

Socioeconomic determinants of cardiovascular risk in underserved communities

Frederick Murunga Wekesah



Socioeconomic determinants of cardiovascular risk in underserved communities

Frederick Murunga Wekesah

Colofon

Socioeconomic determinants of cardiovascular risk in underserved communities

ISBN/EAN: 978-90-393-7220-3

Copyright © 2019 Frederick Murunga Wekesah

All rights reserved. No part of this thesis may be reproduced, stored or transmitted in any way or by any means without the prior permission of the author, or when applicable, of the publishers of the scientific papers.

Cover design and layout by David de Groot | Persoonlijkproefschrift.nl

Printed by Ipskamp Printing | Proefschriften.net

Scholarship award was received from the Global Health Support program of the University Medical Center Utrecht. The author wishes to gratefully acknowledge financial support from the Julius Center for Health Sciences and Primary Care for the publication of this thesis.

Socioeconomic determinants of cardiovascular risk in underserved communities

**Sociaal-economische determinanten en cardiovasculair risico in
achtergestelde gemeenschappen**

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de
Universiteit Utrecht
op gezag van de
rector magnificus, prof.dr. H.R.B.M. Kummeling,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen op

maandag 25 november 2019 des ochtends te 10.30 uur

door

FREDERICK MURUNGA WEKESAH

geboren op 7 januari 1982
te Trans Nzoia, Kenya

Promotor

Prof. dr. D.E. Grobbee

Copromotoren

Dr. K. Klipstein-Grobusch

Dr. C.K. Kyobutungi

This is for Prisca Nasiebanda Wekesa, my grandmother and friend.
The prayerful Matriarch and 'daughter of God', shining down on
your favorite grandson from heaven.

TABLE OF CONTENTS

Chapter 1	9
General introduction	
Part 1 Risk factors for non-communicable diseases in Kenya	
Chapter 2	23
Individual and household level factors associated with presence of multiple non-communicable disease risk factors in Kenyan adults	
Chapter 3	47
Patterns of non-communicable disease and injury risk factors in Kenyan adult population: a cluster analysis	
Part 2 Understanding of and perception towards non-communicable and cardiovascular diseases risk factors	
Chapter 4	77
Knowledge and awareness of and perception towards cardiovascular diseases risk in sub-Saharan Africa: a systematic review	
Chapter 5	123
The connection between non-communicable disease risk factors and risk perception among slum dwellers in Nairobi, Kenya	
Chapter 6	139
Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi	
Part 3 Cardiovascular diseases risk assessment in the slums of Nairobi	
Chapter 7	169
Comparative performance of pooled cohort equations and Framingham risk scores in cardiovascular disease risk classification in a slum setting in Nairobi Kenya	

Part 4 Mortality due to cardiovascular diseases in the slums of Nairobi

Chapter 8 **189**

Determinants of mortality from cardiovascular disease in the slums of Nairobi, Kenya

Chapter 9 **209**

General discussion

Chapter 10 **217**

Summary

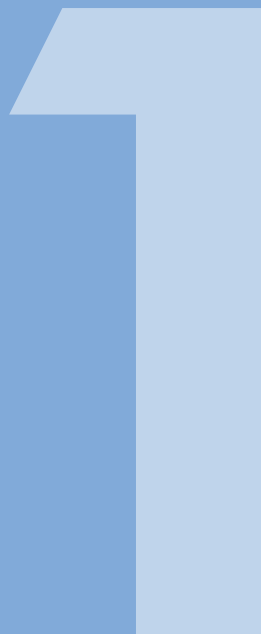
Nederlandse samenvatting

Acknowledgements

Curriculum Vitae and list of publications

Chapter 1

General introduction



BACKGROUND AND OBJECTIVES

The World Health Organization reports that 41 million people die each year from non-communicable diseases (NCDs), which is equivalent to 71% of all deaths globally [1]. Currently, 85% of NCD deaths among individuals aged 30 – 69 occur in low- and middle-income countries (LMICs). By 2030, NCDs will surpass communicable diseases (CD) as the leading cause of death [2-4].

Among the NCDs, special attention is given to cardiovascular disease (CVD) which comprise coronary heart disease (CHD), cerebrovascular disease (e.g. stroke), peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolism [5]. Current data shows that CVD are the singular leading cause of death globally, causing an estimated 17.9 million deaths in 2016, which translated to 31% of all deaths. Eighty-five percent of these CVD deaths were due to heart attack and stroke. Premature deaths i.e. deaths among individuals aged below 70 years were million [6]. Estimates indicate that LMICs carry most of the CVD burden [6].

There is a paucity of data on trends and magnitude of CVD in sub-Saharan Africa (SSA). Data from 2013 reports that SSA's one million deaths from CVD accounted for 11.3% of deaths from all causes in the region, and 5.5% of global CVD deaths, with projections showing that the number will double by the end of the next decade [7].

Risk factors for cardiovascular diseases

Non-modifiable risk factors for CVD include age, sex, and family history. Modifiable risk factors are either classified as behavioral and include tobacco use physical inactivity, harmful alcohol consumption and unhealthy diet; or physiological and include high blood pressure, obesity, dyslipidemia and diabetes [8]. These risk factors often cluster and interact to promote the occurrence of CVD in an individual [9].

Drivers and determinants of cardiovascular disease morbidity and mortality

The burden of CVD is growing in SSA as a result of population growth, increasing average age of the region's population, decreasing age-, sex- and cause-specific death rates [10], and the epidemiological transition [7, 11-13].

SSA is rapidly urbanizing. Africa's urban population is projected to reach 60% in 2050. The sustained rural-urban migration of the population seeking livelihood opportunities in urban areas has resulted in the emergence of slums - informal settlements characterized by absence of adequate infrastructure and basic services, rampant poverty, poor living conditions and widespread insecurity and crime [14, 15]. According to the UN-Habitat, approximately 62% of urban dwellers in SSA live in slum or slum-like conditions [16-18]. In Kenya, the number is about half of the urban population [19].

Slums in Kenya are informal settlements and in some cases are classified as illegal settlements. They are therefore systematically alienated. Residents of slums lack access to quality health care, water and proper sanitation, education and employment, public sector and law enforcement agencies. The built and social environment in the slums serves to promote CVD. Many slum communities lack play grounds because of the way the living structures are organized. The food market in the slums is also supplied with relatively cheap and low quality, unhealthy, and sometimes energy-dense products. Urban slum dwellers are also exposed to tobacco smoking, and high levels of indoor and outdoor pollution [20, 21]. As a consequence, the prevention and control of CVD in such populations is harder, making CVD a serious health threat to urban slum dwellers [22].

Cardiovascular disease risk factors are prevalent in slums and other poor communities. A study conducted in 2010 in the slums in Nairobi recorded the prevalence of diabetes at 5.3% and hypertension at 22.8% among individuals 18 years or older respectively, with diabetes doubling to 10.5% among individuals aged 45 – 54 years. Obesity, high waist circumference, harmful alcohol consumption and tobacco smoking were also high [23, 24]. Other studies conducted between 2008 and 2012 in the same settings reported on the prevalence of central obesity (12.3%), hypercholesterolemia (10.3%), hypertriglyceridemia [25], and on unhealthy diet (57.2%), insufficient physical activity (14.4%), harmful alcohol consumption (10.1%) and tobacco use (12.4%) [26-28]. Level of awareness, treatment and control of diabetes and hypertension in these settings was low [27, 28].

Contribution of poverty to risk and mortality from cardiovascular diseases

Slum dwellers in SSA suffer a disproportionately higher burden of CVD compared to their rural counterparts, and are affected by significant disparities in access to health care. As noted above, important factors that are linked with CVD are widely documented in such populations. Underlying this situation is rampant poverty, which has been linked

in literature as both a cause and outcome of CVD [29]. Evidence shows that the poor, no matter where they live, are at a disproportionately increased risk of developing and dying from CVD compared to the non- poor [30-32].

Prevention, diagnosis, treatment and control of cardiovascular diseases

The burden of complications and deaths resulting from CVD among the urban poor can be reduced if screening for the conditions and treatment were made available. Long term care involving drugs for treatment and management of the conditions has worked effectively in many settings. Regardless, newer strategies that are proactive, patient-centered, community-based, and sustainable for prevention and treatment of CVD are required to address the burden of CVD in underserved communities [33, 34]. Individual level interventions that include lifestyle adjustment, respectively modification (diet, exercise, smoking cessation, alcohol intake reduction) when combined with measures that target physiological risk factors such as drugs for treatment of high blood pressure, elevated blood glucose and cholesterol are required, and will result in high returns of investment when combined with population-level interventions [35-38].

Risk perception and awareness in the care-seeking and treatment-adherence for cardiovascular diseases

Misperception of risk, that is the discordance between the estimated and perceived risk for CVD in an individual, and low levels of awareness of risk factors (even by those who are aware of their condition), insufficient opportunities for screening and access to care and essential treatment are some of the barriers to optimal prevention and management of CVD in underserved and socially deprived settings in SSA [28, 39-41]. It follows therefore that the understanding of and addressing perceptions on CVD and the risk factors can inform the design and tailoring of effective context-specific interventions that can enhance the prevention and control for CVD in SSA.

Risk assessment for cardiovascular disease and effective risk communication

There are benefits linked to screening for well-known CVD risk factors, the identification of individuals at high-risk, in communicating risk effectively, and in motivating adherence to treatment and risk mitigation [42]. Incorporating the absolute risk approach is a proactive preventive strategy that could potentially have a major impact in lowering the incidence and the burden of CVD in resource-constrained settings [42]. CVD risk scores have been

developed and are used in clinical practice globally, a number of which currently exist [43-49].

Very few of existing risk assessment functions are however modifiable or applicable to populations in SSA [8, 48, 50]. The implication of this finding is that novel and context-appropriate functions, with simpler non-laboratory versions for use in under-resourced and rural settings need to be developed and deployed for use in primary health care settings in SSA. There is also need to check what potential role context-specific socioeconomic factors which have been linked to CVD, can play in the development of risk functions for use in these settings.

Urbanization and the emergence slums will keep occurring in SSA in the coming decades. By 2050, more people will be living in urban areas compared to rural areas, most of them in the slums. Complications and deaths from CVD will keep growing. It therefore obtains that understanding of and characterizing the CVD risk profile of the urban slum populations can help generate evidence to inform the thinking, design and implementation of interventions to prevent, treat and control CVD. Exploring the understanding of and perceptions towards cardiovascular diseases, and their risk factors while paying attention to the role socioeconomic determinants in the form of literacy, education, employment and livelihood opportunities and the influence on care-seeking and treatment adherence would thus help us shed light on barriers to awareness and understanding of CVD risk and the risk factors, the mechanisms through which CVD outcomes happen, and barriers and facilitator's to care-seeking and treatment adherence for CVD. Ultimately, we are able to generate useful evidence for CVD prevention and control in underserved communities in SSA.

OBJECTIVES OF THE RESEARCH

This research aims to characterize the cardiovascular disease risk profile of an urban poor population in Nairobi, Kenya by:

- i) exploring the knowledge, understanding and perception towards non-communicable and cardiovascular disease risk and risk factors in sub-Saharan Africa and in the slums of Nairobi;
- ii) studying the factors associated with co-occurrence of and the patterns in the distribution/clustering of NCD risk factors in a Kenyan population;
- iii) describing individual level behavioral, physiological and socioeconomic factors associated with CVD mortality in slums of Nairobi; and
- iv) testing the performance of existing CVD risk scores in risk assessment and classification in an urban slum population in Nairobi.

Outline of the thesis

This PhD thesis addresses three main issues: perceptions towards and understanding of non-communicable and cardiovascular disease risk factors in SSA and in the slums of Nairobi, the individual level factors associated with CVD mortality and CVD risk assessment using available CVD risk scores in a slum community. Part one (chapters 2 & 3) describes the factors associated with co-occurrence of multiple NCD risk factors, and the pattern and distribution in the Kenyan population. Part two (chapters 4 to 6) presents the understanding of and perception towards non-communicable and cardiovascular diseases and their risk factors in SSA and in the slums of Nairobi by employing a systematic review and a phenomenological qualitative study, respectively. In part three (chapter 7) we analyze the predictive performance of the pooled cohort equations (PCE) and the Framingham risk score (FRS) in cardiovascular disease risk stratification in the urban slum population, comparing the 2013 PCE to the revised PCE (2018) and FRS non-laboratory scores. The analysis of individual level behavioral, physiological and socioeconomic factors associated with mortality from CVD in the urban slum community is presented in part four (chapter 8).

REFERENCES

1. World Health Organisation. *Noncommunicable diseases*. 1 June 2018 [cited 2019 17 June]; Available from: <https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases>.
2. Lopez, A.D., et al., *Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data*. The Lancet, 2006. **367**(9524): p. 1747-1757.
3. Boutayeb, A., *The double burden of communicable and non-communicable diseases in developing countries*. Transactions of The Royal Society of Tropical Medicine and Hygiene, 2006. **100**(3): p. 191-199.
4. Murray, C. and A.D. Lopez, *Summary: The global burden of disease: A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020*. Geneva and Boston: World Health Organization and Harvard School of Public Health, 1996.
5. Roth, G.A., et al., *Global and regional patterns in cardiovascular mortality from 1990 to 2013*. Circulation, 2015. **132**(17): p. 1667-1678.
6. World Health Organisation. *Cardiovascular diseases (CVDs)*. 2017 17 May 2017 [cited 2019 12/06]; Available from: [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)).
7. Mensah, G.A., et al., *Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: a systematic analysis of data from the Global Burden of Disease Study 2013*. Cardiovasc J Afr, 2015. **26**(2 Suppl 1): p. S6-10.
8. Yusuf, S., et al., *Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study*. The Lancet, 2004. **364**(9438): p. 937-952.
9. D'Agostino, R.B., et al., *General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study*. Circulation, 2008. **117**(6): p. 743-753.
10. Lozano, R., et al., *Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010*. The Lancet, 2013. **380**(9859): p. 2095-2128.
11. Nulu, S., W.S. Aronow, and W.H. Frishman, *Hypertension in Sub-Saharan Africa: A contextual view of patterns of disease, best management and systems issues*. Cardiol Rev, 2015.
12. Tibazarwa, K.B. and A.A. Damasceno, *Hypertension in developing countries*. Can J Cardiol, 2014. **30**(5): p. 527-33.
13. Roth, G.A., et al., *Demographic and epidemiologic drivers of global cardiovascular mortality*. N Engl J Med, 2015. **372**(14): p. 1333-41.

14. Pawar, A.B., P.V.T.K. Mohan, and R.K. Bansal, *Social determinants, suboptimal health behavior, and morbidity in urban slum population: an Indian perspective*. Journal of Urban Health, 2008. **85**(4): p. 607-618.
15. Faye, O., et al., *Hunger and food insecurity in Nairobi's slums: an assessment using IRT models*. Journal of Urban Health, 2011. **88**(2): p. 235-255.
16. Cohen, B., *Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability*. Technology in Society, 2006. **28**(1): p. 63-80.
17. Observatory, G.U., *Slums of the World: The Face of Urban Poverty in the New Millennium?* 2003: UN-Habitat.
18. Arimah, B.C., *The face of urban poverty: explaining the prevalence of slums in developing countries*. 2010: Working paper//World Institute for Development Economics Research.
19. Obeng-Odoom, F., *The State of African Cities 2008: A framework for addressing urban challenges in Africa*. African Affairs, 2010: p. adq012.
20. Godfrey, R. and M. Julien, *Urbanisation and health*. Clinical medicine, 2005. **5**(2): p. 137-141.
21. Doulougou, B., et al., *Differences in hypertension between informal and formal areas of Ouagadougou, a sub-Saharan African city*. BMC Public Health, 2014. **14**: p. 893.
22. Christensen, D.L., et al., *Obesity and regional fat distribution in Kenyan populations: impact of ethnicity and urbanization*. Annals of Human Biology, 2008. **35**(2): p. 232-249.
23. Ayah, R., et al., *A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya*. BMC Public Health, 2013. **13**(1): p. 371.
24. Joshi, M.D., et al., *Prevalence of hypertension and associated cardiovascular risk factors in an urban slum in Nairobi, Kenya: A population-based survey*. BMC Public Health, 2014. **14**(1): p. 1177.
25. Haregu, T.N., et al., *Interlinkage among cardio-metabolic disease markers in an urban poor setting in Nairobi, Kenya*. Global Health Action, 2016. **9**.
26. Haregu, T.N., et al., *Co-occurrence of behavioral risk factors of common non-communicable diseases among urban slum dwellers in Nairobi, Kenya*. Global Health Action, 2015. **8**: p. 28697.
27. Oti, S.O., et al., *The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya: results from a cross-sectional survey*. Tropical Medicine & International Health, 2013. **18**(12): p. 1520-1530.
28. Van de Vijver, S.J., et al., *Prevalence, awareness, treatment and control of hypertension among slum dwellers in Nairobi, Kenya*. Journal of Hypertension, 2013. **31**(5): p. 1018-1024.
29. Beaglehole, R., S. Reddy, and S.R. Leeder, *Poverty and Human Development*. Circulation, 2007. **116**(17): p. 1871-1873.

30. Sliwa, K., et al., *Impact of Socioeconomic Status, Ethnicity, and Urbanization on Risk Factor Profiles of Cardiovascular Disease in Africa*. *Circulation*, 2016. **133**(12): p. 1199-208.
31. Razak, F. and L. Berkman, *Urban development in Sub-Saharan Africa: bearer of goods and risks*. *PLOS Medicine*, 2014. **11**(7): p. e1001684.
32. Kaplan, G.A. and J.E. Keil, *Socioeconomic factors and cardiovascular disease: a review of the literature*. *Circulation*, 1993. **88**(4): p. 1973-1998.
33. Wei, X., et al., *Cardiovascular disease risk reduction in rural China: a clustered randomized controlled trial in Zhejiang*. *Trials*, 2013. **14**: p. 354.
34. Collaboration, P.S., *Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies*. *The Lancet*, 2002. **360**(9349): p. 1903-1913.
35. Ketola, E., R. Sipilä, and M. Mäkelä, *Effectiveness of individual lifestyle interventions in reducing cardiovascular disease and risk factors*. *Annals of Medicine*, 2000. **32**(4): p. 239-251.
36. Ebrahim, S., et al., *Multiple risk factor interventions for primary prevention of coronary heart disease*. *The Cochrane Library*, 2011.
37. Alwan, A., *Global status report on noncommunicable diseases 2010*. 2011: World Health Organization.
38. Sokol, M.C., et al., *Impact of medication adherence on hospitalization risk and healthcare cost*. *Medical Care*, 2005. **43**(6): p. 521-530.
39. Addo, J., L. Smeeth, and D.A. Leon, *Hypertension in Sub-Saharan Africa a systematic review*. *Hypertension*, 2007. **50**(6): p. 1012-1018.
40. Cappuccio, F.P., et al., *Prevalence, detection, management, and control of hypertension in Ashanti, West Africa*. *Hypertension*, 2004. **43**(5): p. 1017-1022.
41. Chaturvedi, S., M. Pant, and G. Yadav, *Hypertension in Delhi: prevalence, awareness, treatment and control*. *Tropical Doctor*, 2007. **37**(3): p. 142-145.
42. Kariuki, J.K., et al., *Evaluation of the performance of existing non-laboratory based cardiovascular risk assessment algorithms*. *BMC Cardiovascular Disorders*, 2013. **13**(1): p. 1-13.
43. D'Agostino, R.B., et al., *General Cardiovascular Risk Profile for Use in Primary Care*. *Circulation*, 2008. **117**(6): p. 743.
44. Conroy, R., et al., *Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project*. *European Heart Journal*, 2003. **24**(11): p. 987-1003.
45. Woodward, M., P. Brindle, and H. Tunstall-Pedoe, *Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC)*. *Heart*, 2007. **93**(2): p. 172-176.
46. Hippisley-Cox, J., et al., *Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2*. *BMJ*, 2008. **336**(7659): p. 1475-1482.

47. Assmann, G., P. Cullen, and H. Schulte, *Simple scoring scheme for calculating the risk of acute coronary events based on the 10-year follow-up of the prospective cardiovascular Münster (PROCAM) study*. *Circulation*, 2002. **105**(3): p. 310-315.
48. Mendis, S., 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*. *Journal of Hypertension*, 2007. **25**(8): p. 1578-1582.
49. Goff, D.C., et al., *2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines*. *Journal of the American College of Cardiology*, 2014. **63**(25 Part B): p. 2935-2959.
50. Hajifathalian, K., et al., *A novel risk score to predict cardiovascular disease risk in national populations (Globorisk): a pooled analysis of prospective cohorts and health examination surveys*. *The Lancet Diabetes & Endocrinology*, 2015. **3**(5): p. 339-355.

Part 1

Risk factors for non-communicable diseases
in Kenya

Chapter 2

Individual and household level factors associated with presence of multiple non-communicable disease risk factors in Kenyan adults

Frederick M. Wekesah, Loise Nyanjau, Joseph Kibachio,
Martin K. Mutua, Shukri F. Mohamed, Diederick E. Grobbee,
Kerstin Klipstein-Grobusch, Christine Ngaruiya, Tilahun N. Haregu,
Gershim Asiki, Catherine K. Kyobutungi
BMC Public Health 2018, 18 (Suppl 3): 1220

ABSTRACT

Background: Non-communicable diseases (NCDs), are increasing globally, causing about 60% of disability-adjusted life years and 39.8 million deaths in 2015. Risk factors often cluster and interact multiplicatively in an individual and this is strongly associated with the development and severity of NCDs. We assessed the sociodemographic factors associated with the presence of multiple NCD risk factors among individuals aged 18 years and older in the Kenyan population.

Methods: We used national representative data from 4,066 individuals out of 4500 who participated in the WHO STEPs study in 2015. NCD risk factor counts were derived by summing the risk factors present in an individual and categorising into 1-3, 4-6 and 7+ risk factors in any combination of the 12 assessed NCD risk factors (hypertension, diabetes mellitus, cholesterol, insufficient physical activity, excessive alcohol use, tobacco use and obesity, excess sugar intake, insufficient fruit and vegetables intake, high salt consumption, and use of unhealthy cooking fats and oils). Ordered logistic regression was used to investigate the sociodemographic factors associated with an individual possessing multiple NCD risk factors.

Results: Majority (75.8%) of the individuals in the study possessed 4-6 and 10% had ≥ 7 NCDs risk factors. Nearly everyone (99.8%) had insufficient fruits and vegetable intakes, 89.5% consumed high salt in their diet and 80.3% did not engage in sufficient physical activity. Apart from NCD risk count which increased with age among both men and women, associations with other socio-demographic factors differed between men and women. A woman of Akamba ethnicity had lower odds (0.43) while Meru women had higher odds (3.58) of higher NCD risk factor count, compared to the Kalenjin women. Among men, being a Kisii or Luo was associated with lower odds (0.48 and 0.25 respectively) of higher NCD risk factor count. Women in a marital union had higher odds (1.58) of a higher NCD risk factor count.

Conclusion: Majority of Kenyan adults possess more than four NCD risk factors; a clear indication of an emerging epidemic of NCDs in this population. Effective and multi-sectoral interventions targeting multiple risk factors in individuals are required to mitigate especially the behavioural and modifiable NCD risk factors in Kenya.

Key words: Non-communicable disease, Multiple risk, STEPs, Kenya.

BACKGROUND

Non-communicable diseases (NCDs), comprising of cardiovascular diseases (CVDs), diabetes, cancers and chronic pulmonary diseases are currently a major contributor to the burden of disease and mortality worldwide, with predictions showing that by the year 2020, NCDs will account for seven out of every ten deaths in developing countries, surpassing communicable diseases as the leading cause of death [1-3].

Although there exist few reliable data on the prevalence and distribution of NCDs and their risk factors in sub-Saharan Africa SSA [4], NCDs are expected to overtake infectious diseases as major sources of morbidity and mortality by the year 2035 in the region [4]. It is estimated that deaths from NCDs will rise from one in four of all deaths in 2004 to about 46% of all deaths in 2030 [5-7]. Currently, SSA reports a million annual deaths due to CVDs [8]. Findings of a recent review show prevalence of hypertension in SSA ranging from 27% to 34% in 2013 [9]. In 2017, it was estimated that about 15.9 million people aged 18-99 in SSA had diabetes (3.1% prevalence) with projections indicating that the number would increase by 156% to 41.6 million by the year 2045 (3.7% prevalence) [10]. In Kenya, more than half of all recent hospital deaths and almost 50% of all hospital admissions are attributable to NCDs [11].

The rising epidemic of NCDs in SSA is attributable to growing urbanization, changing lifestyles, population growth, ageing and epidemiologic changes in the disease, also known as epidemiological transition [3, 12-16]. The epidemic is propagated by other socio-cultural and environmental factors such as changes in air quality and early childhood exposures to NCD risk factors [17, 18]. The likelihood of occurrence of NCDs in an individual has been closely linked to the presence of four major modifiable behavioural risk factors: unhealthy diet, tobacco use, physical inactivity, and harmful alcohol use. These risk factors, which are well established, are also known to operate in a similar manner all over the world [19].

The World Health Organisation (WHO) has since prioritised action against these four behavioural risk factors globally [7]. A few studies have however shown that in some populations in Kenya, most people lack information and are unaware of NCD risk and the risk factors [20-22]. Other studies on the prevalence and distribution of NCD risk factors in Kenya are either sub-national or were conducted among sub-populations, and only focussed on specific NCD risk factors, mostly on diabetes and hypertension [23-28]. This study which used data from the first nationally representative survey on NCD risk factors

in Kenya using a standardised chronic disease risk factors tool investigated the patterns and distribution of multiple behavioural and physiological risk factors for NCDs, together with their sociodemographic determinants in adult individuals in Kenya [29]. The study supports the efforts by WHO towards the prevention and control NCDs and their risk factors by answering to the call to 'build the case for sustained action by estimating the burden of NCDs and their main risk factors' by developing a national risk factor profile for NCDs [30]. Information on the national NCD risk factor profile could help predict and track the evolution of the NCD epidemic in Kenya, and can inform the design of targeted and effective multisectoral interventions at the policy, environmental and health system levels, to forestall the impending NCD epidemic in the country.

METHODS

Data source, study participants and sampling

The WHO STEPs survey, carried out in Kenya between April and June 2015, employed a cross-sectional household study design that targeted adult individuals aged 18 years and older. A three-stage cluster sampling was used to, in the first stage, select 100 each of urban and rural clusters from the the fifth national sample surveys and evaluation programme (NASSEP V) sampling frame by the Kenya National Bureau of Statistics. In the second stage, a sample of 30 households in each cluster were identified, while in the third stage, one adult (aged between 18 and 69 years) from each household was randomly selected to participate in the study. Further details regarding the design of the study have been published previously [29].

Data collection, measurements and definitions

Data was collected using personal digital assistants (PDA) loaded with the eSTEPS tool provided by the World Health Organization [31]. Data was collected on the four main behavioral risk factors for NCDs (tobacco use, harmful use of alcohol, unhealthy diet and insufficient physical activity), as well as on the key physiological risk factors for NCD: overweight and obesity, raised blood pressure/hypertension, raised blood lipids and raised blood glucose/diabetes mellitus. Anthropometric measures for height and weight were also collected.

Blood pressure (BP) was measured using a validated automated digital BP device (OMRON™ digital automatic BP monitor). Using appropriate cuff sizes, three readings were taken on

the left arm from a respondent in a seated position, at one minute intervals. The mean of the second and the third measurement was recorded. Raised blood pressure/hypertension was based on blood pressure readings cut-off for systolic ≥ 140 mmHg and/or diastolic ≥ 90 mmHg or if they reported to have been previously diagnosed and informed to have hypertension by a health care worker and/or were taking medication for raised blood pressure.

For a small number of respondents (84/4066), random blood sugar was taken because they did not fast as instructed. For all other respondents, fasting blood glucose measurements were taken a day after the first contact with the respondent, after they confirmed to have had an overnight fast. A drop of blood from a finger prick was used to test for glucose levels using a digital meter (ACCU-CHEK™ glucometer and test strips). An individual was classified to have raised blood glucose/ diabetes mellitus based on random and fasting blood capillary glucose measurements cut-offs of 11.1 mmol/L and >7.0 mmol/L respectively, or if they reported to have been previously diagnosed and informed to have diabetes by a health care worker and/or were taking medication for diabetes.

Total blood cholesterol levels were categorized either as ideal or high, with a cut off of point of 5.2 mmol/L or if an individual is currently on treatment for raised blood cholesterol. Low blood HDL cholesterol levels were categorized either as ideal or high, with a cut-off point of 1.17 mmol/L. A drop of blood from a finger prick was used to test for cholesterol levels using a digital meter (ACCU-CHEK™ glucometer and test strips). A drop of blood from a finger prick was used to test for cholesterol levels using a digital meter (ACCU-CHEK™ glucometer and test strips). Sugar intake was self-reported. High sugar intake was defined as regular consumption of excessive sugar in the form of sugary drinks and soda, processed foods high in sugar content on a regular, even daily, basis.

BMI was computed from height and weight measures, collected in centimeters and kilograms using SECA™ height boards and calibrated digital weigh scales respectively. Height was taken while the individual stood in an upright position on a flat surface. Obesity was diagnosed based on international guidelines recommended by the WHO expert consultation for 2008 [32]. General obesity was based on BMI cut-off of ≥ 30 Kg/m² and central obesity on waist circumference of >94 cm for males and >80 cm for females.

The other risk factors/variables were self-reported. Insufficient fruits and vegetables consumption is when an individual consumes less than the recommended five servings of

fruits or vegetables daily. A serving of fruit/vegetables equates to one small fruit, $\frac{1}{2}$ a cup of raw vegetables, one cup of leafy greens or one banana. Insufficient physical activity is less than 150 h/week of moderate-intensity activity or less than 75 h/week of vigorous-intensity physical activities, which may include walking and cycling. An individual that spent 180 min/day sitting or reclining was also classified as physically inactive.

Unhealthy cooking fats referred to the use in cooking of saturated oils and solid fats e.g. lard, margarine, butter and vegetable fat for cooking, instead of unsaturated fats and oils. High salt intake was based on an individual reporting that they consumed salty and processed foods always or often, or if they added salt to cooked food. Excessive alcohol use was defined as the consumption of more than two standard drinks per day for females and more than three standard drinks for males. One standard drink contains about 14 grams of pure alcohol, equivalent to 350ml of beer with 5% alcohol by volume (alc/vol), or 1 glass table wine with 12% alc/vol. Current tobacco use was defined as the daily use of smoked or smokeless tobacco, in the form of cigarettes, cigars, pipes, snuff and other local tobacco products.

Household wealth

A proxy index for wealth was created based on household-level variables including type of dwelling unit; ownership of the dwelling unit; construction materials of the dwelling unit specifically the roof and floor; source of cooking and lighting fuel; several household possessions/goods including a wall clock, electronics like radio and television, refrigerator, and furniture; source of water for drinking and cooking; and type of sanitation facility available for use by the household. A wealth index was then generated using principal component analysis (PCA), multivariate statistical technique. Principal components are weighted averages of the variables used to construct them. The generated index was then used to categorize the households into five categories (quintiles): poorest, second, middle, fourth and richest.

Data analysis

The analysis was done using Stata 14.1 (Stata Corporation, College Station, TX). The outcome variable for this study is the number (count) of NCD risk factors in an individual in any combination out of the twelve described NCD risk factors. The number of NCD risk factors in an individual were categorised into three groups: 1-3, 4-6 and 7+ risk factors. Proportions and bar-graphs were used to summarize frequency/counts of NCD risk factors. Ordered logistic regression was used to assess the association between individual and

household level sociodemographic factors with the presence of one or more NCD risk factors in an individual. Proportional odds assumption was tested using brant command method in Stata , with non-proportional odds model fitted wherever the assumption is violated.

We first fitted bivariate (unadjusted) ordered logistic regression models for each of the sociodemographic factors: age, sex, level of education, occupation, marital status, place of residence, ethnic group and household wealth-status with the outcome variable. We then fitted a multivariate model to assess the strength of association of each of the sociodemographic factors with the number of NCD risk factors in an individual. We used the likelihood ratio test to compare the goodness of fit, comparing a null model which is a special case of the alternative model with one additional variable being tested. Odds ratios are reported together with their 95% confidence intervals. Stratified analysis by sex was done to check for differences in the magnitude and pattern of the NCD risk factors between males and females, after confirming that there existed no statistical interactions between the sociodemographic variables in question with sex. Analysis was weighted at the individual level to account for study design, and to allow for generalizability of the findings.

