2DM. In additional analyses we calculated the proportion controlled (HbA1c $\leq 7.0\%$ (53 mmol/mol)) out of those treated for T2DM (supplemental figure).

The characteristics of the study population were expressed as numbers and percentages, means with corresponding 95% confidence intervals (CI), or medians and 25th and 75th percentiles. We found no significant statistical interaction between sex and site in relation to T2DM awareness, treatment and control. Hence, analyses were combined for men and women. Multivariate logistic regression analyses were conducted to assess the association between site and T2DM awareness, treatment and control with adjustments for age and sex. Differences in education level are present between the sites and might influence T2DM awareness, treatment and control rates. Therefore, additional adjustment for level of education was done to study the differences between sites in T2DM awareness, treatment and control independent of differences in education level. Rural Ghana served in all models as reference category because we conceptualize rural Ghana as the origin from where Ghanaians migrated to urban Ghana, and subsequently to Europe. Data were expressed as odds ratios (OR) and 95% CI. Data were analyzed in SPSS version 23 and R version 3.1.2.

3. Results

3.1 Characteristics

Mean age was similar across sites (Table 1). The mean length of stay among Ghanaian migrants in Europe was approximately 22 years and did not differ between the European sites. All European Ghanaians were first generation migrants except for one participant in London who was second-generation migrant. The mean time span since T2DM diagnosis was longest in London (10.9 years; 95% CI, 8.2-13.8) and shortest in urban Ghana (6.1 years; 95% CI, 4.4-8.2), but it was similar across the other sites. Education level differed significantly between sites with London having the highest proportion of higher vocational/university level education (34%) and Amsterdam (3%) and rural Ghana (2.1%) having the lowest. Mean Body Mass Index (BMI) was higher in European sites (29.2 – 30.8 kg/m²) and urban Ghana (27.1 kg/m²) than in rural Ghana (23.9 kg/m²). Mean waist circumference was higher in European sites (99.5 – 100.6 cm) than in Ghanaian sites (87.5 – 92.3 cm). Mean fasting plasma glucose, HbA1c and insulin levels were higher in urban Ghana and London, but were similar across the other sites.

3.2 Type 2 diabetes mellitus awareness

The highest T2DM awareness rates were observed in the European sites (72.5%-79.3%) (Figure 1). Awareness was higher in Amsterdam (79.3%; 130 aware/164 people with T2DM; 95% CI, 72.3-85) than in urban Ghana (59.1%; 78/132; 95% CI, 50.2-67.6) and rural Ghana (51%; 25/49; 95% CI, 36.3-65.6). Ghanaians in Amsterdam, Berlin and London had 4.7, 3.6 and 2.7 times higher odds to be aware of having T2DM, respectively, compared to rural Ghanaians after adjustment for age, sex and level of education (Table 2).

3.3 Type 2 diabetes mellitus treatment

Proportions of T2DM treatment were higher in Amsterdam (73.3%; 126/172; 95% CI, 66-79.7), Berlin (72.9%; 51/70; 95% CI, 60.9-82.8) and London (66.7%; 68/102; 95% CI, 56.6-75.7) compared to rural Ghana (37.3%; 19/51; 95% CI, 24.1-51.9) (Figure 1). Treatment in urban Ghana (56.3%; 76/135; 95% CI, 47.5-64.8) was lower than in Amsterdam but did not significantly differ from the other sites. After adjusted for age and sex, Ghanaians in all sites had higher odds to be on glucose lowering medication than rural Ghana. Amsterdam and Berlin had the highest odds (6.6 and 7.6, respectively). Additional adjustment for level of education reduced these odds slightly to 6.1 and 6.9, respectively (Table 2). In the European sites, the type of treatment was most often metformin. In Ghana, mostly other/unknown types of medication were prescribed (Table 1).

