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Estimating 10-year cardiovascular disease risk in urban and rural populations in Haiti

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ABSTRACT

Background: Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide, accounting for 10% of disability-adjusted life years lost in low- and middle-income countries. Few studies have been conducted in Haiti. WHO has cited a substantial lack of information on chronic disease prevalence in Haiti impeding progress in interventions. (Organization., 2014) Preventing and managing CVD through use of risk prediction tools is key in addressing this growing problem.

Objective: Using data from 1798 adults aged 25–65 years old with urban and rural Haiti, we estimated the 10-year CVD risk groups (< 10%, 10% to < 20%, 20% to < 30%, 30% to < 40%, and ≥ 40%) based on the WHO/ISH cardiovascular risk score chart.

Methods: In addition to performing a questionnaire based on the WHO STEPS instrument, we measured two blood pressure values, weight, height, abdominal circumference, as well as point of care test finger stick blood sample for hemoglobinA1c, creatinine, and cholesterol (total, HDL and triglycerides). For blood pressure, 2104 (99.1%) completed two measurements, 2074 (97.6%) were measured for height, weight, and waist circumference, 1858 (87.5%) had hemoglobinA1C for diabetes, 1980 (93.2%) had creatinine, and 1819 (85.6%) had cholesterol. As a result, 993 urban and 710 rural had complete data for this analysis.

Results: The overall predicted CVD risk scores were: 75% (< 10%), 15% (10% to < 20%), 5.0% (20% to < 30%), 1.3% (30% to < 40%), and 2.9% (≥ 40%). Female gender and older age were significantly associated with higher 10-year CVD risk while urban/rural location, education, and income were not. Haiti had higher rates of elevated 10-year CVD risk when compared to other Caribbean and sub-Saharan African countries.

1. Introduction

Cardiovascular disease (CVD) leads accounts for nearly half of noncommunicable diseases (NCDs).[1] CVD is also the leading cause of morbidity and mortality worldwide, accounting for 10% of disability-adjusted life years (DALYs) lost in low- and middle-income countries (LMIC).[1,2] In 2015, CVD was responsible for 17.9 million deaths and is projected to increase to more than 23.6 million by 2030.[1,3] Notably, 80% of these deaths occur in LMIC.[4,5] Economists project that from 2011 to 2025, LMIC will likely suffer economic losses of up to $7.28 trillion, nearly 50% of which is due to CVD.[1]

Preventing and managing CVD through use of risk prediction tools is key in addressing this growing problem. There are several different risk prediction tools available as paper charts or online calculators to identify those at risk of developing CVD. Many of these prediction tools are based on studies involving White populations from developed countries and therefore may not be applicable to other populations. The most well-studied among them in black populations is the Framingham Risk Score (FRS), but it relies on the findings of the study conducted in a small American town with a predominantly white population.[6–9] The World Health Organization/International Society of Hypertension (WHO/ISH) risk prediction charts, however, are particularly useful in regions where resources are limited and/or there are no available cohort data.[10,11] They were developed using a total cardiovascular risk approach to assess 10-year risk for fatal or non-fatal cardiovascular event based on CVD risk factor profiles (age, gender, blood pressure,

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smoking status, total blood cholesterol level and the presence or absence of diabetes).[12] These charts are available for each of the 14 WHO epidemiological sub-regions and they inform targeted usage of limited resources for populations most at risk and likely to benefit from interventions.[12,13]

Most developing countries, for example, some Sub-Saharan African nations have no population-based cohort studies on cardiovascular risk. Many CVD risk studies to date come from high and middle-income countries.[14–16] The majority of the available information were obtained through hospital-based and small community cross-sectional studies.[8,10] For example, in a study by Divala et al., the WHO/ISH risk charts were used to assess CVD risk in Malawian adults at urban and rural HIV clinics in the Zomba district of Malawi.[17,18] They found that the proportions with a > 20% 10-year risk for a cardiovascular event was 2.1% (including total cholesterol) and 3.4% (excluding total cholesterol).[18] Sawadogo et al. found that 1.8% of HIV patients in their study at a hospital in Burkina Faso had a > 20% 10-year CVD risk, using the FRS.[19] In Cameroon, a cross-sectional study by Kengne et al., using the FRS, found that 7.2% of newly diagnosed type 2 diabetes patients had > 20% 10-year CVD risk.[20] Chilunga et al. found that 27.4% of Ghanaians living in Ghana had a high (> 7.5%) 10-year CVD risk, which was estimated using the Pooled Cohort Equations (PCE) method.[21]