Ethical considerations

The study protocol was reviewed and approved by the Scientific and Ethics Review Unit at Kenya Medical Research Institute (KEMRI) SSC No. 2607. Informed consent was sought from each and every participant prior to enrolment in the study. The study team was introduced to concepts of research ethics and encouraged to protect the rights of human research participants. Researchers upheld justice, regard for welfare and respect for study participants at all times during the study. During analysis and reporting, personal identifiers were delinked from the data.

RESULTS

Characteristics of study participants

Table 1: Socio-demographic characteristics of study population

Indicator		Female	Male	Total	P-value
Wealth status	Poorest	21.6	16.9	19.3	0.034
	Second	22.2	20.6	21.5	
	Middle	18.7	17.1	17.9	
	Fourth	16.3	20.2	18.2	
	Richest	21.2	25.2	23.1	
Age group	18-29	47.0	45.9	46.4	0.636
	30-44	32.8	32.5	32.7	
	45-59	15.1	16.4	15.7	
	60-69	5.1	5.1	5.1	
Level of education	No schooling	18.0	6.4	12.4	<0.001
	Primary incomplete	23.9	23.3	23.6	
	Primary complete	33.6	30.8	32.2	
	Secondary school and higher	24.6	39.5	31.8	
Place of residence	Rural	65.3	58.2	61.8	0.013
	Urban	34.7	41.8	38.2	
Marital status	Not in union	30.9	37.4	34.1	0.029
	In union	69.1	62.6	65.9	
Ethnicity	Kalenjin	13.2	16.4	14.8	0.001
	Kamba	11.5	6.7	9.1	
	Kikuyu	15.5	17.2	16.3	
	Kisii	6.7	7.2	6.9	
	Luhya	15.1	16.5	15.8	
	Luo	11.2	10.2	10.8	
	Meru	4.2	7.8	6.0	
	Other~	15.8	14.4	15.1	
	Somali	6.7	3.5	5.1	
	Missing	0.0	0.1	0.1	
Occupation	Employed	11.8	30.7	21.0	<0.001
	Self-employed	34.4	43.4	38.7	
	Unemployed	53.8	25.9	40.3	
N		2,467	1,599	4,066	

**Data is weighted at individual participant level*

~The 'other'ethinc group comprises the Borana (22 (0.5%)), Embu (95 (2.1%)), Maasai (84 (1.9%)), Miji Kenda (182 (4.1%)), Turkana (106 (2.4%)) and unclassified category (404 (9.0%)) ethnic groups.

A total of 4066 individuals (51.4% females) were included in this analysis. This number was 90% of the 4500 individuals reached in the STEPs survey, from 4754 households that consented to participate in the study. Demographic characteristics of the study population are shown in Table 1. Forty-six percent of the study participants were under the age of 30 years. Overall, a small proportion of the study population (12.4%) did not possess any formal schooling, a proportion that comprised three times as many females as there were males, 18.0% vs 6.4%, respectively. Almost two in five individuals (38.2%) lived in urban areas. Individuals currently married or living together with a partner (i.e. in marital union) comprised 65.9% of the population, while 59.7% of study respondents were in some form of employment, the proportion of females being smaller (46.2%) compared to that of males (74.1%). There were more women compared to men in the lower wealth quintiles.

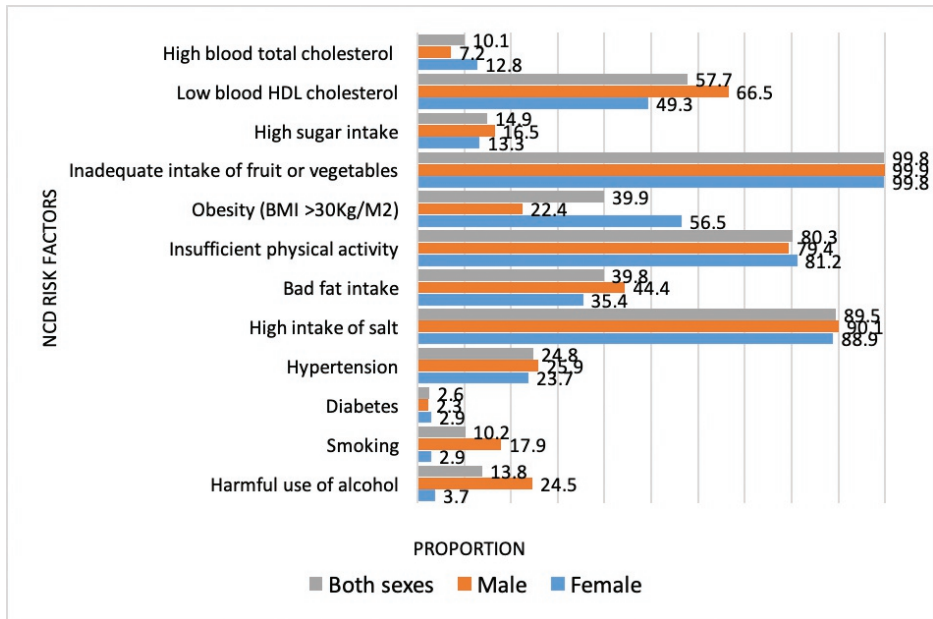


Figure 1: Prevalence of NCD risk factors in the population

The weighted prevalence of the twelve NCD risk factors in this population is shown in Figure 1. Overall (both sexes), the prevalence of insufficient consumption of fruits and vegetables, high salt consumption and insufficient physical activity were 99.8%, 89.5%, and 80.3% respectively. One in four individuals had high blood pressure while the overall prevalence of diabetes was 2.6%. Majority (80%) of individuals with raised blood pressure

were new cases diagnosed in this survey, while about 50% of the individuals with raised blood glucose did not know their status before being diagnosed in this study.

Harmful alcohol use, daily tobacco use, hypertension, low high density lipoprotein (HDL) cholesterol, bad fat intake, and high sugar intake were more prevalent in males than females, 24.5% vs 3.7%, 17.9% vs 2.9%, 25.9% vs 23.7%, 66.5% vs 49.3%, 44.4% vs 35.4%, 16.5% vs 13.3%, while diabetes, obesity, and raised blood total cholesterol were more common among females, 2.9% vs 2.3%, 56.5% vs 22.4%, 12.8% vs 7.2%, respectively.

Occurence of non-communicable disease risk factors in the population

The highest number of risk factors recorded in an individual was ten out of the possible 12 NCD risks factors considered in this study. The bulk of the population (75.8%) possessed between four and six NCD risk factors. The biggest proportion, 30.4%, possessed five; 25.3% four; and 20.0% six NCD risk factors. A little less than 12% possessed three, while only about two percent possessed two or fewer NCD risk factors. About 10% possessed seven and more NCD risk factors. Figure 2 summarises the occurrence of the NCD risk factors, showing the differences between the sexes.

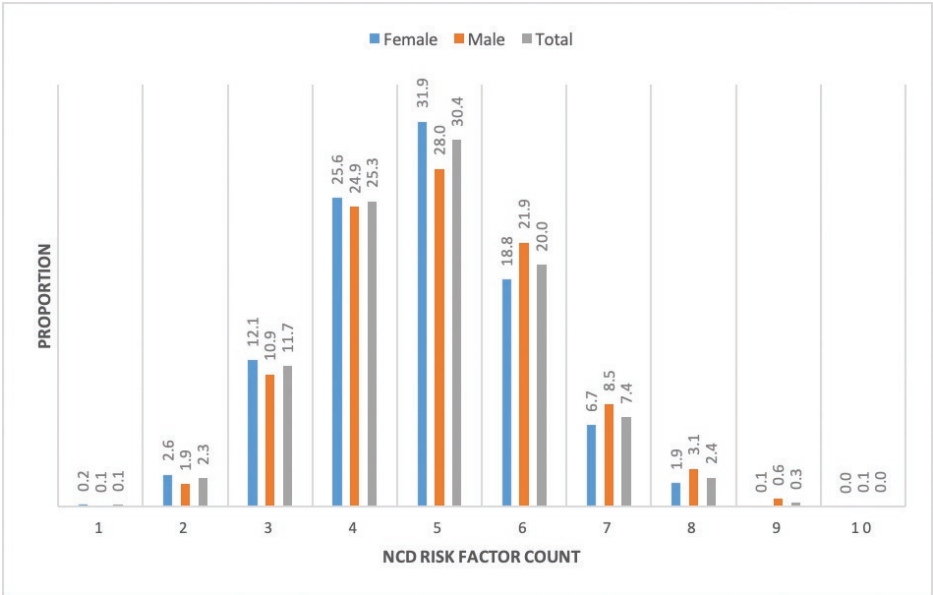


Figure 2: Distribution of NCD risk factors counts in the population

Prevalence of risk factor count by demographic characteristics

The number of NCD risk factors in individuals increased with their age, household wealth status, education, and employment but varied by ethnicity. Overall, men and women showed differences in the risk factor counts. Generally, men tended to have a higher number of NCD risk factors when compared to women. Whereas the NCD risk factor count increased among men by wealth status, education level, and occupation, these factors did not affect risk factor count among women. While women in union had a higher risk factor count compared to those not in union, marital status did not have any effect on risk factor count among men. Participants in the younger age-groups, both male and female, were twice as likely to possess three or less NCD risk factors and thrice least likely to possess seven and more NCD risk factors compared the 45 years or older age-group. No differences were observed among urban and rural residents on the NCD risk factor counts. (Table 2).

Table 2: Distribution of NCD risk factor counts across population characteristics, STEPS survey (Both sexes, Male, Female)

Indicator	Both sexes					Male					Female				
	NCD risk factor count					NCD risk factor count					NCD risk factor count				
	1-3	4-6	7-10	p-value		1-3	4-6	7-10	p-value		1-3	4-6	7-10	p-value	
Total	14.5	75.3	10.2			11.6	76.1	12.3			17.3	74.5	8.1		
Sex															
Female	17.3	74.5	8.1												
Male	11.6	76.1	12.3	0.002											
Wealth status															
Poorest	17.8	76.0	6.2			19.0	73.5	7.5			16.9	77.9	5.3		
Second	13.9	77.8	8.3			11.9	79.0	9.2			15.7	76.8	7.5		
Middle	13.3	74.5	12.1	0.039		10.8	75.8	13.5	0.053		15.6	73.5	11.0	0.252	
Fourth	10.7	76.1	13.2			7.7	76.1	16.2			14.2	76.1	9.8		
Richest	16.4	72.4	11.3			10.1	75.7	14.2			23.5	68.6	7.9		
Age															
18-29	18.6	75.4	5.9			13.6	78.7	7.7			23.2	72.4	4.3		
30-44	12.5	76.9	10.6			10.9	75.6	13.6			14.0	78.3	7.8		
45-59	8.6	71.3	20.1	<0.001		7.1	70.9	22.1	0.001		10.3	71.7	18.0		<0.001
60-69	9.3	75.7	15.0			12.7	73.3	14.0			6.1	78.0	15.9		
Education															
No schooling	14.9	77.9	7.3			20.7	73.0	6.3			12.9	79.6	7.6		
Primary school incomplete	14.4	74.5	11.1			13.1	72.7	14.2			15.6	76.1	8.3		
Primary school complete	13.6	78.5	7.8	0.088		8.9	83.4	7.7	0.002		17.8	74.3	8.0		0.470
Secondary school and higher	15.4	71.6	13.0			11.3	72.9	15.8			21.7	69.7	8.6		

	Both sexes			Male		Female					
	NCD risk factor count			NCD risk factor count		NCD risk factor count					
Residence											
Rural	14.1	76.5	9.4	0.368	12.1	77.4	10.5	15.8	75.8	8.4	0.388
Urban	15.3	73.3	11.5		10.8	74.3	14.8	20.3	72.1	7.6	
Marital status											
Not in union	17.7	73.2	9.1	0.061	13.1	77.7	9.3	22.9	68.1	9.0	0.013
In union	12.9	76.4	10.7		10.7	75.2	14.1	14.9	77.4	7.8	
Ethnic group											
Kalenjin	9.6	81.6	8.9		6.3	82.3	11.4	13.3	80.7	6.0	
Kamba	20.2	73.8	6.0		7.9	84.2	7.9	27.0	68.0	5.0	
Kikuyu	7.9	75.4	16.7		5.6	76.2	18.3	10.3	74.7	15.0	
Kisii	20.6	72.9	6.6		16.6	74.5	9.0	24.7	71.2	4.1	
Luhya	12.4	78.6	9.0	<0.001	8.5	79.2	12.3	16.4	78.0	5.6	0.001
Luo	25.9	67.7	6.4		28.4	64.6	7.1	23.7	70.4	5.9	
Meru	6.6	71.1	22.3		6.3	74.2	19.5	7.0	65.7	27.3	
Other	15.4	75.5	9.1		13.8	74.6	11.6	16.8	76.3	7.0	
Somali	21.4	72.5	6.1		30.8	63.1	6.2	16.7	77.2	6.1	
Employment											
Employed	12.9	70.5	16.6		11.2	71.0	17.9	17.2	69.3	13.4	
Self-employed	14.1	76.4	9.5	0.001	10.5	79.3	10.2	18.3	72.9	8.8	0.260
Unemployed	15.8	76.8	7.4		13.9	76.8	9.3	16.7	76.7	6.5	

NCD Non-communicable diseases

Factors associated with multiple non-communicable disease risk factors in Kenyan adult population

Table 3 shows individual and household level factors associated with an increased number of NCD risk factors in an individual, after adjusting for other factors. An increased number of NCD risk factors was associated with an individual's age, sex, marital status and ethnic group. The odds of having a higher count of NCD risk factors increased from 1.62 to 2.64 from the age group of 30-44 years to age group of 60-69 years when compared to the younger people aged 18-29 years. This was common occurrence for both men and women.

The factors associated with an increase in NCD risk count in the population were mainly driven by the female sex, and thus there existed some differences in socio-demographic factors for a high count of NCD risk factors observed between men and women. Men were one and half times more likely to have higher counts for NCD risk factors compared to women. Being in a marital union was also associated with higher odds (1.27) of possessing higher counts of NCD risk factors. Women in a marital union were one and half times likely to have a higher count of NCD risk factors, but not so among men.

Overall (both sexes), compared to the Kalenjin ethnic group, the Kamba, Kisii, and the Luo had lower odds of having a higher counts of NCD risk factors (0.45, 0.51, 0.38 odds ratio respectively), while the Meru had almost twice as high odds (1.92) of having a higher count of NCD risk factors compared to the Kalenjin. Among men, being a Kisii or Luo was associated with lower odds (0.48 and 0.25 respectively) of having a higher counts of NCD risk factors. However, while a woman of the Akamba ethnic group had lower odds (0.43) of having a high NCD risk factors count, a woman from the Meru ethnic group had 3.58 odds of possessing higher NCD risk factor counts when compared to the Kalenjin women.

DISCUSSION

Our findings reveal that up to 75% of the population in Kenya possessed between four and six NCD risk factors of any combination out of 12 assessed NCD risk factors: one in three of respondents possessed five NCD risk factors, a quarter possessed four risk factors, one in five respondents had six risk factors while about 12% possessed three NCD risk factors. The most prevalent NCD risk factors in the population, for both males and females, were insufficient consumption of fruits and vegetables, high salt consumption and insufficient physical activity, 99.8%, 89.5% and 80.3% respectively. Similar findings

Table 3: Factors associated with multiple non-communicable diseases risk factors among adults in Kenya

Factors	Both sexes				Female				Male			
	1-3 vs. 4-6 & 7-10 factors				1-3 vs. 4-6 & 7-10 factors				1-3 vs. 4-6 & 7-10 factors			
	OR	LL	95%CI	UL	OR	LL	95%CI	UL	OR	LL	95%CI	UL
Sex												
Female	1.00											
Male	1.45	1.13		1.87								
Age groups												
18-29	1.00				1.00				1.00			
30-44	1.62	1.25		2.11	1.67	1.16		2.40	1.62	1.10		2.39
45-59	3.20	2.10		4.86	3.57	2.35		5.43	2.98	1.58		5.62
60-69	2.64	1.83		3.82	4.45	2.98		6.67	1.59	0.87		2.91
Education level												
No schooling	1.00				1.00				1.00			
Primary school incomplete	1.09	0.74		1.60	0.99	0.63		1.57	1.35	0.65		2.82
Primary school complete	0.96	0.66		1.39	0.93	0.60		1.43	1.87	0.86		4.05
Secondary school and higher	0.79	0.48		1.29	0.87	0.43		1.77	1.26	0.57		2.77
Marital status												
Not in union	1.00				1.00				1.00			
In union	1.27	1.02		1.57	1.53	1.09		2.15	1.13	0.77		1.67

Factors	Both sexes						Female						Male					
	1-3 vs. 4-6 & 7-10 factors						1-3 vs. 4-6 & 7-10 factors						1-3 vs. 4-6 & 7-10 factors					
	OR	LL	95%CI	UL	95%CI		OR	LL	95%CI	UL	95%CI		OR	LL	95%CI	UL	95%CI	
Ethnic group																		
Kalenjin	1.00						1.00						1.00					
Kamba	0.45	0.29		0.72			0.43		0.21		0.86		0.62		0.35		1.10	
Kikuyu	1.53	0.99		2.36			1.64		0.91		2.95		1.42		0.81		2.48	
Kisii	0.51	0.30		0.88			0.53		0.26		1.10		0.48		0.24		0.96	
Luhya	0.82	0.56		1.20			0.78		0.47		1.29		0.90		0.56		1.43	
Luo	0.38	0.22		0.65			0.53		0.27		1.04		0.25		0.12		0.52	
Meru	1.92	1.19		3.11			3.58		2.03		6.31		1.33		0.66		2.67	
Other	0.78	0.49		1.23			0.87		0.44		1.69		0.70		0.40		1.22	
Somali	0.59	0.24		1.46			0.87		0.35		2.15		0.38		0.14		1.01	
Observations		4,062							2,464						1,598			
1-3&4-6 vs. 7-10 Sec+																		
Primary Incomplete	1.36	0.84		2.19									3.57		1.34		9.52	
Secondary school and higher													3.40		1.31		8.85	

LL=lower limit, UL=upper limit, CI=Confidence interval
Employment status, place of residence, and household wealth status were not significant in the model and were therefore not presented in this table.

on low fruits and vegetable consumption were reported in a study conducted in a subsample of a Kenyan population [33], and in Bangladesh where more than 93% of the people consumed insufficient amounts of fruit and vegetables i.e. less than the recommended five servings/day [34]. A similar trend with a prevalence of over 70% for low fruit and vegetable consumption among men and women living in LMICs holds [35].

Some NCD risk factors were seemingly gendered. Harmful alcohol use, daily tobacco use, hypertension, low HDL cholesterol, high fat, and high sugar intake were more prevalent in males than females, while the opposite was true for diabetes, obesity, raised blood total cholesterol. These echo findings from other studies in Kenya [33], and in Malawi, which also showed tobacco smoking, alcohol drinking and raised blood pressure to be more prevalent in males compared to the females, with obesity and raised blood cholesterol was more common in females [36].

Although results from the World Health Survey on socioeconomic inequalities in risk factors for non-communicable diseases in LMICs showed that ‘physical inactivity was less prevalent in populations of low socioeconomic status, especially in low-income countries’ [37], and the global estimate for prevalence of physical inactivity among adults is 17% [6], we found very high levels (80.3%) of physical inactivity in the Kenyan population. Modern forms of transportation that include motorbikes both in urban and rural areas, as well as lack of spaces to exercise could contribute to inactivity in the Kenyan population.

NCD risk factors in individuals increased with age, marital status and ethnic group (more significantly among women) indicating that early screening would forestall the accumulation and effect on NCD risk factors in individuals. The association between NCD risk factor and ethnic grouping is not new, as a study conducted among minority groups in the USA reported a similar association [38]. We postulate that behavioral, cultural and societal factors that were not measured in this study, could account for these differences. Perhaps the socioeconomic opportunities accruing to married women or later in their reproductive life could explain the association between being in a marital union with an increased number of NCD risk factors in married women. It could also be that women in a marital union have other factors not measured in this study (such as the use of hormonal contraceptives or hormonal changes during their reproductive cycle) that may be associated with the accumulation of multiple NCD risk factors. Further research on how marital status, especially among women, is associated with multiple NCD risk factors is required to elucidate these findings.

The association between wealth and NCD risk factors has been reported in the World Health Survey [37]. Huge inequalities exist in the distribution and patterns of NCD risk factors across wealth quintiles, with current smoking and low fruit and vegetable consumption being more prevalent in the poorest wealth quintile than in the richest. Contrary to findings from Uganda, where rural dwellers were one and half times more likely to possess multiple NCD risk factors [39], whether one lived in urban or rural Kenya did not influence the number of NCD risk factors they possessed. It seems therefore that no matter where one lives in Kenya, poverty and other social, physical and economic challenges provide little protection from NCDs risk factors. Poverty has been linked to the growth of the NCD burden: the poor, regardless of where they lived were disproportionately affected by the economic burden of the disease [40, 41] which also served to escalate poverty among them [42, 43].

STRENGTHS AND LIMITATIONS

Our findings suffer from one main limitation. Data on behavioral risk factors was based on self-reports and may be affected by potential under-reporting, especially on the socially discouraged practices like smoking/tobacco use and harmful alcohol consumption. That notwithstanding, our study applies a standard chronic disease risk surveillance approach (WHO STEPs) that confers comparability of our findings with those from other settings and countries. Our findings provide new insights on the patterns and the distribution of multiple NCD risk factors together with their sociodemographic determinants nationally.

CONCLUSIONS

The majority (75%) of the Kenyan adults possess between four and six NCD risk factors, while still a substantial proportion (10.1%) possess seven or more NCD risk factors. This is a clear indication of an impending NCD epidemic in this population that needs to be addressed. The epidemiological assessment of key NCD risk factors, their combination/ clustering and distribution across different sociodemographic strata can inform the design of effective, targeted multisectoral interventions, especially those targeting behavioural and modifiable NCD risk factors, for the prevention of NCDs.

The WHO, in the *Global status report on non-communicable diseases 2010*, has ranked the monitoring and surveillance of risk factors a top priority to tackle growing NCD epidemics in low-resource settings like Kenya. More research is needed on perceptions of the Kenyan population regarding risk factors and the accompanying risk for developing NCDs, an aspect that influences individual level actions for the prevention and control of NCDs. Because the risk factors tend to cluster, and these risk factors act in an additive and a multiply way to cause NCDs, a 'comprehensive approach' rather than one based on a single factor is important to forestall cumulative effects of multiple NCD risk factors which occur over time [44]. Effective and multi-sectoral interventions are required to mitigate especially the behavioural and modifiable NCD risk factors in Kenya.

ABBREVIATIONS

BMI – Body mass index; CVD – Cardiovascular diseases; HDL – High-density lipoproteins; LMICS - Low- and middle-income countries; NCD – Non-communicable diseases; PCA – principal component analysis ; PDA - Personal digital assistant; STEPs - WHO STEPwise approach to Surveillance (of NCD risk factors); SSA – sub-Saharan Africa; WHO – World Health Organization.

ACKNOWLEDGEMENTS

The authors would like to thank all individuals and organizations that provided technical support for the design and implementation of the survey, among them the data collection and analysis teams led by the Ministry of Health, WHO and Kenya National Bureau of Statistics, Kenya Medical Research Center and the African Institute for Health and Development. FMW is supervised for his PhD research by CK, KKG and DG.

Funding

Core funding for the STEPs survey was provided by World Bank, WHO, Astrazeneca and MOH/CDC CoAg. The analysis and writing of this paper and the publication cost of the supplement were made possible through funding to the African Population and Health Research Center (APHRC) from International Development Research Center (IDRC) (grant # 107209-001). FMW is supported for his PhD research by the Global Health Support Program of the University Medical Center, Utrecht University.

Availability of data and material

Study materials and de-identified data that support the findings in this study are available by contacting Gladwell Gathecha at the Ministry of Health in Kenya via email address gladwellgathecha@gmail.com

Authors' contributions

FMW and LN equally contributed to the conceptualization of the study, drafting of the plan of analysis, analysis and writing of the manuscript. TNH, JK, MKM, SFM, CN, GA and CK contributed to the design of study, and writing of the manuscript. DEG and KKG contributed to the conceptualisation of the study, read and suggested improvements to the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Scientific and Ethics Review Unit at Kemri under reference number SSC No. 2607. Verbal informed consent was obtained from the study participants.

Consent for publication: Not applicable.

Competing interests

The authors declare that they have no competing interests with regard to the authorship and publication of this article.

REFERENCES

1. Kassebaum, N.J., et al., *Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015*. The Lancet, 2016. **388**(10053): p. 1603-1658.
2. Boutayeb, A., *The double burden of communicable and non-communicable diseases in developing countries*. Transactions of The Royal Society of Tropical Medicine and Hygiene, 2006. **100**(3): p. 191-199.
3. Lozano, R., et al., *Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010*. The Lancet, 2013. **380**(9859): p. 2095-2128.
4. Nyirenda, M.J., *Non-communicable diseases in sub-Saharan Africa: understanding the drivers of the epidemic to inform intervention strategies*. International Health, 2016. **8**(3): p. 157-158.
5. Dalal, S., et al., *Non-communicable diseases in sub-Saharan Africa: what we know now*. International Journal of Epidemiology, 2011. **40**(4): p. 885-901.
6. Mathers, C.D. and D. Loncar, *Projections of global mortality and burden of disease from 2002 to 2030*. PLOS Medicine, 2006. **3**(11): p. e442.
7. World Health Organization., *Global status report on noncommunicable diseases 2014*. 2014, Geneva: World Health Organization.
8. Lopez, A.D., et al., *Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data*. The Lancet, 2006. **367**(9524): p. 1747-1757.
9. Ataklte, F., et al., *Burden of Undiagnosed Hypertension in Sub-Saharan Africa*. Hypertension, 2014.
10. Ogurtsova, K., et al., *IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040*. Diabetes Research and Clinical Practice, 2017. **128**: p. 40-50.
11. Government of Kenya., *Kenya Health Policy 2012-2030*. 2012, Government of Kenya: Nairobi.
12. World Health Organization., *Atlas of African Health Statistics 2016: health situation analysis of the African Region*. 2016.
13. Mensah, G.A., et al., *Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: a systematic analysis of data from the Global Burden of Disease Study 2013*. Cardiovascular Journal of Africa, 2015. **26**(2 Suppl 1): p. S6-10.
14. Miranda, J.J., et al., *Non-communicable diseases in low- and middle-income countries: context, determinants and health policy*. Tropical Medicine & International Health, 2008. **13**(10): p. 1225-1234.
15. BeLue, R., et al., *An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective*. Globalization and Health, 2009. **5**(1): p. 10.

16. Godfrey, R. and M. Julien, *Urbanisation and health*. Clinical Medicine, 2005. **5**(2): p. 137-141.
17. Mayosi, B.M., et al., *The burden of non-communicable diseases in South Africa*. The Lancet, 2009. **374**(9693): p. 934-947.
18. Godfrey, K.M. and D.J. Barker, *Fetal nutrition and adult disease*-. The American Journal of Clinical Nutrition, 2000. **71**(5): p. 1344S-1352S.
19. Yusuf, S., S. Hawken, and S. Ounpuu, *Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study*. Journal of Cardiopulmonary Rehabilitation and Prevention, 2005. **25**(1): p. 56-57.
20. Temu, T.M., et al., *Cardiovascular health knowledge and preventive practices in people living with HIV in Kenya*. BMC Infectious Diseases, 2015. **15**(1): p. 421.
21. Van de Vijver, S.J., et al., *Prevalence, awareness, treatment and control of hypertension among slum dwellers in Nairobi, Kenya*. Journal of Hypertension, 2013. **31**(5): p. 1018-1024.
22. Maina, W.K., et al., *Knowledge, attitude and practices related to diabetes among community members in four provinces in Kenya: a cross-sectional study*. Pan African Medical Journal, 2010. **7**(1).
23. Kaduka, L.U., et al., *Prevalence of metabolic syndrome among an urban population in Kenya*. Diabetes Care, 2012. **35**(4): p. 887-893.
24. Mbochi, R.W., et al., *Predictors of overweight and obesity in adult women in Nairobi Province, Kenya*. BMC Public Health, 2012. **12**(1): p. 823.
25. Gewa, C.A., *Childhood overweight and obesity among Kenyan pre-school children: association with maternal and early child nutritional factors*. Public Health Nutrition, 2010. **13**(4): p. 496-503.
26. Christensen, D.L., et al., *Obesity and regional fat distribution in Kenyan populations: impact of ethnicity and urbanization*. Annals of Human Biology, 2008. **35**(2): p. 232-249.
27. Ayah, R., et al., *A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya*. BMC Public Health, 2013. **13**(1): p. 371.
28. Haregu, T.N., et al., *The connection between non-communicable disease risk factors and risk perception among urban slum dwellers in Nairobi, Kenya*. African Population Studies, 2016. **30**(3): p. 3094-3102.
29. Kenya National Bureau of Statistics., *Kenya STEPwise Survey for Non Communicable Diseases Risk Factors 2015 Report*. 2015, Kenya National Bureau of Statistics: Nairobi.
30. Bonita, R., et al., *Country actions to meet UN commitments on non-communicable diseases: a stepwise approach*. The Lancet, 2013. **381**(9866): p. 575-584.
31. WHO, UNICEF, UNFPA, & The World Bank., *Maternal mortality in 2005: Estimates developed by WHO, UNICEF, UNFPA and The World Bank*. 2007.

32. World Health Organization., *Waist circumference and waist-hip ratio: report of a WHO expert consultation*. 2011, World Health Organization: Geneva.
33. Bloomfield, G.S., et al., *Multiple cardiovascular risk factors in Kenya: evidence from a health and demographic surveillance system using the WHO STEPwise approach to chronic disease risk factor surveillance*. *Heart*, 2013. **99**(18): p. 1323-1329.
34. Zaman, M.M., et al., *Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013*. *BMC Public Health*, 2015. **15**(1): p. 659.
35. Hosseinpoor, A.R., et al., *Socioeconomic inequalities in risk factors for non communicable diseases in low-income and middle-income countries: results from the World Health Survey*. *BMC Public Health*, 2012. **12**(1): p. 912.
36. Msyamboza, K.P., C.J. Mvula, and D. Kathyola, *Prevalence and correlates of diabetes mellitus in Malawi: population-based national NCD STEPS survey*. *BMC Endocr Disord*, 2014. **14**: p. 41.
37. Hosseinpoor, A., et al., *Socioeconomic inequalities in risk factors for non communicable diseases in low-income and middle-income countries: results from the World Health Survey*. *BMC Public Health*, 2012. **12**(1): p. 912.
38. Winkleby, M.A., et al., *Ethnic variation in cardiovascular disease risk factors among children and young adults: findings from the Third National Health and Nutrition Examination Survey, 1988-1994*. *JAMA*, 1999. **281**(11): p. 1006-1013.
39. Wesonga, R., et al., *Burden of cumulative risk factors associated with non-communicable diseases among adults in Uganda: evidence from a national baseline survey*. *International Journal for Equity in Health*, 2016. **15**(1): p. 195.
40. Kankeu, H.T., et al., *The financial burden from non-communicable diseases in low-and middle-income countries: a literature review*. *Health Research Policy and Systems*, 2013. **11**(1): p. 31.
41. Mwai, D. and M. Muriithi, *Catastrophic Health Expenditure and Household Impoverishment: a case of NCDs prevalence in Kenya*. *Epidemiology, Biostatistics and Public Health*, 2016. **13**(1).
42. Ekpenyong, C., et al., *Double burden, non-communicable diseases and risk factors evaluation in sub-Saharan Africa: The Nigerian experience*. *European Journal of Sustainable Development*, 2012. **1**(2): p. 249.
43. Allen, L., et al., *Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review*. *The Lancet Global Health*, 2017. **5**(3): p. e277-e289.
44. Ahmed, S.M., et al., *Clustering of chronic non-communicable disease risk factors among selected Asian populations: levels and determinants*. *Global Health Action*, 2009. **2**(1): p. 1986.