3.4 Type 2 diabetes mellitus control

Proportions of T2DM control were similar in Amsterdam (63.4%; 104/164; 95% CI, 55.5-70.8), Berlin (62.7%; 42/67; 95% CI, 50-74.2), and rural Ghana (63.4%; 26/41; 95% CI, 48.8-79.8). Control in London was lower (40%; 36/90; 95% CI, 29.8-50.9) than in Amsterdam and rural Ghana. Control in urban Ghana was lower (27.5%; 36/131; 95% CI, 20-36) than in Amsterdam, Berlin and rural Ghana (Figure 1). In additional analyses we found the proportion controlled out of treated for T2DM to follow a similar trend (supplemental figure). Adjusted for age, sex and level of education, Ghanaians in London and urban Ghana had lower odds to be controlled than Ghanaians in rural Ghana (ORs of respectively 0.4 and 0.3) (Table 2). Post hoc analyses, in which we adjusted for age, sex, and either years since T2DM diagnosis, physical activity, energy intake, or type of medication, could not further explain the differences between sites (not shown in table). Adjusted for age, sex and years since T2DM diagnosis, Ghanaians in London and urban Ghana had 0.2 times lower odds to be controlled than Ghanaians in rural Ghana (95% CI's 0.1-0.8 and 0.1-0.5, respectively), which did not differ from the OR's when adjusted for age, sex and level of education (Table 2). When physical activity, energy intake or type of medication were added to the model together with age and sex, Ghanaians in urban Ghana had lower odds to be controlled than Ghanaians in rural Ghana, but this did not differ from the OR in the model that adjusted for age, sex and level of education (Table 2).

4. Discussion

4.1 Key findings

Our findings show differences in T2DM management outcomes between Ghanaians resident in multiple sites, in particular in relation to T2DM control. While T2DM awareness and treatment hardly differed between the European sites and urban Ghana, T2DM control was lower in urban Ghana and London compared to the other sites. Despite lower T2DM awareness and treatment rates in rural Ghana compared to all other sites, T2DM control rate was high.

4.2 Discussion of key findings

Awareness of T2DM status, treatment and adequate blood sugar control are essential in prevention of T2DM complications. The levels of T2DM awareness and treatment we found were relatively high for Ghanaians resident in Europe. Ghanaians resident in all European sites had awareness and treatment rates of at least 67% and up to 79%. In the Ghanaian sites awareness and treatment rates were, as expected, lower than in the European sites, and were around 50%.

The lower T2DM awareness and treatment rates in Ghana as compared to Europe could be partially attributed to a difference in access to health information and care. The European sites have health care systems in place that allow for high T2DM awareness and treatment. In the Netherlands and Germany, a mandatory health insurance covers the costs for essential curative care [7, 8], while in the UK, permanent residents have free access to care [10]. In Ghana, a national health insurance structure is in place, yet this is voluntary and despite the low premium, the health insurance remains unaffordable to the poorest part of the population, resulting in a subscription rate of approximately 45% [9]. For the poorest, who most often live in rural areas, this might constrain access to screening and medication [15] which could result in lower awareness and treatment rates in rural Ghana. Local circumstances in rural Ghana could further explain the awareness and treatment rates, such as far distance to a health care facility, unaffordable transportation to reach the health care facility, lack of human resources, or medication that is out of stock [16].

The explanations for the lower control rates in urban Ghana and London are unclear, although most likely multifactorial. Post-hoc analyses in our study showed that factors including years since T2DM diagnosis and type of medication did not contribute to the differences between the sites. Neither did the individual factors physical activity and energy intake, which could affect treatment efficacy, and thereby contribute to differences in control between sites. Possibly, sedentary lifestyle not fully captured by the physical activity questionnaire contributed to the lower control in urban Ghana and London. Sedentary lifestyle is likely to be higher in London compared to Amsterdam and Berlin due to the higher educational level in London, which often results in more sedentary professions. Similarly, a sedentary lifestyle is likely to be more prevalent in urban Ghana compared to rural Ghana. Other unmeasured contextual factors such as factors related to access and use of the health care systems may also be contributing to the differences in control between sites. The relatively low T2DM control in urban Ghana compared to rural Ghana in particular could potentially be explained by a high motivation among rural Ghanaians to adequately take the medication once the barriers to obtain medication are overcome, compared to urban Ghana where these barriers are likely to be

