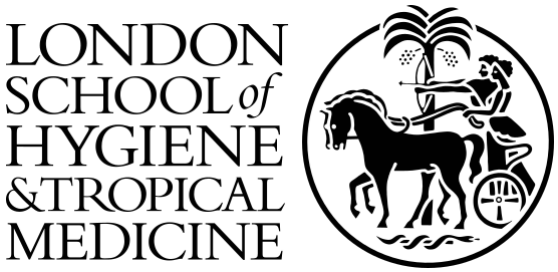

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Innovative ways of studying the effect of migration on obesity and diabetes beyond common designs

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Innovative ways of studying the effect of migration on obesity and diabetes beyond the common designs - lessons from the RODAM study

Short title: Lessons from the RODAM study

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Abstract

Type 2 diabetes and obesity are major global public health problems with migrant populations in high-income countries being particularly affected. Type 2 diabetes and obesity are also major threat in low- and middle-income countries where most migrant populations originate from. Transitioning of societies and resulting changes in lifestyles is thought to be a major driven force, but the key specific factors within this broad category still need to be determined. Migrant studies provide a unique opportunity to understand the potential underlying causes of these conditions, but current research is mainly geared towards differences between migrants and host populations in the countries of settlement. For better understanding, there is a need to extend migrant health research across national boundaries. This paper discusses innovative ways of studying the effect of migration on diabetes and obesity beyond the common designs, and the relevance of extending migrant health studies across national boundaries in the current era of increasing global migration. Specifically, we describe the burden and different methods for conducting migrant studies. We use the RODAM study as an exemplar by discussing the methods, some results and lessons learned including challenges and essential recipe for success that may guide future migrant heath research.

Keywords: Type 2 diabetes; obesity; ethnic minority; migrants; Europe; Sub-Saharan Africa

Introduction

Human migration is a complex historical phenomenon. Migration, by definition is a movement of a person or a group of persons, either across an international border, or within a country.[1] Historically, migration has constituted a natural safety-net as it offers protection in times of disasters such as famine, wars and human right violations.[1] Each generation has experienced its own unique migration patterns depending on the order of the day, and mostly driven by both internal and global social inequalities and injustices. In our current generation, globalisation and technological advances associated with modern transportation and communication have made it easier, cheaper and faster for individuals to migrate.[1-2] At the same time poverty, inequality, wars and religious tensions have become major drivers for migration, as affected people leave their home countries in search of better or safer lives for themselves and their families. Consequently, the number of international migrants worldwide has continued to grow considerably over the past fifteen years reaching 244 million in 2015, up from 173 million in 2000.[1] Currently, high-income countries host more than two thirds of all international migrants.[1] In Europe, according to Eurostat, there were 53.1 million foreign-born residents in the European Union, about 10% of the total population in 2014.[3] The majority, 63%, were born outside the European Union. In 2015, the United States (US) migrant population accounted for over 12% (38.5 million) of the total population,[4] the largest proportion in the US since the early 1900s.[5] By 2050, it is estimated that about 1 in 5 US residents will be a migrant, compared with 1 in 8 in 2005.[6] Despite the many benefits of migration, migrants themselves remain among the most vulnerable members of society as they often, e.g., end up in worse job conditions (so-called 3Ds i.e. Dirty, Dangerous and Demeaning jobs) than national workers while others endure human rights violations, abuse and discrimination.[2]

Such vulnerability can undoubtedly have an adverse effect on the health of migrants. Indeed, evidence suggests that most migrant populations suffer more health problems, especially cardio-metabolic related problems, compared with the host populations in the countries of settlement in high-income countries.[7-8]

Migration experience and its impact on health provide a unique opportunity to study the influence of environmental exposures on health outcomes particularly health conditions such as type 2 diabetes and obesity that are largely influenced by environmental factors.[7-8] However, most of the current research on migration and health is geared towards differences between migrants and host populations in the countries of settlement.[8] Although such studies are required in assessing ethnic inequalities in health in the countries of settlement, for better understanding of how migration and national contextual factors might influence the health of migrant populations, there is a clear need to extend migrant health research across national boundaries. Such knowledge on health outcomes among migrants may also

provide unique insights into the potential health threats that their countries of origins are likely to face in future with increasing levels of urbanisation and economic development.[8]

The purpose of this paper is to discuss the innovative ways of studying the effect of migration on obesity and diabetes beyond the common designs, and the relevance of extending migrant health studies across national boundaries in the current era of increasing global migration. We use standardized data including the World Health Organization (WHO) Global Health Observatory data and International Diabetes Federation data to exemplify the burden and the need for studying migrant health. Next, we describe different methods for conducting migrant studies. Finally, we introduce the **R**esearch on **O**besity and **D**iabetes among **A**frican **M**igrants (RODAM) study as an exemplar by discussing the methods, some results and the lessons learned including challenges and advantages that may guide future migrant heath research.

Burden of obesity and diabetes among migrants

Type 2 diabetes has become a global epidemic with substantial variations across world regions and social groups. The International Diabetes Federation (IDF) recent estimates indicate that 9% of the global adult population (415 million people) have diabetes and the number is set to rise beyond 642 million within the next two decades.[9] This will mean that 1 in 10 adults will be living with diabetes by 2040. The diabetes prevalence has risen faster in low- and middle-income countries than in high-income countries. These projections do not bode well for the future especially given the high risk of disabling and life-threatening complications associated with diabetes, and the enormous individual and societal costs associated with the disease and its complications.[9-10] Diabetes increases cardiovascular risk. The risk for stroke is about twice as high among individuals with diabetes compared with individuals without diabetes.[10] Diabetes is also a leading cause of renal failure in many populations in both high- and low-income countries.[11] According to WHO, lower limb amputations are over 10 times more common in people with diabetes than individuals without diabetes.[11] Diabetes is also one of the leading causes of visual impairment and blindness.[12] The care associated with diabetes may account for up to 15% of national healthcare budgets.[13] The upsurge of type 2 diabetes reflects on the global obesity epidemic. Obesity as defined by body mass index (BMI) is a well-known risk factor for type 2 diabetes; and together with overweight have been estimated to account for about 65 to 80% of new cases of type 2 diabetes.[14] The global prevalence of obesity nearly doubled between 1980 and 2014.[11] In 2014, 11% of men and 15% of women worldwide corresponding to more than half a billion adults were obese.[11]

