Original Article

Migration and Cardiovascular Disease Risk Among Ghanaian Populations in Europe:

The RODAM Study (Research on Obesity and Diabetes Among African Migrants)

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Background—For migrant populations from sub-Saharan Africa, adverse cardiovascular disease (CVD) risk factors have been observed to be higher than found in their home country-based counterparts or among the host populations in high-income countries. Differences in absolute overall CVD risk, however, remain largely unexplained. We, therefore, predicted the differences in 10-year CVD risk among sub-Saharan African migrants (Ghanaians) living in 3 European cities and Ghana.

Methods and Results—For 3864 subjects aged 40 to 70 years from the multicenter RODAM study (Research on Obesity and Diabetes Among African Migrants) conducted among Ghanaian adults residing in rural and urban Ghana and 3 European cities (Amsterdam, Berlin, and London), 10-year risk of CVD was estimated using the Pooled Cohort Equations with estimates ≥7.5% defining high CVD risk. Logistic regressions were used to determine the association of migration on CVD risk. The proportion with CVD risk ≥7.5% among Ghanaian men was 34.7% in rural Ghana, 45.4% in urban Ghana, 53.9% in Amsterdam, 61.0% in Berlin, and 52.2% in London. Compared with rural Ghana, CVD risk was significantly increased for Ghanaian men living in Berlin (adjusted odds ratio, 2.80; 95% confidence interval, 1.76–4.45) and Amsterdam (1.88; 1.25–2.84). Increased risk observed for men was largely not seen for women. CVD risk increased with longer stay in Europe.

Conclusions—Knowledge about predictors of increased CVD risk among sub-Saharan African migrants in Europe and nonmigrants in urban centers will inform and support targeted health care and interventions to these populations. **(*Circ Cardiovasc Qual Outcomes*. 2017;10:e004013. DOI: 10.1161/CIRCOUTCOMES.117.004013.)**

Key Words: cardiovascular diseases ■ Ghana ■ human migration ■ risk factors ■ transients and migrants

Migrants' health is an important public health issue[1] with growing evidence supporting the role of migration in the development of noncommunicable diseases.[2–4] Migrant populations from sub-Saharan Africa (SSA) seem to be affected disproportionately by cardiovascular diseases (CVDs) and related risk factors, including hypertension, obesity, and diabetes mellitus.[5,6] For instance, the prevalence of hypertension in The Netherlands relative to Dutch people is higher in all ethnic minority groups, with the exception of Moroccan women.[7] Evidence from Canada, however, shows better CVD risk profile among migrants than the host population.[8] This shows the importance of diverse factors (including acculturative stress resulting from the feeling of isolation, discrimination, alienation and dislocation,[9]

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WHAT IS KNOWN

- Migrant populations from sub-Saharan Africa to high-income countries are at a higher risk of developing adverse cardiovascular (CVD) risk factors than their home country-based counterparts or the host populations in their new countries.

WHAT THE STUDY ADDS

- This study shows that absolute 10-year CVD risk is higher among Ghanaian men residing in urban centers in Europe and Ghana than their rural Ghana counterparts.
- CVD risk among Ghanaian men residing in Europe differed according to city of residency and increased with longer stay in Europe.
- Increased CVD risk observed for Ghanaian men in Europe was largely not seen for women.
- Contributory CVD risk factors in Ghanian men included elevated blood pressure, diabetes mellitus, smoking, lower physical activity, and greater obesity, as well as potential differences in socioeconomic positions.

lifestyle changes and adaptations,[10] and access to health care) in explaining the differences in CVD risk among migrant populations.

Migrant populations carry along disease characteristics, inherited from their place of origin,[11] which affect future risk of CVD. The CVD risk profile among migrant populations, however, may change over time as they get exposed to the factors of their host environment.[12] This results in differences in CVD risk between similar populations residing in different industrialized countries. For instance, Agyemang et al[13] found that people of African descent residing in England had a lower prevalence of type 2 diabetes mellitus than those residing in The Netherlands, and these differences reflected the difference in prevalence of CVDs of their host countries.[14] The reasons for these differences are unclear but could include cross-national differences in health behaviors and related factors, such as socioeconomic position, accessibility, and utilization of preventive services.[13,15]

CVDs reflect the combined effect of several risk factors,[16] which tend to appear in clusters.[17] Current guidelines for CVD risk reduction have, therefore, reiterated the need to assess all risk factors as a more effective basis to deliver CVD prevention interventions.[16] Absolute CVD risk estimates, using established risk algorithms, help to determine the probability of a cardiovascular event occurring within a specified time horizon.

Most established CVD risk algorithms, however, do not appropriately capture the ethnic and socioeconomic disparities relating to CVDs.[18,19] Distinctive levels of risk factors among various ethnic groups contribute significantly to differences in CVD,[20] making ethnicity an important parameter when estimating CVD risk. The pooled cohort equations (PCE), developed and validated among Black and European and Asian men and women, have been shown to be comparatively more precise in estimating CVD risk.[21] The equations are derived using pooled data from ethnically and geographically diverse community-based cohorts, permitting the creation of sex- and ethnic-specific equations for non-Hispanic White American and Black women and men.[22]

Because most studies on CVDs among African migrant populations have focused on individual risk factors, this study, as part of the RODAM study (Research on Obesity and Diabetes Among African Migrants),[23,24] sought to (1) assess the potential role of migration on CVD risk by assessing the differences in 10-year estimated CVD risk among nonmigrant Ghanaians living in rural and urban Ghana and Ghanaian migrants living in 3 different European countries using the PCE algorithms and (2) assess the modifiable risk factors that predispose them to poor CVD outcomes in their host countries.