lower due to a higher density of health facilities. The T2DM control rate among Ghanaians in London was 40% in our study, compared to 60% among the general British population with T2DM [17]. Because of universal free access to health care in the UK, the lower rates of control in the Ghanaian population are unlikely related to access itself, but rather to health care use, for example differential health care quality, clinician inertia, or specific cultural factors. In the Netherlands, higher control levels (74%) have been reported for the general population compared to what we found among Ghanaians (63%) as well. T2DM control rates in Germany (64%) [17] were similar to control rates among Ghanaians in Berlin in our study (63%). Further research is needed to study the role of health care use in T2DM management among SSA migrants and their compatriots in SSA.

4.3 Strengths and limitations

RODAM is a unique study with data of a relatively homogeneous SSA population resident across different sites. The RODAM study includes a representative sample of Ghanaians as previously described by Agyemang et al. [11] of which all T2DM cases were selected for the present analysis. It is therefore a very suitable study to compare T2DM awareness, treatment and control rates between different sites. The RODAM study sites (Amsterdam, Berlin, London, urban Ghana and rural Ghana) employ different health systems and policies [7-10] that could potentially affect T2DM awareness, treatment and control. Comparison of these sites therefore allows for gaining insight into the role of local contexts.

A point of discussion is the use of HbA1c for T2DM control. Even though ADA [14] ratifies the use of HbA1c to determine T2DM control, certain factors such as anemia, abnormalities of hemoglobin and uremia might disturb the HbA1c level, which is therefore a less reliable measure to use [13]. The alternative measure for T2DM control is fasting plasma glucose. Fasting plasma glucose, however, is subject to short-term fluctuations and is unstable, whereas HbA1c is more stable over time and thus gives a better impression of the T2DM control over the longer term [18]. Therefore, the use of HbA1c was the best choice for the purpose of this study. A sensitivity analysis using fasting plasma glucose showed similar patterns for T2DM control as seen when using HbA1c, although differences between sites were less pronounced when using fasting plasma glucose.

Another limitation to the present analysis is that we could not adjust our models for occupation which is commonly done in other health studies [19] and which could potentially have captured sedentary lifestyle from office professions. The contribution of occupation to differences in T2DM awareness, treatment and control rates between sites could not be studied due to a large number of missing values for the occupation variables. However, level of education was included which has been shown to be a good proxy for socio-economic status [20].

4.4 Conclusion

T2DM awareness and treatment rates among Ghanaian migrants in Europe and urban Ghanaians were better than rural Ghanaians. However, T2DM control rates in London and urban Ghana were lower than other sites. More work is needed to identify potential factors, including the role of health care related factors, contributing to the poor awareness and treatment in rural Ghana, and to the

poor control in urban Ghana and in Ghanaian migrants in London to assist prevention and clinical management efforts.

Author contributions

CA, MB, KM, KS, EB, FPM, EOD, LS, MBS, SB, JS, ID, AdGA, KKG and JA conceived and designed the study. EB, CA, EOD, FPM, SKA, JA, ID, CG, JS, AdGA and KM carried out the recruitment and data collection. MB, KM and CA performed the statistical analyses. MB wrote the manuscript with the cooperation of all co-authors. All authors read, contributed to and approved the final manuscript.

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Competing Interests

The authors have declared that no competing interests exist.

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Tables and figures

Table 1. Characteristics of participants selected for analysis by site (n = 530).