In the Caribbean region, Cuba is the only country that has conducted a total cardiovascular risk assessment of its population. In the study by Nordet et al., using the WHO/ISH risk charts, they found that 2.9% of the Cuban population had a ≥20% 10-year cardiovascular risk (including total cholesterol). When estimates did not include total cholesterol, the proportion of the population with a ≥20% 10-year was 4.6%.[22] Data is relatively sparse in the greater Caribbean region. The largest study conducted in Jamaica, St Lucia and Barbados reported hypertension prevalence as 24.7%, 26.9% and 27.9%.[24] Of note, the same study did report a dramatic increase in hypertension management over previous estimates. Among Caribbean countries that have the highest NCD morbidity and mortality rates, with CVD accounting for the highest rates, Haiti has the highest rate of CVD-related mortality.[20] Several studies conducted in the Caribbean region report on the prevalence of individual NCDs, but few evaluate all NCDS and few have been conducted in Haiti.[24–26] Prior to our investigation, the most comprehensive assessment of chronic disease prevalence in Haiti, more specifically prediabetes, diabetes, hypertension and abdominal obesity attempted in Haiti was the PREDIAH study, conducted in urban Port-au-Prince.[23] PREDIAH was only the second study to date of Haitian diabetes; its limitations include only representing an urban population and a 35% drop out rate of its prediabetes population. Others rely on hypertension prevalence estimation in clinic-only based populations.[27,28] From our Haiti Health Study, the prevalence of risk factors for CVD including hypertension, diabetes and chronic kidney disease were 15.6% (± 2.93%), 19.7% (± 1.57%) and 12.3% (± 2.72%), respectively.[29] The benefit of our point-of-care prevalence study offers potentially more accurate estimates as it does not rely on follow-up which has hindered previous efforts and allows for evaluation rural areas. The review of the literature reveals that there is a paucity of information on the CVD risk of the Haitian population and low-income countries in general. The aim of this study is to assess the total cardiovascular risk in the Haitian population using the WHO/ISH risk prediction charts.

2. Methods

2.1. Study design and setting

This study used data from a cross-sectional study conducted in an urban and rural region of Haiti with a sample size of 2152 people. Rural and urban communities were defined by Haitian national statistics, with 48% of the population currently living in a rural community, a number that continues to decrease annually.[30] Table 1 illustrates the baseline characteristics of each of these communities, of note large are large differences in education and income level, but not smoking. The overall mean age was 40.8 years old, with minimal difference by gender (male = 40.6 years, female = 40.8 years) but age varied by location, with rural participants older (42.4 years) than the urban participants (39.9 years) (p = 0.000).

Table 1
Baseline characteristics of study population by location.

		Urban (n = 1427)		Rural (n = 725)	
		Frequency	%	Frequency	%
Smoking	Yes	115	8.06	64	8.83
	No	1309	91.73	651	89.79
	Missing	3	0.21	7	0.97
Gender	Men	572	40.08	258	35.59
	Women	855	59.92	446	61.52
	Missing			18	2.48
Education	No formal schooling	206	14.44	212	29.24
	Less than primary school	144	10.09	91	12.55
	Primary school	357	25.02	198	27.31
	Secondary school	545	38.19	180	24.83
	University	148	10.37	29	4.00
	Missing	12	0.84	7	0.97
	Refused	15	1.05	5	0.69
Income	Less than $25	421	29.50	436	60.14
	$25-50	333	23.34	68	9.38
	$51-$250	173	12.12	19	2.62
	$251-500	25	1.75	5	0.69
	More than $500	11	0.77	5	0.69
	Missing	23	1.61	18	2.48
	Refused	147	10.30	49	6.76
	Don't Know	294	20.60	122	16.83

A more in-depth review of the study methods is noted in the primary study.[29] Briefly, the study used a multistage random cluster sampling method to choose which areas within the study sites would be sampled. The rural and urban sites were divided into sections with roughly equivalent populations and the clusters to be included in the study were chosen using a random number table.

2.2. Participants

Men and women between 25 and 65 years of age, residing in Rivière Froide, Carrefour (urban) and Cabral region of Thomonde, Central Plateau (rural) were eligible to participate in the study. Men and women who were cognitively impaired or women who were pregnant were excluded as blood pressure and waist circumference vary considerably during pregnancy and assumed would skew results from average baseline. If the selected individual was not home or not free to participate in the survey on first approach, at least two additional attempts to conduct the interview were made.

Within the clusters, the starting household for enumeration was selected using community structure anchor points, such as schools, churches and police stations. Households to be interviewed were selected based on a random interval number that was chosen daily from a pre-sealed envelope. One individual per household was randomly selected to be interviewed using a Kish table.[31]

2.3. Data collection

Data were collected between July 2015 and May 2016 by Haitian Community Health Workers (CHWs) who underwent rigorous training and certification. An adapted version of WHO STEPS instrument was used for the main survey of the study, collecting information on a variety of variables, such as age, gender, education, monthly income and smoking status.[32] Blood pressure values were collected twice and averaged – at the beginning and end of the survey – using the Omron Series 7 electronic wrist blood pressure device.[33] Weight, height and abdominal circumference were measured with portable electronic scales and tape measures as per the WHO STEPwise Surveillance Manual.[34] HbA1c values (A1c Now+, Polymer Technology Systems), creatinine values (StatSensor Creatinine Express device, Nova Biomedical) and total cholesterol, triglycerides, and high density lipoprotein values (CardioChek Lipid Test, Polymer Technology Systems) were obtained from finger stick blood samples using point of care testing devices.[35,36] Lipid point of care results were verified with laboratory standards and HbA1c was compared with that of laboratory-confirmed volunteer HbA1c.