Methods

Study Design and Population

Details of the multicenter RODAM study, including statistical power, sample size estimations, sampling, recruitment, and measurements, are published elsewhere.[24] In brief, in the RODAM study, 6385 Ghanaians from a homogenous population residing in Ghana or had migrated to different European countries were recruited, of whom 5898 were physically examined. As a central feature of the RODAM study, at all study sites, a well-standardized approach was used for data collection. In Ghana, 2 purposively chosen cities and 15 villages in the Ashanti region were used as the urban and rural recruitment sites, respectively. The response rates were 76% in rural Ghana and 74% in urban Ghana. In Amsterdam, 67% replied by response card or after a home visit. Of these, 53% agreed and participated in the study. In London, of those individuals who were invited based on their registration in Ghanaian organizations, 75% agreed and participated in the study. In Berlin, this figure was 68%. For the current analysis, all RODAM study subjects aged 40 to 70 years who had provided informed consent and without history of clinical CVD (n=3864) were included. Missing biomedical and sociodemographic data (systolic blood pressure [BP; 0.3%], cholesterol [3.6%], high-density lipoprotein cholesterol [3.6%], low-density lipoprotein cholesterol [3.7%], smoking [1.1%], and employment [8%]) were excluded from the analysis.

Recruitment and Sampling

The definition of a Ghanaian for this study was to have been either born in Ghana and have either one or both parents born in Ghana (in case of migrants, first generation) or if not born in Ghana, have both parents born in Ghana (in case of migrants, second generation). Recruitment strategies for the various locations differed according to population registration systems across European countries and in Ghana. The study was approved by the respective ethics committees at all the study sites.

Measurements

Information on demographics, educational level, and migration histories was obtained by structured questionnaire. Concentration of total cholesterol was assessed using colorimetric test kits. All biochemical analyses were performed at Berlin with an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba ABX, Germany). Type 2 diabetes mellitus was defined according to the World Health Organization diagnostic criteria (fasting glucose, ≥7.0 mmol/L, or current use of medication prescribed to treat diabetes mellitus or self-reported diabetes mellitus).[24] Using validated semiautomated device (Microlife WatchBP home), BP was measured 3× using appropriate cuffs in a sitting position after at least 5 minutes of rest. The mean of the last 2

measurements was used in the analysis. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Overweight and obesity were defined as 25≤BMI<30 kg/m^2 and BMI ≥30 kg/m^2, respectively.[25] Physical activity was assessed using the World Health Organization Global Physical Activity Questionnaire[26] and categorized into high, medium, and low levels of physical activity. The level of psychosocial stress was assessed from a combined score distinguishing between participants' level of stress at work and at home (never experienced stress/experienced some periods of stress at work or at home or experienced several periods of stress/permanent stress at work or at home).

10-Year CVD Risk

The outcome variable was predicted 10-year CVD risk as estimated from the PCE equations for Black men and women. This model combines age, sex, total cholesterol, high-density lipoprotein cholesterol, systolic BP, use of antihypertensive medication, diagnosed with diabetes mellitus, and smoking to estimate the 10-year absolute risk of CVD in people without preexisting CVD.[22] In their updated clinical practice guidelines for the treatment of blood cholesterol to reduce atherosclerotic CVD, the American College of Cardiology and American Heart Association recommended the PCE as a novel tool to estimate 10-year CVD risk.[27] The guidelines provide a strong recommendation (class I, level of evidence: A) for consideration of statin treatment in individuals with a 10-year CVD risk ≥7.5% and a moderate recommendation (class IIa, level of evidence: B) in individuals with a 10-year CVD risk of 5% to <7.5%. Predicted CVD risk was categorized into <5%, 5% to <7.5%, 7.5% to <10%, 10% to <15%, 15% to <20%, and ≥20%. CVD risk ≥7.5% was considered as elevated risk of CVD based on the prior work by Goff et al.[22] Determinants were migration-related factors (international migration and length of stay in Europe). Other covariates assessed were education, employment, and sources of income.

Data Analysis

General characteristics are summarized as proportions, mean, and median values. Comparisons across recruitment sites used χ^2 test, ANOVA, and Kruskal–Wallis tests as appropriate. Post hoc pairwise comparisons after ANOVA and Kruskal–Wallis tests were conducted by use of the Tukey honest significant difference test and Dunn test for multiple comparison, respectively. The distribution of the predicted CVD risk was examined via density curves, separately by recruitment sites using the Epanechnikov kernel function in STATA (Stata Corp, College Station, TX). Logistic regression models were used to assess the influence of migration-related factors on the odds of elevated CVD risk. Three models were fitted to adjust for possible confounders: model 1, education, employment, and sources of income; model 2: model 1+physical activity and alcohol; and model 3: model 2+psychosocial stress. A logistic postestimation checked for the equality of coefficients for the European cities (and urban Ghana). To assess the influence of length of migration on elevated CVD risk, 2 adjusted models were fitted: model 1 for age and model 2 for age, education, employment, and sources of income. The analyses were stratified by sex after realizing differences in risk factor profiles by sex. All statistical tests were conducted at a significance level of $P<0.05$. Data were analyzed with SPSS, version 22.

Results

General Characteristics and Risk Factor Profile

With the exception of Berlin (where 54.8% were men), the majority of the subjects at the various sites were women (Amsterdam, 57.7%; London, 64.5%; urban Ghana, 70.2%; and rural Ghana, 62.76%; $P<0.001$; Table I in the Data Supplement). Educational level was highest in London and lowest in rural Ghana, where 45.7% of men and 71.1% of women had no formal or only elementary education. The majority of the subjects from all sites were used, either full or part-time. Ghanaians residing in Amsterdam reported the highest proportion on social benefits. On average, median duration of stay among Ghanaians in the European sites was 21 years for both men and women.