	Amsterdam	Berlin	London	Urban Ghana	Rural Ghana
N	172	70	102	135	51
Demographics					
Sex (% males)	49.4	65.7	41.2	34.1	29.4
Age (yrs)*	52.2 (51.1-53.3)	51.1 (48.8-53.5)	54.6 (52.8-56.4)	52.9 (51.2-54.5)	54.5 (51.6-57.4)
Length of stay in Europe (yrs)*	21.3 (20.2-22.4)	21.8 (19.4-24.2)	23.2 (20.7-25.8)	-	-
Years since diabetes diagnosis*	7.0 (5.6-8.8)	8.3 (5.6-11.2)	10.9 (8.2-13.8)	6.1 (4.4-8.2)	9.4 (4.4-15.2)
Education					
None or elementary	63 (38.4)	9 (13)	11 (11.7)	55 (41.7)	26 (54.2)
Lower vocational or lower secondary	59 (36.0)	33 (47.8)	32 (34.0)	54 (40.9)	14 (29.2)
Intermediate vocational or intermediate/higher secondary	37 (22.6)	17 (24.6)	19 (20.2)	16 (12.1)	7 (14.6)
Higher vocational or university	5 (3.0)	10 (14.5)	32 (34.0)	7 (5.3)	1 (2.1)
Anthropometrics					
BMI (kg/m ²)*	29.7 (28.9-30.4)	29.2 (28.0-30.4)	30.8 (29.7-31.8)	27.1 (26.2-28.1)	23.9 (22.6-25.2)
Waist circumference (cm)*	100.6 (98.8-102.5)	99.5 (96.7-102.3)	100.4 (98.0-102.7)	92.3 (90.1-94.4)	87.5 (84.0-91.1)
Diabetes-related characteristics					
Fasting glucose (mmol/l)†	7.0 (5.8-8.5)	6.7 (5.2-9.3)	7.3 (5.4-9.4)	9.9 (7.4-14.4)	7.7 (6.0-11.3)
HbA1c (%)†	6.4 (5.9-7.1)	6.5 (5.8-8.0)	6.9 (6.1-8.2)	8.3 (6.4-10.7)	6 (5.1-7.5)
HbA1c (mmol/mol)†	46 (41-54)	47 (40-64)	52 (43-66)	67 (47-93)	42 (32-59)
Insulin (mU/l)†	7.1 (4.4-10.9)	6.4 (4.2-8.8)	7.6 (4.4-13.2)	7.9 (4.7-12.3)	7.1 (3.8-11.0)
Type of medication					
Metformin	77 (44.8)	18 (25.7)	39 (38.2)	25 (18.5)	3 (5.9)
Insulin	5 (2.9)	13 (18.6)	4 (3.9)	5 (3.7)	1 (2.0)
Metformin and insulin	17 (9.9)	2 (2.9)	10 (9.8)	3 (2.2)	0 (0.0)
Other/unknown type	27 (15.7)	18 (25.7)	15 (14.7)	43 (31.9)	15 (29.4)
Not on treatment	46 (26.7)	19 (27.1)	34 (33.3)	59 (43.7)	32 (62.7)

Data are n (%), or:

* = mean (95% confidence interval)

† = median (25th – 75th percentile)