Chapter 3

Patterns of non-communicable disease and injury risk factors in Kenyan adult population: a cluster analysis

Tilahun N. Haregu, Frederick M. Wekesah, Shukri F. Mohamed, Martin K. Mutua, Gershim Asiki, Catherine Kyobutungi
BMC Public Health 2018, 18 (Suppl 3): 1225

ABSTRACT

Background: Non-communicable diseases and unintentional injuries are emerging public health problems in sub-Saharan Africa. These threats have multiple risk factors with complex interactions. Though some studies have explored the magnitude and distribution of those risk factors in many populations in Kenya, an exploration of segmentation of population at a national level by risk profile, which is crucial for a differentiated approach, is currently lacking. The aim of this study was to examine patterns of non-communicable disease and injury risk through the identification of clusters and investigation of correlates of those clusters among Kenyan adult population.

Methods: We used data from the 2015 STEPs survey of non-communicable disease risk factors conducted among 4,484 adults aged between 18 and 69 years in Kenya. A total of 12 risk factors for NCDs and 9 factors for injury were used as clustering variables. A K-medians Cluster Analysis was applied. We used matching as the measure of the similarity/dissimilarity among the clustering variables. While clusters were described using the risk factors, the predictors of the clustering were investigated using multinomial logistic regression.

Results: We have identified five clusters for NCDs and four clusters for injury based on the risk profile of the population. The NCD risk clusters were labelled as cluster hypertensives, harmful users, the hopefuls, the obese, and the fat lovers. The injury risk clusters were labelled as helmet users, jaywalkers, the defiant and the compliant. Among the possible predictors of clustering, age, gender, education and wealth index came out as strong predictors of the cluster variables.

Conclusion: This cluster analysis has identified important clusters of adult Kenyan population for non-communicable disease and injury risk profiles. Risk reduction interventions could consider these clusters as potential target in the development and segmentation of a differentiated approach.

Key words: Non-communicable disease, injury, risk factor, cluster analysis, STEPS, Kenya

BACKGROUND

Non-communicable diseases (NCDs) cause more deaths globally than all other causes combined together [1, 2]. In 2012, about 38 million people died from NCDs, and the number of deaths is projected to reach 52 million by the year 2030 [1-5]. Cardiovascular diseases (CVDs), cancers, chronic respiratory diseases and diabetes comprise 80% of NCDs. The shift in the global burden of disease from communicable diseases to NCDs is attributed to population growth and the increased average age of the world's population, combined with the decreasing age-, sex- and cause-specific death rates [6].

NCDs are caused by multiple risk factors which interact in a complex way [7]. Many of the risk factors for NCDs are related to lifestyle and are therefore modifiable. These modifiable risk factors include physical inactivity, low fruit and vegetable intake, unhealthy diet and high cholesterol intake. Physiological risk factors for NCDs include overweight and obesity [7, 8].

Achieving the 25*25 target, which is the reduction of premature mortality from four main NCDs—cardiovascular diseases, chronic respiratory diseases, cancers, and diabetes—by 25% from 2010 levels by 2025 [7] will very much depend on achieving the risk factor target on the key risk factors for NCDs (tobacco and alcohol use, salt intake, obesity, and raised blood pressure and glucose) [7].

As the risk factors for many of the common NCDs are shared, the likelihood of their co-occurrence is high. Thus, studies of single risk factors or prevalence of individual risk factors will miss the complex interaction among the risk factors. For a better understanding of risk profiles of a population, the whole set of risk factors should be considered. Hence, there is a need for approaches that consider common risk factors together to describe risk profile of the population.

This study sought to investigate patterns of NCD risk factors, hence profiles of the Kenyan population based on the clustering of these risk factors. Different segments of the population experience, or are exposed to different risk factors and therefore have different risk profiles, and will require targeted approaches and interventions in mitigating these risk factors for the prevention of NCDs.

METHODS

The Kenya 2015 STEPS survey was a cross-sectional household survey that was carried out in Kenya from April to June 2015, targeting individuals aged between 18 and 69 years. The survey used the fifth national sample surveys and evaluation programme (NASSEP V) sampling frame from the Kenya National Bureau of Statistics, developed using the enumeration areas generated from the 2009 Kenya population and Housing census. The sample size was determined to be 6000 to allow for national estimates as per sex and residence (rural or urban).

A three stage cluster sample design was used. In the first stage, 200 clusters (100 urban and 100 rural) were selected. In the second stage, a uniform sample of 30 households from the listed households in each cluster, while in the third stage, one individual was randomly selected from all eligible listed household members.

Data collection

Socio-demographic and behavioral information was collected in step 1, physical measurements such as height, weight and blood pressure were collected in step 2 while biochemical measurements for blood glucose and cholesterol were taken in step 3 with respondents in a fasting state.

The survey focussed on the four main behavioural risk factors of NCDs: tobacco use, harmful alcohol consumption, unhealthy diet and lack of physical activity; and the four key physiological risk factors for NCDs: overweight and obesity, raised blood pressure, raised blood lipids and raised blood glucose. The survey questionnaire was adapted from the WHO STEPS instrument [9], with information being gathered in three sequential steps. Step one involved asking questions on demographic information such as age, sex, marital status, education and occupation, housing and social amenities as well as dietary history on salt, sugar, fat, fruits and vegetable intakes. Data collection was through a personal digital assistant (PDA) loaded with eSTEPS software provided by WHO.

Twenty multidisciplinary teams (supervisor, two research assistants, a clinician and laboratory technologist) were involved in data collection after undergoing a six day training on survey background, sampling method, questioning techniques, PDA use and ethical procedures.

Key variables

Twelve traditional non-communicable disease risk factors and nine risk factors for injuries were used in our analysis. These measures were both self-reported and objectively measured. The inclusion of these risk factors was based on availability of complete data for the study population. The cut-off points for these variables were based on international recommendations [10-13].

Risk variables for NCDs and injury

NCD risk variables: Inadequate fruit/vegetable intake, high sugar intake, insufficient physical activity, harmful alcohol-use, tobacco use, excessive sitting time, general obesity, central obesity, high blood sugar, high salt consumption, high fat intake, and increased blood pressure

Injury risk factors: Didn't use seatbelt, didn't use helmet, involved in traffic crash, had accidental injury, inappropriate road crossing, driving under influence of alcohol, was a passenger of drunk driver, involved in violence, and substance use/e.g. khat.

Data management and analysis

We used Stata 14.1 to analyse the data. Analysis was restricted to individuals with complete data on the key analytic variables listed above. Those with missing values were excluded from the analysis.

Cluster identification

For both categories of risk factors, the variables were recoded as 0 (low risk) and 1 (higher risk). Given the nature of the data, binary data, we used K-median cluster analysis approach. We used matching as a measure of distance of proximity. We used the scree plot to determine the ideal number of clusters.

Cluster characterization

The distribution of the risk factors across the clusters was examined to characterize the clusters based on the risk profile. Clusters were named based on their unique dominant risk profiles. The background characteristics of participants in each cluster were also summarized using proportions and the associations were tested using chi-square statistics.

Predictors of cluster distribution

Predictors of the cluster distributions were examined using logistic regression models. The background characteristics included in the model were age, gender, education, employment, residence, wealth index, and marital status. Results of this are presented in tables.

Ethical considerations

Written informed consent was obtained from every participant. Personal identifiers were delinked from the data by coding and the consent forms that contained personal identifiers were stored separately from the coded data. The data collection team was trained on ethical procedures and appropriate data collection techniques.

RESULTS

Characteristics of study population

In total 4,484 adults aged between 18 and 69 years were included in the study with nearly an equal representation women and men (51.3% versus 48.8%), and about half were young people aged 18-29 years, 65.5% married, 61.9% were rural residents, 12.6% had no formal education, 18.9% were classified as poorest and 23.4% richest and up to 40.1% were unemployed (Table 1).

Table 1: Sociodemographic characteristics of study population

Characteristics	N	%
Sex		
Female	2298	51.3
Male	2186	48.8
Age groups		
18-29	2062	46.0
30-39	1045	23.3
40-49	695	15.5
50-59	443	9.9
60-69	239	5.3
Marital status		
Not married	1039	23.2
Married	2938	65.5

Characteristics	N	%
Formerly married	507	11.3
Residence		
Rural	2776	61.9
Urban	1708	38.1
Education level		
No formal education	563	12.6
Primary education	2043	45.6
Secondary and above	1877	41.9
Household wealth status		
Poorest	848	18.9
Second	937	20.9
Middle	818	18.3
Fourth	832	18.6
Richest	1049	23.4
Occupation		
Unemployed	1799	40.1
Employed	2685	59.9

Cluster analysis of NCD risk factors

Using the 12 risk variables, the optimum number of clusters was found to be five. The distribution of the risk variables across the clusters is shown in Table 2.

Table 2: Distribution of specific non-communicable disease risk factors by clusters

	NCD risk variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Total
1	Inadequate Fruit/vegetables	99.4	100	99.7	99.8	99.8	99.8
2	High sugar intake	12.2	11.8	11.5	16.9	17.0	13.9
3	Insufficient physical activity	7.8	4.8	9.2	11.9	4.7	8.8
4	Excessive alcohol use	10.6	98.5	6.6	5.7	0.0	11.8
5	Tobacco use	9.1	65.8	8.2	3.3	12.6	12.3
6	Excessive sitting time	25.3	20.6	24.8	23.9	15.1	22.1

	NCD risk variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Total
7	General obesity	9.5	5.5	8.4	99.3	6.5	31.4
8	Central obesity	25.1	10.7	14.5	99.2	11.1	36.8
9	High blood sugar	13.5	9.9	9.1	15.7	6.6	10.9
10	High salt consumption	12.9	34.6	21.0	18.5	18.7	19.6
11	High fat intake	38.1	80.1	0.0	29.0	100	41.5
12	Increased blood pressure	100	27.9	0.0	42.0	4.3	27.6
	Cluster size	549	272	1196	1,024	922	3,963
	% of total	14.0	7.0	30.0	26.0	23.0	100
	Suggested cluster name	Hypertensives	Harmful users	Hopefuls	The obese	Fat lovers	

Key: NCD Noun-communicable diseases; The clusters are groups of study participants with similar pattern of NCD risk factors; All the values for risk factors are percentages

As displayed in the Table 2, participants in cluster 1 were all with hypertension. We labelled this cluster as “hypertensives.” Participants in cluster 2 had high rates of harmful use of alcohol, tobacco use and salt consumption as compared to the rest of the clusters. We labelled this cluster as “harmful users.” Participants in the fourth cluster had highest rates of general and abdominal obesity. These were labelled as ‘the obese.’ Those in the fifth cluster had the highest rate of high fat consumption and thus were labelled as “fat lovers.” Participants in the third cluster have no extreme risk and were labelled as the “hopefuls.” Inadequate fruit and vegetable consumption was universal across all cluster. Similarly, physical inactivity was not common in all clusters.

Profile of the NCD risk clusters

As compared to the other clusters, the hopefuls and fat lovers are younger. The mean (SD) ages were 33.9 (12.3) and 34.6 (12.4) years respectively. The mean ages for hypertensive, harmful users and the obese were 43.2 (14.8), 40.9 (12.8), and 41.2 (12.6) years, respectively. As to gender, majority of the harmful users (87%) were male. On the other hand, more than three quarters (78%) of the obese were female. Majority of the obese were urban residents while the fat lovers were rural residents. The hopefuls are equally distributed between rural and urban areas. A little more than half of the hypertensive and harmful users lived in rural areas. Details are shown in Table 3.

Table 3: Clusters of non-communicable risk factors by background variables

	NCD risk variables	Hyperten-sives	Harmful users	Hopefuls	The obese	Fat lovers	p-value
1	Age						
	18-29	23.9	19.5	43.9	20.0	40.1	<0.001
	30-44	29.3	43.8	36.0	42.8	39.8	
	45-59	27.0	24.6	14.9	26.1	14.4	
	60-69	19.9	12.1	5.3	11.1	5.6	
2	Sex						
	Female	53.7	12.9	58.8	78.1	56.3	<0.001
	Male	46.3	87.1	41.2	21.9	43.7	
3	Residence						
	Rural	55.9	57.0	50.1	41.4	60.0	<0.001
	Urban	44.1	43.0	49.9	58.6	40.0	
4	Education						
	No schooling	20.0	13.2	18.6	11.4	16.5	<0.001
	Primary incomplete	21.0	35.3	24.2	20.3	29.0	
	Primary complete	32.6	28.3	27.8	33.4	35.1	
	Secondary+	26.4	23.2	29.4	34.9	19.4	
5	Employment						
	Employed	45.9	30.2	43.1	33.7	47.2	<0.001
	Unemployed	54.1	69.9	56.9	66.3	52.8	
6	Wealth index						
	Poorest	20.0	25.7	24.5	8.1	26.6	<0.001
	Second	23.0	24.6	18.2	12.9	27.3	
	Third	24.4	19.9	17.1	21.2	20.0	
	Fourth	18.4	18.0	19.2	23.7	17.7	
	Richest	14.2	11.8	20.9	34.1	8.5	
7	Marital status						
	Not in Union	34.2	37.5	36.2	27.1	30.4	<0.001
	Union	65.8	62.5	63.8	72.9	69.6	

NCD Non-communicable diseases; Values in the clusters are percentages

The proportion of people in the hopeful and obese groups increased with educational status. The harmful users and the obese were dominated by the unemployed (70% and 66%, respectively). Analysis of wealth index among the clusters showed that the proportion of participants in the obese cluster increased linearly with wealth index.

PREDICTORS OF THE NCD CLUSTERS

For the NCD risk clusters, in multivariate analysis, higher age was found to be the predictor for the hypertensive. Being male was the strongest factor associated with belonging to the harmful users' cluster. We also found that wealth was strongly associated with the obese cluster. Age, educational status and wealth index were associated with the hopefuls' cluster. Details are shown in Table 4.

Cluster analysis of injury risk factors

Using the same cluster analysis approach for the nine injury risk factors, the optimum number of clusters was found to be four. A total of 3,981 participants were included in this cluster analysis. The distribution of the injury risk factors is shown in Table 5.

While characterizing the clusters by risk factors we found that participants in cluster 1 had considerable use of helmets when they use motorcycle, cycle or scooter. This group was labelled as "Helmet users." Those in the second cluster were known for inappropriate road crossing and are labelled as "jaywalkers." All the participants in the third cluster didn't use seatbelt when they had to. We labelled this group as "the defiant." Lastly, those in the fourth cluster, had remarkable level of seatbelt use and they did appropriate road crossing. We labelled this cluster as "the compliant."

Table 5: Distribution of injury risk factors by clusters

	NCD risk variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Total
1	Didn't use seatbelt	25.1	0.0	100	0.0	55.3
2	Didn't use helmet	0.0	100	100	100	67.1
3	Involved in traffic crash	5.6	6.0	4.5	6.4	5.3
4	Had injury	9.3	12.0	12.2	16.7	11.4
5	Inappropriate road crossing	76.5	100	91.4	0.0	84.1
6	Driving under influence of alcohol	2.9	2.7	3.0	2.5	2.9
7	Was a passenger of drunk driver	9.8	12.6	12.9	18.7	12.1
8	Involved in violence	2.9	3.9	4.6	5.9	3.9
9	Substance use	6.9	5.7	6.4	5.9	6.4
	Cluster size	1310	1019	1449	203	3981
	% of total	33.0	26.0	36.0	5.0	100
	Suggested cluster name	Helmet users	Jaywalkers	The defiant	The compliant	

NCD Non-communicable diseases; The clusters are groups of study participants with similar pattern of NCD risk factors; All the values for risk factors are percentages

Profile of injury clusters

The average age decreased modestly as one goes from helmet users to the compliant though the differences were not significant. Education of the participants was found to be an important factor in the profiling of the clusters. We found that the proportion of participants in the compliant cluster increases with their educational level. Close to 60% of the helmet users had completed at least primary education. On the contrary, about 60% of the jaywalkers had a similar educational level. While more than 40% of the seatbelt users and the compliant were on the higher side of wealth index, 46% of the defiant were in the lower wealth index category. Surprisingly, 44% of the jaywalkers were also within the higher wealth index categories. Profile of injury clusters is summarized in Table 6.

Table 4: Predictors of non-communicable diseases risk clusters

	Hypertensives		Harmful users		Hopefuls		The obese		Fat lovers	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age										
18-29 years (reference)	1.00		1.00		1.00		1.00		1.00	
30-44 years	1.11	(0.85, 1.43)	2.11	(1.44, 3.07)	0.59	(0.50, 0.70)	2.76	(2.22, 3.42)	0.67	(0.56, 0.81)
45-59 years	2.09	(1.59, 2.73)	2.54	(1.67, 3.88)	0.4	(0.32, 0.49)	4.37	(3.42, 5.59)	0.4	(0.32, 0.51)
60-69 years	3.62	(2.66, 4.94)	2.43	(1.47, 4.01)	0.25	(0.18, 0.34)	5.25	(3.82, 7.21)	0.3	(0.21, 0.42)
Sex										
Female (reference)	1.00		1.00		1.00		1.00		1.00	
Male	1.44	(1.18, 1.76)	14.3	(9.74, 21.03)	1.08	(0.93, 1.25)	0.19	(0.15, 0.23)	1.37	(1.16, 1.61)
Marital status										
Not in union (reference)	1.00		1.00		1.00		1.00		1.00	
In Union	0.92	(0.74, 1.14)	0.51	(0.37, 0.70)	0.85	(0.72, 1.00)	1.62	(1.33, 1.97)	1.1	(0.92, 1.32)
Residence										
Rural (reference)										
Urban	0.94	(0.76, 1.16)	0.96	(0.71, 1.31)	1.13	(0.96, 1.33)	0.99	(0.82, 1.20)	1.02	(0.85, 1.22)
Education										
No schooling (reference)	1.00		1.00		1.00		1.00		1.00	
Primary incomplete	0.76	(0.56, 1.04)	1.43	(0.91, 2.25)	0.71	(0.56, 0.90)	1.21	(0.90, 1.63)	1.13	(0.88, 1.46)
Primary complete	1.08	(0.79, 1.47)	0.87	(0.54, 1.40)	0.56	(0.44, 0.72)	1.48	(1.10, 1.99)	1.14	(0.87, 1.48)
Secondary +	1.14	(0.81, 1.61)	0.79	(0.47, 1.33)	0.67	(0.52, 0.88)	1.63	(1.18, 2.24)	0.86	(0.64, 1.17)

	Hypertensives		Harmful users		Hopefuls		The obese		Fat lovers	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Employment										
Unemployed (reference)	1.00		1.00		1.00		1.00		1.00	
Employed	0.77	(0.63, 0.95)	0.96	(0.70, 1.31)	1.04	(0.88, 1.22)	1.35	(1.12, 1.62)	0.86	(0.73, 1.03)
Wealth index										
Poorest (reference)	1.00		1.00		1.00		1.00		1.00	
Second quintile	1.22	(0.90, 1.66)	0.8	(0.54, 1.20)	0.75	(0.59, 0.94)	1.65	(1.19, 2.27)	1.04	(0.83, 1.32)
Third quintile	1.26	(0.93, 1.71)	0.68	(0.45, 1.05)	0.7	(0.55, 0.89)	2.94	(2.15, 4.02)	0.71	(0.55, 0.91)
Fourth quintile	1	(0.71, 1.41)	0.61	(0.38, 0.97)	0.72	(0.56, 0.93)	4.63	(3.33, 6.45)	0.54	(0.41, 0.71)
Richest	0.82	(0.55, 1.22)	0.42	(0.24, 0.74)	0.74	(0.56, 0.99)	9.43	(6.57, 13.53)	0.23	(0.16, 0.33)
Adults in household										
One (reference)	1.00		1.00		1.00		1.00		1.00	
Two adults	0.98	(0.79, 1.23)	1	(0.73, 1.37)	1.02	(0.86, 1.20)	1.01	(0.84, 1.22)	0.95	(0.79, 1.13)
Three or more adults	0.96	(0.73, 1.27)	0.51	(0.33, 0.80)	1.41	(1.15, 1.74)	1.07	(0.83, 1.37)	0.66	(0.52, 0.84)
Constant	0.11	(0.08, 0.16)	0.02	(0.01, 0.03)	1.22	(0.95, 1.57)	0.03	(0.02, 0.05)	0.63	(0.48, 0.84)

Table 6: Clusters of injury risk factors by background variables

	NCD risk variables	Helmet users	Jaywalkers	The defiant	The compliant	Chi-square (P-value)
1	Age					
	18-29	30.9	32.2	36.3	37.4	Chi=16.6 P=0.055
	30-44	39.2	40.7	36.2	38.4	
	45-59	20.0	19.3	18.2	15.3	
	60-69	9.9	7.8	9.3	8.9	
2	Sex					
	Female	54.4	58.6	65.1	58.1	Chi=33.6 P=0.000
	Male	45.7	41.4	34.9	41.9	
3	Residence					
	Rural	54.1	49.2	52.3	43.8	Chi=10.7 P=0.013
	Urban	46.0	50.8	47.7	56.2	
4	Education					
	No schooling	17.1	9.3	26.4	6.4	Chi=155.6 P=0.000
	Primary incomplete	24.7	25.1	24.0	26.1	
	Primary complete	31.0	34.0	28.3	30.1	
	Secondary+	27.2	31.6	21.3	37.4	
5	Employment					
	Employed	38.5	37.6	46.5	34.0	Chi=30.7 P=0.000
	Unemployed	61.5	62.4	53.5	66.0	
6	Wealth index					
	Poorest	20.4	14.0	27.7	12.3	Chi= P=0.000
	Second	18.4	22.0	19.6	22.2	
	Third	19.6	19.6	19.2	16.8	
	Fourth	20.2	20.9	19.5	20.7	
	Richest	21.5	23.5	14.0	28.1	
7	Marital status					
	Not in Union	29.9	31.9	32.0	35.0	Chi=108.1 P=0.383
	Union	70.2	68.1	68.0	65.0	

NCD Non-communicable diseases; Values in the clusters are percentages

Predictors of the injury clusters

In the injury clusters, age, education and wealth were negatively associated with the likelihood of an individual to belong to the defiant group. Educational status was also a predictor of the compliant cluster, but also the jaywalkers' cluster. Richest groups had high level of helmet use as compared to others. Predictors of injury clusters is displayed in Table 7.

DISCUSSION

The STEPs survey is the first countrywide population based NCD survey in Kenya and has provided important insights into the burden of NCD and injury risk profiles of both rural and urban populations. Cluster analysis was employed to determine patterns of NCD and injury risks and this segmented the population into five heterogeneous NCD risk clusters and four injury risk clusters. Two of the NCD risk clusters named fat lovers (23%) and harmful users (7%) demonstrated patterns consistent with three known behavioral NCD risk factors- unhealthy diet, tobacco smoking and harmful use of alcohol, and two NCD risk clusters referred to as the obese (26%) and the hypertensive (14%) fell in the physiological NCD risk group. One cluster had no extreme NCD risk. However, in all clusters fruit and vegetables consumption was way below the recommended five servings per day and physical inactivity was not common.

These findings are consistent with literature from rural and urban settings in Kenya highlighting that the burden of NCDs is driven by all the known behavioural and physiological NCD risk factors but not physical inactivity [14-16]. Recent publications from other countries in East Africa have revealed similar findings of dietary habits characterised by poor consumption of fruits and vegetables and a high consumption of fats and carbohydrate amidst adequate physical activity [17, 18], a pattern typical of an early phase of nutrition transition [19].

Our study has identified distinct population groups with prevalent NCD risk factors for targeted interventions. It is interesting to note that the smallest NCD risk cluster represents tobacco consumption, harmful alcohol consumption and excessive salt use. The lower frequency of harmful alcohol use and tobacco smoking may be a reflection of the relative success in the development and implementation of policies addressing the WHO "best buy" interventions for NCD prevention. These policies should ideally include measures to reduce

Table 7: Predictors of the injury clusters

	Helmet users		Jaywalkers		The defiant		The compliant	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age								
18-29 (reference)	1.00		1.00		1.00		1.00	
30-44	1.14	(0.96, 1.34)	1.22	(1.02, 1.46)	0.76	(0.65, 0.90)	0.92	(0.65, 1.30)
45-59	1.23	(1.00, 1.50)	1.25	(1.01, 1.56)	0.71	(0.58, 0.87)	0.79	(0.50, 1.23)
60-69	1.31	(1.01, 1.70)	1.19	(0.89, 1.61)	0.64	(0.50, 0.83)	1.23	(0.71, 2.15)
Sex								
Female (reference)	1.00		1.00		1.00		1.00	
Male	1.38	(1.20, 1.59)	0.93	(0.80, 1.09)	0.79	(0.68, 0.92)	0.89	(0.66, 1.21)
Marital Status								
Not in union (reference)	1.00		1.00		1.00		1.00	
In union	1.10	(0.93, 1.29)	0.94	(0.79, 1.12)	0.95	(0.81, 1.11)	1.02	(0.73, 1.42)
Residence								
Rural (reference)	1.00		1.00		1.00		1.00	
Urban	0.72	(0.62, 0.85)	0.95	(0.80, 1.12)	1.40	(1.19, 1.64)	1.14	(0.81, 1.61)
Education								
No schooling (reference)	1.00		1.00		1.00		1.00	
Primary incomplete	1.05	(0.84, 1.32)	2.11	(1.60, 2.79)	0.52	(0.42, 0.64)	2.97	(1.55, 5.69)
Primary complete	1.04	(0.82, 1.31)	2.32	(1.75, 3.07)	0.49	(0.39, 0.61)	2.68	(1.38, 5.20)
Secondary +	0.94	(0.73, 1.22)	2.51	(1.85, 3.39)	0.46	(0.36, 0.59)	3.75	(1.88, 7.47)

	Helmet users		Jaywalkers		The defiant		The compliant	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Employment								
Unemployed (reference)	1.00		1.00		1.00		1.00	
Employed	1.00	(0.86, 1.17)	0.98	(0.83, 1.15)	0.99	(0.85, 1.15)	1.13	(0.81, 1.58)
Wealth Index								
Poorest (reference)	1.00		1.00		1.00		1.00	
Second	0.93	(0.74, 1.17)	1.41	(1.09, 1.82)	0.79	(0.63, 0.98)	1.38	(0.82, 2.34)
Third	1.12	(0.89, 1.42)	1.25	(0.96, 1.62)	0.78	(0.62, 0.97)	1.01	(0.57, 1.76)
Fourth	1.24	(0.97, 1.59)	1.31	(0.99, 1.73)	0.67	(0.53, 0.85)	1.06	(0.59, 1.88)
Richest	1.59	(1.20, 2.11)	1.52	(1.12, 2.06)	0.43	(0.32, 0.56)	1.28	(0.69, 2.36)
Adults in household								
One (reference)	1.00		1.00		1.00		1.00	
Two	0.97	(0.83, 1.14)	1.10	(0.93, 1.31)	1.01	(0.86, 1.18)	0.76	(0.54, 1.06)
Three or more	0.98	(0.80, 1.21)	1.03	(0.83, 1.29)	1.01	(0.83, 1.24)	0.92	(0.60, 1.40)
Constant	0.36	(0.29, 0.47)	0.12	(0.09, 0.16)	1.69	(1.34, 2.14)	0.02	(0.01, 0.04)

common NCD risk factors such as tobacco use, unhealthy diet, physical inactivity and the harmful use of alcohol – that would deliver the greatest benefit in reducing population level risks in a cost-effective manner [20].

A recent NCD prevention policy review for Kenya revealed a fairly better formulated tobacco control policy addressing all WHO “best buy” interventions such as tax increases, bans on tobacco advertising, and warnings on the dangers of tobacco; a weak alcoholic drinks control act (ADCA) addressing some of the “best buy” interventions including taxation and restriction to alcohol access; and a deficient food and nutrition policy not adequately addressing “best buy” interventions for unhealthy diet [21]. Although physical activity policies are not given priority, no cluster emerged with physical inactivity as the main risk factor because most people are active through work and travel other than recreation [22].

For injuries, 62% of the population was classified into two high risk injury clusters referred to as the defiant (36 %) for not using seatbelts and jaywalkers (26%) because of inappropriate road crossing. The remaining two clusters which were low risk included helmet users (33%) and the compliant (5%) who used belts consistently and crossed roads appropriately. A recent survey conducted in five regional referral hospitals in Kenya showed that road traffic accidents were the most common injury among patients admitted in the emergency department and this is consistent with the clustering of risk factors at population level in this study [23]. Two other studies in Kenya have also revealed that among road traffic injuries, passengers in public transport vehicles followed by pedestrians were most involved [24, 25]. These accidents could have occurred because of non-compliance with belt use or jaywalking (inappropriate road crossing) reported in our study.

Identification of demographic characteristics associated with NCD risk clusters and the injury risk clusters is essential for programming successful primary preventive measures. We therefore profiled the NCD and injury risk clusters to inform differentiated prevention and care services. The factors that stood out as independent predictors of NCD risk clusters were; age, gender, education, wealth and living arrangements. Hypertension, harmful use of alcohol or salt and tobacco smoking, and obesity increased with age while fat consumption reduced with age. Men were more likely to be hypertensive, harmful users and fat lovers, while women were more likely to be obese.

The gender and age association with NCD risk has been well established before in Kenya [14]. An interesting finding in relation to age is the high consumption of fats by younger

people. This may be explained by growing westernization of diet that young people are quickly adapting to and it is often observed in the early phase of nutrition transition characterized by a high consumption of fats, sweeteners and inadequate fruit intake as in the fat lovers' cluster that was dominated by young people this study [19]. Shopping in supermarkets in Kenya is increasing and making in-roads beyond the richer consumers to lower-income groups in smaller towns with up to 56% of the customers in supermarkets reported to be from low income groups [26]. This has implications on the food choices of young people.

Education has an additional benefit in reducing NCD risk as illustrated in our study by the increase in the proportion of those in the hopeful cluster with education, however obesity increased with education. Likewise, wealth was associated with a reduction in NCD risk due to less harmful use of alcohol, salt and reduced tobacco smoking, less fat consumption but obesity also increased with wealth. Education influences health behaviors and attitudes and consequently, lifestyle through exposure to relevant health information and comprehension of the information [27]. The increase in obesity by education and wealth may be a result of increased exposure to advertisements by the food industry that has the potential to change food choices among the educated and wealthy who can afford to buy these foods.

It was also interesting to note that when three or more people shared a household, they were less likely to engage in high consumption of salt, fat, harmful consumption of alcohol and tobacco smoking. This may be largely attributed to a social audit by other household members checking on each other's lifestyle and eating habits. For the same reason, the married are less likely to smoke or consume alcohol. Personal social networks have been reported to be associated with compliance to good health promoting behaviors [28].

Surprisingly no difference in NCD risk profile was observed between rural and urban residents contrary to studies showing that urbanicity is associated several NCD risk factors in India and Philippines [29, 30]. A recent study in rural Uganda also showed that increasing urbanicity was associated with an increase in lifestyle risk factors particularly physical inactivity, low fruit and vegetable consumption and high body mass index [31]. The common feature among these studies was the use of a multi-component scale to accurately define urbanicity even among villages considered to be rural and they found marked variation in levels of urbanicity across the villages, largely attributable to differences in economic activity, civil infrastructure, and availability of educational and healthcare

services. Studies that loosely defined villages as urban or rural based on demarcation by national statistical bureaus as in this study have found no difference in NCD risk profiles among rural and urban populations, especially for hypertension [17, 18]. This suggests that even within rural populations social inequalities may exist which are often missed by the statistical bureaus because their classification of communities into rural and urban centers may not capture all the urbanicity scale components.

Regarding injuries, age, education and wealth improved compliant behaviors such as use of belts and helmets, and reduced defiant behaviors meaning as people get older or more educated or wealthier they become more responsible and tend to follow injury risk prevention measures. Education mediates comprehension of information such as written traffic rules or through an early exposure to a teaching curriculum in schools that includes traffic rules. It is worthwhile to mention that on the contrary jaywalking did not reduce with education, age, or wealth, but was instead seen to increase. A systematic review of literature on road traffic injuries in Kenya revealed that road traffic injuries have increased by four fold in three decades and up to 75% of the casualties are young adults aged 18-44 years, 80% of deaths are accounted for by pedestrians and passengers [25]. The traffic rules and enforcement seem to pay little attention to pedestrians. Most times the pedestrians break traffic rules and are not apprehended but instead treated as the victim of accidents. Public awareness about road safety especially for passengers and pedestrians is limited, thus the high risk of injuries among these groups.