Migrant populations in high-income countries are particularly affected by type 2 diabetes compared with the local majority populations with important variations across the various ethnic groups.[15-19] In our recent meta-analysis among ethnic minority groups in Europe, spanning from 1994 to 2014, the pooled odds of type 2 diabetes ranged from 30% increase in South and Central American origin to 270% increase in South Asian origin groups compared to the European host populations (Figure 1).[16] When the South Asian subgroups were assessed separately, the Bangladeshi ethnic group had 520% increase rate than the European population. Sub-Saharan African migrants, the main focus of this paper, had 160% increase rate than the European populations. Similar high prevalence of type 2 diabetes has also been found among migrant groups relative to the European populations in North America.[19]

Ethnic minority and migrant populations also develop type 2 diabetes at a younger age; and they have higher morbidity and mortality from type 2 diabetes and related complications such as cardiovascular diseases than European populations.[20] Sight threatening diabetic retinopathy is also twice as common in African-Caribbean and South-Asian diabetic patients than in White European diabetic patients.[21] These ethnic differences in type 2 diabetes and related complications are in agreement with the higher type 2 diabetes mortality among migrant groups relative to the European locally born populations.[17,22] In one European study with data from seven European countries, diabetes mortality was found to be much higher in migrant groups than the rates for the local born residents. On the average, diabetes mortality was increased by 90% for men and by 120% for women of migrant groups than the local born residents.[22] The high prevalence of type 2 diabetes among migrants generally substantiates the higher prevalence of obesity among these groups.[16]

Burden of obesity and diabetes in low- and middle income countries

Type 2 diabetes prevalence is also increasing rapidly in low-and middle-income countries where most of migrant populations in high-income countries originate from. Africa region is expected to experience the fastest increase in the number of people living with type 2 diabetes (141%) in the next two decades in the world.[9] While type 2 diabetes seemed to be almost absent in Africa about half a century ago,[23] today it has become a major health problem affecting all countries with age-standardized prevalence ranging from 5% in Burundi to as high as 16% in Equatorial Guinea in the WHO African region (Figure 2).[24] The obesity prevalence rates based on WHO 2014 estimates for the African region countries are indicated in Figure 3. The prevalence of obesity ranged from 3% in Burundi to 27% in South Africa.

Possible explanations for ethnic inequalities in obesity and diabetes

This huge ethnic inequality in type 2 diabetes and associated obesity has long raised a critical question about the factors driving the high prevalence of these conditions among minority ethnic and migrant populations in high income countries. Although the high prevalence of type 2 diabetes among migrant populations has long been a focus of discussion, the underlying reasons for the increases still remain unclear mainly due to lack of data on cohort studies in migrants particularly in Europe.[25-26] Notwithstanding the limited data, several explanatory models have been proposed for the high burden of type 2 diabetes among migrants including rapid changes in lifestyle and nutritional transition following migration, and changing social and psychosocial circumstances, although the key specific modifiable risk factors within these broad categories still remain to be determined.[26-28] Furthermore, ethnic differences persist even when demographic, socioeconomic status, behavioural and clinical parameters have been taken into account,[27-28] suggesting that other factors such as genetics and epigenetic factors may be important. The validity of this finding, nonetheless, is limited because of the heterogeneity of migrant studies so far.

Innovative migration studies as an ideal framework to improve better understanding of obesity and diabetes epidemic

Migration studies provide important windows of opportunity to understand the potential factors driving the high prevalence of type 2 diabetes and obesity among migrant populations. However, most of the research on migration and health is narrowed both conceptually and empirically to the differences between migrants and host populations in the countries of settlement.[8] Though the country of settlement specific studies are required in assessing ethnic inequalities in health, extending migrant health research across national boundaries will further deepen our understanding of how migration and national contextual factors might influence the health of migrant populations. This is particularly relevant because the observed ethnic inequalities might stem from multiple sources including pre-migratory and post-migratory factors as well as the health status of the host populations.[24,29-30] For example, if migrants were exposed to poor childhood social circumstances in the home country, this might adversely affect their health status as adults following migration. Thus, the ethnic health inequalities that are observed may be partly due to early life factors, and not necessary due to the situation in the host country.[31] Furthermore, the health status of the host populations in the country of settlement is critical for the health standing of migrants as they are the reference populations to which migrant populations are compared i.e. the migrant pond effect.[8] Thus, factors driving ethnic inequalities might be far broader encompassing pre-migration and post-migration factors, which are hard to capture in current epidemiological studies.

Once migrants are settled in the new country, the local circumstances of the country such as opportunities for socioeconomic development and integration, acceptance by the local population and access to healthcare and preventive services will undoubtedly influence their current and future health outcomes.[2,8] The local circumstances in the host countries differ greatly among industrialised countries and these differences can influence health behaviour, psychosocial stress and healthcare use among migrant groups in different ways, and subsequently lead to differences in health outcomes even among similar populations living in different high-income countries.[8]

For better understanding of the role of migration on health, extending migration and health research across national borders, particularly to the source population in migrant home countries, is therefore essential. This can be done by comparing migrant populations with similar populations in the country of origin who did not migrate[32-34]; and/or by comparing similar migrant populations living in different locations in high-income countries.[27,35] The former assesses the role of migration while the latter assesses the role of national context on the health of migrants. Each of these methods can reveal important aspects of migration and national contextual risk factors in the new countries of settlement that may affect the health outcomes of migrant populations. Knowledge on health outcomes that are directly linked to migration and host national context will allow for the most effective and appropriate use of interventions, efforts and investment to improve and promote the health of these populations.[2] Comparison of migrant populations with the same populations in the countries of origin will also disclose the future health threats in their home countries as many of these countries continue to urbanise and adopt unhealthy aspects of Western lifestyle. Ideally, this should involve comparing a homogeneous migrant population with the source population in their country of origin. However, such data are scant, particularly among African origin populations due in part to the logistical challenges in locating homogenous populations in high income countries. As a result, most studies typically used migration surrogates such as multinational comparison of African descent populations living in diverse geographic environments while relying on secondary data.[27,36-37] The heterogeneous nature of the migrant populations studied so far, and the reliance on secondary analyses of data from different studies makes it difficult to interpret the results. Nevertheless, these few studies have shown the importance of these methods, and we need to do more to advance on these methods in migrant health research.