Point of care testing equipment ideally is used often in primary care clinics in developed nations and are designed under those conditions. The study was conducted in Haiti where ambient temperatures reached 35C daily. On trouble shooting processes to maintain ideal testing conditions, please see our previous report.[37] Briefly, through trial and error, testing devices worked well and most participants fell within testing limits.

Diabetes is defined based on fasting or postprandial glucose by WHO, but American Diabetes Association and others allow for HbA1C to be used as an alternative means of diabetes diagnosis.[38] Smokers were considered those who smoke currently or quit within the last 12 months. Systolic blood pressure, taken as the mean of two readings on each of two occasions, of greater than 140mmg Hg systolic or 90 mm Hg diastolic was considered hypertensive. Cholesterol varied by layout in the chart which varied by region. Diabetes was diagnosed using HbA1c values with normal defined as < 5.7%, prediabetes defined by 5.7%–6.4%, and diabetes as defined by ≥ 6.5% or on diabetes treatment, per modified guidelines. Diagnosis of HbA1c using the previous definition requires in-laboratory testing, which was not feasible in our study and depended on point of care HbA1c.[40]

2.4. Study size

The study size was originally calculated for prevalence of hypertension, obesity, and diabetes[29] and this is a secondary analysis. The sample size calculation assumed a 4% difference between the urban and rural groups in terms of hypertension, a 5% difference in obesity and a 3.5% difference in diabetes. There were no plausible estimates for the difference in chronic renal insufficiency. Using the smallest predicted difference, diabetes, the sample size needed was calculated to be 1798, on the basis of 80% power and 0.05 significance level. To account for possible lower participation in point of care testing, an additional 10% buffer was added, for rounded sample size of 2000 people.

2.5. Variables

The distribution of baseline characteristics of urban and rural participants were evaluated, tabulated, and presented in Table 1. Continuous variables, including age and BMI, were expressed as mean and standard deviation values. Categorical variables were presented as counts and proportions. Self-reported data included education level, smoking status, gender and income. Measured data includes blood pressure, weight, height and abdominal circumference as well as biochemical tests for hyperlipidemia, diabetes and kidney disease definition.

2.6. Statistical analysis

The 10-year cardiovascular disease (CVD) risk scores were calculated using the WHO/ISH cardiovascular risk score chart[38] taking into consideration the following risk factors: age, gender, smoking status, systolic blood pressure, diabetes mellitus status (based on hemoglobin A1C), total cholesterol level, and WHO Epidemiological Subregion.[39] Haiti is in the Americas subregion D, along with the five other poorest countries in the Western Hemisphere. The CVD risk scores were predicted in the following categories: < 10%, 10% to < 20%, 20% to < 30%, 30% to < 40%, and ≥ 40%.

Associations between participant characteristics and CVD risk scores were analyzed using the Mantel-Haenzsel odds ratio and the chi-squared test. Ordinal logistic regression was then performed by controlling factors of age, BMI, gender, education, income, and region (urban and rural).

2.7. Ethics

This study was approved by La Comité National de Bioéthique at the Haitian Medical Association (1415-54) and the Institutional Review Board at the University of Florida (IRB201400437). Written informed consent was obtained from all participants before participation in the study.

3. Results

The age of study participants ranged from 25 to 65 years, with a mean age of 40.8 years (39.9 urban, 42.5 rural). Women made up 60.5% of participants (59.9% urban, 61.5% rural).

Ten-year CVD risk scores were calculated based on 1427 subjects from the urban area and 725 subjects from the rural area, a combined 2152 participants. For blood pressure, 2104 completed two measurements, 2074 were measured for height, weight, and waist circumference, 1858 had hemoglobinA1C for diabetes, 1980 had creatinine, and 1819 had cholesterol. As a result, only 993 urban and 710 rural had complete data for this analysis (Table 2). The rural community health workers were better trained and with closer daily supervision, resulting in the higher rate of success with the blood tests than their urban counterparts.

We present the overall 10-year CVD risk by gender or location in Table 3 and disaggregated by gender and location in Table 4.