The findings of this study have important implication for policy, practice and research. The identified clusters can guide where NCD policies and strategies need to focus. The resulting clusters would also be useful in the planning, implementation and evaluation of segmented approach to the prevention and control of NCDs. Similarly, future research projects could use these clusters to further explore the various characteristics associated with NCD profiles of the population of Kenya.

STRENGTHS AND LIMITATIONS

A major strength of this paper is the large sample size representative of the Kenyan population and this has provided an opportunity to investigate NCD and injury risk factors at national level. Secondly, the cluster analytical approach used in this paper identified important clusters of adult Kenyans with specific NCD and injury risk profiles

for potential development of differentiated population based interventions. However the main limitation of this cluster analytical approach is that it does not take into consideration the concurrency of risk factors, thus excludes important messages for those with multiple risk factors. Self-reported behavioural risk factors such as dietary intake and harmful use of alcohol are prone to bias, as participants may not accurately estimate quantities consumed or could purposively conceal information for social desirability. We also removed from the analysis individuals with incomplete records with respect to the key NCD and injury variables, which may have affected our analysis approach.

CONCLUSIONS

In conclusion, this nationally representative survey reveals interesting patterns of NCD and injury risk clusters generated through K-medians cluster analysis which is a popular form of cluster analysis due to its simplicity of implementation, ability to partition large data sets, and ease in interpretation of its cluster solution and tolerance of outliers [32, 33]. This analysis has provided a holistic view of patterns of risk at population level for decision-makers to target populations with appropriate interventions. The main population groups to be prioritized for targeted NCD prevention interventions include; those with unhealthy diet (young fat lovers), the obese and hypertensive (older, wealthy and educated, men) and harmful users of alcohol, salt and tobacco (unmarried, older, living alone). When designing NCD preventive interventions rural populations should also be considered. Since Kenya is in the early stage of epidemiological transition, there is a window of opportunity to implement primordial NCD prevention measures to curtail the growing NCD epidemic. There is need for a multi-sectoral action to strengthen policies and implementation of programs with a focus on tackling unhealthy diet, prevention and management of hypertension and obesity. Strengthening the existing policies for tobacco and alcohol control to further reduce the current frequency of consumption and the experiences of developing these policies should inform the design of robust nutrition policies.

For injuries, there is need to design targeted messaging for road safety measures particularly for young, poor and uneducated people. Clear guidelines on safety measures for pedestrians and general public awareness on traffic guidelines for pedestrians are needed. Lastly, enhanced enforcement of traffic laws for pedestrians and passengers in public transport will be crucial in reducing road traffic injuries.

LIST OF ABBREVIATIONS

ADCA - Alcoholic Drinks Control Act; APHRC - African Population and Health Research Center; CVD - Cardiovascular diseases; MoH - Ministry of Health, Kenya; NASSEP V - National sample surveys and evaluation programme; NCD - Non-communicable diseases; PDA - Personal digital assistant; STEPS - The WHO STEPwise approach to Surveillance; SSA - sub-Saharan Africa; WHO - World Health Organization

ACKNOWLEDGEMENTS

Authors would like to thank all the individuals and organizations that provided technical support for the design and implementation of the main survey. Funding for the main survey was provided by World Bank, World Health Organization (WHO), Astrazeneca and the Ministry of Health (MOH) and the Center for Diseases Control (CDC). Authors are also grateful to the data collection and analysis team led by the MOH, WHO and Kenya National Bureau of Statistics (KNBS), Kenya Medical Research Institute (KEMRI) and African Institute for Health and Development (AIHD).

Funding

The writing of this paper was made possible through the generous funding made to African Population and Health Research Center (APHRC), from International Development Research Center (IDRC).

Availability for data and materials

Data and materials are available by writing to Gladwell Gatheca-gladwellgathecha@gmail.com.

Author contributions

TNH and FMW conceptualized the study, drafted the plan of analysis, conducted the analysis and led the writing of the manuscript. MKM, SFM, GA and CK contributed to the design of study, and writing of the manuscript. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Kenya Medical Research Institute's Ethics Review Committee had reviewed and approved the study (SSC No. 2607). Study respondents were provided with information in a language easy to understand, and an opportunity to determine if they wanted to participate or not.

Consent for publication

NA

Competing interests

The authors declare no competing interest

REFERENCES

1. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization; 2014.
2. World Health Organization. Noncommunicable Diseases Country Profiles, 2014. 2014.
3. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *The Lancet*. 2006;367(9524):1747-57.
4. Boutayeb A. The double burden of communicable and non-communicable diseases in developing countries. *Transactions of The Royal Society of Tropical Medicine and Hygiene*. 2006;100(3):191-9.
5. Murray C, Lopez AD. Summary: The global burden of disease: A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Geneva and Boston: World Health Organization and Harvard School of Public Health. 1996.
6. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2013;380(9859):2095-128.
7. Kontis V, Mathers CD, Rehm J, Stevens GA, Shield KD, Bonita R, et al. Contribution of six risk factors to achieving the 25×25 non-communicable disease mortality reduction target: a modelling study. *The Lancet*. 2014;384(9941):427-37.
8. Khatib O. Noncommunicable diseases: risk factors and regional strategies for prevention and care. *Eastern Mediterranean Health Journal*. 2004;10(6):778-88.
9. World Health Organization. World Health Organization STEPwise approach to chronic disease risk factor surveillance (STEPS) instrument. . Geneva: World Health Organization 2007.
10. World Health Organization. Global recommendations on physical activity for health. Switzerland: World Health Organization; 2010.
11. World Health Organization. Guideline: Sodium intake for adults and children. Geneva, Switzerland: WHO; 2012.
12. World Health Organization. Healthy Diet: WHO; 2015 [cited 2017 April 15]. Available from: <http://www.who.int/en/news-room/fact-sheets/detail/healthy-diet>.
13. World Health Organization. BMI Classification: WHO; 2018 [cited 2017 April 25]. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.
14. Kaduka LU, Kombe Y, Kenya E, Kuria E, Bore JK, Bukania ZN, et al. Prevalence of metabolic syndrome among an urban population in Kenya. *Diabetes Care*. 2012;35(4):887-93.

15. Christensen DL, Friis H, Mwaniki D, Kilonzo B, Tetens I, Boit M, et al. Prevalence of glucose intolerance and associated risk factors in rural and urban populations of different ethnic groups in Kenya. *Diabetes Research and Clinical Practice*. 2009;84(3):303-10.
16. Van de Vijver SJ, Oti SO, Agyemang C, Gomez GB, Kyobutungi C. Prevalence, awareness, treatment and control of hypertension among slum dwellers in Nairobi, Kenya. *Journal of Hypertension*. 2013;31(5):1018-24.
17. Guwatudde D, Mutungi G, Wesonga R, Kajjura R, Kasule H, Muwonge J, et al. The epidemiology of hypertension in Uganda: findings from the national non-communicable diseases risk factor survey. *PLOS One*. 2015;10(9):e0138991.
18. Kavishe B, Biraro S, Baisley K, Vanobberghen F, Kapiga S, Munderi P, et al. High prevalence of hypertension and of risk factors for non-communicable diseases (NCDs): a population based cross-sectional survey of NCDs and HIV infection in Northwestern Tanzania and Southern Uganda. *BMC Medicine*. 2015;13(1):126.
19. Popkin BM. The nutrition transition and its health implications in lower-income countries. *Public Health Nutrition*. 1998;1(1):5-21.
20. Organization WH. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. 2013.
21. Juma P, Mohamed S, Kyobutungi C. Analysis of non-communicable disease prevention policies in Kenya. African Population and Health Research Centre (APHRC)/IDRC; 2017.
22. Ayah R, Joshi MD, Wanjiru R, Njau EK, Otieno CF, Njeru EK, et al. A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya. *BMC Public Health*. 2013;13(1):371.
23. Botchey IM, Hung YW, Bachani AM, Paruk F, Mehmood A, Saidi H, et al. Epidemiology and outcomes of injuries in Kenya: a multisite surveillance study. *Surgery*. 2017.
24. Odero W, Kibosia J. Incidence and characteristics of injuries in Eldoret, Kenya. *East African Medical Journal*. 1995;72(11):706-10.
25. Odero W, Khayesi M, Heda P. Road traffic injuries in Kenya: magnitude, causes and status of intervention. *Injury Control and Safety Promotion*. 2003;10(1-2):53-61.
26. Neven D, Reardon T, Chege J, Wang H. Supermarkets and consumers in Africa: the case of Nairobi, Kenya. *Journal of International Food & Agribusiness Marketing*. 2006;18(1-2):103-23.
27. Scuteri A, Vuga M, Najjar S, Mehta V, Everson-Rose S, Sutton-Tyrrell K, et al. Education eclipses ethnicity in predicting the development of the metabolic syndrome in different ethnic groups in midlife: the Study of Women's Health Across the Nation (SWAN). *Diabetic Medicine*. 2008;25(12):1390-9.
28. Marquez B, Elder JP, Arredondo EM, Madanat H, Ji M, Ayala GX. Social network characteristics associated with health promoting behaviors among Latinos. *Health Psychology*. 2014;33(6):544.

29. Allender S, Lacey B, Webster P, Rayner M, Deepa M, Scarborough P, et al. Level of urbanization and noncommunicable disease risk factors in Tamil Nadu, India. *Bulletin of the World Health Organization*. 2010;88(4):297-304.
30. Allender S, Wickramasinghe K, Goldacre M, Matthews D, Katulanda P. Quantifying urbanization as a risk factor for noncommunicable disease. *Journal of Urban Health*. 2011;88(5):906.
31. Riha J, Karabarinde A, Ssenyomo G, Allender S, Asiki G, Kamali A, et al. Urbanicity and lifestyle risk factors for cardiometabolic diseases in rural Uganda: a cross-sectional study. *PLOS Medicine*. 2014;11(7):e1001683.
32. Bailey KD. *Typologies and taxonomies: an introduction to classification techniques*: Sage; 1994.
33. Gan G, Ma C, Wu J. *Data clustering: theory, algorithms, and applications*: SIAM; 2007.

Part 2

Understanding of and perception towards non-communicable and cardiovascular diseases risk factors

Chapter 4

Knowledge and awareness of and perception towards cardiovascular diseases risk in sub-Saharan Africa: a systematic review

Daniel Boateng, Frederick Wekesah, Joyce Browne, Charles Agyemang, Peter Agyei-Baffour, Ama de-Graft Aikins, Henriette A. Smit, Diederick E Grobbee, Kerstin Klipstein-Grobusch

PLoS ONE. 2017. 12 (12): e0189264

ABSTRACT

Introduction: Cardiovascular diseases (CVDs) are the most common cause of non-communicable disease mortality in sub-Saharan African (SSA) countries. Gaps in knowledge of CVD conditions and their risk factors are important barriers in effective prevention and treatment. Yet, evidence on the awareness and knowledge level of CVD and associated risk factors among populations of SSA is scarce. This review aimed to synthesize available evidence of the level of knowledge of and perceptions towards CVDs and risk factors in the SSA region.

Methods: Five databases were searched for publications up to December 2016. Narrative synthesis was conducted for knowledge level of CVDs, knowledge of risk factors and clinical signs, factors influencing knowledge of CVDs and source of health information on CVDs. The review was registered with PROSPERO (CRD42016049165).

Results: Of 2212 titles and abstracts screened, 45 full-text papers were retrieved and reviewed and 20 were included: eighteen quantitative and two qualitative studies. Levels of knowledge and awareness for CVD and risk factors were generally low, coupled with poor perception. Most studies reported less than half of their study participants having good knowledge of CVDs and/or risk factors. Proportion of participants who were unable to identify a single risk factor and clinical symptom for CVDs ranged from 1.8% in a study among hospital staff in Nigeria to a high of 73% in a population-based survey in Uganda and 7% among University staff in Nigeria to 75.1% in a general population in Uganda respectively. High educational attainment and place of residence had a significant influence on the levels of knowledge for CVDs among SSA populations.

Conclusion: Low knowledge of CVDs, risk factors and clinical symptoms is strongly associated with the low levels of educational attainment and rural residency in the region. These findings provide useful information for implementers of interventions targeted at the prevention and control of CVDs, and encourage them to incorporate health promotion and awareness campaigns in order to enhance knowledge and awareness of CVDs in the region.

Keywords: Cardiovascular disease risk; risk factors; knowledge; awareness; sub-Saharan Africa; perception

INTRODUCTION

Non-communicable diseases (NCDs) pose a major health challenge globally, currently causing more deaths than all other causes combined [1]. In 2012, about 38 million people died from NCDs and this is expected to increase to 52 million by 2030 [1]. About 80% of these deaths are caused by four NCDs: cardiovascular diseases (CVDs), cancers, chronic respiratory diseases and diabetes. CVDs account for almost half of NCDs deaths [1, 2] estimated at an annual 17.3 million deaths, and 10% of the global disease DALY burden [2, 3]. It is expected that by the year 2030, more than 23 million deaths will be caused by CVDs [3, 4], with stroke and coronary heart disease (CHD) being the leading contributors [5, 6].

Deaths from CVDs have declined progressively over the past three decades in high-income countries because of implementation of population-wide preventive strategies, effective primary and secondary preventive healthcare, and availability of improved treatment for acute events [7]. However, rates of CVD deaths have increased in LMICs over the same period [8, 9]. In addition to increased prevalence of risk factors of CVDs in these settings, this rise in CVD deaths reflects lower availability of population strategies for prevention and health care [1]. The rise in CVD risk factors in sub-Saharan Africa (SSA) is attributed to rapid urbanization, globalization and urban poverty [10]. Both are associated with a change in diets and lifestyle, where traditional diets are replaced with energy-dense and processed foods and increasing physical inactivity [10]. As poverty and inequality trigger the upsurge of communicable diseases [11], as well as propagate risk factors for NCDs as smoking, drinking and poor diet [11], the burden of disease disproportionately affects the urban poor.

Gaps in knowledge of CVD conditions and their risk factors in the general population are important barriers in the effective prevention and treatment of CVDs [12]. The role of knowledge in health behaviors and sustained behavioral changes has been proposed by several models including the health belief model [13-15]. These models posit that knowledge of a disease condition influences patient's attitude and practice, improves compliance with treatment and has been shown to lead to reduction in prevalence and aversion of complications [16]. These models, although they may differ in content and viewpoint, emphasize the importance of appraising the beliefs, views and attitudes of individuals to apprehend observed behaviors and to guide behavioral change.

Success in the implementation of any health promotion program is dependent on context-specific information on knowledge, awareness and perception of the targeted population. There is however a regional level scarcity of evidence on the knowledge and awareness levels of CVDs and risk factors among the populations of SSA [17]. This systematic review therefore aims at synthesizing existing evidence on knowledge, awareness and perception towards these conditions.

METHODS

This review was conducted according to the recommendations outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement [18]. It was registered with Prospero (CRD42016049165).

Search strategy

We searched PubMed, Medline, Science Direct, Google Scholar, Africa Index Medicus (AIM), Africa Journals Online (AJOL) databases to retrieve relevant primary studies conducted in SSA, using pre-defined search (Title/Abstract) and indexing terms (MeSH/Emtree). Keywords and MeSH terms and their combinations used in the searches were “knowledge”, “stroke”, “heart attack”, “coronary heart disease”, “myocardial infarction”, “congenital heart disease”, “heart diseases”, “vascular diseases”. Reference lists of full-text papers were hand searched for additional articles and reviewed for relevance in this review. The strategy is provided as a supplementary file (S1 Text).

Inclusion criteria

We included studies that were published in SSA, in English, and in peer-reviewed journals between 2007 and 2015. Papers were from primary research of any design and methodology: quantitative and qualitative and exploring knowledge, awareness and perception of CVD and the risk factors. Studies that were carried out among SSA populations living in Western countries or only described interventions leading to increased knowledge and awareness of CVDs or risk factors and symptoms of CVDs were also excluded.

Definition of terms and concepts

CVDs include vascular diseases in general, CHD, cerebrovascular disease (e.g. stroke), myocardial infarction (MI) and congenital heart diseases. Individuals were required to correctly identify CVD conditions, risk factors and clinical symptoms from a list to gauge

their knowledge. Perception was based on individuals' self-assessment of chances of developing CVDs, as well as their understanding of who was at risk to develop the condition. Perception was mostly explored in qualitative studies. The SSA region was classified based on the United Nations classification of countries [19].

Data extraction

Two reviewers (DB, FW) conducted data extraction from the identified studies. Information was extracted on: authors, year of publication, study design and population, research methods, types of CVDs studied, findings on the knowledge, awareness of and perception towards CVDs and the risk factors. We extracted additional data on the factors influencing knowledge and perceptions of CVD and the reported sources of information on CVD and risk factors. The exercise was reviewed by JB and KKG, who were also consulted on the extraction process.

Quality assessment

The quality of the quantitative studies, were assessed based on National Institute of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [20]. This form appraised the reliability, validity and generalizability of the quantitative studies. The NIH quality assessment tool uses 13 criteria to assess and rate the quality of studies. This included the research question, study population, sample size estimation, exposure and outcome assessment, loss to follow-up and statistical analysis. General guidance is provided for determining the overall quality of the studies and to grade their level of quality as good, fair or poor.

Qualitative studies were appraised using the Critical Appraisal Skill Program(CASP) tool [21]. The CASP tool has 10 items that look at the relevance and clarity of research goals, appropriateness of the research design and methodology in addressing the research question, recruitment strategies, data collection, data analysis, findings, ethical consideration and value of the research. Questions attached to these items enable critical self-reflection about biases and assess the extent to which findings from the study could be transferred to other settings or groups. The quality assessment and criteria are available as a supplementary file (S1 File).

Synthesis of findings

Qualitative data synthesis of the findings on the knowledge, awareness of and perception towards CVD risk and risk factors in SSA was conducted. Findings from the quantitative

papers were absorbed using the multi-source synthesis method, an analytical technique that enhances transparency when synthesizing quantitative and/or contextual data, thus providing a platform for comparison between studies [22]. Findings from qualitative articles were integrated with those from the quantitative studies based on similar themes or topics. Due to the heterogeneity in outcomes, data were not pooled to conduct a meta-analysis.

RESULTS

Study characteristics

A total of 2212 titles were identified from electronic database searches. 2167 titles were excluded for being irrelevant to the review question, and 45 full-text articles were assessed for inclusion. Twenty-five articles were excluded based on reasons such as not reporting the link between risk factors to general knowledge and awareness of CVDs or reporting results of an impact of an intervention in the levels of knowledge and awareness of CVD and risk factors. In the end, 20 articles were included in the review. The assessment and inclusion criteria are reported in Figure 1. One of the 18 quantitative studies out of the final 20 studies was quasi experimental, while the rest were cross-sectional. Respondents were recruited from varied settings, including from general population samples living in urban and rural areas, and from specific samples like academic staff, hospital staff and health professionals, patients, and employees in banks and in the military. The age of the participants in the different studies ranged from 16 to 82 years. More information on characteristics of study participants is presented in Table 1.

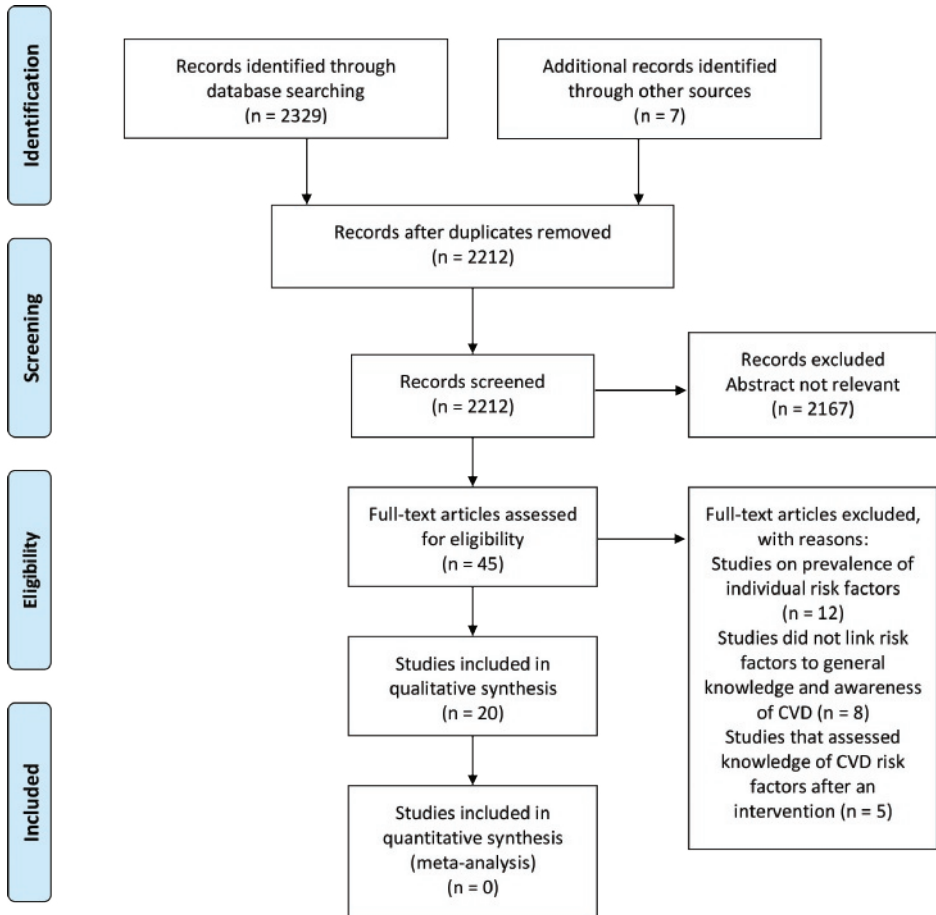


Figure 1: PRISMA Flow Diagram on search and selection of review articles

Table 1: Characteristics of included studies

Study, year, country	Design and methods	Sample size	Study population and setting	Quality [†]
Akintunde et al (2015) ²³ , Nigeria	Study design: Descriptive cross-sectional Methods: Quantitative; random sampling	206 (M 96, W110)	Adult university staff (academic and non-academic) Mean age 45.3years	Fair
Mohammed (2012) ²⁶ Nigeria	Study design: Cross-sectional Methods: Quantitative Sampling: Not stated	82 (M 80; W 2)	Military personnel (Army, Navy, Air force) of the Nigerian Armed Forces 30–60years; mean 49years	Poor
Uchenna, Ambakederomo, Jesuorobo (2012) ⁴² , Nigeria	Study design: Cross-sectional Methods: Quantitative; convenient sampling	236 (M 136, W 100)	Outpatients of university teaching hospital 16–82 years; mean 42.1	Poor
Awosan et al (2013) ²⁵ Nigeria	Study design: Cross-sectional Methods: Quantitative, multistage random sampling	210 (M 141; W 69)	Bankers and secondary school teachers (>1yr experience) a Metropolis 25–56years teachers; 20–49years bankers	Good
Oladapo et al (2013) ³³ Nigeria	Study design: Cross-sectional survey Methods: Quantitative Sampling: Systematic random	2000 (M 873; W 1127)	Rural community members in Southwestern Nigeria	Good
Akinyemi et al (2009) ²⁸ , Nigeria	Study design: Cross-sectional survey Methods: Quantitative, systematic random	400 (M 137; W 233)	Hospital staff of federal medical centre 20–64years (mean age 34.4years)	Fair
Wahab, Kayode & Musa (2015) ³⁷ Nigeria	Study design: Cross-sectional survey Methods: Quantitative	354 (M 148; W 166)	Patients on follow-up for hypertension and/or diabetes at specialist medical outpatient clinics Mean age 56.4years	Good

Study, year, country	Design and methods	Sample size	Study population and setting	Quality†
Obembe et al (2014) ²⁹ Nigeria	Study design: Cross-sectional survey Methods: Quantitative, multistage stratified sampling	494 (M 284; W 210)	Staff of government-owned tertiary institution	Good
Komolafe et al (2015) ³¹ Nigeria	Study design: Cross-sectional survey Methods: Quantitative	Size: 114 (M 51; W 63)	Secondary school teachers of 2 towns in Nigeria 20-50years	Fair
Ajayi and Ojo (2007) ⁴⁰	Study design: Descriptive cross-sectional Methods: Quantitative	155 (M 87; W 68)	Patients attending a medical out-patient clinic Mean age 58.4	Poor
Akinyemi RO et al (2015) ^{30§} Nigeria	Study design: Quasi experimental Methods: Quantitative	116 (M 50; W 66)	Non-neurologist health workers Mean age 46.1	Fair
Ansa, Oyo-Ita and Essien (2007) ¹⁷ Nigeria	Study design: Cross-sectional Methods: Quantitative; systematic random sampling	500 (M 302; W 198)	Staff of university hospital 41-50years	Fair
Donkor et al (2014) ³⁵ Ghana	Study design: Cross-sectional survey Methods: Quantitative, systematic random	693 (M 374; W 319)	Inhabitants of a metropolitan city, Mean age, 36.8years	Good
Cossi et al (2012) ³⁶ Benin	Study design: Cross-sectional survey Methods: Quantitative Sampling: All included	15155 (M 6293; W 8862)	Adults in an urban district Mean age, 31years	Good
Kaddumukasa et al (2015) ³² Uganda	Study design: Cross-sectional survey Methods: Quantitative multistage stratified random	370 (M 117; W 253)	Households in selected urban and rural areas 18-85years; Median age, 34years	Good

Study, year, country	Design and methods	Sample size	Study population and setting	Quality [†]
Nakibuuka et al (2014) ²⁴	Study design: Cross-sectional Methods: Quantitative; multistage stratified sampling	1616 (M 510; W 1,106)	Urban and rural residents; 1161 urban, 455 rural.	Good
Uganda	Analysis: Chi square, logistic regression		Mean age 39.6	
Temu et al (2015) ⁴¹ ; Kenya	Study design: Cross-sectional Methods: Quantitative; convenient sampling	300 (M108; W 192)	PLWH on or not yet on ART (outpatients) from HIV clinic of Teaching and referral hospital >=18years	Good
Yuqiu & Wright (2008) ³⁴	Study design: Cross-sectional survey Methods: Quantitative, census sampling	551 (M 302; W 249)	Adults of working age living in a community 18-40years	Fair
South Africa				
Qualitative study				
Surka et al (2015) ²⁷	Study design: Cross-sectional Methods: Qualitative (FGDs of 8-10 participants); Purposive sampling	28 (M 4; W 24)	Male and female community members (≥ 25 years) with no previous experience in being assessed for CVD risk Mean age 53years	Good
South Africa				
Awah et al (2008) ³⁹	Study design: Cross-sectional Methods: Qualitative; Purposive sampling	82 (M 44; W 38)	Community members, health workers, policy makers	Good
Cameroon	FGDs and IDI			

Heart Disease Fact Questionnaire; CVD Cardiovascular disease; IHD Ischemic heart disease; PLWH People Living with HIV/AIDS; CHD Coronary Heart Disease; BP Blood pressure; FGD=Focus group discussions; IDI=In depth interviews

[†]The quality assessment and criteria are available in the S2,^sOnly those in the pre-intervention phase included in this review;

QUALITY OF INCLUDED STUDIES

The majority of the quantitative studies were rated to be of good or high quality (n = 10). They described in detail the design and methodology used, the process of recruiting participants, justification and methods of arriving at required sample size, study setting, clear and detailed presentation of findings. Studies that were rated to be of fair or poor quality (n = 8) were papers that failed to describe details of subject recruitment processes including inclusion criteria and sampling strategies and lacked justification of sample size and other issues that could lead to a high risk of bias and undermine generalizability of the study (S1 File).

Knowledge and awareness regarding cardiovascular diseases

Most studies in this review did not state a priori the criteria used in measuring and classifying levels of knowledge and awareness. However, most of them classified knowledge and awareness of CVD or the risk factors as poor, acceptable or good. In the study by Akintunde et al [23], among university staff, a knowledge score of <50% was classified as low; 50-69% moderate and ≥70% good. Nakibuuka et al [24], in a study in Uganda classified urban and rural residents who could identify 5-10, 2-4 and <2 CVD risk factors or warning signs as having good, fair and poor knowledge respectively.

Awareness of CVDs was high among studies that reported on it; 76.2% among bankers and teachers [25] and 75.6% among military personnel [26] in Nigeria. Most people in a low-income peri-urban community in South Africa [27], were familiar with the terminology used to describe CVDs. However, the studies reported generally low knowledge levels of CVDs with most studies reporting less than 50.0% of respondents having good knowledge. In studies conducted among workers in a Nigerian University Hospital, one reported that 19.0% had good knowledge of CVDs [23] while another showed that 53.5% knew the mechanism through which stroke occurs [28]. Findings on the knowledge and awareness of CVDs in SSA is summarized in Table 2 and Figure 2.