As shown in Table 1, men were generally older than women at all sites with the exception of London. Mean systolic BP among men was significantly higher in Berlin than in urban ($P=0.001$) and rural Ghana ($P<0.001$) but not significantly different from Amsterdam and London. Mean total cholesterol and high-density lipoprotein cholesterol were significantly higher in Berlin than at all sites with the exception of urban Ghana. Mean low-density lipoprotein was significantly higher in urban Ghana than all sites with the exception of Berlin. Mean BMI (SEM) among men was 25.7 (0.1) and was significantly higher in London, 27.8 (0.2) compared with the other sites. Smoking and obesity were significantly higher in Berlin, whereas diabetes mellitus was significantly lower in rural Ghana. Among women, mean systolic BP was significantly higher in London than all sites except Berlin and lowest in rural Ghana. Mean total and low-density lipoprotein cholesterol were highest among women from urban Ghana than all sites. Similar to men, the proportions of type 2 diabetes mellitus were significantly lower in rural Ghana, whereas the percentage of current smokers was highest in Berlin. Mean BMI (SEM) was 29.0 (0.1) and significantly higher in London, 31.4 (0.2) compared with the other sites. Alcohol intake among women was significantly higher in urban Ghana and lower in Amsterdam.

10-Year CVD Risk for Fatal and Nonfatal Events

Distributions of 10-year CVD risk scores per study sites are given in Figure I in the Data Supplement. Peak density corresponded with a much higher CVD risk score for Berlin and lower score for rural Ghana. A Kruskal–Wallis test showed a statistically significant difference in the distribution of CVD risk score between the various sites ($P<0.001$).

The proportion of subjects with ≥20% 10-year risk of CVD was highest in Berlin (15%) and lowest in rural Ghana (0.9%) for men, respectively. Elevated 10-year risk of CVD (≥7.5%) among men was equally higher in Berlin (61.0%) and lowest in rural Ghana (35.6%), $P<0.001$. However, among women, there was no significant difference in CVD risk between the various sites (Table 1). In general, the CVD risk predictions were higher in men than in women, with the exception of rural Ghana, where CVD risk of ≥20% was 1.6% among women and 0.9% among men.

Influence of Migration on 10-Year CVD Risk, RODAM Study

Two models were built, to control for education (model 1) and education, employment, and income (model 2). Ghanaian migrants in urban Ghana and European cities had increased propensity to be at elevated CVD risk as compared with their rural Ghana counterparts. Compared with men in rural Ghana, the univariable results showed ≈3× higher odds of elevated CVD risk for those living in Berlin (odds ratio [OR], 2.97; 95% confidence interval [CI], 2.00–4.40; Figure 1). Adjustment for possible confounders only slightly attenuated the

Table 1. Risk Factor Profile Overall and Across RODAM by Study Sites

Variables	Total (n=3864)	Study Site					*P* Value
		Rural Ghana (n=633)	Urban Ghana (n=916)	Amsterdam (n=1176)	Berlin (n=365)	London (n=774)	
Men, N	1481	236	273	497	200	275	
Age, y	52±0.2	53±0.5	53±0.5	52±0.9	52±0.5	52±0.4	0.049
Mean systolic BP	136.5±0.5	126.0±1.2	134.5±1.3	139.5±0.8	141.3±1.3	138.5±1.1	<0.001
BP medication, N (%)	345 (23.3)	13 (5.5)	22 (8.1)	157 (31.6)	75 (37.5)	78 (28.4)	<0.001
Total cholesterol, mmol/L	5.00±0.03	4.2±0.1	5.2±0.1	5.1±0.05	5.3±0.1	5.0±0.1	<0.001
LDL cholesterol, mmol/L	3.2±0.02	2.5±0.1	3.5±0.1	3.3±0.04	3.3±0.1	3.3±01	<0.001
HDL cholesterol, mmol/L	1.3±0.01	1.2±0.02	1.2±0.02	1.3±0.01	1.4±0.02	1.3±0.02	<0.001
Type 2 diabetes mellitus, N (%)*	204 (13.8)	11 (4.7)	40 (14.7)	79 (15.9)	37 (18.5)	37 (13.5)	<0.001
Smoking, N (%)							
Current	91 (6.6)	17 (7.7)	8 (3.1)	33 (7.3)	31 (15.5)	2 (0.8)	<0.001
Past	225 (16.3)	46 (20.8)	52 (20.2)	67 (14.8)	395 (17.5)	25 (10.0)	
BMI, kg/m^2, ≥30, N (%)	215 (14.5)	2 (0.8)	21 (7.7)	96 (23.8)	33 (16.5)	63 (22.9)	<0.001
High-level physical activity, N (%)	667 (45.0)	156 (66.1)	138 (50.5)	193 (38.8)	104 (52.0)	72 (27.6)	<0.001
Psychosocial stress: home and work, N (%)							
Never experienced	606 (44.4)	50 (23.0)	97 (37.9)	241 (53.3)	103 (51.5)	111 (48.3)	<0.001
Permanent stress	48 (3.5)	5 (2.3)	3 (1.2)	28 (6.2)	6 (3.0)	6 (2.6)	
Alcohol consumption, N (%)	525 (35.4)	76 (32.2)	101 (37.0)	189 (38.0)	66 (33.0)	93 (33.8)	0.454
10-y CVD risk, N (%)							
<5	289 (27.3)	96 (34.6)	93 (34.6)	95 (20.5)	37 (18.5)	68 (26.1)	<0.001
5–7.5	328 (23.0)	55 (23.8)	55 (20.4)	119 (25.6)	42 (21.0)	57 (21.8)	
7.5–10	210 (14.7)	22 (9.5)	38 (14.1)	69 (14.9)	33 (16.5)	48 (18.4)	
10–15	259 (18.2)	42 (18.2)	37 (13.8)	96 (20.7)	42 (21.0)	42 (16.1)	
15–20	121 (8.5)	14 (6.1)	23 (8.6)	41 (8.8)	17 (8.5)	26 (10.0)	
>20	118 (8.3)	2 (0.9)	23 (8.6)	44 (9.5)	29 (14.5)	20 (7.7)	
Women, N	2383	397	643	679	165	499	
Age, y	51±0.1	52±0.4	51±0.3	50±0.2	50±0.5	52±0.3	<0.001
Mean systolic BP, mm Hg	132.4±0.4	126.5±1.1	128.9±0.7	134.9±0.7	135.1±1.3	137.4±0.7	<0.001
BP medication, N (%)	649 (27.2)	42 (10.6)	109 (17.0)	249 (36.7)	69 (41.8)	180 (36.1)	<0.001
Total cholesterol, mmol/L	5.1±0.02	4.8±0.1	5.4±0.04	5.1±0.04	5.2±0.1	5.1±0.04	<0.001
LDL cholesterol, mmol/L	3.3±0.02	3.1±0.05	3.7±0.04	3.3±0.03	3.3±0.1	3.2±0.04	<0.001
HDL cholesterol, mmol/L	1.4±0.01	1.2±0.02	1.3±0.01	1.5±0.01	1.6±0.03	1.5±0.01	<0.001
Type 2 diabetes mellitus, N (%)*	241 (10.1)	24 (6.0)	68 (10.6)	76 (11.2)	19 (11.5)	54 (10.8)	<0.001
Smoking, N (%)							
Current	18 (0.8)	0 (0)	0 (0.0)	13 (2.1)	5 (3.1)	0 (0)	<0.001
Past	83 (3.7)	3 (0.8)	16 (2.6)	40 (6.5)	11 (6.8)	13 (3.0)	
BMI, kg/m^2, ≥30, N (%)	984 (41.4)	37 (9.3)	233 (36.2)	359 (53.0)	66 (40.0)	289 (58.6)	<0.001
High-level physical activity, N (%)	912 (38.3)	198 (49.9)	260 (38.7)	263 (46.1)	76 (46.1)	115 (23.0)	
Psychosocial stress: home and work, N (%)							
Never experienced	878 (38.8)	75 (20.5)	184 (29.8)	280 (46.4)	70 (43.5)	228 (55.3)	<0.001
Permanent stress	65 (3.0)	9 (2.5)	7 (1.1)	31 (5.1)	10 (6.2)	8 (1.9)	