To investigate the association between CVD risk score and other risk factors, we performed ordinal logistic regression by controlling factors of age, BMI, gender, education, monthly income (converted to US dollars with exchange rate used during date of data collection), and region (urban and rural) results are in Table 5. Based on Table 5, we conclude when a subject's age increases 1 year, the odds of CVD risk score moving from one risk category to another (i.e. < 10%" probability to "10% to < 20%" probability), are multiplied by 1.113 given that all of the other variables in the model are held constant and the difference is statistically significant ($p < 0.001$). Similarly, when a subject's BMI increases by 1 unit, the above odds of CVD risk score moving probabilities are multiplied by 1.023 given that all of the other variables in the model are held constant and the difference is

Table 2
Biochemical test results by location.

Variable	Urban (n = 1427)	Rural (n = 725)
	Mean (SD)	Mean (SD)
Age (years)	39.9 (11.8)	42.5 (11.7)
BMI (kg/m^2)	23.3 (5.5)	22.1 (4.5)
Systolic1 (mm Hg)	124.7 (21.9)	124.6 (21.8)
Systolic2 (mm Hg)	123.5 (31.2)	120.6 (21.1)
Diastolic1 (mm Hg)	79.6 (15.2)	79.0 (15.1)
Diastolic2 (mm Hg)	79.1 (28.5)	76.7 (14.4)
Total Cholesterol (mg/dL)	145.8 (41.5)	145.9 (39.3)
HDL (mg/dL)	41.4 (16.9)	43.1 (16.5)
Triglycerides (mg/dL)	103.9 (58.5)	106.0 (61.6)
Creatinine (mg/dL)	1.1 (3.4)	1.0 (2.7)
HemoglobinA1C (% HbA1c)	5.9 (1.3)	6.1 (1.1)

Table 3
Overall 10-year CVD risk score distribution by gender or location.

	% (N)	Men % (N)	Women % (N)	Urban % (N)	Rural % (N)
< 10%	75% (1284)	80% (529)	72% (742)	77% (768)	73% (516)
10% to < 20%	15% (262)	12% (78)	18% (180)	13% (133)	18% (129)
20% to < 30%	5.0% (85)	3.5% (23)	5.9% (61)	5.1% (51)	4.8% (34)
30% to < 40%	1.3% (23)	1.9% (12)	1.1% (11)	1.0% (10)	1.8% (13)
≥40%	2.9% (49)	2.6% (17)	3.1% (32)	3.1% (31)	2.5% (18)

Table 4
10-Year CVD risk score disaggregated by location and gender.

		Urban % (N)	Rural % (N)
Men	< 10%	83% (337)	76% (192)
	10% to < 20%	10% (39)	15% (39)
	20% to < 30%	3.0% (12)	4.3% (11)
	30% to < 40%	1.5% (6)	2.4% (6)
	≥40%	3.0% (12)	2.0% (5)
Women	< 10%	73% (431)	71% (311)
	10% to < 20%	16% (94)	20% (86)
	20% to < 30%	6.6% (39)	5.0% (22)
	30% to < 40%	0.7% (4)	1.6% (7)
	≥40%	3.2% (19)	3.0% (13)

marginally significant (p = 0.060). Similar interpretations for gender, location, education and income variables can be similarly obtained from the table.

4. Discussion

As published previously, the prevalence rates of hypertension, diabetes and chronic kidney disease were 15.6% (± 2.9%), 19.7% (± 1.6%) and 12.3% (± 2.7%), respectively.[29] Of the three non-communicable diseases (NCDs), only diabetes showed a significant difference between rural and urban sites (p = 0.000), with the rural site (23.1%) having a higher prevalence than the urban site (16.4%). The results of our study include first time estimates of chronic kidney disease prevalence, prediabetes, diabetes prevalence in both rural and urban populations and add more robust knowledge of hypertension prevalence. Compared to other CVD risk studies in other low-income countries, Haiti had much higher rates of those with > 20% 10-year risk for a cardiovascular event with 9.2% in a general population cohort. Previous estimates of > 20% 10-year risk for cardiovascular events in African descendant populations include 2.1% in Malawi[17,18] and 1.8% in Burkina Faso in HIV-positive cohorts,[19] 7.2% in a diabetic population in Cameroon,[20] and 4.6% in the general population Cuba, a middle-income Caribbean country.[22] The Haiti rate for those with > 20% 10-year risk for a cardiovascular event is similarly high across gender and location. Based on the few results in other low-income countries, this is higher than might have been expected, especially for cohort with mean age of 40 years.