Three methods for migrant health research:

- Comparing migrants with host population in country of settlement
- Comparing migrants with compatriots who did not migrate
- Comparing migrants resident in different host countries

Careful standardisation of the study protocols among migrants and non-migrants including appropriate comparable populations in the country of origin is key to successful assessment of the role of migration and national context in the countries of settlements on health outcomes of migrants. The importance of such studies is highlighted by the 2012 European Commission initiative on gene-environmental interactions on obesity and diabetes among specific populations.[38] The RODAM study, one of the studies supported by the European Commission initiative on gene-environmental interactions, focuses specifically on African migrants living in three European countries and their compatriots who did not migrate and living in rural and urban Africa. Below we describe the RODAM study, provide examples of the key findings, lessons learnt, and the recommendations for future initiatives on migrant populations in high-income countries.

The RODAM study as an example

The RODAM study (an acronym for **R**esearch on **O**besity and **D**iabetes among **A**frican **M**igrants) is a multi-centre project (http://www.rod-am.eu/). The RODAM study's rationale, conceptual framework, design and methodology have been described in detail elsewhere.[39] In brief, the main aim of the RODAM study is to understand the reasons for the high prevalence of type 2 diabetes and obesity among Sub-Saharan African migrants by (a) investigating the complex interplay between environmental exposures and genetics and their contributions to the high prevalence of type 2 diabetes and obesity; (b) to identify specific risk factors within these broad categories to guide intervention programmes; and (c) to provide basic knowledge for improving diagnosis and treatment. The main hypothesis is that following migration, migrants may be exposed to different contexts in terms of different opportunities for socioeconomic development, different food availability, different health systems and policies and different cultural traditions; and these differences may influence their health behaviour, physical and psychosocial stress and subsequently lead to differences in obesity and type 2 diabetes risks (Figure 4).

The RODAM study was carried out between 2012 and 2015 by a multidisciplinary consortium of researchers from Europe and Africa with broad experience on chronic diseases in Africans and African migrants following the approval of the study protocols by the respective ethics committees at all the study sites. A central feature of the RODAM study is the use of highly standardised protocols for data collection at all study sites with the focus on one relatively homogenous sub-Saharan African migrant

group (i.e., Ghanaians) aged 25-70 years living in three European countries (Germany, the Netherlands and UK), and their compatriots who did not migrate and reside in rural and urban Ghana.

Earlier works among migrant communities indicate that involvement of the community leaders improves study participation.[40-41] The RODAM study team, therefore, involved Ghanaian community leaders in all five geographical sites. This included working with religious communities, endorsement from local key leaders and establishing relationships with healthcare organizations that serve these communities. In addition, the study team provided information about the study via local media including Ghanaian radio and television stations.

Due to the differences in the population registration systems across European countries as well as in Ghana, different approaches were needed for the recruitment of the study populations across different geographical sites. In the Netherlands, Ghanaian migrant participants were randomly drawn from Amsterdam Municipal Health register which holds data on country of birth of all registered citizens and their parents in Amsterdam. In the UK, there was no population register for Ghanaian migrants. As a result, Ghanaian organizations in London served as the sampling frame. The Ghanaian Embassy and the Association of Ghanaian Churches provided the lists of Ghanaian organizations in the boroughs known to have the highest concentration of Ghanaians. In addition, lists of all members of their organizations were requested. In Germany, a list of Ghanaian individuals who were born in Ghana or who hold a Ghanaian passport and living in Berlin was provided by the registration office of the federal state of Berlin. In these three European cities, all participants selected from these lists were sent a written invitation combined with written information regarding the study and a response card. In Ghana, two cities (Kumasi and Obuasi) and 15 villages in the Ashanti region served as the urban and rural recruitment sites. Urban and rural participants were randomly drawn from the list of 30 enumeration areas based on 2010 census. All potential participants selected from these list were visited by RODAM team members and sampled based on eligibility. Physical examinations were performed with validated devices according to standardised operational procedures across all five study sites. Fasting venous blood samples and urine samples were collected and further processed for analysis and storage by trained research and laboratory assistants in all sites according to standard operation procedures. To avoid intra-laboratory variability, all the stored samples from the local research centres were transported according to standardized shipment procedures to Berlin, Germany for biochemical analyses; and to Nottingham, UK for DNA extraction, genotyping and epigenetic determination. Details of the variables assessed by questionnaire, physical and biological measures are given in Table 1. The questionnaire covered demographics, socio-economic status, migration related factors, medical history, psychosocial factors, health care use and health behaviour. Physical

measurements include anthropometrics, bioimpedance analysis, and blood pressure. Biochemical analyses include glucose metabolism, lipid profile, electrolytes and renal function, uric acid metabolism, liver metabolism, oxidative status and iron metabolism and inflammation. DNA was extracted from all samples. Genotyping was done on 2000 obese and diabetic cases and non-obese and non-diabetic controls. For epigenetic, epigenome-wide analysis of DNA methylation was performed among 745 obese and diabetic cases and controls.

Lay perceptions and poor knowledge of obesity and type 2 diabetes may have negative impact on the effectiveness of interventions aim at reducing these conditions particularly in migrant populations.[42] It is generally acknowledged that access to preventive and curative services may depend on several factors including knowledge of services and how to use them, health beliefs and attitudes, language barriers, the sensitivity of services to differing needs and the quality of care provided; and this may vary across ethnic groups.[18] Gaining insight into these factors requires qualitative methodology. Hence, individual in-depth semi-structured interviews and focus group discussions about perceptions and knowledge on obesity and diabetes with people with diabetes and healthy individuals were carried out in each location using standardised protocols.

Main results on RODAM study

The data collection was completed in October 2014. Of those individuals that were registered in the various Ghanaian organizations and were invited in London, 75% agreed and participated in the study. In Amsterdam, of those that were identified from the population register and were invited, 67% replied, either by response card or after a home visit by an ethnically-matched interviewer. Of these, 53% agreed and participated in the study. In Berlin, of all the participants that were registered in the registration office and were contacted, only 7% replied to the invitations by mail. Because only 7% replied, and we were restricted by the Berlin ethics committee not to personally contact potential participants at their homes, we applied a network sampling approach where Ghanaian migrants were openly invited at the community gatherings such as church masses and festivities to participate in the study. Eventually, approximately one in five Ghanaians living in Berlin participated. In Ghana, of the individuals that were registered in the list of 30 enumeration areas and were approached, 76% in rural setting agreed and participated; and 74% in urban setting agreed and participated. In total, 6376 participants were interviewed and 5898 were physically examined. The distribution of the sample sizes by site for participants with both interview and physical measurements are given in Supplementary Figure 1. Inclusion in Berlin was lower than the anticipated number, because of local circumstances

but the research sites in Amsterdam and Ghana were able to oversample to compensate for this shortfall in Berlin.