(*Continued*)

Table 1. Continued

Variables	Total (n=3864)	Study Site					*P* Value
		Rural Ghana (n=633)	Urban Ghana (n=916)	Amsterdam (n=1176)	Berlin (n=365)	London (n=774)	
Alcohol consumption, N (%)	835 (35.0)	138 (34.8)	257 (40.0)	218 (32.1)	64 (38.8)	158 (31.7)	0.011
10-y CVD risk, N (%)							
<5	1494 (66.7)	266 (69.3)	427 (67.2)	418 (68.9)	114 (69.5)	269 (59.8)	0.155
5–7.5	271 (12.1)	44 (11.5)	69 (10.9)	73 (12.0)	19 (11.6)	66 (14.7)	
7.5–10	178 (7.9)	27 (7.0)	47 (7.4)	49 (8.1)	14 (8.5)	41 (9.1)	
10–15	165 (7.4)	27 (7.0)	50 (7.9)	38 (6.3)	7 (4.3)	43 (9.6)	
15–20	74 (3.3)	14 (3.6)	26 (4.1)	18 (3.0)	4 (2.4)	12 (2.7)	
>20	58 (2.6)	6 (1.6)	16 (2.5)	11 (1.8)	6 (3.7)	19 (4.2)	

BMI indicates body mass index; BP, blood pressure; CVD, cardiovascular disease; HDL, high-density lipoprotein; LDL, low-density lipoprotein; and WHO, World Health Organization.

*Based on self-report, use of hypoglycemic medication or fasting plasma glucose, ≥7 mmol/L (WHO criteria); Data presented as means±SEM unless stated otherwise.

association. The odds of elevated CVD risk were also significantly higher for Ghanaian men living in Amsterdam (OR, 2.21; 95% CI, 1.59–3.06) and urban Ghana (OR, 1.57; 95% CI, 1.09–2.25), with only minor changes after adjustment for education, employment, and sources of income. A post-estimation test showed that the coefficients for urban Ghana differed significantly from those for Berlin and Amsterdam. An association of migration with CVD risk was observed for Ghanaian women living in London compared with those in rural Ghana (OR, 1.45; 95% CI, 1.04–2.01); adjustment for education, employment, and sources of income did not materially alter the risk estimate (Figure 2).

Among Ghanaians based in Europe, each additional year in length of stay was associated with 11% higher odds of elevated 10-year predicted risk of CVD in men (OR, 1.11; 95% CI, 1.09–1.13) and 9% in women (OR, 1.08; 95% CI, 1.06–1.10; Table 2). The effect size and strength of association were similar across the various European sites. On adjusting for age, education, employment, and sources of income, an increased risk of CVD was observed with increased length of stay in men (OR, 1.03; 95% CI, 1.01–1.06), whereas the effect in women was attenuated and no longer statistically significant (OR, 1.02; 95% CI, 0.99–1.04).

Discussion

Key Findings

This study has 3 important findings: first, the 10-year estimated risk of CVD is significantly increased for migrant Ghanaian men living in Amsterdam, 53.9%; Berlin, 61.0%; and urban Ghana, 45.4% compared with nonmigrants residing in rural Ghana, 34.7%. For men, the 10-year risk of CVD differed by city of residence in Europe, with the risk in men being higher in Berlin than in Amsterdam. For women, 10-year CVD risk was elevated in London; differences observed between Ghana, Berlin, and Amsterdam were minor. Secondly, modifiable risk factors of CVD are important contributors to differences in CVD between SSA migrant and home populations, as well as same migrant populations living in different European cities. Finally, for men, each additional year in length of stay in Europe increased 10-year predicted risk of CVD in European Ghanaian migrants.

Discussion of Key Findings

In this study, migrating to Europe increased the probability of elevated 10-year risk of CVD among Ghanaian men. Ghanaians in rural Ghana had lower CVD risk, which reflected better risk factor profile compared with urban Ghana and Ghanaian migrants in Europe. With the exception of current smoking in men, all risk factors were lower in rural Ghana.