There are few comprehensive studies on NCDs in low-income countries to date; the baseline study by DeGennaro et al. is one of the largest and most comprehensive studies to date. The use of point of care biochemical testing allowed us to calculate the CVD risk groups in a novel way for a low-income country as well. Recent work by Orantes-Navarro used laboratory obtained biochemical testing to define CKD prevalence in El Salvador[41]; the sheer volume of work that may be at least partially avoided by point of care testing may aid in researchers to define local prevalence of developing communities. The other studies mentioned in the introduction relied on subsets of the general population like those with HIV or diabetes, limiting generalizability. In addition, the biochemical measurements were done specifically for this study, collected through prospective door to door sampling, with a consistent protocol and identical machines that might not have been observed in a clinic population using public health resources. While too small to claim that this is a nationally representative sample, the data on CVD risk is important to Haiti and likely to other low-income countries in the Caribbean and Africa with largely black populations. With the data, the Haitian government and healthcare providers in general can plan for treatment on a population and individual level. In a resource-poor environment, public health planning can help reduce unnecessary testing and increase positive predictive value where laboratory testing quality can be quite variable.

Such a higher percentage of people at risk for a CVD event has a profound impact on the number of people in need of treatment for the underlying risk factors. All those with > 20% 10-year risk for a cardiovascular event should be treated for hypertension for a goal of less than 140/90 mmHg and treatment of all those with diabetes, which is one in five Haitian adults. These data also can also help to determine potential primary prevention interventions with aspirin therapy in

Table 5
Logistic regression by variable.

Covariate (N = 2152)		OR	95% CI	p-value
Age		1.113	(1.099, 1.128)	< 0.001
BMI (nominal)		1.023	(0.999, 1.047)	0.060
Men (vs Women)		0.577	(0.440, 0.754)	< 0.001
Urban (vs Rural)		1.023	(0.783, 1.339)	0.865
Education	No formal schooling	0.575	(0.185, 1.977)	0.354
	Less than primary school	0.415	(0.129, 1.466)	0.151
	Primary school	0.518	(0.167, 1.778)	0.269
	Secondary school	0.499	(0.159, 1.728)	0.247
	University	0.330	(0.085, 1.340)	0.111
Monthly Income	Don't Know	1.121	(0.670, 1.901)	0.668
	Less than $25	1.030	(0.642, 1.688)	0.904
	$25-50	0.922	(0.537, 1.601)	0.770
	$51-$250	0.958	(0.499, 1.832)	0.897
	$251-500	1.232	(0.254, 4.468)	0.769
	More than $500	0.177	(0.009, 1.086)	0.118

those qualifying participants. Statins are not widely available in Haiti, largely because cholesterol testing itself is more expensive and out of reach financially for most of the population. However, WHO recognizes that treating all those with > 20% risk would lead to expensive over-treatment and recommends only treating those with serum cholesterol above 320 mg/dl.

Haitian men had a significantly lower 10-year risk for a cardiovascular event than Haitian women, which makes sense given that women had significantly higher rates of all CVD risk factors with the exception of smoking.[25] This did not vary between urban and rural locations. Reasons for this may include less physical activity in women, child-bearing and subsequent weight gain, and standards of beauty that generally value a higher BMI than 25kg/m2. This is an area where further study is needed as no other low-income country studies address these factors.

Age was a significant risk factor which is to be expected. BMI would also be expected to be an independent risk factor but was just shy of significance at $p = 0.06$. This may be secondary to sample size to inadequately detect a significant difference.

There was a non-significant trend towards lowest CVD risk in the most educated and wealthiest. It does not appear that the trend held up across all income and education levels, but that the highest in each was nearly significantly different than the others. Culturally, there is a large difference between a university-educated person or someone making more than $500 and the lower groups in each category. In addition, income over $500 makes someone solidly in the middle class in Haiti, which usually also signifies that they come from the professional class. Again, more research is needed to further explore these issues in low-income countries.

We found no difference between urban and rural as traditional wisdom might expect[42–46] but this mirrors the similarities in each risk factor between the two locations. In Haiti at least, it appears as though significant NCD prevalence has expanded into rural areas and similar prevention, screening, and treatment programs must be put in place to combat the rising epidemic of CVD.

Instead of blood glucose, we used HbA1c to diagnose prediabetes and diabetes to eliminate inaccuracies due to ingestion of food or drink and the inability to control for last oral intake. This method also allowed us to diagnose diabetes in one visit instead of two, important for rural populations. We have previously determined through bootstrap analysis that this did not affect the estimated prevalence of diabetes.[29] The 19.7% prevalence of diabetes played a large role in the high prevalence of those with risk > 20%.

There are several strengths and a few limitations of the study. Blood pressure was used as an average of two blood pressure measurements during one visit. This was done secondary to logistical issues of returning to households for repeat measurements. Often vast distances of rural communities had to be covered and this was a limitation we accepted in our study. Point of care biochemical tests were used for definition of diabetes and dyslipidemia. Much of the equipment needed to be refrigerated while in field, which is different than primary care centers that they were designed for. POCT for HbA1c,[47,48] creatinine[49,50] and cholesterol (total, HDL, TGs)[51,52] has been well validated as comparable to that in laboratory setting. (insert citations, this was copied and pasted from previous paper). Most limitations of the overall study are addressed elsewhere.[29,37] For this subset analysis, an additional limitation is that the WHO/ISH has not been validated in Haiti nor in low-income countries. Some of our data was self-reported which is susceptible to patient's honesty and perhaps cultural reservation on discussing alcohol use, smoking and food choice.