For the qualitative study, 10 pilot focus group discussions and 39 individual interviews were conducted in rural and urban Ashanti region, Amsterdam and London. For the main study, 26 focus group discussions were conducted with 179 individuals across the 5 sites, 152 interviews with people with diabetes conducted across the 5 sites and an additional 30 interviews were conducted with overweight and underweight individuals in rural and urban Ashanti. All the focus group discussions and individual interviews conducted in Ghana, Amsterdam, London and Berlin have been transcribed verbatim. Focus groups and interviews conducted in two main local languages – Twi and Ga – were directly transcribed into English and checked for accuracy in meaning by bilingual analysts and further validated through team discussion.

The RODAM study analyses are currently ongoing, but the preliminary results indicate that the prevalence of obesity as measured by BMI was lower in rural Ghana than urban Ghana and Ghanaian migrants in different European sites. Urban Ghanaians had a similar prevalence of obesity as Ghanaian migrants in Berlin, and both urban Ghanaians and Ghanaian migrants in Berlin had a lower prevalence than Ghanaian migrants in London and Amsterdam (Figure 5). The prevalence rates of type 2 diabetes varied by site (Figure 6). Similar to obesity, there was no clear gradient from rural through urban Ghana to Europe. The prevalence rate was lower in rural Ghanaians than in urban Ghanaians and Ghanaians in Europe. However, the prevalence of type 2 diabetes in urban Ghana was similar to the prevalence rates in Ghanaian migrants in different European sites although the prevalence rate in Berlin was somewhat higher than in all other sites.

Preliminary analysis of the qualitative data showed that respondents across all sites had more comprehensive knowledge on obesity, weight and body image issues compared to diabetes. Two major findings emerged on differences between migrant and non-migrant groups. Ghanaians in Europe were more likely to associate obesity with diabetes, compared to rural and urban Ghanaians. Ghanaians in Europe were also more likely to attribute their health, weight and diabetes status to obesogenic environments and structural factors including poor working conditions.

Lessons learnt from the RODAM study

Successful execution of migrant health study in multiple settings

The execution of the RODAM study in multiple sites in Europe and Africa demonstrates that with a concerted effort and effective collaboration among partners, such studies can be successfully carried out in spite of the many challenges associated with conducting a multi-centre study among migrant populations. Most of the challenges regarding the execution of the study related to the national circumstances including pre-established links between research institutions and migrant communities, the strength of migrant networks, trust of the migrant communities towards researchers and their respective institutions, national regulations regarding research conduct, strong involvement of researchers from migrant background and a strong leadership (Table 2). In Amsterdam, for example, where the research team had built strong relationships and trust within the African communities through several years of collaborations, the community leaders themselves took charge of the recruitment campaigns that led to a successful recruitment of Ghanaian migrants in Amsterdam. The RODAM study in Amsterdam site was nested in the HELIUS study,[26] which also collected data on European Dutch and other ethnic groups in Amsterdam. The participation rate among Ghanaian migrants in Amsterdam was actually marginally higher than the local Dutch people in Amsterdam suggesting that with appropriate measures, migrants who are usually perceived by researchers as hard to reach group, can equally be recruited for scientific studies.

A multidisciplinary team with strong commitment and respect for all partners is an essential recipe for carrying out such a complex multicentre study.[43] Several expert working groups (e.g. on nutrition, genetics & epigenetics, biochemical characterisation) were formed, which addressed specific technical areas with rigor. Strong commitment goes hand in hand with flexibility in terms of re-allocation of resources, and adjustment of research protocols to suit technological developments. For example, costs for shipment of samples in one location was far higher than expected and resources needed to be re-allocated to take this excess costs into account. Furthermore, genotyping and epigenetic methods needed to be adjusted several times to suit fast developing genomic technologies. Continuous monitoring of data collection activities and provision of feedback to research teams in various sites by the central coordinator was vital in ensuring that the same methods were applied across sites.

Another important lesson is that the national population registration systems in the host countries influence the sampling process among migrant populations very importantly. For example, there is a population register in the Netherlands where the Ghanaian migrants could easily be identified and randomly selected for the study. In the UK and Germany, there were no population registers that could be used for easy identification of these migrant populations. This means that different sampling

approaches needed to be used for recruiting migrants in these countries. Furthermore, national regulations can also affect the recruitment strategy. In Berlin, Germany, there was a requirement of the ethics committee not to personally contact potential participants at their homes, which further complicated the sampling strategy. These restrictions in Berlin had a profound impact on the recruitment of the study participants in terms of randomisation and the participation rate. These national differential regulations are highly relevant to take into account when carrying out a multi-centre study among migrants.

The role of migration on obesity and type 2 diabetes among African communities

The RODAM study has a huge potential to teach us about the impact of migration on obesity and type 2 diabetes. Although the analysis is currently ongoing, the preliminary results on the differences between sites already provide important insights into the role of migration on obesity and type 2 diabetes. A major lesson from these results is that type 2 diabetes epidemic in urban centres in Africa is almost similar to African migrants in high-income countries in Europe. Earlier studies found a clearly positive gradient in type 2 diabetes and obesity among African populations living in rural Africa, urban Africa and high-income countries in Europe and US.[36-37] In our present RODAM study, a positive gradient was not apparent suggesting that this well-established notion of the positive gradient from rural through urban to more industrialized settings is disappearing due to the rapid rises of type 2 diabetes rate in urban communities in Africa. The disappearance of the differences between urban African and African migrants in Europe may be driven by the fast changes in urban environments in urban Africa partly attributed to modernization with consequent adoption of unhealthy aspects of western lifestyles such as physical inactivity and poor dietary behavior.[44] If the current trend in urban communities in Africa continues, this will undoubtedly put a lot of strain on the already overburdened health systems in Africa.