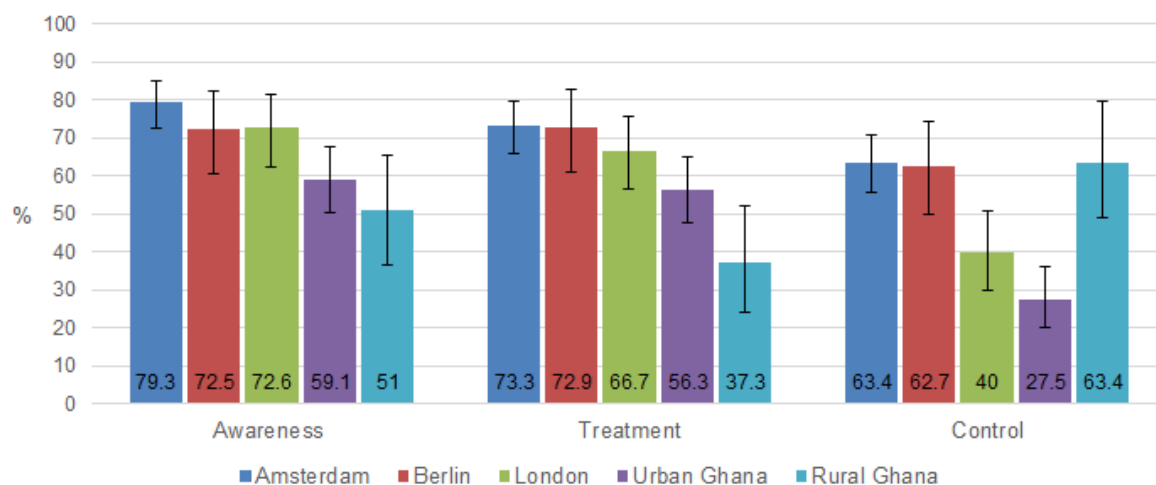


Figure 1. Crude prevalence with corresponding 95% confidence intervals for T2DM awareness, treatment and control among those with diabetes by site

Table 2. Odds ratios and 95% confidence intervals for T2DM awareness, treatment, control by site

	Rural Ghana	Amsterdam	Berlin	London	Urban Ghana
Awareness					
Model 1	1.0	4.4 (2.2-9.0)	3.3 (1.5-7.6)	2.7 (1.3-5.6)	1.5 (0.8-3.1)
Model 2	1.0	4.7 (2.3-9.6)	3.6 (1.5-8.3)	2.7 (1.2-6.0)	1.7 (0.8-3.3)
Treatment					
Model 1	1.0	6.6 (3.2-13.2)	7.6 (3.3-17.6)	4.0 (1.9-8.3)	2.6 (1.3-5.3)
Model 2	1.0	6.1 (3.0-12.7)	6.9 (2.9-16.4)	3.4 (1.5-7.5)	2.6 (1.3-5.3)
Control					
Model 1	1.0	1.1 (0.5-2.3)	1.1 (0.5-2.4)	0.4 (0.2-0.9)	0.2 (0.1-0.5)
Model 2	1.0	1.2 (0.6-2.6)	1.2 (0.5-2.8)	0.4 (0.2-0.9)	0.3 (0.1-0.6)

Reference category is rural Ghana.

Model 1: Adjusted for age and sex.

Model 2: Adjusted for age, sex and level of education.

Supplementary figure

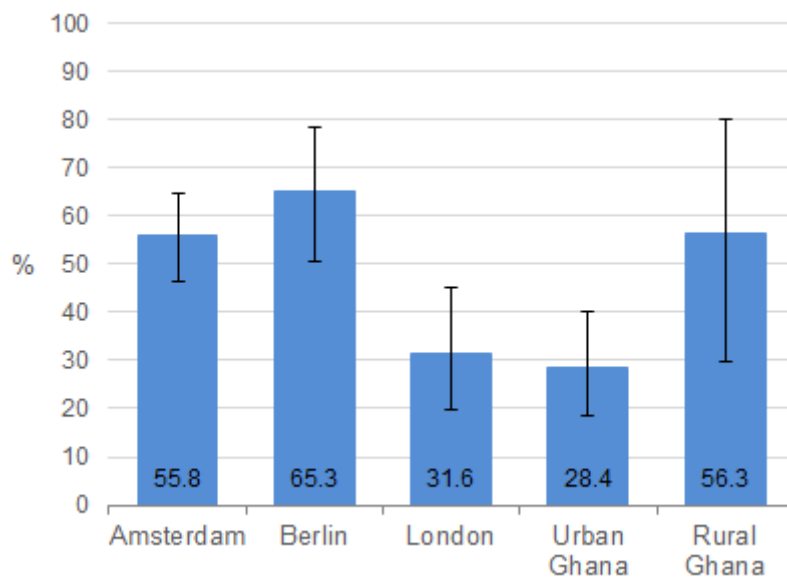


Figure S1. Crude prevalence with corresponding 95% confidence intervals for T2DM control among those treated for T2DM

Highlights

- T2D management outcomes among Ghanaians differ between geographical locations
- European and urban Ghanaians are more often aware of their T2D status
- Similarly, European and urban Ghanaians are more often treated for T2D
- However, T2D control is lower in London and urban Ghana compared to other sites

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