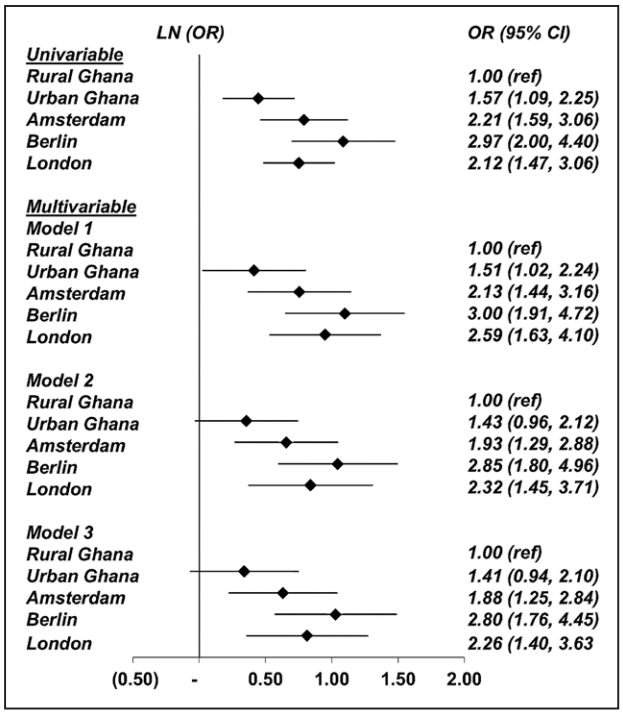

Figure 1. Logistic regression analysis of migration on elevated 10-y cardiovascular disease (≥7.5%) in men. Model 1: adjusted for education, employment, and sources of income. Model 2: model 1+physical activity and alcohol intake. Model 3: model 2+psychosocial stress. CI indicates confidence interval; LN, natural logarithmic function; and OR, odds ratio.

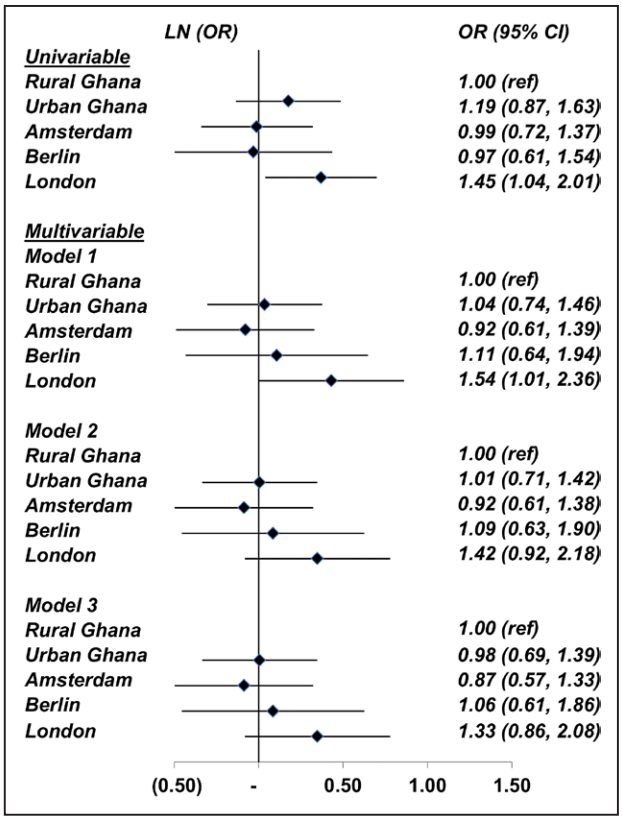

Figure 2. Logistic regression analysis of migration on elevated 10-y cardiovascular disease (≥7.5%) in women. Model 1: adjusted for education, employment, and sources of income. Model 2: model 1+physical activity and alcohol intake. Model 3: model 2+psychosocial stress. CI indicates confidence interval; LN, natural logarithmic function; and OR, odds ratio.

This corroborate findings from previous studies that looked at differences in CVD risk between residents in rural and urbanized cities in their respective countries or overseas.[28,29]

Contributory risk factors to increased CVD risk included BP levels, diabetes mellitus, and smoking, which were higher among the male migrant populations. This is consistent with previous studies, which showed an increase in CVD risk in migrant populations compared with their counterparts in their countries of origin.[30,31] After controlling for education, employment, and sources of income, the effect between migrant and rural population increased in both men and women. In a subanalysis (Table II in the Data Supplement), the relationship between CVD risk and migration was similar across the various levels of attained education, with 10-year CVD risk being higher among the European sites and urban Ghana as compared with rural Ghana. Socioeconomic position has been observed to differ with regard to prevalence of diabetes mellitus among Ghanaians in different geographical locations[32] highlighting a complex interaction of socioeconomic position and the development of diabetes mellitus. These findings suggest the need to consider socioeconomic variations in CVD risk predictions and management, particularly in ethnic minority populations. We also observed marked differences in BMI, which could partly explain the differences in CVD risk among these populations because a recent study that explored BMI among Ghanaian migrants and their home counterparts found increasing prevalence of obesity, with a rising gradient from rural Ghana to urban Ghana to Europe.[23]

Other lifestyle and behavioral changes after migration have been cited as possible explanation for increased CVD risk among migrant populations. In this study, we observed differences in physical activity and psychosocial stress between the migrants and their home counterparts. Physical activity, for instance, was higher in rural Ghana than all European cities and lowest in London. When adjusted for in the multivariable models, there was marginal attenuation of the effect size across sites, although the increased CVD risk in the European cities among men still remained. Previous studies among many diverse migrant populations, including SSA migrants, have also shown high risk of physical inactivity among these populations, partly explaining their increased risk of CVD.[33,34] The effect of psychosocial

Table 2. Logistic Regression Analysis of Influence of Length of Stay in Europe on Risk of Elevated 10-Year Cardiovascular Disease Risk (≥7.5%)