Available risk prediction tools are not based on the population cohort presented in our study, in that 100% of the population surveyed was of African descent in a developing nation. We cannot be sure about the accuracy of the risk prediction; however, the data collected by the Haiti Health Study is aimed at being longitudinal and will allow for follow-up of these populations, although a much smaller population than the Framingham Study. However, with the advent of newer measurement technologies and availability of tracking participants electronically or through the internet, perhaps we are entering a period of time when a greater number of data will be collected on people in low-income countries. Therefore, these estimates are of limited use in informing healthy policy or resource allocation but remain our best estimate to date.

5. Conclusions

The prevalence rates of hypertension, diabetes and chronic kidney disease were 15.6% (± 2.9%), 19.7% (± 1.6%) and 12.3% (± 2.7%) respectively. CVD risk analysis of 1703 patients showed > 20% 10-year risk of CVD in 9.2% of the population and > 40% in 2.9%. CVD risk factor data is lacking in nearly all low-income countries. This relatively low-cost study[36] provides a road map for other low-income countries to calculate population-based CVD risk, a necessary first step to planning for national programs to address NCDs and CVD risk factors. Given Haiti's high prevalence of > 20-year CVD risk, treatment of NCDs and the other CVD risk factors, particularly in women, is an urgent public health need.

Disclosures

The authors have declared that no competing interests exist.

Declaration of competing interest

All authors have no conflict of interest to report.

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References

1. Saldivar F, Clark BA, Laslett LJ, et al. The worldwide environment of cardiovascular disease: prevalence, diagnosis, therapy, and policy issues. *J Am Cardiol.* 2012;60(25):S1–S49. https://doi.org/10.1016/j.jacc.2012.11.002.
2. Moran A. Latin America & caribbean CVD RIsk. *Global Heart.* 2014;9(1):35–40. https://doi.org/10.1016/j.gheart.2014.03.2444.
3. WHO. *Fact Sheet: Cardiovascular Diseases (CVDs).* WHO; 2017https://doi.org/10.1002/oby.21009.
4. Benziger CP, Roth GA, Moran AE. The global burden of disease study and the preventable burden of NCD. *Global Heart.* 2016;11(4):393–397. https://doi.org/10.1016/j.gheart.2016.10.024.
5. Organization WH. *WHO | Noncommunicable Diseases Country Profiles 2014.* WHO; 2014 ISBN 9789241564854.
6. Dawber TR, Meadors GF, Moore FE. Epidemiological approaches to heart disease: the Framingham Study. *Am J Publ Health.* 1951;41(3):279–281. https://doi.org/10.2105/AJPH.41.3.279.
7. Lloyd-Jones DM, Wilson PWF, Larson MG, et al. Framingham risk score and prediction of lifetime risk for coronary heart disease. *Am J Cardiol.* 2004;94(1):20–24. https://doi.org/10.1016/j.amjcard.2004.03.023.
8. Boateng D, Agyemang C, Beune E, et al. Cardiovascular disease risk prediction in sub-Saharan African populations — comparative analysis of risk algorithms in the RODAM study. *Int J Cardiol.* 2018;254:310–315. https://doi.org/10.1016/j.ijcard.2017.11.082.
9. Hemann BA, Bimson WF, Taylor AJ. The Framingham Risk Score: an appraisal of its benefits and limitations. *Am Heart Hosp J.* 2007;5(2):91–96. https://doi.org/10.1111/j.1541-9215.2007.06350.x.
10. Ofori SN, Odia OJ. Risk assessment in the prevention of cardiovascular disease in low-resource settings. *Indian Heart J.* 2016;68(3):391–398. https://doi.org/10.1016/j.ihj.2015.07.004.
11. Alderman M, Lim S, Whitworth J, et al. World Health Organization (WHO) and International Society of Hypertension (ISH) risk prediction charts: assessment of cardiovascular risk for prevention and control of cardiovascular disease in low and middle-income countries. *J Hypertens.* 2007;25(8):1578–1582. https://doi.org/10.1097/hjh.0b013e3282861fd3.
12. World Health Organization. *WHO/ISH Cardiovascular Risk Prediction Charts Strengths and Limitations.* World Health Organization; 2011.
13. Mendis S, Lindholm LH, Anderson SG, et al. Total cardiovascular risk approach to improve efficiency of cardiovascular prevention in resource constrained settings. *J*