Table 2: Outcome assessment and findings of included studies

Study	Condition	Assessment of knowledge	General knowledge/ awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Akintunde et al ²³	CVD	HDFQ scores were used to determine the level of knowledge	<i>Low knowledge of CVDs</i> - 50% low; 31.1% moderate; 19.9% high	- Poor knowledge on cholesterol and heart disease - Moderate knowledge of smoking, diabetes, overweight and high BP		Age; gender; education NOT associated with knowledge of CVDs
Uchenna, Ambakederomo, Jesuorobo ⁴²	CVD	Structured questionnaire- researcher administered	-91.2% never been counseled on heart disease prevention	Poor knowledge -51.7% had no knowledge of any cause of heart disease	-Low knowledge of symptoms of heart disease; 24.6%	Education; gender NOT associated with awareness of CVDs
Mohammed ²⁶	CVD	Self-designed knowledge and awareness Questionnaire	Level of knowledge -75.6% enlightened on CVD	Low knowledge level of - Primary risk factors; 31.7% - Secondary risk factors; 41.5% <i>Most identified</i> -Smoking (70.6%); excessive alcohol (52.8%); stress (87.5%) <i>Least identified</i> -Sedentary lifestyle (16.6%), poor dietary intake (6.4%)		

Study	Condition	Assessment of knowledge	General knowledge/ awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Awosan et al ²⁵	CHD	Questionnaire adapted from the American Heart Association's questionnaire	High level of awareness of CHD -76.2%	<p><i>Generally, low</i></p> <p>-Up to 50% in 4/7 among teachers; 1/7 in bankers</p> <p>-Hypertension – 50.5% teachers; 59% bankers</p> <p>-Overweight/obesity- 47.6% teachers; 55.2% bankers</p> <p>- Physical activity, cigarette smoking and fatty foods – up to 50% bankers; less among teachers</p>		
Oladapo et al ³³	Stroke, Heart failure	Structured questionnaire	<p>Low knowledge of clinical features of stroke – 21.9%</p> <p>-Clinical features of heart attack or angina -0.4%</p>	<p>Low knowledge of CVD risk factors- About 56% unable to identify a single risk factor</p> <p>-Hypertension- 16.2%</p> <p>Diabetes- 5.4%</p> <p>Tobacco use – 36.2%</p> <p>Obesity- 1.6%</p> <p>Lack of exercise; 1.2%</p> <p>Stress- 42.7%</p>		<p>-Age, gender, family history, history of stroke NOT related</p> <p>Tertiary education (OR, 95% CI= 3.11, 2.06-7.14)</p>

Study	Condition	Assessment of knowledge	General knowledge/awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Akinyemi et al ²⁸	Stroke	Structured, semi-closed questionnaire	Low knowledge of organ affected -16.9% clinical workers; -35.0 non-clinical workers -53.5% knew mechanism through which stroke occurs - Knowledge of occurrence of stroke through rupture of vessels-64.9%	-4.3% could not identify a single risk factor -27.6% identified 1-3; 68.1% identified >=4 -Hypertension 88.6%; stress 70.8% most cited -High Cholesterol 43.8%; alcohol use 43.4%; Smoking 35.9%; lack of exercise 34.6%; ageing 30.8%; diabetes 29.5%; bad diet 22.4%. -Some participants cited evil spirits, 13.8% and will of God, 1.1%).	One sided body weakness - most identified - 61.9%; slurring of speech, 52.2% -Dizziness, altered consciousness, loss of vision, chest pain least identified. -8.6% could not identify a single warning symptom	Tertiary education demonstrated better knowledge of how stroke occurs (p<0.001) Tertiary education knew <=4 warning symptoms (p<0.004)
Wahab, Kayode & Musa ³⁷	Stroke	Author designed questionnaires		Low knowledge level of stroke risk factors -Only 39.8% correctly mention 1 modifiable stroke risk factor -Hypertension- 34.7%; diabetes 7.3%; smoking 3.8%; alcohol 4.5%; stress 12.7%; overweight/obesity 1.9%; Sedentary lifestyle 0.6%	Age < 55 years (OR, 1.832; 95% CI, 1.160-2.893); > 12 years of formal education (OR, 2.712; 95% CI, 1.678-4.382); family history (OR, 2.112; 95% CI, 1.116-3.998); urban residence (OR, 2.726; 95% CI, 1.256-5.919)	

Study	Condition	Assessment of knowledge	General knowledge/ awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Obembe et al ²⁹	Stroke	Author designed questionnaires		<p><i>Inadequate knowledge</i></p> <ul style="list-style-type: none"> -1.8%% knew NO risk factor -Hypertension most identified- 91.7% -Stress 80.2%; ageing 63.8%; cholesterol 51.4%; smoking 46.2%; obesity 56.1%; lack of exercise 50.8%; family history 55.5%; diabetes 45.7%; alcohol 40.3%; diet 36.0% 	<p><i>Low knowledge</i></p> <ul style="list-style-type: none"> -7.7% identified NO warning sign; only 15.2% identified all warning signs -Slurred speech 58.7%; dizziness 52.8%; numbness 69.4%; weakness 69.8%; headache 39.9%; vision problem 39.5%; difficulty in understanding 34.4% 	Age, education, family history significantly influenced awareness of stroke
Komolafe et al ³¹	Stroke	Previously validated questionnaire to recognize and identify risk factors and early warning signs	Inadequate awareness of stroke	<p><i>Low knowledge</i></p> <ul style="list-style-type: none"> -13.2% identified NO risk factor -Hypertension 79.8%; Age 43.9%; Stress 65.8%; Cholesterol 50.9%; Obesity 49.1%; Lack of exercise 57%; Family history 52.6%; Diabetes 47.4%; alcohol 52.6%; diet 99.1%; hyperlipidemia 22.8%; smoking 49.6%; Ageing 43.9% 	<p><i>Low knowledge</i></p> <ul style="list-style-type: none"> -23.7% identified NO warning sign; only 3.5% identified all warning signs -Slurred speech 50%; dizziness 27.2%; numbness 33.3%; weakness 42.1%; headache 36.8%; vision problem 20.2%; shortness of breath 32.5% 	

Study	Condition	Assessment of knowledge	General knowledge/awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Donkor et al ³⁵	Stroke	Author designed, validated questionnaire, based on previously used questionnaires	Inadequate awareness of stroke	-19% identified NO risk factor -Lack of exercise 37%; Hypertension 34%; Alcohol 33%; High cholesterol 32.0%; Family history 28%; Smoking 24%; stress 22%; (heart disease, obesity, diabetes) <15%	Low knowledge of stroke warning signs -22% identified NO warning sign -Slurred speech 37%; dizziness 17%; numbness 21%; weakness 38%; severe headache 25%; vision problem 15%; shortness of breath 13%	Age, gender, education not related to stroke awareness
Ajayi and Ojo (2007) ⁴⁰	Stroke	Structured questionnaire- researcher administered		- Hypertension, most identified, 60.6%; Previous history, 16.1%; Cholesterol, 3.2%; family history, 3.2%; smoking, 1.3% - None identified drinking of alcohol	Poor knowledge - Paralysis on one side of body, 55.6%; Weakness on one side, 27.1%; Sudden difficulty in speaking and understanding, 7.1%; Tingling sensation, 5.8%; blurred vision, vertigo, difficulty swallowing <1%. - None identified chest pain	Higher education association with increase awareness of stroke risk factors

Study	Condition	Assessment of knowledge	General knowledge/ awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Akinyemi RO et al ³⁰	Stroke	Self-administered questionnaire.	Knowledge of epidemiology – 81%;	90.5% identified ≥ 4 risk factors; 7.8% 1-3 risk factors. 1.7% identified no risk factor. 95.7% - hypertension as major risk factor	79.3% identified ≥ 4 risk symptoms; 19% 1-3 symptoms. Face drop 11.2%; arm weakness 12.1%; speech affected/slurred 18.1%.	
Ansa, Oyo-Ita and Essien ¹⁷	IHD	Self-administered questionnaire		Smoking, 70.6%; excessive alcohol, 52.8%; obesity, 41.6%; sedentary lifestyle, 16.6%; oral contraceptives, 6.4%.		Higher education increased knowledge of risk factors
Cossi et al ³⁶	Stroke	Author designed semi-structured questionnaires adopted from previous studies	<i>Low knowledge</i> Majority unable to name organ affected	<i>Inadequate knowledge</i> -21.8% knew NO risk factor -Hypertension most identified- 34.5% -Stress 7.6%; diet 4.7%; diabetes 0.3%; cardiac problems 0.3%; obesity 1%	Low knowledge of warning signs – 22.7% knew no warning sign -33% knew ≥ 1 warning sign -Paralysis and hemiplegia – most cited 34.4% -Weakness, walking in speaking and seeing 12.8% -Headache and dizziness – 11.8%	Education, age, occupation associated with knowledge of stroke risk factors

Study	Condition	Assessment of knowledge	General knowledge/awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Kaddumukasa et al ³²	Stroke	Modified standardized questionnaire already used in SSA settings	<i>Low knowledge</i> -59.4% did not know brain as site affected by stroke	Inadequate awareness of stroke risk factors -42.4% knew NO risk factor -Stress most identified risk factor-43% -Hypertension-28.9% -None identified smoking -(Age, diabetes, fats, diet, lack of exercise) <10%	Low knowledge of warning signs -57% knew NO warning sign -Paralysis most identified warning sign - 18% -Body weakness – 12%; numbness 10%	Residence associated with knowledge of stroke (p=0.038)
Nakibuuka et al ²⁴	Stroke	Structured questionnaires, modified from previous studies	- Low knowledge of stroke; 76.2% urban, 78.9% rural did not know organ affected by stroke - Some believe stroke affect the heart, liver and kidneys. Preventability of stroke: Yes, 39.5%; No, 30.9%; don't know, 29.6%.	- 73% knew NO stroke risk factor. - Identified risk factors: hypertension, 56%; stress, 51.4%; bad diet, 29.6%; lack of exercise 25.7%; diabetes, 14.9%; old age, 12.6%; High cholesterol, 12.2%; obesity, alcohol <10%; smoking, 0.7%. - Misconceptions: demons or witchcraft, 0.9%; God's will, 6%	- 75.1% knew NO stroke symptom; 40.3% only 1 symptom; Only 3% knew ≥ 5. - Identified symptoms: paralysis on one side, 28.6%; weakness on one side, 26.1%; dizziness, 23.6%; paralysis on any part, 17.4%; tiredness, 16.4%; headache 16.2%; shortness of breath, fever/sweating, 9.7%; weakness on any part of body, 7.5%; blackout, 6.5%; blurred vision, 2.7%; speaking difficulty, 2.2%.	Tertiary education associated with good knowledge of; -risk factors, (OR 5.96; 95% CI 2.94-12.06). -Warning symptoms (OR 4.29; 95% CI 2.13-8.62). Urban residence increased knowledge or CVD.

Study	Condition	Assessment of knowledge	General knowledge/ awareness of CVDs	Knowledge of risk factors	Knowledge of warning signs/symptoms	Factors related
Temu et al ⁴¹	CVD; CHD	Questionnaire constructed from multiple validated surveys. Knowledge measured on a continuous scale and scored		<i>Low knowledge; mean score 1.3/10</i> -High knowledge of stress (74%). -Low knowledge of other risk factors; obesity 9.3%; raised BP 9%; excessive alcohol 7.6%; smoking 4%; age 2.3; Family history 1.3%	<i>Low knowledge; mean score 0.28/7</i> -77.3% didn't know heart attack -<3% could identify chest pain, excessive sweating, nausea vomiting, pain in teeth, jaw or arm as symptoms	Education à (OR 5.21, 95% CI 0.99-27.37)
Yuqiu & Wright ³⁴	CVD	Author designed questionnaire	Generally low knowledge of CVDs	-Stress most frequently mentioned risk factor, 53.5%; followed by smoking. -Low knowledge level of hypertension, physical inactivity, obesity, alcohol (<30% in males and females) and diabetes (<10%)		
Qualitative studies						
Surka et al ²⁷	CVD, heart attack, stroke, MI	Thematic discussions on Knowledge of CVD and its prevention, perception of risk	Majority familiar with terminologies for CVDs; Limited insight into the conditions	Cited risk factors for CVD: Tobacco smoking, excessive alcohol consumption, stress, unhealthy diets		
Awah et al ³⁹	CVD	FGD and IDI guides		Perceived risk factors of CVDs were; Diet, obesity, smoking, alcohol, sedentary lifestyle.		

Key: BP Blood pressure; MI Myocardial infarction IHD Ischemic heart disease

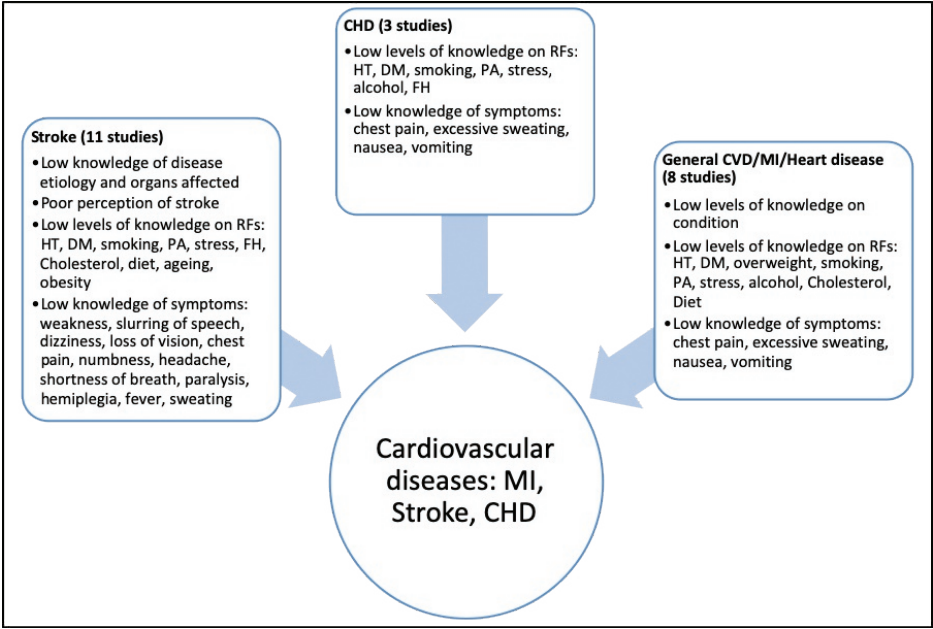


Figure 2: Summary of systematic review findings

Key: RF Risk factors HT Hypertension DM Diabetes mellitus PA Physical activity FH Family history CVD Cardiovascular diseases MI Myocardial infarction.

KNOWLEDGE OF RISK FACTORS FOR CARDIOVASCULAR DISEASES

To gauge knowledge of risk factors for CVDs, individuals were required to correctly identify them from a list. Just like it was the case with CVD risk, majority of the studies also reported low levels of knowledge on risk factors for CVDs. Hypertension and stress were the most known and cited risk factors in most of the studies. Participants who were unable to identify a single risk factor for CVDs ranged from as low as 1.8% in a study among hospital staff in Nigeria [29] to a high of 73.0% in a population-based survey in Uganda [24]. Specifically, among studies that looked at stroke, participants who could not identify a single risk factor was <20% among hospital workers [28, 30], university staff [29] and secondary school teachers [31] in Nigeria and 40-80% among rural and urban Ugandans [24, 32] and rural Nigerians [33]. A study that looked into coronary heart disease among teachers and bankers in Nigeria also described about 20% of the study population as having no knowledge of risk factors for the disease [25]. The studies also reported some

misconceptions regarding the risk factors for CVDs to include evil spirits, demons and will of God as causes of CVDs [24, 28].

Hypertension

Knowledge levels of hypertension as a risk factor for CVD ranged from as low as 16.2% in a study among rural community members in Nigeria [33] to 95.7% in a study among health workers in Nigeria [28]. In a low-income peri-urban community in South Africa, none of the respondents cited hypertension as a risk factor of CVD [27]. Low knowledge levels of hypertension as risk factor for CVDs, ranging from 16.2% to 34.5% were reported among studies conducted within urban and rural communities [32-36] whereas high percentages were reported in studies conducted among health workers (95.7%) [30]; (88.6%) [28], secondary school teachers (79.8%) [31] and staff of tertiary institution (91.7%) [29].

Diabetes

The knowledge level of diabetes as a risk factor of CVD ranged from 0.3% in a study among urban adult population in Benin [36] to 47.4% among secondary school teachers in Nigeria [31]. Two community-based studies from Ghana [35] and Uganda [24] reported less than 15% of study participants possessing any knowledge of diabetes as a risk factor for stroke. Knowledge of diabetes as a CVD risk factor among hypertension and diabetes patients at a specialist medical center in Southern Nigeria was very low, at 7.3% [37].

Smoking and tobacco use

Knowledge of smoking as a CVD risk factor was 70.6% among military personnel in Nigeria [26] and less than one percent among the general populations in Central Uganda [24]. Less than 50% of respondents across all studies could identify smoking as a risk factor for CVD, with the exception of the study among Armed Forces personnel in Nigeria, 70.6% [26]. In a study in rural Uganda, none of the respondents identified smoking as a risk factor for CVD [32]. In all, 14 studies reported on knowledge of smoking as CVD risk factor, three of which reported <5% with knowledge of smoking as a risk factor for stroke [26, 42] and for CHD [38].

Insufficient physical activity

Knowledge of physical inactivity or sedentary lifestyle as risk factors for CVD ranged from 0.6% [37] to 57% [31], in Nigeria. Two other studies reported knowledge level of less than 10%; 1.2% in a rural Nigerian community [33] and 3.8% among hospital outpatients [37].

Heavy alcohol consumption

Heavy alcohol consumption as a risk factor for CVD was reported by 4.5% in a study among patients with hypertension and/or diabetes at specialist medical outpatient clinics in Nigeria [37] to as high as 52.8% among staff at a University Hospital and same proportion among military personnel in Nigeria [26]. Another study among secondary school teachers [31] and Hospital staff in Nigeria [28] reported 52.6% and 43.4% of knowledge of alcohol as risk factor, respectively. Participants enrolled in qualitative studies conducted in South Africa and Cameroon [27,39] also mentioned heavy alcohol consumption as risk factor for CVD. Respondents in a study among outpatients in Nigeria were, however, not able to identify heavy alcohol use as a risk factor for CVD [40].

Emotional stress

Stress was reported as a risk factor for CVD by 7.6% of adults in an urban district of Benin [36] to 87.5% of members of Nigerian Armed forces [26]. Other studies conducted among formally employed workers reported high knowledge level; health workers 70.8% [28], among university staff 80.2% [29] and secondary school teachers 65.8% [31]. Among community level studies, knowledge level of 53.5% as among a South African community [34] whereas studies among urban communities in Ghana [35] and Benin [36] reported low knowledge of stress (22% and 7.6%) respectively.

Other risk factors for cardiovascular diseases

Other risk factors for CVD were ageing, family history, obesity and unhealthy diet. Knowledge of these risk factors was low across studies reviewed and was least cited or known among study subjects. Ageing was identified as a risk factor for CVD by 63.8%, 43.9% and 38% among university staff [29], secondary school teachers [31] and hospital staff [28] respectively in Nigeria. Among the studies that reported on family history, knowledge level was >50% in two of the studies that were conducted among formal working populations in Nigeria [29,31], 3.2% among medical outpatients in Nigeria [40] and as low as 1.3% in the study conducted among people living with HIV/AIDS in Cameroon [38]. Of nine studies, five that were conducted among people living with HIV [38], hypertension and/ or diabetes outpatients [37], rural population [33], urban population [36] and the general population [24], <10% identified obesity as a CVD risk factor. The biggest proportion with knowledge of obesity as a CVD risk factor, 56.1% was reported among staff of a University in Nigeria [29]. Knowledge on diet as risk factor for CVD was 99.1% among secondary school teachers [31] and <10% among Armed Forces personnel [26] in Nigeria and the general household

population in Uganda [32]. Unhealthy diet was also reported as a risk factor in two studies [27, 39].

KNOWLEDGE OF SYMPTOMS AND CLINICAL SIGNS FOR CARDIOVASCULAR DISEASES

The proportion of respondents who could not identify a single symptom of any CVD condition ranged from 7.0% among academic staff in a University in Nigeria [29] to 75.1% among the general population in Uganda [24]. The proportion of respondents who could identify all symptoms ranged from 3.5% among teachers [31] to 15.2% among health staff [29] in Nigeria. Knowledge of chest pain, excessive sweating, nausea, vomiting, and pain, as symptoms of CVDs were also very low (<3%) [38, 40]. Knowledge of symptoms of stroke was <50% in all the studies that reported on stroke with the exception of three, which reported >50% knowledge level of one (paralysis, 55.6%) among medical outpatients [40], two (weakness, 52.2%; slurring speech, 61.9%) among hospital staff [31] and four symptoms (slurring speech, 58.7%; dizziness, 52.8%; numbness, 69.4% and weakness, 69.8%) among university teachers [32]. The most reported symptoms of stroke were weakness, 61.9% [28] and 69.8% [29], slurring speech, 59% [29]²⁹ and paralysis on one side, 55.6% [40]. Dizziness, loss of vision, chest pain and altered consciousness, headache, vision problem, shortness of breath and numbness were least reported across the studies.

Perception of cardiovascular disease risk

Four studies investigated the perception of CVDs [24, 27, 40, 41]. Among people living with HIV/AIDS, 31% believed they were at high risk of developing CVDs, while older women were more likely to agree that they were at a higher risk for CVDs [41]. In a qualitative study from South Africa [27], participants were described as being generally unfamiliar with the concept of risk, while the two respondents who were familiar with the concept of risk could also not explain in detail what it actually meant. In a study of medical out-patients in a tertiary health institution in Nigeria [40],⁴⁰ majority (65.8%) of the respondents were never concerned about the possibility of developing stroke, 16.1% sometimes thought of it, 12.3% occasionally and 5.8% always had the concern. 34.1% of respondents in a population-based study from Uganda [24] perceived no chance while 14.4% perceived high chance of possible stroke in lifetime.

Factors influencing knowledge of cardiovascular diseases and risk factors among reported studies

Factors such as age and family history, type of residence and education were reported to be associated with knowledge of CVDs. The significant influence of age on knowledge of CVD was reported by three studies [29, 36, 37]. In two studies from Nigeria conducted among hospital outpatients [37] and university staff [29], age <55 and <40 were a significant predictor of knowledge of CVDs. There was a significant relationship between educational attainment and knowledge of CVDs [17, 29, 33, 36, 37, 40]. As reported in a study from rural South-Western Nigeria [33], people with tertiary education were three times more likely to be knowledgeable of CVD risk factors and a study among hospital outpatients in Nigeria [37] showed that more than 12 years of education increased the odds of being knowledgeable about CVD risk factors by more than twice. A significant association between type of residence and knowledge of CVD was also described: urban residents were more knowledgeable about CVDs compared to their rural counterparts in a community study in Uganda [24] and a study among diabetic/hypertensive outpatients [37]. No study reported a relationship between gender with knowledge of CVDs [33,42].

Source of information on cardiovascular diseases

The sources of information for CVD and risk factors included electronic media like television [25, 26, 31, 36, 41], radio [26, 31, 41], and print media in the form of magazines or newspapers [25, 31, 41], health care professionals [25, 26, 31, 33, 36, 40, 41] and family members or relatives [25, 31, 33, 36]. The internet was reported as a source of information among secondary school teachers [31] and among people living with HIV/AIDS [41]. Television was the most cited source of CVD information across the studies that reported on it, with a proportion of 31.7% in a study of Nigerian Armed forces [26] to 75.5% in a study among University staff [29] in the same country. Healthcare professionals as source of CVD information ranged from 4% [41] to 64.4% [17] in people living with HIV and university staff respectively. In the study among hospital workers in Nigeria [28], 66.9% and 23.2% of clinical and non-clinical staff had read on CVDs from other sources. Details of the sources of information reported across the studies are presented in Table 3.

Table 3: Sources of information on cardiovascular diseases

Source of information	Temu et al ⁴¹	Awosan et al ²⁵			Akinyemi et al ²⁸		Komolafe et al ³¹	Cossiet al ³⁶	Ansa, Oyo-Ita and Essien ¹⁷
		Mohammed ²⁶	Teachers	Bankers	Oladapo et al ³³	Clinical	Non-clinical		
Television	51	31.7	53.8	43.8			75.4	13.9 [§]	
Radio	44	12.2					56.1		
Magazine/newspaper	19		21.3	27.5			59.4		
Internet	4						40.4		
Healthcare professional	4	22.9	7.5	13.8	9.1		45.0	11.8	64.4
Media*					24.6	37.3	27.7		28.8
Family					59.9	30.3	20.5	25.1	
Friend						44.4	33.3		
School education						68.3	10.3	9.5	
Seen someone with the condition						81.0	82.0	16.6	
Health campaigns							33.8		
Read from other sources [§]						66.9	23.2%	20.4	36.2

*Radio, public enlightenment programs, and newspapers; §Include radio and Internet

DISCUSSION

This review identified low levels of knowledge and awareness of CVDs and associated risk factors and clinical signs or symptoms for CVDs among populations in SSA. The knowledge gap is also apparent in the low perception regarding the risk of developing and dying from CVDs in the region [24, 40]. In population-based studies conducted in Uganda [24] and Benin [36], respondents were unable to identify the organ affected by stroke, despite it being a condition with poor survival outcomes in this region [43-45]. Knowledge of clinical symptoms was as low as 3.5% among teachers in Nigeria [31], while as few as 16.2% in a rural Nigerian community [33] knew that of hypertension, 0.3% for diabetes, 1% for obesity and 7.6% for stress in urban Beninese population [36], as risk factors or developing CVD.

A systematic review of awareness of hypertension in West Africa reported overall low knowledge of hypertension [46]. Studies that explored knowledge and perceptions of obesity and sedentary lifestyles showed poor perceptions and subjective norms such as overweight being socially desirable, and a sign of beauty and riches thereby inducing unwillingness to lose weight [47, 48]. African belief systems are however not static – they are complex and dynamic, tied as they are to shifting social identities. Other body of evidence suggests that contrary to the often-cited fatness equals wealth, health and beauty theory, young African women view fatness as a precursor for CVDs [49]. These women are interested in living a healthy life and are willing to reduce their body size in order to reduce the risk of obesity-related diseases despite the resistance to lose weight because of the cultural value on weight and the impact of the husband's preference [50]. These inherent perceptions and desire to lose weight should be important considerations when designing educational interventions to improve knowledge of CVDs.

Despite the rise in CVD risk factors in SSA populations, our findings indicate that the populations generally did not recognize their potential relation to the development of CVDs. In SSA, the incidence and prevalence of classical risk factors of CVDs such as smoking [51], hypertension [52], obesity [53, 54], high cholesterol, fatty diets, alcohol consumption [56-58] and lowered physical activity [55] are rising. This rise is linked to rapid urbanization, resulting in an epidemiological and nutrition transition, where energy-dense diets replace traditional diets and sedentary lifestyles prevail poverty [10]. As such, there is a shift in disease burden from under-nutrition and highly active lifestyle to over-nutrition-related and sedentary lifestyle related chronic diseases.

Knowledge of alcohol intake as a risk factor for CVD was low in the region. Four studies [24, 34, 37, 41] reported on this and found that <30% of study participants cited alcohol consumption as a risk factor for CVDs; in a study among medical outpatients [40], none identified alcohol consumption as a risk factor for CVD. In most societies in SSA, use of alcohol has been defined by cultural and religious parameters, with little acceptance of the potential health effect of alcohol consumption on health [59]. This is of concern, considering the expansion of alcoholic industries commercial activities in SSA to increase sales in this region [60, 61]. Adequate policies to address these challenges in SSA are however few whereas there are no developed multi-sectorial approaches, that involves the private sector, civil society, informal sector, community leaders and traditional healers [62]. Further, in countries where there are preventive interventions such as enactment of drinking and driving laws, taxation, restrictions on advertising and community information, implementation is *ad hoc*, informal, fragmented and often lacks adequate control and enforcement systems [62].

The relationship between alcohol consumption and CVDs is nuanced. Light to moderate drinking has been suggested to decrease the incidence of ischemic stroke, whereas heavy drinking has been implicated as an independent risk factor for ischemic and hemorrhagic stroke [63-65]. For hypertension, cardiac dysrhythmias and hemorrhagic stroke, alcohol is considered to be an independent risk factor, regardless of the drinking pattern [66]. This emphasizes the need for the development and enforcement of adequate and effective policy measures, public awareness and surveillance mechanisms in the SSA region. Without awareness of personal susceptibility and health consequences related to alcohol consumption, alcohol consumption behaviors are less likely to be modified to reduce risk of CVD.

Knowledge on stress as a risk factor of CVD was relatively high, especially among urban populations, despite the complex relationship between stress and CVDs [67]. Susceptibility to stress is influenced by type of personality, social support, coping strategies and genetic vulnerability [67]. Stress could be positive, by forcing us to adopt and thus to increase the strength of our adaptation mechanisms (eustress) or negative, when it exceeds our ability to cope, fatigues body systems and causes behavioral or physical problems (stressors) [67, 68]. A strong association has been observed between perceived stress and CHD [69-71] and current evidence shows perceived stress to be an independent risk factor for stroke [72]. The belief and perception of the influence of stress on CVDs in SSA populations could however be related to experiences of psychosocial stressors arising out of urbanization

and poverty [73, 74]. Experiences of chronic poverty-related stressors, such as inadequate housing, sanitation, water, overcrowding, environmental conditions, low education and unemployment, are potent predictors of poor cardiovascular health [75-77]. Strategies to deal with perceived psychosocial stress among these populations, include smoking and alcohol consumption, which themselves are precursors of poor cardiovascular health [78, 79].

This review shows knowledge of CVDs and their risk factors to be significantly related to the type of population studied and place of residence, and the level of exposure to health information about CVDs. Studies that formally tested the association between place of residence and education on knowledge of CVDs, also reported a significant relationship [24, 32, 37]. There is the possibility that the differences observed in the levels of knowledge among the urban and the rural populations are driven by the fact that the urban, and mostly formally employed/ working population is more likely to be educated and more exposed to the media and other modern sources of health information, including the internet [80, 81]. The rural population and uneducated on the other hand, are most likely to be poor, and less likely to be exposed to print and electronic media which have been reported as major sources of information on CVDs and risk factors. The rural populations in SSA have also been shown to utilize health services less than their urban counterparts [82, 83], and rely on information from their families [33]. Exploring the determinants of health in rural areas, such as the role of the family, is therefore important if health promotion policies and strategies are to result in significant improvements in health status.

Traditionally the major sources of information on CVD, respectively CVD risk factors have been shown to include electronic and print media (television, radio, newspaper) and health workers [84, 85]. Recent studies have quoted the internet as an important source of health information, especially among urban populations, teachers and other formally employed individuals, clearly illustrating the influence of the internet in health care. This situation presents an important consideration for public health policy and resource allocation for health promotion strategies in these settings.

STRENGTHS AND LIMITATIONS

This review presents evidence regarding the knowledge and awareness of CVDs in SSA. To the best of our knowledge, this is the first systematic review of the knowledge and

perceptions of CVDs in SSA. Our results are based on a systematic search of five databases, integrating both qualitative and quantitative evidence on the topic. The inclusion of qualitative studies in this review meant that research findings on perceptions towards CVDs were incorporated and contributed to our understanding of and explanation of the trends of knowledge of CVDs in this study setting. As the criteria of measurement of knowledge of CVD (risk factors) was not uniform across studies (different criteria were used for classifying knowledge into low, medium or high resulting in heterogeneity across study findings), a meta- analysis could not be conducted. As the study populations differ considerably within and between countries it is difficult to disentangle to what extent educational level or cultural or country level determine knowledge and awareness levels. Still, the qualitative synthesis of available evidence of knowledge and perceptions of and perception towards CVD risk and risk factors presented in this review should speak to the current situation as most studies were published.

CONCLUSIONS

Generally, inadequate knowledge of CVDs and the associated risk factors continues to be one of the most important factors in determining health-seeking behaviors in SSA. Knowledge levels of CVDs, risk factors and warning signs were mainly varied by type of populations and influenced by the type of employment, education levels and place of residence. Formal workers were more aware of and knowledgeable about CVD and the risk factors compared to studies conducted within rural and urban households. What this means is that education must be tailored for different groups. One-size fits all messaging is unlikely to work. Misconceptions (damaging cultural beliefs such as witchcraft and spiritual causal theories) must be addressed in ways that enhance biomedical understandings without stigmatizing cultural understandings. Adequate attention and awareness creation on the adverse implications of CVD related risk behaviors such as smoking, alcohol consumption and sedentary lifestyle on this population cannot be overemphasized. Effective policy measures, public awareness and surveillance mechanisms that takes into consideration the socio-cultural context of these behaviors need to be developed and implemented in this region. Evidence provided in this study can guide context specific interventions, aimed at mitigating CVDs by improving levels of knowledge and awareness of the conditions and risk factors among SSA populations.

List of abbreviations

NCD, Non-communicable diseases; CVD, Cardiovascular disease; CHD, Coronary Heart Disease; MI, Myocardial infarction; SSA, Sub-Saharan Africa.

ACKNOWLEDGEMENTS

DB and FW are supported by the Global Health Support Program of the University Medical Center Utrecht, Utrecht University, the Netherlands.

Conflict of interest

The authors declare that they have no competing interests relating to this review. All authors read and approved final manuscript.

REFERENCES

1. WHO. Global Status Report on Noncommunicable Diseases 2014. Geneva; 2014. doi:ISBN 9789241564854.
2. Mendis S, Puska P, Norrving B. Global Atlas on Cardiovascular Disease Prevention and Control. World Health Organization; 2011.
3. Mozaffarian D, Benjamin E, Go A, et al. Heart disease and stroke statistics— 2015 update: a report from the American Heart Association. American Heart Association. 2015;(1):7-10. doi:10.1161/CIR.000000000000152.
4. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 2006;3(11):e442.
5. WHO. Cardiovascular diseases (CVDs): Fact sheet. <http://www.who.int/mediacentre/factsheets/fs317/en/>. Published 2016. Accessed July 27, 2016.
6. World Health Statistics. Causes of death 2008: data sources and methods. World Health. 2011;2010(September 2010):1-28. http://www.who.int/healthinfo/global_burden_disease/cod_2008_sources_methods.pdf
7. O'Flaherty M, Buchan I, Capewell S. Contributions of treatment and lifestyle to declining CVD mortality: Why have CVD mortality rates declined so much since the 1960s? Heart. 2012;159-162. doi:10.1136/heartjnl-2012-302300.
8. Agyemang C. Cardiovascular diseases in poor resource settings A neglected disease. Glob Med. 2005;10. <http://globalmedicine.nl/issues/gm10/article6.pdf>.
9. WHO. The world health report 2003: Shaping the future. Geneva World Heal Organ. 2003;204. doi:10.1146/annurev.ecolsys.35.021103.105711.
10. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70(1):3-21. doi:10.1111/j.1753-4887.2011.00456.x.
11. Naik R, Kaneda T. Non-communicable Diseases in Africa: Youth are key to curbing the epidemic and achieving sustainable development. 2015;2014(April).
12. Adkins H. Getting the message across. Cater Hotelk. 2006;196(4447):13. doi:10.1136/bmj.294.6586.1534.
13. Prochaska JO, DiClemente CC, Norcross JC. In search of how people change: Applications to addictive behaviors. Am Psychol. 1992;47(9):1102-1114. doi:doi:10.3109/10884609309149692.
14. Stretcher V, Rosenstock IM. The Health Belief Model. Heal Behav Heal Educ Theory, Res Pract. 1997;31-36. doi:10.1111/j.1365-2648.2010.05450.x.
15. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. Health Educ Q. 1988;15(2):175-183. doi:10.1177/109019818801500203.