	OR (95% CI)			
Variables	Amsterdam	Berlin	London	All
Men				
Length of stay	1.13 (1.10–1.17)*	1.13 (1.09–1.18)*	1.08 (1.04–1.11)*	1.11 (1.09–1.13)*
Multivariable				
Model 1	1.06 (1.02–1.10)†	1.04 (0.99–1.10)	1.01 (0.96–1.05)	1.04 (1.01–1.06)†
Model 2	1.05 (1.00–1.09)‡	1.03 (0.97–1.09)	1.00 (0.95–1.06)	1.03 (1.01–1.06)‡
Women				
Length of stay	1.09 (1.05–1.13)*	1.06 (1.00–1.11)‡	1.08 (1.06–1.11)*	1.08 (1.06–1.10)*
Multivariable				
Model 1	1.01 (0.97–1.05)	1.00 (0.95–1.06)	1.02 (0.99–1.05)	1.01 (0.99–1.04)
Model 2	1.00 (0.96–1.05)	1.01 (0.95–1.08)	1.03 (0.99–1.07)	1.02 (0.99–1.04)

Model 1: adjusted for age. Model 2: adjusted for age, education, employment, and source of income. CI indicates confidence interval; and OR, odds ratio.
*P<0.001, †P<0.01, ‡P<0.05.

stress was minimal and corroborates previous findings of nonsignificant influence of psychosocial stress on CVDs in this population.[35] These risk factors, however, do not explain all the observed differences in CVD risk. Other risk factors, such as dietary habits after migration and adoption of Western dietary habits, linked to CVDs[36] need to be further explored in this population.

The study also showed marked differences in risk of CVD between the cities of residence of European Ghanaian migrants, particularly in men. Elevated 10-year CVD risk among men was highest in Berlin (Germany) than Amsterdam (The Netherlands). Elevated CVD risk in Ghanaian migrants in the current study reflected the differences in the prevalence and burden of CVDs in the general population in these European countries, with CVD burden being highest in Germany (12.8%) and The Netherlands (9.7%).[37] This finding in Ghanaian men is supportive of the contextual environment hypothesis, which postulates that the prevalence and risk factors of CVDs among migrant populations changes to reflect the existing trend in their host countries over time. This also means that a similar population of migrants residing in different countries could have different prevalence of diseases because they mirror the prevailing situation in that country as observed previously for prevalence of diabetes mellitus in African Caribbeans and South Asians residing in the United Kingdom and The Netherlands.[13] Differences in diabetes mellitus prevalence among these migrant populations reflected differences in prevalence among their host countries (3.6% in the United Kingdom and 6.7% in The Netherlands),[14] suggesting that contextual circumstances, which include socioeconomic development and access to and practice from healthcare and preventive services, vary significantly among the industrialized host countries of migrants and influence healthcare behavior and utilization.[38] However, although CVD prevalence mirrors that of the host populations, overall, it has been found to be higher in the migrant populations than in the European host populations.[30,39]

Challenges in healthcare access among migrants may contribute to the contextual differences in CVD risk among migrant populations in different industrialized cities.[8,40] Although this mostly affects newly arriving and undocumented migrants, health challenges in health provision, such as lack of knowledge about available services, language differences, and varying cultural attitudes to health and health care, can be persistent for migrants who have resided in their host countries for some time.[40] An explorative study among Ghanaians in The Netherlands documented difficulties with the Dutch language and mistrust in healthcare providers as major barriers in access to health care.[41] In Canada, new migrants receive access to health care within 3 months of arrival,[8] whereas legal migrants in the United States have difficulties in accessing health insurance,[42] and this has been cited as a possible contributor to lower cardiac risk factor score among migrants in Canada.[8]

As seen previously in studies elsewhere, marked differences for men and women were also observed for the RODAM study population.[41,42] CVD risk was generally higher in men than in women at all sites, with the exception of rural Ghana. Sex differences in CVDs develop from sociocultural processes, such as differences in behaviors of women and men, different dietary habits after migration, lifestyles or stress, and different attitudes toward treatments and prevention.[43,44] In general, men have a less-favorable cardiac risk factor profile than women (for example, smoking and high blood viscosity).[43,44] As part of preventive efforts, these sex differences in CVD risk factors need to be considered when evaluating one's probability of developing CVD.

This study shows an increased CVD risk with increasing length of stay in Europe, especially among Ghanaian men. This parallels other evidence of increased CVD risk factors among diverse migrant populations with increasing residence in the United States[45,46] and suggests that migrants more frequently engage in unhealthy behaviors with longer stay in the host country, leading to increased risk of CVD among migrant populations. There is the need for prospective studies to better understand how acculturation processes influence health behaviors and outcomes. The influence of length of stay on health of migrants on CVD risk was not seen for Ghanaian women, which further outlines how sociocultural processes and environmental exposures manifest differently in men and women with respect to CVDs. In a study among ethnically diverse groups of United States immigrants, the odds of obesity/overweight and current smoking were greater for women than for men, whereas hyperlipidemia increased with increasing length of stay among men.[46]

A unique strength of RODAM is the homogenous study population of Ghanaians living in different settings in Africa and Europe. Previous studies, which attempted to assess the role of migration on CVD, used heterogeneous ancestry of populations who have left Africa long ago and now live in the Caribbean, United Kingdom, and United States.[47] Focusing on one population, the limitations of heterogeneous ancestry of populations are dealt with by the RODAM study. However, given its cross-sectional nature, the correlation of predicted CVD risk with incident CVD events requires confirmation from prospective studies. The PCE risk algorithms use in predicting CVD in this study have not been yet validated for SSA populations. The risk factors of increased CVD risk observed could not explain all the differences between migrant and home populations. Further studies into dietary habits, access to health services, acculturation and integration, and origin of migration are recommended.