Another important lesson is that it matters where migrants live in Europe. The prevalence rates of obesity and type 2 diabetes among Ghanaian migrants in European cities are also much higher than among the European host populations. Recent WHO data show that in 2014, the age-standardised prevalence of obesity was 19.8% in the Netherlands, 20.1% in Germany, and 28.1% in the UK.[24] The IDF 2014 data show that the age-standardized prevalence of type 2 diabetes was 4.7% in the UK, 5.65% in the Netherlands, and 7.4% in Germany.[9] These figures are far lower than the prevalence rates found for both obesity and type 2 diabetes among Ghanaian migrants living these countries. The patterns of obesity and type 2 diabetes prevalence among the migrant populations bear a resemblance to their respective host European countries though on an increased level. As highlighted above, obesity is more common in the UK than in most European countries despite the lower rate of type 2 diabetes.[9,24] Interestingly, a similar pattern was observed among our study populations with Ghanaian

migrants in London having a higher prevalence of obesity but a lower prevalence of type 2 diabetes compared with their counterparts in Amsterdam and Berlin. The explanations for these varying results among these European countries are unclear and require in-depth analysis, which the RODAM study will further explore. Nonetheless, the consistent patterns in the prevalence of obesity and type 2 diabetes among migrants and the host populations in the countries of settlements in Europe seems to suggest that the contextual factors in these countries, for example predominant health behaviours, health-related policies and access to preventive services, may be shaping these health conditions in different ways in various countries.[27,45] The high prevalence of obesity and type 2 diabetes among African migrants clearly highlights an urgent need for action among these populations in Europe.

Benefits of comparative studies among migrants and non-migrants in their country of origin

High-income country governments such as those in Europe are faced with the challenges of integrating health needs of migrants into national plans, policies and strategies particularly given the current wave of migrant flow to Europe from the war-torn areas such as Syria.[2,45] Addressing the health needs of migrants improves health, avoids stigma and long term health and social costs, facilitates integration and contributes to social and economic development.[2,46] As obesity and type 2 diabetes are among the top health problems confronting migrants, prevention and effective treatment of these conditions are of paramount importance in addressing the problem and subsequent ethnic health inequalities.[2,16] Low and middle-income countries such as those in sub-Sahara Africa are also facing huge challenges regarding obesity and type 2 diabetes epidemic particularly in urban centres as the RODAM findings clearly demonstrate. As these conditions are largely influenced by environmental exposures,[7] comparative studies on similar migrant populations living in different industrialized countries as well as similar populations in their home countries, provide promising windows of opportunity to identify specific factors driving the epidemic in both migrant populations and the populations in their home countries.[8] For migrants, such data may give more insights into how exposure to different environments can influence their health outcomes. Data on direct comparison between migrants and the source populations in their home countries may also serve as a powerful health education tool to influence behavior change among migrant communities as such data are more likely to be taken seriously by migrants than comparison with the host populations. For migrants' compatriots in their home countries, the rapid rises of obesity and type 2 diabetes following migration to industrialized countries may give a clear indication of the potential future threats as these countries continue to urbanize and to adopt western lifestyles. Such data may also serve as a wake-up call for action in these countries.

Furthermore, such studies may also provide important opportunities to dig deep into the potential factors driving the high prevalence of obesity and type 2 diabetes among these populations including moving migrant health research forward into unexplored areas such as the contribution of epigenetics to the increased susceptibility of urban and migrant populations towards these conditions. Recently, the role of epigenetic changes and its effect on health is increasing becoming important.[47] The role of epigenetic modifications invoked by environmental and behavioural changes can be best studied among individuals who are exposed to rapid environmental and lifestyle changes such as migrant populations. The findings from the RODAM study will therefore make important contributions to epigenetics studies.

The RODAM study consortium convened an international dissemination meeting in Accra in September 2015, which was attended by 130 delegates affiliated with academic, research, media, health and allied institutions from Ghana, Germany, The Netherlands, South Africa, Uganda and the United Kingdom. This meeting demonstrated the power of comparative migrant studies (https://www.ug.edu.gh/news/rips-holds-rodam-2015-research-conference). Following discussion with stakeholders including leading academics, clinicians, policy makers, patient organisations and Ghanaian public about the key findings of the RODAM study, it became clear to stakeholders that Ghana (the migrant home country) also has a public health crisis with the rising prevalence of obesity and type 2 diabetes and that there was an urgent need for action with strong support by government and civil societies. Recommendations that came from the discussion with panels of experts and civic societies focused on the need for prevention strategies using the population-wide approach and the high risk approach are summarised below.

Summary of the key recommendations from the RODAM conference with stakeholders in Accra

Population wide approach:

- Intersectoral approach focusing on healthy school meals; sugar tax; serving water in schools; salt reduction in food and tobacco control etc. both in Ghana and in Europe. Governments in Ghana and Europe could play crucial role in this.
- Raise awareness of health risks of overweight and diabetes and related complications both in Ghana and in Europe through media and public health education and reinforcing credible messages from certified organisations.
- Use community health workers – they are already providing care for existing conditions – to screen and provide basic services for diabetes and other NCDs ('task-shifting') in Ghana.

High risk approach

- Lower the number of people with undetected diabetes in Ghana through national wide screening programmes.
- Target people at high risk (e.g. pre-diabetes) both in Ghana and in Europe and offer them lifestyle or behavioural support.
- Educate people both in Ghana and in Europe about health risks associated with overweight and diabetes (e.g. through task shifting).

Individuals with diabetes

- Prevent complications through treatment in Ghana.
- Improving access to medication and adherence to treatment both in Ghana and in Europe is crucial for improving

control of diabetes.
- Ghanaian and African specific guidelines are needed for treatment.
- European guidelines on diabetes and obesity need to highlight African migrants burden.

Future prospective
- Further investment to transform the current cross-sectional RODAM study into longitudinal cohort for African migrants in Europe and non-migrants in Africa is needed.
- Further investment to assess other major risk factors within RODAM e.g. hypertension, chronic kidney disease.
- Explore with potential funders (e.g. the European commission) for further investment into RODAM project as the infrastructure for future study has now been created. An unique opportunity for Europe and Africa.

Conclusions

The successful conduct of the RODAM study in multiple sites in Europe and in rural and urban Africa demonstrates that with concerted efforts, migrant health studies can be extended across national boundaries including migrants home countries of origins. Such studies undoubtedly provide rich data that will facilitate better understanding of the health burden among migrants in high-income countries on one hand, and their compatriots in the home countries on the other hand, which can simultaneously inform policy and clinical care for migrants and people in their home countries – win-win situation. Such studies need to go beyond the commonest design of cross-sectional studies, to include cohort studies and interventions study designs. Essential recipe for success in carrying out such studies includes multidisciplinary team with strong commitment and respect for all partners, involvement of the migrant communities and researchers, strong leadership, and flexibility in adapting to the latest technologies.