Clin Epidemiol. 2011. https://doi.org/10.1016/j.jclinepi.2011.02.001.
14. Paia NN, Meenakshi G. *Metabolic Syndrome Risk Assessment Among Adults in Udupi District, Karnataka, Clinical Epidemiology and Global Health.* 8 June 2019; 8 June 2019https://doi.org/10.1016/j.cegh.2019.06.003.
15. Khursheed H, Mohydin B, Fawwad A, Waris N, Jawaide M. Predicting the risk of atherosclerotic cardiovascular disease (ASCVD) in Pakistani population. *Clin. Epidemiol. Global Health.* June 2019;7(2):184–187.
16. Nikbakht H, Rezaianzadeh A, Seif M, Ghaem H. *Prevalence of Metabolic Syndrome and its Components Among a Population-Based Study in South of Iran, Persian Kharameh Cohort Study.* Clinical Epidemiology and Global HealthIn press; 16 January 2020 corrected proofAvailable online.
17. Harries AD, Kathyola D, Msyamboza KP, et al. The burden of selected chronic non-communicable diseases and their risk factors in Malawi: nationwide STEPS survey. *PloS One.* 2011;6(5):e20316. https://doi.org/10.1371/journal.pone.0020316.
18. Divala OH, Amberbir A, Ismail Z, et al. The burden of hypertension, diabetes mellitus, and cardiovascular risk factors among adult Malawians in HIV care: consequences for integrated services. *BMC Publ Health.* 2016;16(1):1–11. https://doi.org/10.1186/s12889-016-3916-x.
19. Sanou S, Konate A, Hema A, et al. Syndrome métabolique et risque cardiovasculaire chez des patients sous antirétroviraux à l'hôpital de jour de Bobo-Dioulasso (Burkina Faso)Metabolic syndrome and cardiovascular risk patients under antiretrovirals in a hospital day at Bobo-Dioulasso (Burki. *Bull la Société Pathol Exot.* 2014;107(3):151–158. https://doi.org/10.1007/s13149-014-0371-8.
20. Kengne AP, Dehayem M, Choukem SP, Awah P, Mbanya J-C. Application of the modified Framingham cardiovascular risk score to newly diagnosed type 2 black African diabetic patients. *Cardiovasc J Africa.* 2007;18(4):234–237.
21. Chilunga FP, Boateng D, Henneman P, et al. Perceived discrimination and stressful life events are associated with cardiovascular risk score in migrant and non-migrant populations: the RODAM study. *Int J Cardiol.* 2019. https://doi.org/10.1016/j.ijcard.2018.12.056 xxxx.
22. Nordet PR, Mendis S, Duenas a, et al. Total cardiovascular risk assessment and management using two prediction tools, with and without blood cholesterol. *MEDICC Rev.* 2013.
23. Samuels TA, Guell C, Legetic B, Unwin N. Ethnicity & Health Policy initiatives, culture and the prevention and control of chronic non-communicable diseases (NCDs) in the Caribbean. 2015;17(6) https://doi.org/10.1080/13557858.2012.752072.
24. Freeman V, Fraser H, Forrester T, et al. A comparative study of hypertension prevalence, awareness, treatment and control rates in St Lucia, Jamaica and Barbados. *J Hypertens.* 1996.
25. Pierce L, Shannon A, Sonnenfeld J, Pearlmutter M, Previl H, Forrester JE. Hypertension prevalence and knowledge assessment in rural Haiti. *Ethn Dis.* 2014;24(2):213–219.
26. Jean-Baptiste ED, Larco P, Charles-Larco N, Vilgrain C, Simon D, Charles R. Glucose intolerance and other cardiovascular risk factors in Haiti (PREDIAH). *Diabetes Metabol.* 2006;32(5):443–451. https://doi.org/10.1016/S1262-3636(07)70302-6.
27. Lluberas G, Parrish LA, Kling CM. Hypertension prevalence in a rural Haitian missionary clinic. *Nurs Pract.* 2000;25:59–61.
28. Martin P. Describing the chief complaints in a mobile, primary care clinic in Haiti: using data to enlighten the knowledge of the burden of non-communicable diseases. *141st APHA Annual Meeting (November 2-November 6, 2013).* 2013; 2013.
29. DeGennaro Jr V, Malcolm S, Crompton L, et al. Community-based diagnosis of non-communicable diseases and their risk factors in rural and urban Haiti: a cross-sectional prevalence study. *BMJ Open.* 2018;8:e020317. https://doi.org/10.1136/bmjopen-2017-020317.
30. World Bank. *Rural Population (% of Total Population) – Haiti.* 2018; 2018.
31. Kish L. A procedure for objective respondent selection within the household. *J Am Stat Assoc.* 1949;44:380–387.
32. World Health Organization. STEPS Instruments for NCD Risk Factors (Core and Expanded Version 1.4): The WHO STEPwise Approach to Surveillance of Noncommunicable Diseases (STEPS). Geneva: World Health Organization.