Although across all sites, well-standardized approaches for measurement procedures were applied, the recruitment strategies had to be adapted to local circumstances as a result of different civil registration systems in the various countries. As suggested in previous studies on the effect of nonresponse on CVD risk analysis, study participants are a somewhat biased subset of the target population because they tend to over-represent those with risk factors but without the disease, referred to as the worried well. This represents independent bias in both risk factor and disease distribution, and could produce minor to moderate errors in odds of CVD risk calculated in this study.[48] Nonrespondent analysis undertaken, however, showed a fairly similar distribution of respondents and nonrespondents in Berlin. Evidence suggests that most Ghanaians in Europe are affiliated with Ghanaian organizations,[49] indicating that members of these organizations may be representative of

the Ghanaian population residing in various European cities and rendering bias of CVD risk factor differences between European sites by the variation in sampling strategy unlikely.

Conclusions

In conclusion, this study indicates profound 10-year increased risk of CVD among Ghanaians residing in urban Ghana and urbanized cities in Europe. This calls for imperative efforts to disentangle the important predictors of increased CVD risk among SSA migrants in Europe and nonmigrants in urban centers to inform targeted health care and interventions. The risk of CVD was also observed to be different among similar populations of the same ancestry residing in different industrialized European countries, suggesting the need to take into account the contextual differences in studying the causes of increased CVD risk among homogenous migrant populations.

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Disclosures

None.

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Migration and Cardiovascular Disease Risk Among Ghanaian Populations in Europe:: The RODAM Study (Research on Obesity and Diabetes Among African Migrants)

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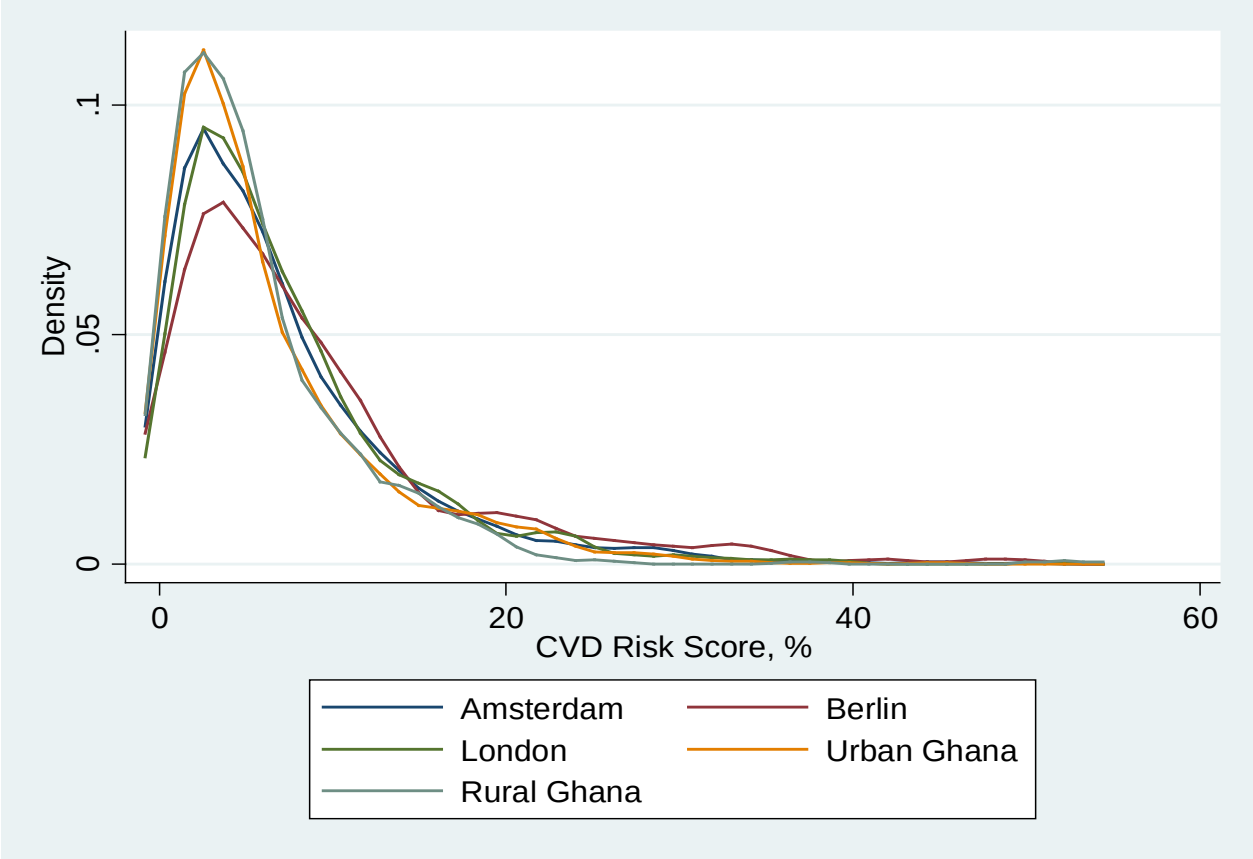