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Competing Interests

The authors have declared that no competing interests exist

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Table 1: Variables measured in the RODAM study

Themes	Variable/measure	Instrument/measures
Questionnaire		
Demographics	Age, sex, marital status, religion, tribe, locality	–
Socioeconomic status	1. Education 2. Employment status 3. Wealth 4. Parental socioeconomic status	1. Education attainment 2. Nature of work 3. Household index; wealth index (only in Ghana) 4. Father's and mother's education attainment and profession
Migration-related factors	Generation, duration of residence in Europe, religion, cultural distance, migration history	–
Health status	1. General health 2. Presence and history of diseases and family history of diseases	1. SF-12 2. Various health conditions
Psychosocial factors	1. Perceived discrimination 2. Perceived social support 3. Dealing with everyday problems 4. Recent experiences (stressful life events) 5. Psychological stress 6. Recent well-being	1. Everyday Discrimination Scale 2. SSQT Satisfaction Emotional Support subscale 3. Mastery 4. List of threatening experiences 5. 2 items from INTERHEART 6. Patient Health Questionnaire-9
Health behaviour	1. Smoking 2. Alcohol intake 3. Physical activity 4. Dietary behaviour 5. Perceived body weight and body shape 6. Adherence to medication	1. – 2. – 3. WHO GPAQ V.2 4. Ghana-specific FPQ, 24-h dietary recalls for subsample (n=5*100) 5. Pulvers instrument to measure body image 6. Self-reported adherence
Physical		
Anthropometrics	1. Weight 2. Height and trunk 3. Waist circumference 4. Hip circumference 5. Body fat (Bio Impedance Analysis)	1. SECA 877 2. SECA 217 3. Measuring tape 4. Measuring tape 5. BODYSTAT 1500 MDD analyser for BIA
Blood pressure	Systolic and diastolic blood pressure, measured 3 times in a sitting position after at least 5 min rest	Microlife WatchBP home
Ankle-Brachial Index	Ankle-Brachial Index, measured in a supine position after at least 10 min rest	Microlife WatchBP Office ABI
Biochemical		
Glucose metabolism	1. Fasting glucose 2. Insulin 3. HbA1c	1. ABX PENTRA 400 (Horiba), 2. Mercodia ELISA 3. Ion-exchange HPLC analyser
Lipid profile	Total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and triglycerides	ABX PENTRA 400 (Horiba)
Electrolytes and renal function	Creatinine, albumin, sodium, potassium, calcium	ABX PENTRA 400 (Horiba)
Uric acid metabolism	Uric acid	ABX PENTRA 400 (Horiba)
Liver metabolism	Alanine transaminase, aspartate aminotransferase, γ-glutamyl transpeptidase	ABX PENTRA 400 (Horiba)
Oxidative status and iron metabolism	Ferritin	ABX PENTRA 400 (Horiba)
Inflammation	High-sensitivity C reactive protein	ABX PENTRA 400 (Horiba)
(Epi)Genetics		
Genetics	Genotyping (2000 samples)	African Diaspora Power SNP chip (ADPC)
Epigenetics	DNA methylation (745 sample)	The Infinium HumanMethylation450 BeadChip array

FPQ, Food Propensity Questionnaire; GP, general practitioner; GPAQ, Global Physical Activity Questionnaire; SSQT, Social Support Questionnaire for Transactions. (Adapted from Agyemang et al. BMJ Open 2015; **4:**e004877)[39]

Table 2: Challenges and lessons learned in conducting the Multicentre RODAM study

Challenge	Coping strategy	Lesson learned
Collaboration in consortium		
Effective collaboration within an international and intercontinental consortium of nine partners	Invest in contacts and trust within and between research institutions	Build on pre-established links between research institutions
Maintaining collaborative spirit within complex project with different interests and keeping within timelines	Implement regular updates & meetings and coordination with strong leadership	Intense coordination is prerequisite for success but requires considerable time investment (enough capacity)
Specific knowledge required on various disciplines (clinical, biochemical, (epi)genetics, nutrition, health behavior, mixed methods research methodologies)	Involve experts and set up expert working groups to guide specific tasks	Multidisciplinary team is crucial
Recruitment & Participation		
Engagement of Ghanaian community	Build trust and community ownership: Take the community seriously and listen to their views; Focus on the gains of participation – for the individual and for the community as a whole; Involve researchers from migrant background	Continuous engagement with the community is needed to maintain interest and participation, but requires considerable time investment
Population registers for identification of migrant populations not always available in all countries	Different sampling approaches across research locations needed to be used for recruiting migrants	National population registration systems in the host countries influence the sampling process among migrant populations very importantly.
Differences in national regulations regarding research conduct (i.e.; ethics committee do not always allow personal contact with potential participants at their homes)	Apply a network sampling approach where Ghanaian migrants were openly invited at the community gatherings	National differential regulations can have profound impact on the recruitment of the study participants in terms of randomization and participation rate
Hard to reach research locations (distance – long travel)	Flexibility and adaptation to local circumstances (e.g.; conduct research in a central point or in various locations; research assistants work in weekends)	National infrastructures in the host countries influence the participation among migrant populations very importantly.
Data collection		
Ensuring applications of same methods across sites	Central training of researchers and research assistants	Regular discussion with coordinating center is key
Guarantee quality of data collection methods across sites Competencies gaps of (new) research assistants	Monitoring system, site visits by central and local research coordinator and training updates. Re-training organized Keep experienced (fixed) team	Continuous monitoring and feedback to research assistants requires considerable time investment and is very important Skilled and motivated personnel is crucial
Managing multiple languages	Training in administering standard protocols in different languages	Continuous monitoring of emerging issues, concepts and practices associated with language and culture
Data handling, transporting and storage		
Guarantee quality of samples across sites (e.g.; processing time within 1-3 hours, sample storage in freezers within time)	24 h protection of electricity in all research locations Use aggregates and additional freezers in rural Ghana	Provision for additional resources, constant inspection and comparison with protocols are key
Genetic & Epigenetic analysis		
Genomics world is changing rapidly	Give room for protocol changes with new methods	Keeping up with the fast changing genomics world is crucial in epigenetic research
Dissemination of results		
Get the message to the people (participants, clinicians & policy makers)	Build on community ownership	Engage participants, clinicians and local policy makers in dissemination strategy

Figure legend

Figure 1. Prevalence of type 2 diabetes between ethnic groups in Europe (1994-2014): meta-analysis of European studies.[16]

Figure 2. Age-standardized prevalence of type 2 diabetes among adults in WHO Africa region (aged ≥18 years), 2014 (Source: WHO Global Health Observatory data).[24]

Figure 3. Age-standardized prevalence of obesity (BMI ≥30 kg/m2) among adults in WHO Africa region (aged ≥18 years), 2014 (Source: WHO Global Health Observatory data).[24]

Figure 4. Conceptual model: Adapted from Agyemang et al. Epidemiology 2011;22:563-7.[27]

Figure 5. Age-standardized prevalence of obesity among migrants and non-migrants in RODAM study. Error bars are 95% confidence intervals.