33. *Omron 7 Series wrist blood pressure monitor (BP652).* Omron Healthcare; 2018 https://www.omronhealthcare.ca/products/7- series-wrist-blood-pressure-monitor-bp652/ cited 3 Jan 2018.
34. World Health Organization. WHO STEPS Surveillance Manual: The WHO STEPwise Approach to Chronic Disease Risk Factor Surveillance. Geneva: World Health Organization.
35. A1c Now+. Polymer technology Systems. Ptsdiagnostics-apps.com. http://ptsdiagnostics-apps.com/product_labeling/a1cnow_ professional/user_guides/A1CNOW_Pro_UG_PN-9708.pdf; 2018 cited 3 Jan 2018.
36. CardioChek Lipid Test. *Polymer Technology Systems.* Ptsdiagnostics.com; 2018 http://www.ptsdiagnostics.com/uploads/2/6/2/8/26289179/ps-002461_en_rev._4_user_guide_cardiochek_pa. pdf cited 3 Jan 2018.
37. Malcolm S, Cadet J, Crompton L, DeGennaro Jr V. A model for point of care testing for non-communicable disease diagnosis in resource-limited countries. *Global Health, Epidemiol Genom.* 2019;4(e7):1–6. https://doi.org/10.1017/gheg.2019.6.
38. Collins D, Lee J, Bobrovitz N, et al. whoishRisk – an R package to calculate WHO/ISH cardiovascular risk scores for all epidemiological subregions of the world [version 2; peer review: 3 approved]. *F1000Res.* 2017;5:2522. https://doi.org/10.12688/f1000research.9742.2.
39. World health organization/international society of hypertension (WH0/ISH) risk prediction charts. Figure 7, page 15 https://www.who.int/ncds/management/WHO_ISH_Risk_Prediction_Charts.pdf?ua=1.
40. American Diabetes Association. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes—2018. *Diabetes Care.* 2018 Jan 1;41(Supplement 1):S13–S27.
41. Orantes-Navarro CM, Almaguer-López MM, Alonso-Galbán P, et al. The chronic kidney disease epidemic in El Salvador: a cross-sectional study. *MEDICC Rev.* 2019.
42. Abegunde KA1, Owoaje ET. Health problems and associated risk factors in selected urban and rural elderly population groups of South-West Nigeria. *Ann Afr Med.* 2013 Apr-Jun;12(2):90–97. https://doi.org/10.4103/1596-3519.112398.
43. Siddharthan T, Grigsby M, Morgan B, et al. Prevalence of chronic respiratory disease in urban and rural Uganda. *Bull World Health Organ.* 2019 May 1;97(5):318–327. https://doi.org/10.2471/BLT.18.216523 Epub 2019 Mar 26.
44. Bello AK, Hemmelgarn B, Lin M, et al. Alberta Kidney Disease Network. Impact of remote location on quality care delivery and relationships to adverse health outcomes in patients with diabetes and chronic kidney disease. *Nephrol Dial Transplant.* 2012 Oct;27(10):3849–3855.
45. Ru X, Wang W, Sun H, et al. GeographicalDifference, rural-urban transition and trend in stroke prevalence in China: findings from a national epidemiological survey of stroke in China. *Sci Rep.* 2019 Nov 22;9(1):17330. https://doi.org/10.1038/s41598-019-53848-1.
46. Oyebode Oyinlola, Pape Utz J, Laverty Anthony A, Lee John T, Bhan 1 Nandita, Millett Christopher. Rural, urban and migrant differences in non-communicable disease risk-factors in middle income countries: a cross-sectional study of WHO-SAGE data. *PloS One.* 2015;10(4):e0122747. https://doi.org/10.1371/journal.pone.0122747 Published online 2015 Apr 7.
47. Knaebel J, Irvin BR, Xie CZ. Accuracy and clinical utility of a point-of-care HbA1c testing device. *Postgrad Med.* 2013;1*25*. https://doi.org/10.3810/pgm.2013.05.2664 91–8.
48. Leal S, Soto-Rowen M. *Usefulness of Point-Of-Care Testing in the Treatment of Diabetes in an Underserved Population.* SAGE Publications; 2009.
49. Shephard MD. Point-of-Care testing and creatinine measurement. *Clin Biochem Rev.* 2011;32:109.
50. Service. *N.N.H. Point of Care Tests for the Measurement of Blood Creatinine (CEP10042).* London: NHS and Supply Agency; 2010.
51. Batki AD, Nayyar P, Thomason HL. *Buyer's guide: point-of-care testing for cholesterol measurement.* NHS Purchasing and Supply Agency: Center for Evidence-based Purchasing. CEP; 2009:*9020*.
52. Plüddemann A, Thompson M, Price CP, et al. Point-of-care testing for the analysis of lipid panels: primary care diagnostic technology update. *Br J Gen Pract.* 2012;62:224–226. https://doi.org/10.3399/bjgp12X630241.