16. Busari, O. A.; Olusegun, T.; Olufemi, O.; Desalu, O.; Opadijo, O. G.; Jimoh, A. K.; Agboola, S. M.; Busari, O. E.; Olalekan O. Impact of Patients' Knowledge, Attitude and Practices on Hypertension on Compliance with Antihypertensive Drugs in a Resource-poor Setting. *Prev Med (Baltim)*. 2010;9(2):87-92. <http://www.scopemed.org/fulltextpdf.php?mno=836>.
17. Ansa VO, Oyo-Ita A, Essien OE. Perception of ischaemic heart disease, knowledge of and attitude to reduction of its risk factors. *East Afr Med J*. 2007;84(7):318-323.
18. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. In: *Journal of Clinical Epidemiology*. Vol 62. ; 2009:e1-34. doi:10.1016/j.jclinepi.2009.06.006.
19. UN. World Population Prospects - The 2012 Revision. ESA/P/WP.235. 2014:44. http://esa.un.org/wpp/Documentation/pdf/WPP2012_Methodology.pdf
20. National Institute of Health. Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. <http://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort>. Published 2014. Accessed July 25, 2016.
21. Critical Appraisal Skills Programme (CASP). Critical Appraisal Skills Programme (CASP) Qualitative Research Checklist. http://media.wix.com/ugd/dded87_29c5b002d99342f788c6ac670e49f274.pdf Published 2013. Accessed July 25, 2016.
22. Pedersen VH, Dagenais P, Lehoux P. Multi-source synthesis of data to inform health policy. *Int J Technol Assess Health Care*. 2011;27(3):238-246. doi:10.1017/S0266462311000213.
23. Akintunde A, Akintunde T, Opadijo O. Knowledge of heart disease risk factors among workers in a Nigerian University: A call for concern. *Niger Med J*. 2015;56(2):89. doi:10.4103/0300-1652.150688.
24. Nakibuuka J, Sajatovic M, Katabira E, Ddumba E, Byakika-Tusiime J, Furlan AJ. Knowledge and Perception of Stroke: A Population-Based Survey in Uganda. *ISRN stroke*. 2014;2014:1-7. doi:10.1155/2014/309106.
25. Awosan KJ., Ibrahim MTO, A.A. S, Ejimodu P. Awareness and prevalence of risk factors of coronary heart disease among teachers and bankers in Sokoto, Nigeria. *J Med Med Sci*. 2013;4(September):335-342. doi:http://dx.doi.org/10.14303/jmms.2013.116.
26. Mohammed J. Knowledge of, and Attitude to Cardiovascular Disease Risk Factors Among Members Of The Nigerian Armed Forces. *World J Public Heal Sci*. 2012;11(2):23-27. <http://www.rrpjournals.com>.
27. Surka S, Steyn K, Everett-Murphy K, Gaziano TA, Levitt N. Knowledge and perceptions of risk for cardiovascular disease: Findings of a qualitative investigation from a low-income peri-urban community in the Western Cape, South Africa. *African J Prim Heal care Fam Med*. 2015;7(1):E1-8. doi:10.4102/phcfm.v7i1.891.

28. Akinyemi RO, Ogah OS, Ogundipe RF, et al. Knowledge and perception of stroke amongst hospital workers in an African community. *Eur J Neurol*. 2009;16(9):998-1003. doi:10.1111/j.1468-1331.2009.02666.x.
29. Obembe AO, Olaogun MO, Bamikole AA, Komolafe MA, Odetunde MO. Awareness of risk factors and warning signs of stroke in a Nigeria University. *J Stroke Cerebrovasc Dis*. 2014;23(4):749-758. doi:10.1016/j.jstrokecerebrovasdis.2013.06.036.
30. Akinyemi RO, Owolabi MO, Adebayo PB, et al. Task-shifting training improves stroke knowledge among Nigerian non-neurologist health workers. *J Neurol Sci*. 2015;359(1-2):112-116. doi:10.1016/j.jns.2015.10.019.
31. Komolafe MA, Obembe AO, Olaogun MO, et al. Awareness of stroke risk factors and warning signs in nigerian adolescents compared with adults. *J Stroke Cerebrovasc Dis*. 2015;24(3):687-693. doi:10.1016/j.jstrokecerebrovasdis.2014.11.013.
32. Kaddumukasa M, Kayima J, Kaddumukasa MN, et al. Knowledge, attitudes and perceptions of stroke: a cross-sectional survey in rural and urban Uganda. *BMC Res Notes*. 2015;8:819. doi:10.1186/s13104-015-1820-6.
33. Oladapo O., Salako L, Sadiq L, Soyinka K, A.O F. Knowledge of Hypertension and other Risk Factors for Heart Disease among Yoruba Rural Southwestern Nigerian Population. *Br J Med Med Res*. 2013;3(4):983-1003. doi:10.9734/BJMMR/2013/2685.
34. Yuqiu L, Wright SCD. Knowledge and awareness of risk factors for cardiovascular disease in the ga-rankuwa community. *Heal SA Gesondheid*. 2008;13(3):3-4. <http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2010041868&lang=es&site=ehost-liv>.
35. Donkor ES, Owolabi MO, Bampoh P, Aspelund T, Gudnason V. Community Awareness of Stroke in Accra Donkor 2014. 2014:1-7.
36. Cossi M-JJ, Preux P-MM, Chabriat H, Gobron C, Houinato D. Knowledge of stroke among an urban population in Cotonou (Benin). *Neuroepidemiology*. 2012;38(3):172-178. doi:10.1159/000336862.
37. Wahab KW, Kayode OO, Musa OI. Knowledge of stroke risk factors among Nigerians at high risk. *J Stroke Cerebrovasc Dis*. 2015;24(1):125-129. doi:10.1016/j.jstrokecerebrovasdis.2014.07.053.
38. Temu TM, Kirui N, Wanjalla C, et al. Cardiovascular health knowledge and preventive practices in people living with HIV in Kenya. *BMC Infect Dis*. 2015;15(1). <http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L606397595>.
39. Awah PK, Kengne AP, Fezeu LLK, Mbanya J-C. Perceived risk factors of cardiovascular diseases and diabetes in Cameroon. *Health Educ Res*. 2008;23(4):612-620. doi:10.1093/her/cym037.
40. Ajayi AO, Ojo OO. Knowledge and perception of stroke among at risk medical out-patients in a tertiary health institution in Nigeria. *Ann Afr Med*. 2007;6(2):51-53.
41. Temu TM, Kirui N, Wanjalla C, et al. Cardiovascular health knowledge and preventive practices in people living with HIV in Kenya. *BMC Infect Dis*. 2015;15(1):421. doi:10.1186/s12879-015-1157-8.

42. Ucheana D, Ambakederemo T, Jesuorobo D. Awareness of Heart Disease Prevention Among Patients Attending a Specialist Clinic in Southern Nigeria. 2012;1(3):40-43. doi:10.5923/j.ijpt.20120103.01.
43. Kolapo KO, Vento S. Stroke: a realistic approach to a growing problem in sub-Saharan Africa is urgently needed. *Trop Med Int Heal*. 2011;16(6):707-710. doi:10.1111/j.1365-3156.2011.02759.x.
44. Owolabi MO, Akarolo-Anthony S, Akinyemi R, et al. The burden of stroke in Africa: a glance at the present and a glimpse into the future. *Cardiovasc J Afr*. 2015;26(2 Suppl 1):S27-38. doi:10.5830/CVJA-2015-038.
45. Nakibuuka J, Sajatovic M, Nankabirwa J, et al. Early mortality and functional outcome after acute stroke in Uganda: prospective study with 30 day follow-up. *Springerplus*. 2015;4:450. doi:10.1186/s40064-015-1252-8.
46. Bosu WK. The prevalence, awareness, and control of hypertension among workers in West Africa: A systematic review. *Glob Health Action*. 2015;8(1). doi:10.3402/gha.v8.26227.
47. Appiah C a., Steiner-Asiedu M, Otoo GE. Predictors of Overweight/Obesity in Urban Ghanaian Women. *Int J Clin Nutr*. 2014;2(3):60-68. doi:10.12691/ijcn-2-3-3.
48. Okop KJ, Mukumbang FC, Mathole T, Levitt N, Puoane T. Perceptions of body size, obesity threat and the willingness to lose weight among black South African adults: a qualitative study. *BMC Public Health*. 2016;16(1):365. doi:10.1186/s12889-016-3028-7.
49. Puoane T, Tsolekile L, Steyn N. Perceptions about body image and sizes among Black African girls living in Cape Town. *Ethn Dis*. 2010;20(1):29-34. <http://www.ncbi.nlm.nih.gov/pubmed/20178179>. Accessed May 29, 2017.
50. Duda RB, Jumah NA, Hill AG, Seffah J, Biritwum R. Interest in healthy living outweighs presumed cultural norms for obesity for Ghanaian women. *Health Qual Life Outcomes*. 2006;4:44. doi:10.1186/1477-7525-4-44.
51. World Health Organization Regional office for Africa. Cardiovascular diseases in the African Region: Current Situation and Perspectives. Rep Reg Dir Fifty-fifth Sess. 2005. <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle: CARDIOVASCULAR+DISEASES+IN+THE+AFRICAN+REGION:+CURRENT+SITUATION+AND+PERSPECTIVES#3>.
52. Addo J, Agyemang C, Smeeth L, de-Graft Aikins a, Edusei a K, Ogedegbe O. A review of population-based studies on hypertension in Ghana. *Ghana Med J*. 2012;46(June):4-11. doi:10.4314/gmj.v46i2.
53. Campbell T, Campbell A. Emerging disease burdens and the poor in cities of the developing world. *J Urban Heal*. 2007;84(SUPPL. 1). doi:10.1007/s11524-007-9181-7.
54. Agyemang C, Owusu-Dabo E, de Jonge A, Martins D, Ogedegbe G, Stronks K. Overweight and obesity among Ghanaian residents in The Netherlands: how do they weigh against their urban and rural counterparts in Ghana? *Public Health Nutr*. 2009;12(7):909-916. doi:10.1017/S1368980008003510.

55. Ofori-Asenso R, Garcia D. Cardiovascular diseases in Ghana within the context of globalization. *Cardiovasc Diagn Ther*. 2016;6(1):67-77. doi:10.3978/j.issn.2223-3652.2015.09.02.
56. African Business. Alcohol consumption rising in Africa despite obstacles - African Business Magazine. <http://africanbusinessmagazine.com/sectors/retail/alcohol-consumption-rising-in-africa-despite-obstacles/>. Published 2017. Accessed October 24, 2017.
57. BeLue R, Okoror T, Iwelunmor J, et al. An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective. *Global Health*. 2009;5(1):10. doi:10.1186/1744-8603-5-10.
58. World Health Organization. Global Status Report on Alcohol and Health. Geneva; 2011. http://www.who.int/substance_abuse/publications/global_alcohol_report/msbgsruprofiles.pdf. Accessed October 24, 2017.
59. Akyeampong E. Alcoholism in Ghana? A socio-cultural exploration. *Cult Med Psychiatry*. 1995;19(2):261-280. doi:10.1007/BF01379414.
60. Ferreira-Borges C, Rehm J, Dias S, Babor T, Parry CDH. The impact of alcohol consumption on African people in 2012: an analysis of burden of disease. *Trop Med Int Heal*. 2016;21(1):52-60. doi:10.1111/tmi.12618.
61. Kickbusch I, Allen L, Franz C. The commercial determinants of health. *Lancet Glob Heal*. 2016;4(12):e895-e896. doi:10.1016/S2214-109X(16)30217-0.
62. Ferreira-borges C, Ketsela T, Munodawafa D, Alisalak A. Reduction of the Harmful Use of Alcohol: A Strategy for the WHO African Region. Geneva; 2013. <https://www.who.int/en/ahm/issue/16>.
63. World Health Organisation. Global status report on alcohol and health 2014. *Glob status Rep alcohol*. 2014;1-392. doi:/entity/substance_abuse/publications/global_alcohol_report/en/index.html.
64. Kalla A, Figueredo VM. Alcohol and cardiovascular disease in the geriatric population. doi:10.1002/clc.22681.
65. Palomäki H, Kaste M. Regular light-to-moderate intake of alcohol and the risk of ischemic stroke. Is there a beneficial effect? *Stroke*. 1993;24(12):1828-1832. <http://www.ncbi.nlm.nih.gov/pubmed/8248963>. Accessed October 24, 2017.
66. Rehm J, Baliunas D, Borges GLG, et al. The relation between different dimensions of alcohol consumption and burden of disease: an overview. *Addiction*. 2010;105(5):817-843. doi:10.1111/j.1360-0443.2010.02899.x.
67. Salleh MR. Life event, stress and illness. *Malays J Med Sci*. 2008;15(4):9-18. <http://www.ncbi.nlm.nih.gov/pubmed/22589633>. Accessed October 24, 2017.
68. Selye H. *The Stress of Life*. McGraw-Hill; 1978.

69. Rosengren A, Hawken S, Ôunpuu S, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet*. 2004;364(9438):953-962. doi:10.1016/S0140-6736(04)17019-0.
70. Stansfeld SA, Fuhrer R, Shipley MJ, Marmot MG. Psychological distress as a risk factor for coronary heart disease in the Whitehall II Study. *Int J Epidemiol*. 2002;31(1):248-255. <http://www.ncbi.nlm.nih.gov/pubmed/11914328>. Accessed October 25, 2017.
71. Iso H, Date C, Yamamoto A, et al. Perceived mental stress and mortality from cardiovascular disease among Japanese men and women: the Japan Collaborative Cohort Study for Evaluation of Cancer Risk Sponsored by Monbusho (JACC Study). *Circulation*. 2002;106(10):1229-1236. <http://www.ncbi.nlm.nih.gov/pubmed/12208798>. Accessed October 25, 2017.
72. Booth J, Connelly L, Lawrence M, et al. Evidence of perceived psychosocial stress as a risk factor for stroke in adults: a meta-analysis. *BMC Neurol*. 2015;15:233. doi:10.1186/s12883-015-0456-4.
73. Olufemi O, Oluseyi M. The Urban Poor and Mobility Stress in Nigerian Cities. *Environ Res J*. 2007;1(1):1-8. <https://www.medwelljournals.com/abstract/?doi=erj.2007.1.8>. Accessed October 25, 2017.
74. BeLue R, Schreiner AS, Taylor-Richardson K, Murray-Kolb LE, Beard JL. What Matters Most: An Investigation of Predictors of Perceived Stress Among Young Mothers in Khayelitsha. *Health Care Women Int*. 2008;29(6):638-648. doi:10.1080/07399330802089198.
75. Baum A, Garofalo JP, Yali AM. Socioeconomic status and chronic stress. Does stress account for SES effects on health? *Ann N Y Acad Sci*. 1999;896:131-144. <http://www.ncbi.nlm.nih.gov/pubmed/10681894>. Accessed October 24, 2017.
76. Mfenyana K, Griffin M, Yogeswaran P, et al. Socio-economic inequalities as a predictor of health in South Africa--the Yenza cross-sectional study. *S Afr Med J*. 2006;96(4):323-330. <http://www.ncbi.nlm.nih.gov/pubmed/16670806>. Accessed October 24, 2017.
77. Gulis G, Mulumba JAA, Juma O, Kakosova B. Health status of people of slums in Nairobi, Kenya. *Environ Res*. 2004;96(2):219-227. doi:10.1016/j.envres.2004.01.016.
78. Stubbs B, Veronese N, Vancampfort D, et al. Perceived stress and smoking across 41 countries: A global perspective across Europe, Africa, Asia and the Americas. *Sci Rep*. 2017;7(1):7597. doi:10.1038/s41598-017-07579-w.
79. Watt MH, Eaton LA, Choi KW, et al. It's better for me to drink, at least the stress is going away"; perspectives on alcohol use during pregnancy among South African women attending drinking establishments. *Soc Sci Med*. 2014;116:119-125. doi:10.1016/j.socscimed.2014.06.048.
80. Altindag DT, Cannonier C, Mocan NH. The Impact of Education on Health Knowledge. NBER Work Pap No 16422. 2010. <http://www.nber.org/papers/w16422>.
81. Mehrotra R, Bajaj S, Kumar D, Singh KJ. Influence of education and occupation on knowledge about diabetes control. *Natl Med J India*. 2000;13(6):293-296.

82. Salinas JJ, Al Snih S, Markides K, Ray LA, Angel RJ. The rural-urban divide: health services utilization among older Mexicans in Mexico. *J Rural Health*. 2010;26(4):333-341. doi:10.1111/j.1748-0361.2010.00297.x.
83. Begashaw B, Tesfaye T. Healthcare Utilization among Urban and Rural Households in Esera District: Comparative Cross-sectional Study. *Am J Public Heal Res Vol 4*, 2016, Pages 56-61. 2016;4(2):56-61. doi:10.12691/AJPHR-4-2-3.
84. Finken LR, Coomes E, Bajaj RR, Sharieff W, Bagai A, Cheema AN. Has google replaced traditional sources of cardiovascular disease and risk factor information? *Can J Cardiol*. 2014;30(10):S180. doi:10.1016/j.cjca.2014.07.282.
85. Redmond N, Baer HJ, Clark CR, Lipsitz S, Hicks LS. Sources of Health Information Related to Preventive Health Behaviors in a National Study. *Am J Prev Med*. 2010;38(6):620-627.e2. doi:10.1016/j.amepre.2010.03.001.

SUPPLEMENTARY INFORMATION

S1 Text - Search strategy - PubMed

#30,"Search (#20 OR #27) Filters: Humans Sort by: [relevance]",2192

#29,"Search (#20 OR #27) Sort by: [relevance]",3029

#28,"Search #20 AND #27",158

#27,"Search #21 AND #26",2815

#26,"Search #22 AND #25",244406

#25,"Search #23 OR #24",3554020

#24,"Search Smoking OR Dyslipidemia OR Cholesterol OR Sedentary lifestyle OR Physical *activity OR Stress OR Alcohol Diabetes OR Obesity OR LDL OR Hypertension OR Blood pressure[Title/Abstract]",2183841

#23,"Search Cardiovascular diseases* OR Stroke OR Ischemic heart disease OR Coronary heart disease OR Cerebrovascular OR Vascular disease OR Myocardial infarction[Title/Abstract]",1912226

#22,"Search Perception* OR Awareness OR Knowledge OR Perceiv* OR Belief* OR Understanding[Title/Abstract]",1603245

#21,"Search Benin OR Botswana OR Burkina Faso OR Cameroun OR Cameroon OR Congo OR Congo, Ethiopia OR Ghana OR Guinea OR Ivory Coast OR Kenya OR Lesotho OR Madagascar OR Malawi OR Mauritius OR Mozambique OR Namibia OR Niger OR Nigeria OR Rwanda OR Senegal OR Sierra Leone OR South Africa OR Swaziland OR Tanzania OR Togo OR Uganda OR Zambia[Title/Abstract]",406296

#20,"Search #11 AND #19",372

#19,"Search #7 AND #18",30771

#18,"Search #9 OR #10",2327837

#14,"Search #12 AND #13",2018

#13,"Search #7 AND #10",10691

#12,"Search #7 AND #9",22098

#11,"Search ""Africa South of the Sahara""[Mesh]",165794

#10,"Search ""Tobacco Use""[Mesh] OR ""Hyperlipidemias""[Majr] OR ""Sedentary Lifestyle""[Majr] OR ""Exercise""[Majr:NoExp] OR ""Stress, Psychological""[Majr:NoExp] AND ""Obesity, Abdominal""[Majr] OR ""Diabetes Mellitus""[Mesh]",353269

#9,"Search Cardiovascular Diseases[Mesh]",2071805

#7,"Search (((""Awareness""[Mesh]) OR ""Attitude to Health""[Mesh]) OR ""Sociology, Medical""[Mesh]) OR ""Comprehension""[Majr]",358241

S1 File a: Results of quality assessment of quantitative studies

Nakibuuka et al; 2014								
Ansa, Oyo-Ita & Essien; 2007								
Akinyemi et al; 2015								
Ajayi & Ojo; 2007								
Komolafe et al; 2015								
Obembe et al; 2014								
Cossi et al; 2012								
Kaddamu et al; 2015								
Donkor et al; 2014								
Wahab, Kayode, Musa; 2015								
Akinyemi et al; 2009								
Oladepo et al; 2013								
Awosan et al; 2013								
Yiq & Wright; 2008								
Mohammed; 2012								
Temu et al; 2015								
Uch, Amb, Jes; 2012								
Akintunde et al; 2015								
Item								
Was the research question or objective in this paper clearly stated?								
Was the study population clearly specified and defined?								
Was the participation rate of eligible persons at least 50%?								
Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?								
Was a sample size justification, power description, or variance and effect estimates provided?								
For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?								
Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?								

									GOOD
									FAIR
									FAIR
									POOR
									GOOD
									GOOD
									GOOD
									GOOD
									GOOD
									GOOD
									FAIR
									GOOD
									GOOD
									FAIR
									POOR
									GOOD
									POOR
									FAIR
For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?									
Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?									
Was the exposure(s) assessed more than once over time?									
Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?									
Were the outcome assessors blinded to the exposure status of participant(s)?									
Was loss to follow-up after baseline 20% or less?									
Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?									
OVERALL RATING									

Key: ■ Yes ■ Not applicable ■ No ■ Not reported

S1 File b: Results of quality assessment of qualitative studies

Item	Surka et al, 2015	Awah et al, 2008
Was there clear statement of aims of the research?		
Is the qualitative methodology appropriate?		
Was the research design appropriate to address aims of the research?		
Was the recruitment strategy appropriate to the aims of the research?		
Was the data collected in a way that address the research issue?		
Has the relationship between researcher and participants been adequately considered?		
Has ethical issues been taken into consideration?		
Was the data analysis sufficiently rigorous?		
Is there a clear statement of findings?		
How valuable is the research	Valuable	Valuable
Quality score	Good	Good

Key:  Yes  Can't tell

PRISMA CHECKLIST

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	0
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3

Section/topic	#	Checklist item	Reported on page #
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	4
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	4
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	4
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	5
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	5 - 8

Section/topic	#	Checklist item	Reported on page #
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health-care providers, users, and policy makers).	8-10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	10
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	11

Chapter 5

The connection between non-communicable
disease risk factors and risk perception among
slum dwellers in Nairobi, Kenya

Tilahun Nigatu Haregu, Frederick Murunga Wekesah, Samuel Oti, Thaddaeus
Egondi, Catherine Kyobutungi
African Population Studies, 2016. 30(3)

ABSTRACT

Non-communicable diseases (NCDs) are emerging as a public health issue in sub-Saharan Africa. This paper examines the relationship between the risk of NCDs and perceptions about such risk among urban slum population in Nairobi, Kenya. The analysis is based on data collected between 2008 and 2009 as part of a cross-sectional survey that was designed to assess linkages between socioeconomic status, perceived personal risk, and risk factors for cardiovascular and non-communicable diseases in urban slums of Nairobi. A total 5,190 study participants were included in the analysis. Low risk perception about NCDs in spite of the presence of NCD risk factors suggests the need for programs aimed at creating awareness about the diseases and promoting the adoption of preventive healthy lifestyles among the urban poor populations of Nairobi.

Key words: Non-communicable disease, risk factors, risk perception

INTRODUCTION

The magnitude and burden of non-communicable diseases (NCDs) is rapidly increasing in the developing world [1, 2]. Along with the epidemiological, nutritional, demographic transitions, and environmental changes, rapid change in behavioral and lifestyle factors plays a significant role in the emergence of NCDs in many low and middle income countries. Among the known NCD risk factors, the four common behavioral risk factors (unhealthy diet, insufficient physical activity, harmful use of alcohol and tobacco use) contribute to the biggest share of NCD burden [3, 4]. Analysis of trends of these common risk factors shows that their prevalence and the prevalence of their hazardous effects are consistently increasing in the developing world, including in sub-Saharan Africa [5-7].

NCD risk perception is central to behavioral change related to the prevention of these diseases [8, 9]. It is crucial for the adoption of healthy lifestyles. Low level of perceived risk is usually associated with risky behaviors. Acknowledgement and understanding of NCD risk would lead to intentions towards healthy behaviors or less risky ones. Despite the importance of NCD risk perception in behavior and lifestyle changes, studies have shown that underestimation of risk by individuals is very common. In this regard, it is essential to address people's misperception about their risk and/or underestimation of their risk level [10-12].

Appropriate level of risk perception is needed to change or limit NCD risk factors. However, in the analysis of risk perception of NCDs, much emphasis has been given to the relationship between perceived risk and clinical outcomes. A few studies have addressed the link between perceived and actual risk for NCDs [13, 14]. Moreover, available studies on perceptions about NCD risk factors are limited to a single disease condition [15]. Other studies focused on the perceived need to change a single NCD risk factor or the levels of risk perception only [16, 17]. The linkage between NCD risk perception and the common NCD risk factors (unhealthy diet, insufficient physical activity, harmful use of alcohol and smoking) has not received sufficient research attention especially in the context of low and middle income countries.

Therefore, this paper assesses the association between the common NCD risk factors and NCD risk perception in a poor urban setting in Nairobi, Kenya. Available evidence indicates that the prevalence of hypertension and diabetes in this population is 12% and 5% respectively [18, 19]. Obesity was more prevalent among women (15.5%) than among

men (2.3%) [20]. The socio-economic status of the population is also low as informal work is the source of income for more than half of the study population and about two-thirds did not go beyond primary school. In this community, as it is also the case with other studies done elsewhere in Africa, the focus has been on identifying the prevalence and distribution of NCD risk factors among different segments of the population [21-28]. As behavioral and lifestyle change starts from perceptions towards the risk, understanding the link between NCD risk factors and NCD risk perception is important for informing the design and implementation of behavioral interventions aimed at preventing and controlling NCDs.

METHODS

Data source

This paper draws on data from a large study that assessed the linkages between socio-economic status, perceived personal risk, and risk factors for cardiovascular and related NCDs. The study was implemented by the African Population and Health Research Center (APHRC) within the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) population between May 2008 and April 2009. It used the sampling frame of the NUHDSS: a stratified sampling strategy based on the WHO STEPwise protocol with a target of 250 respondents in each of the following strata: sex, age group (18-24, 25-30, 31-40, 41-50, 51-60, and 60+), and slum of residence (*Korogocho* and *Viwandani*) for a total of 24 strata. Data were collected from a total of 5,190 individuals of age 18 years and above. Details of the sampling strategy, data collection methods, and data quality assurance mechanisms of the CVD study are published elsewhere [18].

Measurements

NCD risk factors: The four common NCD risk factors (unhealthy diet, insufficient physical activity, harmful use of alcohol and tobacco use) were included in this analysis. Using standards for the definition of these risk factors (Table 1), their presence or absence in an individual at the time of survey was ascertained using self-reported methods.

Table 1: Definition of the four non-communicable diseases risk factors

NCD risk factor	Definition used in this study
1 Unhealthy diet	Consumption of less than 5 portions of fruit and vegetables a day on at least five days on an average week and/or greater than 6 teaspoon of sugar a day [29]
2 Insufficient physical activity	Less than 75 minutes of vigorous-intensity physical activity or Less than 150 minutes of Moderate-intensity physical activity per week or equivalent of combinations of these (from work, walking/cycling and leisure) [30].
3 Harmful use of alcohol (based on daily consumption)	More than 3 standard units/day for men; more than 2 standard units/day for women (regardless of the type of alcohol consumed) [31]
4 Tobacco use	Current tobacco use as self-reported by the respondent [32]

NCD risk perception: The self-perceived risk to five major NCDs (Diabetes, hypertension, stroke, heart disease and heart attack) was measured in a five-point Likert scale (very high, high, moderate, low and very low). Those study participants with the disease were labelled as "already have the disease." These individuals were excluded from the analysis.

Data analysis

For the purpose of this analysis the risk perception scale was recoded in to a three-point scale (High, Moderate, and Low) for disease-specific risk perception and finally in to a dichotomous scale (Low and above low) for overall NCD risk perception. Summated scores were used to compute overall perceived risk to the five NCDs. Levels of perceived risk were used as predictor variables and presence of NCD risk factors were considered as outcome variables. Age categories of less than 45 years, 45-60 years and above 60 years were used. Proportions, mean and standard deviation were used to describe data; and tables and charts were used to present the findings. Chi-square statistics and logistic regression were used to assess the association between risk perception and risk factors. The regression models controlled for age and sex of the respondents. The results are presented as odds ratios (OR) with 95% confidence intervals.

Sampling probability weight was computed using the size of the stratum in the NUHDSS database as denominator and response probability was calculated using the total number sampled per stratum as denominator. A composite weight taking both sampling and response weights into account was applied to the main prevalence estimates.

RESULTS

Non-communicable disease risk factors and risk perception

Characteristics of the study population

Slightly less than half (46%) of the study participants were females. Most of the participants (56%) were aged between 18 and 45 years while 13% were more than 60 years old. More than half (56%) were married at the time of the survey while 25% were widowed.

Prevalence of NCD risk factors

The weighted prevalence of unhealthy diet, insufficient physical activity, harmful use of alcohol and current smoking were 57.2%, 14.4%, 10.1% and 12.4%, respectively. Unhealthy diet and insufficient physical activity were more prevalent among women than men while use of alcohol and smoking were more prevalent among men than women.

Non-communicable disease risk perception

The majority of the study population had low level of risk perception for the five NCDs considered in this analysis. For each of the five NCDs, at least three-fourth of the study participants felt that their chance of getting the specific NCD is low (Table 2). Those who felt that they have moderate level of risk ranges between 10% and 20%. The mean (SD) perceived risk score for the five diseases was 5.85(1.52). In the overall categorized risk score, 87.6% had low perceived risk and 12.4% had high perceived risk for NCDs. Nearly two-third (64.2%) of the study population had low perceived risk for all the five NCDs combined (not shown).

Table 2: Levels of non-communicable disease risk perception

Type of NCD	High (=3)	Moderate (=2)	Low (=1)	“I don’t know”
1 Diabetes	144(3.5%)	716(17.3%)	3,278(79.2%)	958(18.5%)
2 Hypertension	275(6.8%)	817(20.0%)	2,984(73.2%)	867(16.7%)
3 Stroke	63(1.6%)	394(10.1%)	3,443(88.3%)	1,279(24.7%)
4 Heart disease	123(3.0%)	632(15.3%)	3,379(81.7%)	1,040(20.0%)
5 Heart attack	83(2.3%)	356(9.8%)	3,200 (87.9%)	1,542(29.7%)

There were statistically significant variations in the levels of perceived risk of NCDs by sex. In particular, levels of perceived risk of NCDs were significantly higher among women than men. Similarly, the mean considered in the analysis was significantly higher among women than men (5.95 and 5.78 respectively; $p < 0.001$). The distribution of NCD risk perception by sex is shown in Figure 1.

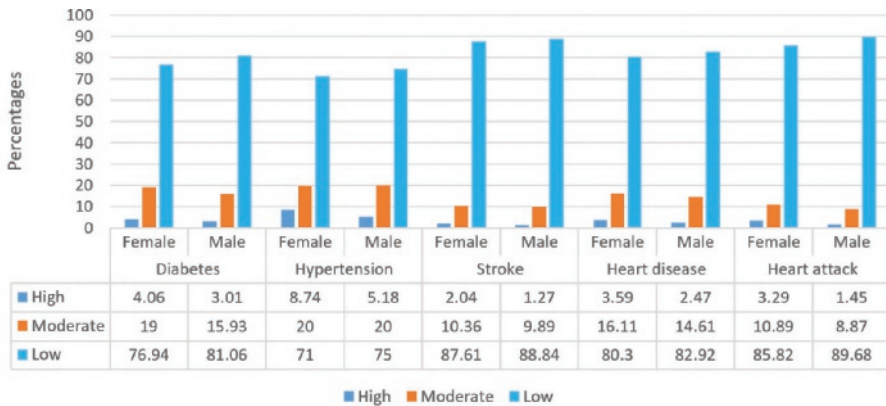


Figure 1: Non-communicable diseases risk perception by sex

Analysis of NCD risk perception by age also shows that there is no substantial increment in levels of perceived risk as age increases despite the fact that the actual risk of getting NCDs increases with age. However, there is some level of increase in perceived risk between those less than 45 years and those 45-60 years.