Figure 6. Age-standardized prevalence of type 2 diabetes among migrants and non-migrants in RODAM study. Error bars are 95% confidence intervals.

Supplementary Figure 1. Distribution of the sample sizes (interviews and physical measurements) by site.

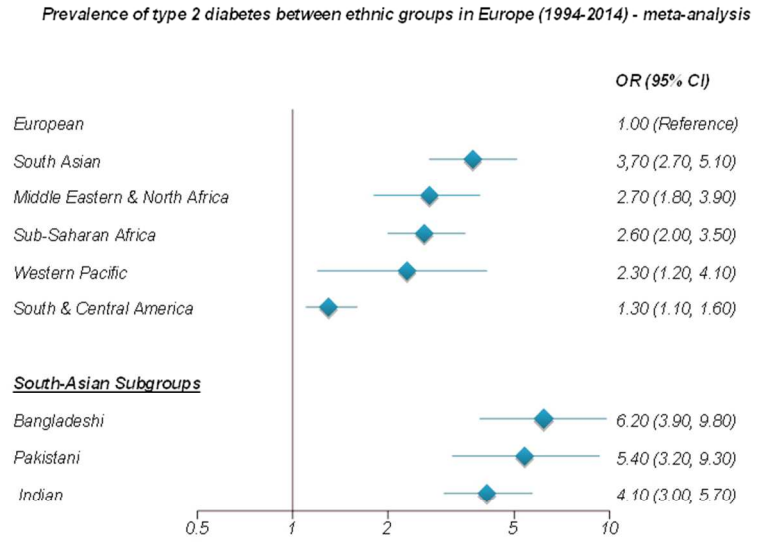

Figure 1: Prevalence of type 2 diabetes between ethnic groups in Europe (1994-2014): meta-analysis of European studies.[16]
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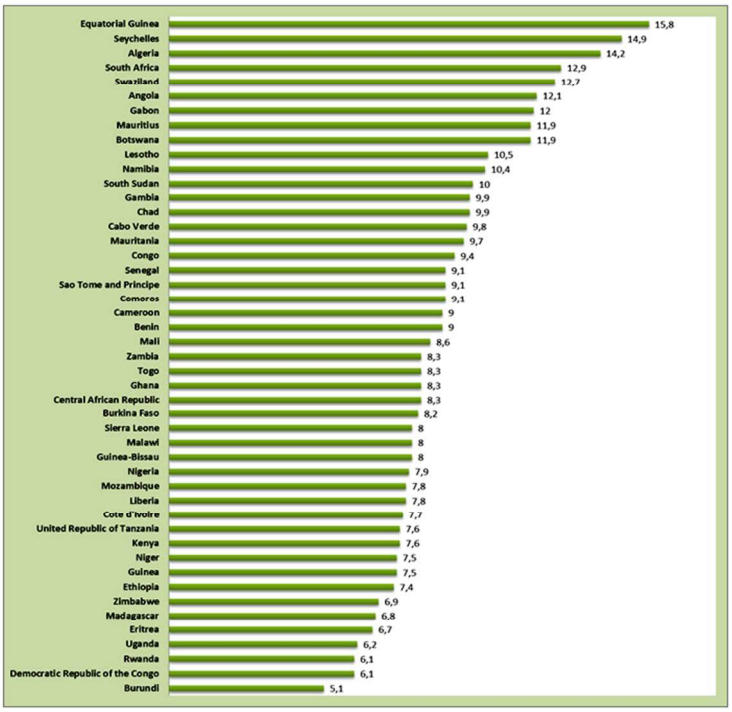

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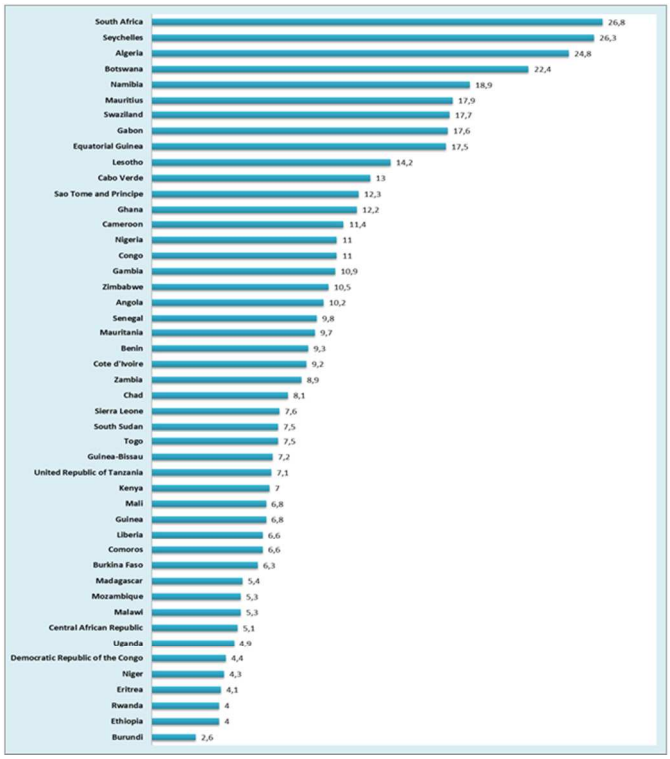