Supplemental Fig. 1: Kernel density of CVD risk distribution by RODAM study site

Supplemental Table 1: Socio-economic and migration characteristics of subjects

Variables	Total	Rural Ghana	Urban Ghana	Amsterdam	Berlin	London	p-value
Men, N	***1481***	***236***	***273***	***497***	***200***	***275***	
Education, N (%)							
Never /elementary only	305 (21.9)	101 (45.7)	66 (25.8)	109 (23.0)	13 (6.5)	16 (6.5)	<0.001
Lower vocational	578 (41.4)	82 (37.1)	115 (44.9)	205 (43.3)	100 (50.3)	76 (31.0)	
Intermediate vocational/higher							
Secondary schooling	301 (21.6)	28 (12.7)	48 (18.8)	121 (25.6)	59 (29.6)	45 (18.4)	
Higher vocational or university	210 (15.1)	10 (4.5)	27 (10.5)	38 (8.0)	27 (13.6)	108 (44.1)	
Employment, N (%)							
Full time*	715 (51.9)	64 (29.0)	75 (29.2)	262 (57.7)	122 (61.6)	192 (77.7)	<0.001
Part-time	381 (27.7)	128 (57.8)	138 (53.7)	55 (12.1)	35 (17.7)	25 (10.1)	
Unemployed/looking for work	98 (7.1)	9 (4.1)	7 (2.7)	60 (13.2)	13 (6.6)	9 (3.6)	
Full time housekeeper	5 (0.4)	0 (0.0)	0 (0.0)	2 (0.4)	1 (0.5)	2 (0.8)	
On social benefit	55 (4.0)	0 (0.0)	8 (3.1)	30 (6.6)	16 (8.1)	1 (0.4	
Retired/unable to work	123 (8.9)	20 (9.0)	29 (11.3)	45 (9.9)	11 (5.6)	18 (7.3))	
Sources of income, N (%)							
Own company or investments	1081(73.0)	204 (86.4)	216 (79.1)	327 (65.8)	146 (73.0)	188 (68.4)	<0.001
Benefits/pension	116 (7.8)	2 (0.8)	15 (5.5)	50 (10.1)	36 (18.0)	13 (4.7)	
Combined wages	63 (4.3)	4 (1.7)	8 (2.9)	17 (3.4)	13 (6.5)	21 (7.6)	
Other e.g. remittance	37 (2.5)	11 (4.7)	17 (6.2)	2 (0.4)	3(1.5)	4 (1.5)	
Unknown	184 (12.4)	15 (6.4)	17 (6.2)	101 (20.3)	2 (1.0)	49 (17.8)	
Length of stay in Europe, Median (25th, 75th percentile)	21.3 (12.8, 25.0)			21.7 (14.4, 24.9)	22.6 (15.1, 29.2)	15.0 (10.8, 24.1)	
<5years, N (%)	48 (5.5)			17 (3.8)	16 (8.2)	15 (6.4)	<0.001
5-10, N (%)	63 (7.2)			32 (7.1)	6 (3.1)	25 (10.6)	
10-15, N (%)	152 (17.3)			61 (13.6)	22 (11.3)	69 (29.4)	
15-20, N (%)	121 (13.8)			63 (14.0)	28 (14.4)	30 (12.8)	

>20years, N (%)	495 (56.3)			276 (61.5)	123 (63.1)	96 (40.9)	
Women, N	**2383**	397	643	679	165	499	
Education, N (%)							
Never /elementary only	1011(45.8)	261 (71.1)	356 (57.0)	311 (49.4)	23 (14.4)	60 (14.1)	
Lower vocational	740 (33.5)	92 (25.1)	214 (34.2)	205 (32.5)	83 (51.8)	146 (34.2)	<0.001
Intermediate vocational/higher secondary schooling	339 (15.3)	8 (2.2)	44 (7.0)	102 (16.2)	50 (31.3)	135 (31.6)	
Higher vocational or university	119 (5.4)	6 (1.6)	11 (1.8)	12 (1.9)	4 (2.5)	86 (20.1)	
Employment, N (%)							
Full time*	660 (30.3)	80 (21.8)	139 (22.2)	171 (28.6)	61 (38.1)	209 (48.9)	<0.001
Part-time	949 (43.6)	249 (67.8)	374 (60.2)	139 (23.3)	54 (33.8)	131 (30.7)	
Unemployed/looking for work	110 (5.1)	11 (3.0)	20 (3.2)	48 (8.0)	15 (9.4)	16 (3.7)	
Full time housewife	45 (2.1)	3 (0.8)	8 (1.3)	9 (1.5)	7 (4.4)	18 (4.2)	
On social benefit	167 (7.7)	0 (0.0)	2 (0.3)	143 (24.0)	16 (10.0)	6 (1.4)	
Retired/unable to work	245 (11.3)	24 (6.5)	80 (12.8)	87 (14.6)	7 (4.4)	47 (11.0)	
Sources of income, N (%)							
Own company or investments	1523(63.9)	329 (82.9)	486 (75.6)	331 (48.7)	92 (55.8)	285 (57.1)	<0.001
Benefits/pension	236 (9.9)	1 (0.3)	11 (1.7)	136 (20.0)	41 (24.8)	47 (9.4)	
Combined wages	104 (4.4)	0 (0.0)	7 (1.1)	20 (2.9)	25 (15.2)	52 (10.4)	
Other e.g. remittance	179 (7.5)	33 (8.3)	120 (18.7)	7 (1.0)	1 (0.6)	18 (3.6)	
Unknown	341 (14.3)	34 (8.6)	19 (3.0)	185 (27.2)	6 (3.6)	97 (19.4)	
Length of stay in Europe, Median (25th, 75th percentile)	20.7 (12.8, 25.9)			20.6 (14.6, 24.9)	21.4 (15.2, 26.3)	20.0 (10.8, 28.1)	
<5years, N (%)	54 (4.7)			15 (2.5)	8 (5.1)	31 (7.8)	<0.001
5-10 years, N (%)	100 (8.7)			53 (8.8)	8 (5.1)	39 (9.8)	
10-15 years, N (%)	183 (15.8)			72 (12.0)	20 (12.7)	91 (22.8)	
15-20 years, N (%)	177 (15.3)			120 (20.0)	27 (17.2)	30 (7.5)	
>20years, N (%)	642 (55.5)			340 (56.7)	94 (59.9)	208 (52.1)	

*SEM=Standard error of the mean; * Includes students*

Supplemental Table 2: Logistic regression analysis of migration on elevated 10-year CVD (>7.5%), stratified by level of educational attainment

	Never/elementary only	Lower vocational	Intermediate vocational/higher SS/tertiary
Sites			
— Rural Ghana	1.00	1.00	1.00
— Urban Ghana	3.17 [1.17, 8.63]	3.15 [0.91, 10.84]	2.48 [0.29, 21.14]
— Amsterdam	2.67 [0.95, 7.49]**	3.50 [1.04, 11.82]*	3.83 [0.50, 29.36]
— Berlin	8.70 [2.23, 34.02]*	3.16 [0.85, 11.68]	9.83 [1.29, 74.79]*
— London	5.19 [1.46, 18.44]*	3.27 [0.91, 11.80]	3.19 [0.42, 24.25]

**P<0.05; **p<0.01*