Likewise, the mean (SD) of the summated perceived risk score for those aged below 45 years, 45-60 years, and above 60 years were 5.83(1.51), 5.89(1.55) and 5.87(1.53), respectively. However, there was no statistically significant difference in the mean of summated perceived risk scores across these age categories. The levels of perceived risk for the different NCDs are shown in Figure 2.

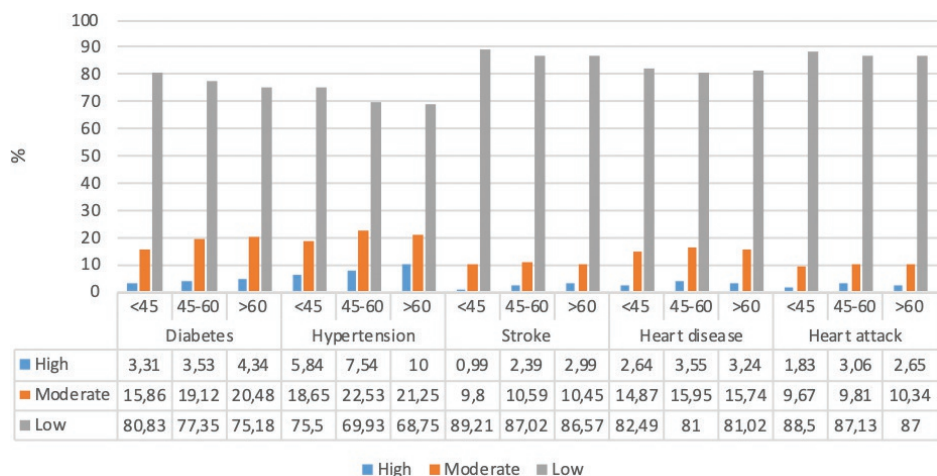


Figure 2: Levels of perceived non-communicable disease risk by age categories

Association between NCD risk perception and risk factors *NCD risk perception and risk factors for specific diseases* Results from analysis of the association between perceived risk of diabetes and its risk factors showed that those with moderate perceived risk were significantly more likely to have unhealthy dietary behavior (OR=1.18; 95% CI: 1.01, 1.40) than those with low perceived risk (Table 3). By contrast, having moderate perceived risk of the disease was associated with significantly lower likelihood of engaging in insufficient physical activity compared with having low perceived risk (OR=0.63; 95% CI: 0.49, 0.81).

With respect to hypertension, the results showed that those with moderate levels of perceived risk were significantly more likely to have unhealthy diet (OR=1.31; 95% CI: 1.11, 1.54) but significantly less likely to be engaged in insufficient physical activity (OR=0.55; 95% CI: 0.44, 0.71) compared with those having low perceived risk. The results for stroke, on the other hand, showed that those with moderate perceived risk were significantly less likely to be engaged in insufficient physical activity compared with those with low perceived risk (OR=0.55; 95% CI: 0.39, 0.78).

The results examining the association between perceived risk of heart disease and its risk factors showed that those with moderate or high perceived risk were significantly less likely to be engaged in insufficient physical activity compared with those having low perceived risk (OR=0.53; 95% CI: 0.40, 0.69; and OR=0.35; 95% CI: 0.18, 0.68 respectively). In addition, those with moderate perceived risk were significantly less likely to be engaged in harmful use of alcohol compared with those having low perceived risk (OR=0.68; 95%

CI: 0.48, 0.98). The results for heart attack, on the other hand, showed that those with moderate risk perception were significantly more likely to report insufficient physical activity compared with those having low perceived risk (OR=1.55; 95% CI: 1.10, 2.21).

Table 3: Association between dichotomous categories of risk perception and risk factors

	Unhealthy diet	Insufficient physical activity	Harmful use of alcohol	Current smoking
Diabetes	1.22[1.05,1.43]	0.67[0.54,0.84]	0.88[0.66,1.18]	0.85[0.66,1.11]
Hypertension	1.26[1.09,1.46]	0.61[0.49,0.76]	1.15[0.89,1.49]	1.03[0.82,1.29]
Stroke	1.05[0.86,1.28]	0.60[0.45,0.82]	0.72[0.48,1.08]	1.06[0.77,1.46]
Heart disease	1.38[1.17,1.63]	0.49[0.38,0.64]	0.66[0.47,0.92]	1.05[0.81,1.37]
Heart attack	1.16[0.94,1.42]	0.69[0.52,0.93]	1.14[0.79,1.64]	1.49[1.10,2.04]
All NCDs	1.21[0.97,1.51]	0.69[0.51,0.95]	0.95[0.63,1.43]	1.08[0.76,1.55]

Note: All associations are adjusted for age and sex

NCD risk factors and Overall NCD risk perception

There were no statistically significant differences in the proportions of respondents that had moderate or high overall risk perception of NCDs among those with and without unhealthy diet (11% and 14% respectively; OR=1.21; 95% CI: 0.97, 1.51), harmful use of alcohol (13% and 11% respectively; OR=0.95; 95% CI: 0.63, 1.43) or smoking behaviors (13% and 11% respectively; OR=1.08; 95% CI: 0.75, 1.55). However, the proportion having moderate or high overall perceived risk was significantly lower among those reporting than among those who did not report insufficient physical activity (10% and 13% respectively; OR=0.70; 95% CI: 0.51, 0.95) (Table 4).

NCD risk perception and co-occurrence of NCD risk factors

The majority (88%) of the respondents who did not have any of the four NCD risk factors had low risk perception about the diseases. Although those with moderate or high risk perception were more likely to have at least one NCD risk factor compared with those having low risk perception, the difference was not statistically significant (OR=1.08; 95% CI: 0.85, 1.36). Similar to those having no risk factors, the majority (89%) of respondents with multiple NCD risk factors had low risk perception about the diseases (86% of females and 90% of males). There was no statistically significant association between risk perception and having multiple NCD risk factors (OR=0.89; 95% CI: 0.68, 1.18).

Table 4: Overall NCD risk perception and NCD risk factors

NCD risk factors		Overall Perceived NCD risk			OR (95% CI)
		Low (n, %)	Above low (n, %)	Total (N)	
Unhealthy diet	No	1,308(88.9)	162(11.0)	1,470	1.21
	Yes	1,444(86.4)	227(13.6)	1,671	[0.97, 1.51]
Insufficient physical activity	No	2,287(87.2)	335(12.8)	2,622	0.70
	Yes	465(89.6)	54(10.4)	519	[0.51, 0.95]
Harmful use of alcohol	No	2,500(87.4)	359(12.6)	2,859	0.95
	Yes	252(89.4)	30(10.6)	282	[0.63, 1.43]
Current smoking	No	2,417(87.5)	346(12.5)	2,763	1.08
	Yes	335(88.6)	43(11.4)	378	[0.75, 1.55]

DISCUSSION

The main findings of this study show that the majority of the urban poor adults have relatively low prevalence of the three key NCD risk factors (insufficient physical activity, harmful use of alcohol and smoking). However, the prevalence of unhealthy diet was high. The majority of the study participants perceived that they had low risk of getting each of the five NCDs that are considered in this analysis (Diabetes, Hypertension, Stroke, Heart disease and heart attack). Even among those with multiple NCD risk factors, only 12% had above low risk perception.

The findings showed that unhealthy diet and tobacco use were not significantly associated with NCD risk perception. However, those with moderate or high risk perception were significantly less likely to be engaged in insufficient physical activity or harmful use of alcohol. In addition, there was no significant difference in risk perception between those with and those without multiple risk factors. The findings imply that knowledge about NCDs and their risk factors is generally low among the urban slum populations of Nairobi. Studies show that underestimation of risk among high risk individuals is common and may lead to a situation where those reporting lower risks for NCDs are less likely to seek treatment and adopt healthy and preventive lifestyles [33, 34].

A study conducted in Croatia showed that there was no difference in the perceptions of risk among older adults who had the actual risk factors present compared to those older

adults without the risk factors [35]. A study in the United States showed that despite the potential high risk of developing diabetes among the African American living in urban settings, their perception for risk was low [36]. The findings of this paper regarding the lack of significant association between NCD risk factors and perceived risk of the diseases are consistent with existing evidence.

The low perception of NCD risk among this urban poor population could be attributed to lack of awareness, and low education levels in the community as has been demonstrated elsewhere [37]. Studies show that there are variations in the prevalence of NCD risk factors in low- and middle-income countries with those from the poorest households bearing the heaviest burden [38, 39]. The evidence suggests the need for creating awareness about NCDs and designing evidence-informed interventions to reduce the risk factors associated with the diseases among urban poor populations.

The findings of this paper have important implications for policy and practice. For appropriate behavioral and lifestyle modification, people with NCD risk factors need to have an appropriate level of risk perception (i.e. a risk perception that concurs with actual risk) where those with heightened risks for NCDs due to behavioral and physiological risk factors take deliberate decisions to adopt health lifestyles and behavior modification. However, this study has revealed that most of those having NCD risk factors had low risk perception. Low risk perception in the context of growing NCD epidemic is likely to affect efforts aimed at creating awareness about and improving the uptake of preventive and healthy lifestyles, especially among the urban poor [40].

Understanding how individuals estimate and assess their own risk factors for NCDs is also useful for designing targeted interventions aimed at improving risk communication and health outcomes among the urban poor [41]. In particular, behavioral interventions should aim at creating awareness about NCDs and promoting the adoption of healthy lifestyles among those at high risk. Based on the findings, such interventions should mainly focus on unhealthy diet and tobacco use as individuals with these risk factors had low risk perception about contracting NCDs.

The findings of the paper may be influenced by certain limitations. In particular, given the cross-sectional nature of the study that provided the data for the paper, it is not possible to determine cause and effect regarding the relationship between NCD risk factors and risk perception. As change in perception can result in change in behavior and vice versa,

antecedent-consequence uncertainty is a major limitation due to fact that temporal sequence could not be established. In addition, the measurement of both risk perception and risk factors for NCDs was self-reported and could be subject to bias, mostly towards underestimation of risk.

In conclusion, low risk perception about NCDs in spite of the presence of NCD risk factors suggests the need for programs aimed at creating awareness about the diseases and promoting the adoption of preventive healthy lifestyles among the urban poor populations of Nairobi.

ACKNOWLEDGEMENTS

The study was part of a larger research project supported by a grant from the Wellcome Trust UK (grant no. WT092775MA). We also acknowledge all the study participants and all members of the research team who conducted the study.

Authors' contribution

TNH and FW conceptualized the study, drafted the plan of analysis, conducted the analysis and drafted the manuscript. SO, TE, and CK provided substantial inputs in the design of the study, plan of analysis and the draft manuscript. They were also among the core team members in the main cardiovascular disease study.

Ethics statement

Approval to conduct the study was sought from and granted by the Kenya Medical Research Institute's Ethical Review Committee (NON-SSC Protocol No.339). Participants provided written consent following full disclosure regarding the study objectives before data collection.

Conflict of interest

The authors declare that they have no conflict of interests associated with this study.

REFERENCES

1. Wagner, K.H. and H. Brath, *A global view on the development of non communicable diseases*. Prev Med, 2012. **54 Suppl**: p. S38-41.
2. Murray, C., et al., *Global burden of diseases and injuries for 291 causes and 21 regions. 1990–2012: a systematic analysis for the Global Burden of Disease Study 2010*. The Lancet, 2012. **380**(9859): p. 2197-2223.
3. Low, W.Y., Y.K. Lee, and A.L. Samy, *Non-communicable diseases in the Asia-Pacific region: Prevalence, risk factors and community-based prevention*. Int J Occup Med Environ Health, 2014.
4. Martin-Diener, E., et al., *The combined effect on survival of four main behavioural risk factors for non-communicable diseases*. Prev Med, 2014. **65**: p. 148-52.
5. Ezzati, M. and E. Riboli, *Behavioral and dietary risk factors for noncommunicable diseases*. New England Journal of Medicine, 2013. **369**(10): p. 954-964.
6. Manjrekar, S.S., M.S. Sherkhane, and J.V. Chowti, *Behavioral risk factors for noncommunicable diseases in working and nonworking women of urban slums*. J Midlife Health, 2014. **5**(3): p. 143-9.
7. Sugathan, T.N., C.R. Soman, and K. Sankaranarayanan, *Behavioural risk factors for non communicable diseases among adults in Kerala, India*. Indian J Med Res, 2008. **127**(6): p. 555-63.
8. Brewer, N.T., et al., *Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination*. Health Psychology, 2007. **26**(2): p. 136.
9. Weinstein, N.D., *Testing four competing theories of health-protective behavior*. Health Psychology, 1993. **12**(4): p. 324.
10. Halpern-Felsher, B.L., et al., *Perceived risks and benefits of smoking: differences among adolescents with different smoking experiences and intentions*. Prev Med, 2004. **39**(3): p. 559-67.
11. Diaz, V.A., et al., *Cardiovascular and diabetes risk perception in a Hispanic community sample*. Ethn Dis, 2012. **22**(1): p. 5-11.
12. Morrison, M.K., J.M. Lowe, and C.E. Collins, *Perceived risk of Type 2 diabetes in Australian women with a recent history of gestational diabetes mellitus*. Diabet Med, 2010. **27**(8): p. 882-6.
13. Hivert, M.F., et al., *Diabetes Risk Perception and Intention to Adopt Healthy Lifestyles Among Primary Care Patients*. Diabetes Care, 2009. **32**(10): p. 1820-2.
14. Godino, J.G., et al., *Understanding perceived risk of type 2 diabetes in healthy middle-aged adults: a cross-sectional study of associations with modelled risk, clinical risk factors, and psychological factors*. Diabetes Res Clin Pract, 2014. **106**(3): p. 412-9.
15. Dabbak, H. and M.A. Arafa, *Risk Assessment and Risk Perception of Coronary Heart Disease in Gaza Strip, Palastine*. Health, 2014. **Vol.06 No.21**: p. 11.

16. Vahasarja, K., et al., *Perceived need to increase physical activity levels among adults at high risk of type 2 diabetes: a cross-sectional analysis within a community-based diabetes prevention project FIN-D2D*. BMC Public Health, 2012. **12**: p. 514.
17. Echouffo-Tcheugui, J.B. and A.P. Kengne, *Chronic non-communicable diseases in Cameroon - burden, determinants and current policies*. Global Health, 2011. **7**: p. 44.
18. van de Vijver, S.J., et al., *Prevalence, awareness, treatment and control of hypertension among slum dwellers in Nairobi, Kenya*. J Hypertens, 2013. **31**(5): p. 1018-24.
19. Oti, S.O., et al., *The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya: results from a cross-sectional survey*. Trop Med Int Health, 2013. **18**(12): p. 1520-30.
20. Ettarh, R., et al., *Overweight, Obesity, and Perception of Body Image Among Slum Residents in Nairobi, Kenya, 2008-2009*. Preventing Chronic Disease, 2014. **11**: p. E212.
21. Wandera, S.O., B. Kwagala, and J. Ntozi, *Prevalence and risk factors for self-reported non-communicable diseases among older Ugandans: a cross-sectional study*. Glob Health Action, 2015. **8**: p. 27923.
22. Kavishe, B., et al., *High prevalence of hypertension and of risk factors for non-communicable diseases (NCDs): a population based cross-sectional survey of NCDs and HIV infection in Northwestern Tanzania and Southern Uganda*. BMC Medicine, 2015. **13**: p. 126.
23. Kyari, F., et al., *Prevalence and risk factors for diabetes and diabetic retinopathy: results from the Nigeria national blindness and visual impairment survey*. BMC Public Health, 2014. **14**: p. 1299.
24. Helelo, T.P., Y.A. Gelaw, and A.A. Adane, *Prevalence and associated factors of hypertension among adults in Durame Town, Southern Ethiopia*. PLoS One, 2014. **9**(11): p. e112790.
25. Moges, B., et al., *High prevalence of overweight, obesity, and hypertension with increased risk to cardiovascular disorders among adults in northwest Ethiopia: a cross sectional study*. BMC Cardiovasc Disord, 2014. **14**: p. 155.
26. Oladimeji, A.M., et al., *Prevalence and factors associated with hypertension and obesity among civil servants in Kaduna, Kaduna State, June 2012*. Pan Afr Med J, 2014. **18 Suppl 1**: p. 13.
27. Kagaruki, G.B., et al., *Magnitude and risk factors of non-communicable diseases among people living with HIV in Tanzania: a cross sectional study from Mbeya and Dar es Salaam regions*. BMC Public Health, 2014. **14**: p. 904.
28. Msyamboza, K.P., C.J. Mvula, and D. Kathyola, *Prevalence and correlates of diabetes mellitus in Malawi: population-based national NCD STEPS survey*. BMC Endocr Disord, 2014. **14**: p. 41.
29. World Health Organization. *Healthy Diet*. 2010 [cited 2015 Jan 25]; Available from: <http://www.who.int/mediacentre/factsheets/fs394/en/>.
30. World Health Organization., *Global recommendations on physical activity for health*. 2010, WHO Press: Geneva, Switzerland.

31. World Health Organization., *Global status report on alcohol and health 2014*, World Health Organization: Luxembourg.
32. World Health Organization., *WHO Framework Convention on Tobacco Control*. 2003.
33. Petr, E.J., et al., *Perceived lifetime risk for cardiovascular disease (from the Dallas Heart Study)*. Am J Cardiol, 2014. **114**(1): p. 53-8.
34. Everett, B., et al., *Underestimation of risk perception in patients at risk of heart disease*. Eur J Cardiovasc Nurs, 2014.
35. Mazalin Protulipac, J., Z. Sonicki, and Z. Reiner, *Cardiovascular disease (CVD) risk factors in older adults - Perception and reality*. Arch Gerontol Geriatr, 2015. **61**(1): p. 88-92.
36. Calvin, D., et al., *African Americans' perception of risk for diabetes complications*. Diabetes Educ, 2011. **37**(5): p. 689-98.
37. Miranda, J., et al., *Non-communicable diseases in low- and middle-income countries: context, determinants and health policy*. Trop Med Int Health, 2008. **13**: p. 1225 - 1234.
38. Hosseinpoor, A., et al., *Socioeconomic inequalities in risk factors for non communicable diseases in low-income and middle-income countries: results from the World Health Survey*. BMC Public Health, 2012. **12**(1): p. 912.
39. Marins, V., et al., *The association between socioeconomic indicators and cardiovascular disease risk factors in Rio de Janeiro, Brazil*. J Biosoc Sci, 2007. **39**: p. 221 - 229.
40. Katz, M., et al., *Calculated and perceived cardiovascular risk in asymptomatic subjects submitted to a routine medical evaluation: The perception gap**. Eur J Prev Cardiol, 2014.
41. Renner, B., et al., *Risk perception, risk communication and health behavior change: Health psychology at the University of Konstanz*. Zeitschrift für Gesundheitspsychologie, 2008. **16**(3): p. 150-153.

Chapter 6

Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi

Frederick M. Wekesah, Catherine K. Kyobutungi, Diederick E. Grobbee,
Kerstin Klipstein-Grobusch
BMJ Open. 2019. 9(6): e026852

ABSTRACT

Objectives: The study explored the understanding of and perception towards cardiovascular disease (CVD) and risk factors, and how they influence prevention and development of the conditions, care-seeking and adhering to treatment.

Setting: Informal settlements of Nairobi.

Participants: Nine focus group discussions consisting of between six and eight purposively sampled participants were conducted among healthy individuals aged 20 years or older. A total of 65 participants (41 female) were involved.

Results: Poverty, ignorance and illiteracy promoted behaviors like smoking, [harmful] alcohol consumption, physical inactivity and unhealthy diet, implicated in the development of obesity, diabetes and hypertension. Some respondents could not see the link between behavioral risk factors with diabetes, hypertension, and stroke and heart attacks. Contaminated food items consumed by the residents, and familial inheritance were factors that caused CVD, whereas emotional stress from constant worry was linked to hypertension, stroke and heart attacks. Few and inadequately equipped public health facilities were hindrances to treatment seeking and adherence to treatment for CVD conditions. Lack of medication in public health facilities was considered to be the single most important barrier to adherence to treatment next to lack of family support among older patients.

Conclusion: Interventions to prevent and manage CVD in low resource and urban poor settings should consider perceptions and understanding of risk factors for CVD, and the interrelationships among them while accounting for cultural and contextual issues e.g. stigma and disregard for conventional medicine. Programs should be informed by locally-generated evidence on awareness and opportunities for CVD care, coupled with effective risk communication through health care providers. Screening for and treatment of CVD must address perceptions such as prohibitive cost of healthcare. Finally, social determinants of disease and health, mainly poverty and illiteracy, which are implicated in addressing CVD in low-resource settings, should be addressed.

Key words: Cardiovascular disease, risk factors, perception, understanding, treatment adherence, urbanization.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The study employed focus group discussions to explore general community-level knowledge and understanding of and perceptions towards cardiovascular diseases and risk factors
- Quality of data and focus of the research was ensured by the discussions being moderated by researchers trained in qualitative research.
- Explanations, clarifications and examples were offered to study participants to enhance their understanding of the cardiovascular diseases in question (stroke and heart attack), and the risk factors being explored (obesity, diabetes, hypertension, smoking and excessive alcohol consumption).
- Despite our best effort to explain and clarify to the study respondents CVD conditions and risk factors being investigated, their understanding seems to have been unclear in some instances.
- Although the study was carried out among the slum residents of Nairobi, we expect the findings to apply to the general population in Kenya and to be used to inform programming for CVD prevention in the country.

BACKGROUND

Cardiovascular diseases (CVD) which include stroke and ischemic heart diseases caused 31.7% of all deaths globally in 2016, accounting for 50% of deaths from non-communicable diseases [1-3]. Low- and middle-income countries (LMICs) account for more than 80 percent of CVD deaths [3]. In 2013, sub-Saharan Africa (SSA) reported nearly one million deaths, translating to 5.5% of global CVD deaths, [4] and the number is expected to increase due to population growth, ageing and epidemiologic changes being experienced in the region [4, 5].

Poor understanding and knowledge of the potential risks for developing CVD exists in SSA [6]. In addition, many individuals in the region lack knowledge regarding risk factors for CVD [7, 8]. Beyond the widely known behavioral/modifiable and physiological risk factors for CVD, psychosocial stressors that cause anger, anxiety and depression, especially

among the materially-deprived populations in SSA have been proposed as an emerging and important risk factor for CVD [6, 9, 10].

The poor sections of the populations living in rampant poverty in SSA are also faced with high illiteracy levels. Growing and unplanned urbanization in SSA has resulted in poor quality of urban housing, sanitation issues, and limited access to efficient health care systems. These key issues have been identified as psychosocial stressors that can trigger the deterioration of health and well-being of people, and have been linked to the development of CVD [11, 12]. Existing evidence also shows that in LMICs, urban populations are disproportionately affected by the CVD burden compared to the rural populations [13, 14].

An individual's perception towards CVD risk is key in influencing action towards prevention of and adherence to treatment [15]. Existing models of health behavior propose that individuals who perceive themselves to be at a higher risk of developing a disease, may take action and institute risk mitigation and consequently lower their chances of developing the disease when perceived severity, susceptibility, and benefits for taking such steps are high [15-18].

In this study conducted among the residents of Nairobi slums, where more than half of the urban dwellers of the city live, we investigated the understanding of and perceptions towards CVD and their risk factors, and how the understanding and perception affected actions taken by individuals to prevent CVD, and in seeking care and adhering to treatment. These findings offer insights into existing perceptions regarding CVD and its risk factors, as well as what influences these perceptions. Evidence could inform strategies for and enhance the effectiveness of CVD prevention and treatment programs.

METHODS

Study site and sampling

The qualitative study was conducted in Korogocho and Viwandani, two urban slums in Nairobi Kenya. The sites are characterized by rampant poverty, congestion, poor housing, lack of basic social and health infrastructure and services, poor water and sanitation amenities, widespread insecurity and violence, and high unemployment rates [19]. Participants for the focus group discussions (FGDs) were purposively sampled from the

general 'healthy' population, among individuals aged 20 years and older, and living in the study community. Research assistants approached individuals in their households and invited them to participate in the study. FGDs composed of between six and eight participants who were not diagnosed with or on treatment for diabetes, high blood cholesterol and hypertension, or had suffered stroke, heart attack or heart disease and heart failure in the past. A total of 65 participants (41 female) were involved in the study.

Study design

This phenomenological qualitative study aimed to explore the knowledge and understanding, as well as the experiences of the urban slum community with CVD conditions, their risk factors and how this knowledge and understanding influenced their care-seeking and treatment behaviors.

Data collection, management and analysis

Data was collected in April 2017. Trained research assistants identified eligible participants and invited them to participate in the study. The FGDs were moderated by the lead researcher who is experienced in qualitative research methodology. During the interviews, the researcher explained to the participants the cardiovascular disease conditions and their risk factors being discussed. Cardiovascular diseases were defined as disorders of the heart and blood vessels that included heart disease (angina), heart attack and heart failure, and stroke. Risk factors were listed as hypertension and raised blood pressure, diabetes and raised blood sugar, overweight and obesity, physical inactivity, smoking and harmful/excessive alcohol consumption. Perceptions comprised opinions on CVD and the risk factors, as well as what influenced these opinions, and the understanding and interpretation of individuals considered to be at risk.

Interviews were conducted in Kiswahili, a language widely spoken and understood by the population. A semi-structured guide (*Appendix 1*) was used, interviews were tape-recorded and transcribed verbatim, and translated into English by two professional transcribers familiar with the objectives of the study.

Coding was done using NVivo 10 (QSR International Pty Ltd). The coding scheme was developed from the interview guides and from a first reading of the transcripts. Thematic analysis was carried out while paying attention to emerging themes and to contradictions and diversity of views. Triangulation utilized field and debrief notes taken during the conduct of the interviews.

Ethical considerations

The study protocol was approved by the Scientific and Ethics Review Unit of the Kenya Medical Research Institute (Ref SERU/CPHR/0003/3430). Interviews were conducted in a private and convenient location in the community. Participants were informed of potential benefits and risks of their involvement in the study in a language that they understood. Research assistants were trained on the objectives of the study, and the emphasis on protecting research participants during and after the study. Prior to inclusion in the study, written consent was obtained from each of the study participants.

Patient and public involvement

The objectives and the design of the study were informed by previous findings from research in the community that showed that despite there being opportunities for free and subsidized treatment for CVD and their risk factors, the response of the public was poor to the extent that those who signed up in the program dropped off soon after.

FINDINGS

The demographic characteristics of the study respondents are shown in Table 1. Nine focus group discussions involved 65 participants, aged between 20 and 65 years, mean age 45 years, and 63% female. The main themes emerging from the focus group discussions were related to (i) Knowledge, understanding and awareness regarding CVD and CVD risk factors; (ii) Understanding of and perception towards risk factors for CVD; and (iii) Barriers to screening, care-seeking, and adherence to treatment for CVD.

During the interviews, the researcher explained to the participants the conditions being discussed. Cardiovascular diseases were defined as disorders of the heart and blood vessels namely heart disease (angina), heart attack and heart failure, and stroke. Risk factors were listed as hypertension and raised blood pressure, diabetes and raised blood sugar, overweight and obesity, physical inactivity, smoking and harmful alcohol consumption. Perceptions comprised opinions on CVD and the risk factors and what influenced these opinions, and understanding and interpretation of individuals at risk.

Table 1: Characteristics of focus group discussions study participants (N=65)

Participant characteristics	Korogocho (N=30)	Viwandani (N=35)
Number of focus group discussions	4	5
Age (SD)	42.4 (9.46)	46.6 (8.86)
Sex		
Female	23	18
Male	7	17
Education		
No schooling/ below primary school education	12	1
Primary	10	16
Secondary	8	16
Post-secondary/Tertiary	0	2
Marital status		
Single/not married	2	5
Married	24	26
Divorced/separated	4	4
Employment/occupation		
Unemployed	12	13
Casual worker	7	3
Formally employed	1	3
Self-employed	10	16
Religion		
Christian	26	30
Muslim	4	5

Knowledge, understanding and awareness regarding CVD and the risk factors

Generally, among the residents of Nairobi slums, there was poor knowledge of CVD conditions, and understanding of the risk factors involved. A small number of respondents reported that some of their family members discovered 'only by chance' that they suffered from conditions such as diabetes and hypertension, which would mostly happen when they experienced stroke and heart attacks and were hospitalized. In most instances, it was too late to treat the conditions.

R: Not many people are aware of these diseases ... not many people know about the diseases and you know they normally find out when they are sick, maybe when they have a cold and they go to the hospital. When they undergo the tests the doctor may ask them whether they suffer from [blood] pressure and they may say no. Some of them don't even know about the symptoms. So there are very few people who know about these diseases. Participant, FGD #02, Site_1.

The magnitude of the CVD burden in the community was not obvious among many of the study respondents, because in their own opinion, 'these conditions were discrete and considered private'. Many respondents however were of the opinion that hypertension, a known risk factor for CVD, when compared to, say diabetes, was more common in the community, especially amongst women.

R4: Like blood pressure is very much widespread. There is a period when we were being screened for it, most women who went for that screening were found to be having high blood pressure. FGD #05, Site_1.

There was some knowledge among the respondents regarding the relationship and co-existence of CVD risk factors in individuals, as well as the relationships between risk factors and CVD outcomes. For instance, obesity was commonly linked with diabetes and hypertension, conditions which were said to consequently lead to heart attacks as shown in the quotes below.

R5: I think...that (over)weight, isn't it just fat? Now the fats get into the veins, and bring about the risk of blood not flowing through the body and that causes hypertension. Participant, FGD #01, Site_2.

R: You can see that person who has obesity ... he can easily develop (high blood) pressure, he can easily develop diabetes ... he can easily develop heart attack because it is like they follow each other, they move together. Participant, FGD #04 Site_2.

Risk for CVD was an abstract concept to a majority of the respondents involved in our study. Most respondents could not readily identify individuals that were likely to suffer from CVD, or relate common risk factors like smoking and alcohol consumption with increased risk of developing heart attack and/or stroke. However, 'anyone-all members of the community' were considered at risk of developing CVD. This opinion was based on observed trends

in the community where 'even younger people as well as children' were diagnosed with diabetes and hypertension.

According to a few of the study respondents, independent of their age, individuals who harbored worry and suffered stress were more likely to develop CVD. Women were especially singled out as those likely to develop CVD resulting from stress and worry.

R4: Because if you look at the causes of this disease, and more so stress, to a woman, when a child is sent away from school for lack of school fees, that will be a challenge to her. When we [her family] miss supper, it is just a challenge to the woman. The man will not see that as a problem, and even when this man comes back home drunk, still it will be a problem to her. That is why the women have higher risks of developing the sickness (high blood pressure) than men. Participant, FGD #01, Site_1.

CVD conditions could also be inherited or passed down generations, and according to one respondent, in certain cases were considered a 'curse'.

R2: For a disease like diabetes ... I don't think one can avoid it because [some of these diseases are] inherited from the parents. It is in the family. It is like a chain in the family. Some of these [diseases] you cannot avoid. So for me I think it is only God who can help someone [suffering these diseases]. Participant, FGD #03, Site_2.

R: So you just wonder, if the children are getting these diseases then this must be as a result of a curse ... because if even a child in class eight can be diabetic ... so some believe that the Lord is just angry with us. Participant, FGD #04, Site_1.

A female respondent thought that hormonal contraceptives may cause women to gain weight, become obese and consequently develop high blood pressure.

R6: Family planning [contraceptives] bring these problems because when you go there [to a health facility], the first thing they have to check is your weight and [blood] pressure. I wonder if they do that to check if they [contraceptives] have given you pressure or what. Let's just say they may cause these diseases. Participant, FGD #01, Site_1.

Understanding of and perception towards risk factors for CVD

Poverty and stress as the underlying risk factors for CVD

The study respondents almost unanimously agreed that widespread poverty in their community was the major reason they had health challenges and that poverty was an impediment to them seeking prevention and treatment services for CVD. The thinking here was that poverty bred stress as a result of everyday worry, insecurities, and lack of livelihood opportunities to address family and personal needs. Family conflicts were also more likely to arise, more often, in poor households. Stressed individuals were likely to suffer from diabetes, a condition that was said to also cause stroke and heart attacks.