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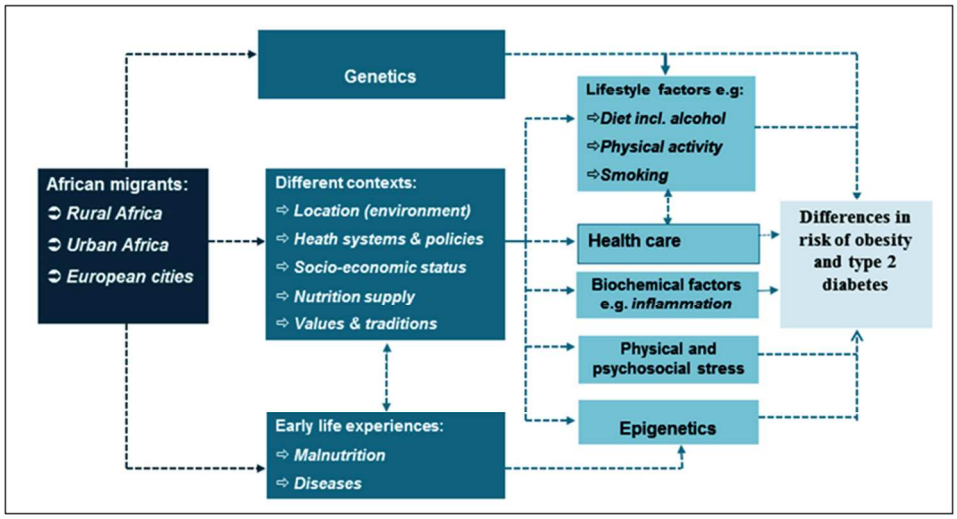

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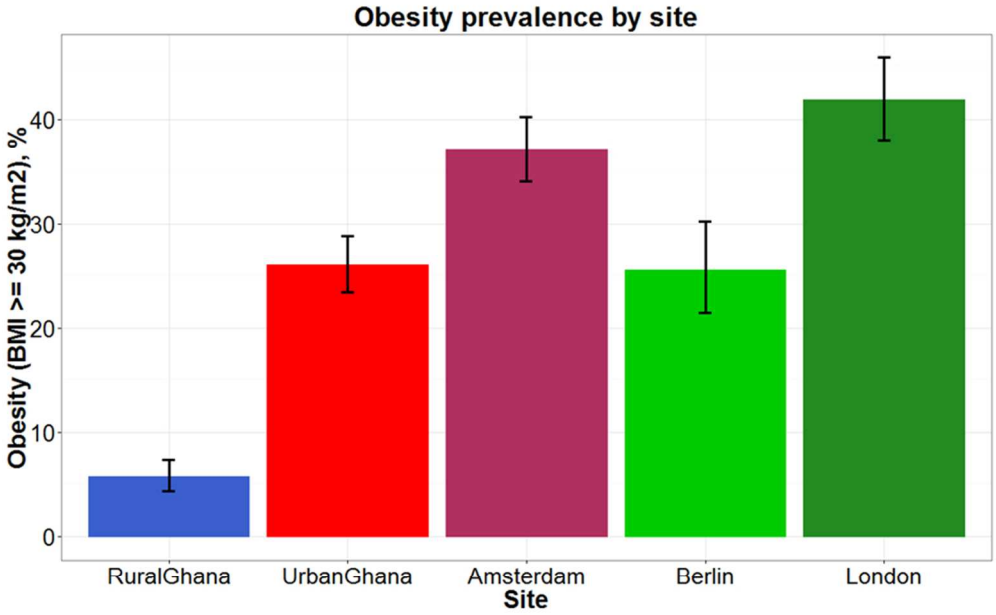

Figure 5: Age-standardized prevalence of obesity among migrants and non-migrants in RODAM study. Error bars are 95% confidence intervals
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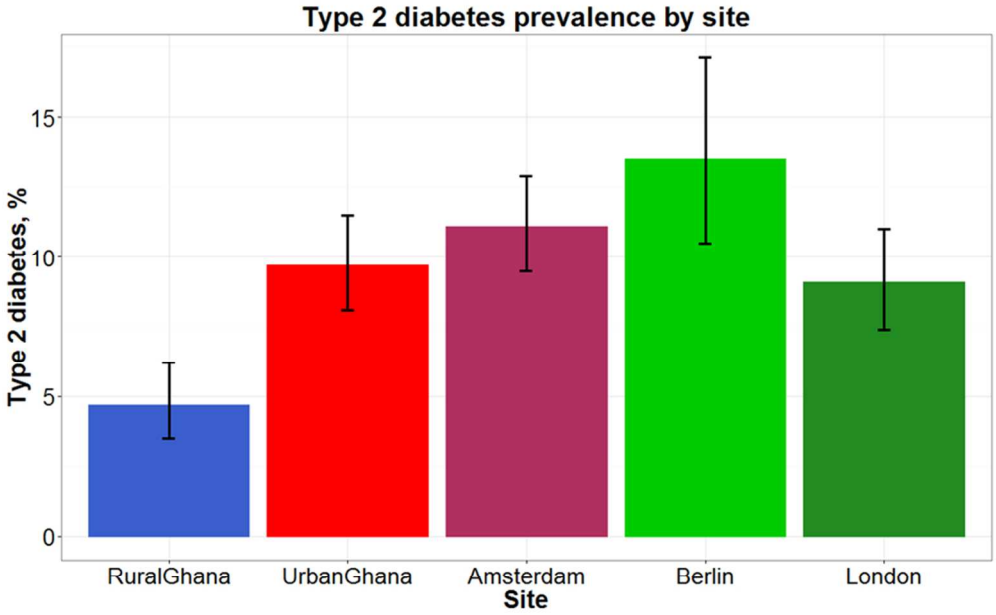

Figure 6: Age-standardized prevalence of type 2 diabetes among migrants and non-migrants in RODAM study. Error bars are 95% confidence intervals.
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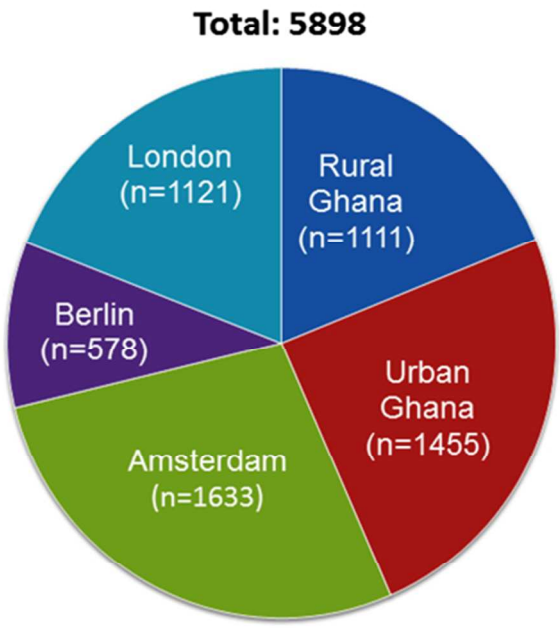

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