R6: For me what I know is that when you have stress.....it is like when you think too much then the sugar levels also rise in your body. And they continue rising ... so stress in my opinion also contributes to these diseases. Participant, FGD #04, Site_1.

Study participants held the opinion that urban slum dwellers were predisposed to indoor and outdoor environmental pollution through their use of low quality fuels like kerosene and wood charcoal for cooking, as well as from gaseous emissions and effluents from industries surrounding their homes. An opinion that was supported by majority of the participants was that the food items and commodities consumed in their community contained harmful toxins and chemicals that could cause CVD because they were grown along polluted river banks. The 'bad food' was blamed for the rise in the burden of CVD, especially among the younger population which was not known to suffer CVD in the years gone by.

Factors that cause cardiovascular diseases

One theme that we explored in this study was the link between the conventional risk factors for CVD: behavioral risk factors like smoking, [harmful] alcohol consumption, physical inactivity and unhealthy diet, with physiological risk factors that include obesity, hypertension and diabetes, and with the CVD outcomes stroke and heart attacks.

Unhealthy diet, salt and sugar

Foods rich in fat were said to lead to 'blockage of blood vessels', consequently leading to stroke and heart attacks. Despite this understanding, participants argued that avoiding fat when cooking was a difficult proposition, because women whose role was to prepare food for the family were under pressure to satisfy the tastes of their family members, especially

that of their husbands. Using 'enough cooking fat' was one such negative practice that was difficult to stop. Two female respondents noted:

"You know if you do not use oil on [cooking] vegetables, it (food) will just taste like it has been boiled; but if you use a lot of oil, it will taste like you have fried it" and "some (family members) will ask you, 'is this house a hospital where we eat food that is not fried?'"
Participants #02 & #05, FGD #01, Site_1.

Although sugary drinks were mentioned as a cause for CVD, according to respondents that were involved in heavy lifting and energy-sapping manual work it was still okay to consume a lot of sugar (sometimes up to five teaspoons in a cup of tea) because of their high energy requirements, and because they would 'sweat a lot' and thus would get rid of the excess sugar in the process. The understanding and the requirement to consume healthy diets in order to prevent against CVD was met with a big challenge to the community. Majority of the respondents noted that their access to healthy food was constrained by the inability of the community members to afford them.

R2: When I talk of types [of food], I mean that human body needs a lot of elements even from the fruits, and so we don't eat different healthy foods not because we like it that way but [because] it is due to financial constraints. Sometimes you may want to eat the right food but because you cannot afford it, you will have to take what your money can buy. FGD #03 Site_2.

On the flipside however, respondents pointed out families that were considered 'well off', and had the opportunity to eat 'good food' e.g. meat, but were generally physical inactive. Members of such families were perceived to be more likely to be obese, with an enhanced chance of developing hypertension and suffering heart attacks.

Smoking and harmful consumption of alcohol

Very few individuals among the respondents possessed the awareness or understanding on how harmful and/or excessive alcohol consumption and tobacco smoking could lead to CVD.

R2: On that point [on how excessive alcohol can cause CVD] I am not very sure but I normally hear that when you have high blood pressure you should not use alcohol at all because even the alcohol makes the blood pressure to rise very fast and very high. Participant, FGD#04, Site_2.

Tobacco smoking and alcohol consumption were said to be closely associated, with individuals that consumed alcohol being more likely to smoke. The urban slum environment was awash with illicit brews that contained harmful chemicals that could cause CVD, and in many cases, also lead to death. Alcohol consumption was also linked to stress, an issue that we earlier alluded to as a cause for CVD. There was a perception among the study participants that among the married, female partners were stressed by conflicts brought about by their alcoholic/drunken partners, and from the fear that their partners would engage in reckless sexual behaviors when drunk, which may lead them to contracting infections and transmitting to them.

Physical inactivity

An opinion held by most of participants was that the residents of urban slums had increasingly become less and less physically active. The new and cheap forms of transportation, including the commonly used *boda boda* (motorcycle taxi) mean that people ride even for distances they would have walked. Another issue linked to community members practicing insufficient physical activity was the widespread crime and insecurity which has made safe spaces for children and adults to play to shrink. Insecurity was also blamed for decreased episodes of walking, and engagement in other forms of physical activity. As seen below:

".....previously, there was a field, we used to play [there at the Chief's camp]. But these days, it (the field) is no longer there". Participant, FGD #01, Site_1.

Overweight and obesity

In this community, being overweight or 'fat' was an indication that an individual was living a 'good and stress-free life'. Some respondents also mentioned that there were individuals who were born with a 'fat gene' and would therefore get fat whether or not they ate fatty or unhealthy food. Respondents linked overweight and obesity to high blood pressure, and subsequently to stroke and heart attacks, with some holding the perception that obesity affected women more than men in the community. A female respondent noted that obesity came about because women who use a lot of fat for cooking also ate oily and unhealthy food more than men.

R: When it comes to eating chips (fried potatoes), it is the women who mostly eat the chips. If you ask a man the last time he took chips.... he may tell you about a long time ago. But when you find these things that are normally deep fried using these fats ... it is

us women that normally feed on these things ... so you find that these are the things [fatty food causing obesity] that are causing [blood] pressure. Participant, FGD #04, Site_1.

Barriers to screening, care-seeking and adherence to treatment for cardiovascular diseases

Individual and community level barriers

There was a widely held opinion that the cost of treatment for any illness, let alone for CVD was prohibitive and therefore members of the community could not afford. Cost of healthcare was singled out as one of the greatest barrier to care-seeking and adherence to treatment for CVD, and specifically for diabetes and hypertension. Consultation fees charged at private health facilities were considered 'hefty', and the cost of purchasing medication from private pharmacies due to their unavailability at the public health facilities was also high. For diabetic patients, the cost of 'healthy and special' foods required for them to manage their condition, as well as insulin was unaffordable.

R4: Because they [patients] are buying medicine [insulin] and also buying [healthy] food because they have to really be careful with their diets.

R5: When you meet them and begin telling them they should eat this and that [healthy food], they [respond] that for them to do that they have to plan their pockets well. FGD #01, Site_1.

A small number of respondents felt that most urban slum residents did not even seek care in the first place because they despaired just from the thought of discovering that they suffered CVD, yet they felt poor, helpless and could do nothing to manage their condition. Participants talked of conditions such as diabetes and hypertension, as well as stroke and heart attacks being untreatable by conventional medicine, and did not therefore see the need to seek treatment. Such a misconception, especially with respect to treatment of hypertension and diabetes, made some members of the community to hesitate to seek treatment for their conditions from health facilities, and instead chose to seek care from traditional healers and herbalists.

Respondents also recognized lack of knowledge about CVD and the attendant risk factors, together with misinformation on what causes these conditions and how they can be mitigated as additional barrier to care-seeking. In one instance and a clear case of misconception, a respondent suggested that stroke could result from a mental disorder.

"In my own opinion of which I am not sure if I am right or not.....I think stroke comes in when you are affected mentally. Like when you encounter many difficult problems, like the death of a child then this begins to disturb you [mentally] and you end up with stroke".

Participant FGD #01, Site_1.

It was not clear to some respondents how behaviors like excessive/harmful alcohol consumption and smoking were related to CVD. One can speculate that this would be the reason why, as reported by the respondents, many community members failed to take action to prevent themselves from CVD, by getting screening and treatment for conditions they could have. Participants suggested that there was an urgent need to sensitize the urban poor on the mechanisms through which behavioral (and other) risk factors may lead to CVD, while suggesting pragmatic and inexpensive strategies for the community to prevent and protect themselves from developing CVD. One such suggestion proposed that sensitization on the dangers of the use of unhealthy fat in cooking target entire family members, including the men.

R5: You know we are women. If our husbands are not also sensitized and made aware of the risks associated with it [unhealthy fat in cooking], he will think I am cooking just the way I want, and he will not know the dangers which come with the fats. He will say that is something I learnt on my own and he will insist that I just cook the way it should be done [with fats] in the house. Participant, FGD #01 Site_1.

Relatively younger people were said to be dismissive of any suggestions that they could suffer from CVD, despite earlier statements indicating the understanding that anyone, regardless of their age or sex, could suffer from CVD. A respondent mentioned that the youth felt that the information to screen for CVD was better targeted to the older members of the society.

R3: People (in the community) have not really understood what these diseases are all about ... you just normally hear ... someone had a heart attack and he died ... he just woke up feeling very well but he just collapsed and died. So people have not understood it ... how it affects a person ... they only know when the person dies. Participant FGD #04 Site_1.

One issue that was said to be was a major barrier to care-seeking and management of CVD and specific to the elderly was the lack of family support. This situation mostly affected elderly individuals living on their own or away from their families, who struggled with

activities such as visiting health facilities for treatment and lacked effective guidance on and when taking medication.

R2: There are many challenges you may go to the hospital and sometimes it's a grandmother or grandfather, they will not know how to take drugs, how many to take in the evening, at noon or in the morning. So they have to have someone to help them. Participant FGD #02, Site_2.

Non-dominant themes that emerged from this research included the mention of perceived stigma towards conditions such as stroke, as they were believed to a result of curses or evil. For instance, some respondents talked of individuals suffering stroke in their community being discouraged from discussing their conditions in public, and in some cases patients being locked away from the public's sight by their caregivers to avoid bringing an embarrassment to their families. The result therefore was that patients were afraid to reveal their conditions to family and friends.

Excessive alcohol consumption and substance use was said to contribute to low levels of screening for CVD risk factors among a section of the community. Excessive alcohol consumers and illicit drug users were less likely to get screened or tested for CVD, a situation that meant very few of them were aware of the conditions.

R6: Again alcohol is not very good, because you say that you are not sick but when you go to take alcohol and you have not been tested, it will affect your health because maybe you have the disease but you have not been tested. Participant FGD #05, Site_1.

Healthcare system barriers

Respondents identified healthcare system barriers that affected their access to screening, care-seeking and treatment for CVD. These barriers included the lack of enough healthcare facilities in and around the community where residents could seek care and information regarding CVD. Although few health facilities were present, they were privately run, and there was a perception by the community that they were costly and unaffordable. The issue of unaffordable and costly health care can be linked to poverty which was tagged as the biggest driver of and cause for the risk factors.

The community lacks access to specialist clinics for CVD. In addition, there is overcrowding at the few public health facilities, a situation that adds to the inaccessibility to services,

especially for hypertension and diabetes patients. The unavailability of drugs following diagnosis also means that patients are required to purchase drugs at private pharmacies at high prices. Few respondents alluded to the poor attitude of health care providers, and lack of empathy patients whenever patients visited their facilities as a barrier to care-seeking.

Addressing barriers to screening, care seeking, and treatment for cardiovascular diseases

We sought to explore suggestions on how CVD can be prevented, and strategies to enhance care-seeking, and access to and effectiveness of care for CVD in the community. Many respondents agreed that addressing poverty, ignorance and high levels of illiteracy in the community was key and the first place to begin. These three issues were considered the main drivers of stress and worry, and were linked to the factors that caused CVD in the community.

Individuals would minimize stress, by avoiding thinking too much or worrying themselves too much, and if they also limited their exposure to pollution, chemicals and toxins air by living in clean houses, using clean toilets and avoiding bad food sold in the community. Physical activity was recognized a strategy to prevent CVD, and was especially an advice directed at individuals considered obese or 'too fat' (from living comfortable lives). The main benefit ascribed to engaging in physical activity was the reduction in the amount of fat in blood, leading to unclogging of blood vessels and reduction in the risk of developing high blood pressure. Physical activity was also said to help in easing the mind and to reduce stress, while respondents that engaged in vigorous activities said the resulting sweating helped 'remove' harmful toxins ingested through poor quality food from the body.

R2: Instead of just sitting in the house and getting stressed up, one should get out and look for something to do. Through this one is kept busy outdoors, and so they don't get stressed up. Participant FGD #03, Site_2.

One key suggestion by a section of the respondents regarding an effective program to enhance prevention of CVD was with respect to raising awareness in the community on the main CVD conditions, the common risk factors and how individuals could avoid/prevent them. For efficiency and a wide reach, health promotion campaigns should be led by health care workers 'in their element, and dressed up in white coats' and employ public events and forums where majority of the community members were likely to be found. Yet other respondents favored door-to-door screening, suggesting that this method 'preserved the

dignity of the would-be patients' as opposed to when screening was done in public or at the health facilities. Door-to-door screening has the benefit of reducing the propagation of stigma tied to conditions such as stroke in this community as we saw earlier, and which was identified as a barrier to care-seeking among patients.

R2: The question is if they can go door to door because it's only his family members who know he has this disease so if they go door to door they can know the problem that these people are facing. Participant, FGD #02, Site_2.

Another favored strategy by a section of the participants was the short messaging service (SMS) and the use of social media platforms to disseminate messages on the risk for CVD, to inform on available opportunities to screen and advice on where care and treatment could be sought. Respondents highlighted how the use of community health volunteers (CHVs) has worked well for them in other programs to pass information and in providing services. The participants suggested CHVs can also be used to conduct screening for CVD in the community. Screening for CVD can happen in the households, and by so doing, would ensure the identities and dignity of the individuals diagnosed with CVD are protected. The other advantage of using CHVs was that they live in the community, are accepted by the locals, can communicate in a language the community members understand. Living in the community also made it easier for the CHVs to carry out follow-up with defaulters.

R6: CHVs ... those people ... they should be educated and then be sent into the Villages to educate the people. Participant, FGD #02, Site_1.

DISCUSSION

This study conducted among healthy adult members of an urban slum community in Nairobi sought to explore their understanding of and perceptions towards CVD and CVD risk factors, care-seeking and adhering to treatment. Study participants were on average 45 years, a period in life when exposure to CVD risk factors is high and the risk for developing CVD is real.

A key finding of this work was the identification of widespread poverty, illiteracy and ignorance in the urban community considered to be a key contributor to the perceived low levels of understanding and awareness of the risk factors for CVD conditions such as

diabetes, hypertension, stroke and heart attack. For instance, majority of the respondents did not see the association between smoking and excessive/harmful alcohol consumption with CVD. We also observed that a good number of the respondents were unaware of the link between stroke and heart attacks with smoking, excessive alcohol consumption, and insufficient physical activity, as well as with obesity, diabetes and hypertension. It was also apparent that most of our study respondents could neither see how the coexistence and interrelationships among the said risk factors could lead to CVD outcomes, nor the pathways and mechanisms involved. Respondents believed that with respect to the environment in which they lived, toxins from contaminated foodstuff and from illicit alcohol, and the effect of indoor and outdoor pollutants contributed to the risk for hypertension, diabetes, stroke and heart attacks, and consequently to death.

Individuals diagnosed with diabetes and hypertension in this community on many occasions noted their condition at a late stage impacting negatively on available management options. Respondents recounted that members of their community diagnosed with stroke chose to suffer in silence due to the perceived stigma directed at the conditions because of their association with curses and evil deeds, and abstained from speaking about their conditions in public, which would embarrass their families.

Respondents also referred to the widespread insecurity and crime posing a detrimental effect on recreational physical activities, as public spaces were considered to be unsafe for walking and playing.

Poor diet was caused by lack of access to healthy foods, which compromised the nutrition and health of the people. Urban populations are known to experience marked changes in dietary patterns following the adoption of unhealthy diets common in their environments [20], practice little physical activity, and display increased smoking and harmful alcohol consumption rates, all of which are key risk factors for CVD [20-22]. The respondents also mentioned that in their community emotional stress was a cause for CVD conditions, mostly hypertension and heart attacks. There exists a perception that the slum environment in which they live predisposed them to psychosocial stressors and constant worry that enhanced their risk of developing strokes and heart attacks. Elsewhere, chronic stress resulting from everyday challenges from family and work has been shown to contribute to worsening health behaviors, and in promoting behavioral risk factors for CVD like smoking and physical inactivity [23]. The INTERHEART study conducted in LMICs reports that

“permanent stress” at work or at home doubled the risk of an individual developing a myocardial infarction [24].

The perception by the urban slum residents that CVD conditions were inherited, and that there was very little one could do to prevent these may hinder the adoption and maintenance of preventive behaviors against disease, as has been reported previously [15]. A notable barrier to treatment and care seeking for CVD in this community was reported to be the lack of knowledge on where to find appropriate health care, as well as frustrations arising from previous experiences by the members of the community with poor quality of services received at public health facilities, lack of clinicians and unavailability of drugs following screening, and overcrowding of patients in the few public facilities available in the community. Similar findings have been documented elsewhere in the region [25]. Lack of awareness by the public of CVD risk factors has been shown to be associated with lack of national programming for NCDs elsewhere [26]. Generally, in SSA, structural and health system level barriers such as lack of sufficient health facilities, widespread poverty and the inability to raise money to afford treatment, are the main reasons for lack of prevention, surveillance and treatment efforts for conditions such as CVD [27].

The practice of lifestyle and behavior modification to prevent CVD, like the adoption of a healthy diet was affected by the cost of so-called ‘healthy foods’ in the urban slum settings described to be higher compared to cheaply and readily available less healthy options.

There was a perception that some CVD risk factors were gendered. Some respondents insisted that obesity affected more women than men in their community because the latter practiced less physically activity that included sports, walking and manual labor. Smoking and [excessive] alcohol consumption was however ascribed to men. These perceptions point to the need for the redesign of health promotion and awareness campaigns by taking into consideration locally held perceptions. There is also a need to address the misconceptions by the different sections of the community on who they consider most-at-risk of CVD in order to influence the actions taken to prevent, and enhance care-seeking and adherence to treatment for CVD. Similar findings were reported in a recent systematic review [27], and from other studies conducted in the same population [14, 28]. A study reported that many communities in SSA perceive a larger body size as ‘a sign of affluence and good living’, highly desirable and respectful [29]. For instance, obese men in Cameroon were considered to live a ‘good life’ [30]. We found similar results in this study, where positive terms like ‘*mdosi*’, loosely translated as ‘big man’, indicating well-to-do, were used to refer to men with

bigger bodies. Previous evidence also suggests that individuals from low socioeconomic groups were more likely to engage in harmful alcohol consumption and tobacco use, and to consume less fruit and vegetables [31, 32]. In SSA, socioeconomic stressors, including poverty and urbanization, have been linked to the rise of mortality and morbidity from CVD [7, 8, 33, 34].

We acknowledge that the understanding of the study respondents regarding the CVD conditions being investigated, including stroke and heart attack may have been unclear in some instances in our study, despite our best effort to clarify and explain. Despite this limitation, we believe that the study provides important insights into how CVD risk and risk factors are understood in a low-resource urban setting and how the understanding and perception affects treatment-seeking and management for CVD in the community. Urban lifestyles that include sedentary behavior, practice of insufficient physical activity, together with the consumption of energy-dense, salty and sugary foods and drinks are increasingly diffusing to and being adopted by the rural populations in Kenya.

These findings offer useful information to policy makers and program implementers in their design of programs to enhance awareness on CVD risk and risk factors, and insights into how to deliver effective CVD prevention and care in low-resourced communities, for both urban and rural populations. Specifically, the findings bring to the fore the need to take into account perceptions on and understanding of risk factors for CVD within the cultural context issues e.g. how stigma for stroke is a barrier to care seeking and how a perception that conventional medicine is unable to treat certain CVD conditions make individuals seek help from traditional healers and herbalists. It therefore follows that effective health promotion should tap into locally generated knowledge and perspectives derived from those directly affected by these conditions. Programs for CVD prevention and treatment for low-resourced settings should aim to address the social determinants of health and disease in the form of poverty, illiteracy and ignorance. This can be done by creating awareness on CVD and its risk factors, and risk communication by health care providers, alongside deliberate efforts to improve the performance and effectiveness of existing health care systems.

Contributors: FMW, DEG, CK and KKG conceptualized and planned for the study. FMW took charge of the data collection and data processing. DEG, CK and KKG supported the analysis, write-up and review of the manuscript. All authors approved the final manuscript for submission.

Funding: This study was supported by a Global Health Support Scholarship of the University Medical Center, Utrecht to FMW. Core support for the African Population and Health Research Center (APHRC) provided by The William and Flora Hewlett Foundation (Grant #2009–40510), Sida (Grant #2011-001578) and the Rockefeller Foundation (Grant #2009SCG302) is acknowledged.

Declaration of conflict of interest: The authors have no conflict of interest to declare in regard to the research, authorship and publication of this article.

Patient consent: not applicable

Ethics approval: the study was approved by the scientific and ethics review unit sitting at the Kenya Medical Research Institute (KEMRI) on April 6, 2017 (Ref KEMRI/SERU/CPHR/0003/3430).

Data sharing statement: data (transcripts) and coding schemes used in this paper are available on request from the corresponding author.

REFERENCES

1. Roth, G.A., et al., *Global and regional patterns in cardiovascular mortality from 1990 to 2013*. *Circulation*, 2015. **132**(17): p. 1667-1678.
2. World Health Organisation., *Global health risks: mortality and burden of disease attributable to selected major risks*. 2009, World Health Organisation: Geneva.
3. World Health Organisation., *Disease burden and mortality estimates: 2016*, in *Cause-specific mortality, 2000–2016*. 2016, World Health Organisation: Geneva.
4. Mensah, G.A., et al., *Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: a systematic analysis of data from the Global Burden of Disease Study 2013*. *Cardiovascular Journal of Africa*, 2015. **26**(2 Suppl 1): p. S6-10.
5. Roth, G.A., et al., *Demographic and epidemiologic drivers of global cardiovascular mortality*. *New England Journal of Medicine*, 2015. **372**(14): p. 1333-41.
6. Boateng, D., et al., *Knowledge and awareness of and perception towards cardiovascular disease risk in sub-Saharan Africa: A systematic review*. *PLOS One*, 2017. **12**(12): p. e0189264.
7. Yen, I.H. and G.A. Kaplan, *Poverty area residence and changes in depression and perceived health status: evidence from the Alameda County Study*. *International Journal of Epidemiology*, 1999. **28**(1): p. 90-94.
8. BeLue, R., et al., *What matters most: an investigation of predictors of perceived stress among young mothers in Khayelitsha*. *Health Care for Women International*, 2008. **29**(6): p. 638-648.
9. Suls, J. and J. Bunde, *Anger, anxiety, and depression as risk factors for cardiovascular disease: the problems and implications of overlapping affective dispositions*. *Psychological Bulletin*, 2005. **131**(2): p. 260.
10. Rozanski, A., J.A. Blumenthal, and J. Kaplan, *Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy*. *Circulation*, 1999. **99**(16): p. 2192-2217.
11. Olufemi, O. and M. Oluseyi, *The urban poor and mobility stress in Nigerian cities*. *Environmental Research Journal*, 2007. **1**(1-4): p. 1-8.
12. Contractor, A., et al., *Addressing Cardiovascular Disease Burden in low and Middle Income Countries (LMICs)*. *Current Cardiovascular Risk Reports*, 2014. **8**(11): p. 405.
13. Phillips-Howard, P.A., et al., *Deaths ascribed to non-communicable diseases among rural Kenyan adults are proportionately increasing: evidence from a health and demographic surveillance system, 2003-2010*. *PLOS ONE*, 2014. **9**(11): p. e114010.
14. Haregu, T.N., et al., *Co-occurrence of behavioral risk factors of common non-communicable diseases among urban slum dwellers in Nairobi, Kenya*. *Global Health Action*, 2015. **8**: p. 28697.

15. Pligt, J.v.d., *Risk Perception and Self-Protective Behavior*. European Psychologist, 1996. **1**(1): p. 34-43.
16. Lundborg, P. and B. Lindgren, *Do they know what they are doing? Risk perceptions and smoking behaviour among Swedish teenagers*. Journal of Risk and Uncertainty, 2004. **28**(3): p. 261-286.
17. Rimal Rajiv N. and R. Kevin, *Perceived Risk and Efficacy Beliefs as Motivators of Change*. Human Communication Research, 2003. **29**(3): p. 370-399.
18. Rosenstock, I.M., *The health belief model and preventive health behavior*. Health Education Monographs, 1974. **2**(4): p. 354-386.
19. Emina, J., et al., *Monitoring of Health and Demographic Outcomes in Poor Urban Settlements: Evidence from the Nairobi Urban Health and Demographic Surveillance System*. Journal of Urban Health, 2011. **88**(2): p. 200-218.
20. Waxman, A., *Why a global strategy on diet, physical activity and health?*, in *Nutrition and Fitness: Mental Health, Aging, and the Implementation of a Healthy Diet and Physical Activity Lifestyle*. 2005, Karger Publishers. p. 162-166.
21. Godfrey, R. and M. Julien, *Urbanisation and health*. Clinical Medicine, 2005. **5**(2): p. 137-141.
22. Doulougou, B., et al., *Differences in hypertension between informal and formal areas of Ouagadougou, a sub-Saharan African city*. BMC Public Health, 2014. **14**: p. 893.
23. Twisk, J., et al., *Changes in daily hassles and life events and the relation with coronary heart disease risk factors: a two year longitudinal study in 27 to 29 year old males and females*. Journal of Psychosomatic Research, 1999. **46**: p. 70-76.
24. Rosengren, A., et al., *Association of psychosocial risk factors with risk of acute myocardial infarction in 11 119 cases and 13 648 controls from 52 countries (the INTERHEART study): case-control study*. The Lancet, 2004. **364**(9438): p. 953-962.
25. Motala, A.A., *Diabetes trends in Africa*. Diabetes/metabolism research and reviews, 2002. **18**(S3).
26. Awah, P.K., et al., *Perceived risk factors of cardiovascular diseases and diabetes in Cameroon*. Health Education Research, 2007. **23**(4): p. 612-620.
27. BeLue, R., et al., *An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective*. Globalization and Health, 2009. **5**(1): p. 10.
28. Haregu, T.N., et al., *The connection between non-communicable disease risk factors and risk perception among urban slum dwellers in Nairobi, Kenya*. African Population Studies, 2016. **30**(3): p. 3094-3102.
29. Nyirenda, M.J., *Non-communicable diseases in sub-Saharan Africa: understanding the drivers of the epidemic to inform intervention strategies*. International Health, 2016. **8**(3): p. 157-158.
30. Kiawi, E., et al., *Knowledge, attitudes, and behavior relating to diabetes and its main risk factors among urban residents in Cameroon: a qualitative survey*. Ethnicity & Disease, 2006. **16**(2): p. 503-509.

31. Schneider, M., et al., *Poverty and non-communicable diseases in South Africa*. Scandinavian Journal of Public Health, 2009. **37**(2): p. 176-186.
32. Allen, L., et al., *Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review*. The Lancet Global Health, 2017. **5**(3): p. e277-e289.
33. Siervo, M., et al., *Urbanization and obesity in The Gambia: a country in the early stages of the demographic transition*. European Journal of Clinical Nutrition, 2006. **60**(4): p. 455.
34. Levenstein, S., M.W. Smith, and G.A. Kaplan, *Psychosocial predictors of hypertension in men and women*. Archives of Internal Medicine, 2001. **161**(10): p. 1341-1346.

APPENDIX I: FOCUS GROUP DISCUSSION GUIDE

Understanding of and perceptions towards cardiovascular disease risk and risk factors in the informal settlements of Nairobi

Introduction: Different people in our communities suffer from conditions of the heart and of the blood vessels. Examples of these conditions include heart diseases characterized by sharp pain of left side of the chest where the heart is located while carrying out heavy tasks, and heart attacks which are usually abrupt and fatal, and sometime leading to death, and stroke which are accidents in the brain caused by blockage of blood flow or rupturing of the blood vessels, and which leads to paralysis and loss of feeling to one side of the body, and may also lead to death. These conditions happen mostly to people suffering from diabetes and high blood pressure/hypertension. We would like to discuss your understanding of and experience with these conditions, in order to understand their causes and how they can be prevented. We will seek your views on challenges the community faces in preventing these diseases and what can be done to improve the situation.

Icebreaker

How widespread are these conditions in your community?

1. Which lifestyles and behaviors can cause someone to get the conditions discussed above?

Probe: for each lifestyle and behavior which condition it causes

Probe: the mechanism through which the condition(s) is/are caused

Probe: which community members/section (men, women, children, old, industry workers etc.) are more likely affected. Why?

2. Apart from the lifestyle choices and behaviors, are there other factors that can cause an individual to be at risk of acquiring the conditions/diseases described above?

Probe: for each factor which condition it causes

Probe: the mechanism through which the condition(s) is/are caused

Probe: which community members/section (men, women, children, old, industry workers etc.) are more likely affected. Why?

3. How are the lifestyle and behaviors, and the other mentioned factors interrelated?
Probe: which factor enhances the risk from the other?
4. How do you think the conditions described above can be avoided, prevented?
Probe on what can be done (actions) to prevent someone from acquiring any of the conditions described above?
5. What do you think the community members know about these conditions?
6. What do you think the community members know about how to prevent the conditions?
7. What care/interventions are available in the community for the conditions discussed?
Probe for care/treatment for specific conditions
8. What makes it difficult to access and utilize care/treatment for the conditions described above?
9. What can be done to raise awareness of such diseases/conditions in the community?

Part 3

Cardiovascular diseases risk assessment in the
slums of Nairobi

Chapter 7

Comparative performance of pooled cohort equations and Framingham risk scores in cardiovascular disease risk classification in a slum setting in Nairobi Kenya

Frederick M. Wekesah, Martin K. Mutua, Daniel Boateng, Diederick E. Grobbee, Gershim Asiki, Catherine K. Kyobutungi, Kerstin Klipstein-Grobusch
Submitted

ABSTRACT

Background: Cardiovascular diseases (CVD) cause 18 million deaths annually. Low- and middle-income countries (LMICs) account for 80% of the CVD burden and it is the region where the burden is expected to grow in the coming decades. Inadequate screening for individuals at high risk for CVD is rampant. A number of multivariable scores are available for use in screening for and identifying individuals at high risk for CVD in primary care settings but few have been validated/recalibrated for use in SSA.

Methods: The 2013 and 2018 Pooled Cohort Equations (PCE) and Framingham risk scores for 10-year CVD risk were calculated for 1960 men and women aged 40 years and older from the AWI-Gen (Africa, Wits-INDEPTH Partnership for GENomic studies) study 2015. Participants were classified as low, moderate or high CVD risk, corresponding to <10%, 10–20% and >20% respectively. Agreement between the risk algorithms was assessed using kappa and correlation coefficients.

Results: High CVD risk (>20% probability of developing CVD in 10 years) was 10.3% in PCE 2013, 0.4% in PCE 2018, 2.9% in Framingham and 3.6% in Framingham non-laboratory scores. Conversely, low CVD risk category (<10% probability of developing CVD in 10 years) was 62.2% in PCE 2013 and 95.6% in PCE 2018, 84.0% and 80.1% in Framingham and Framingham non-laboratory scores, respectively. A moderate agreement existed between the Framingham functions (kappa = 0.64, 95% CI 0.59 - 0.68, correlation, $r_s = 0.711$). There was no agreement between the PCE 2013 and 2018 functions (kappa = 0.05, 95% CI 0.04 - 0.06).

Conclusions: Newer cohort-based data is required to validate and recalibrate existing functions for development of appropriate CVD scores for use in SSA.

Key words: Risk, risk assessment, risk communication, Framingham, pooled cohort equations, Kenya

INTRODUCTION

Cardiovascular diseases (CVD) account for 17.9 million deaths annually, equivalent to 31% of all deaths globally [1, 2]. About 75% of these deaths, 85% of which are caused by heart attacks and stroke, occur in low- and middle-income countries (LMICs) [1]. Sub-Saharan Africa (SSA) contributes about 5.5% of global CVD deaths, the proportion estimated to double by 2030 [3]. Known risk factors for CVD include high systolic blood pressure, smoking, high fasting plasma glucose, high body-mass index, and particulate matter pollution [4].

The poor suffer a disproportionately higher burden of cardiovascular diseases. They are also affected by significant disparities in accessing health care and services [5]. In populations underserved by health care services, CVD risk is often perceived inappropriately: individuals display optimistic bias in their self-assessment for CVD risk (when individuals think that they are less likely to develop CVD when compared with others) [6, 7]. Optimistic bias in individual risk assessment could be as result of the widespread low levels of awareness of CVD and risk factors, itself a result of the existing higher rates of illiteracy and widespread levels of social deprivation. Risk misperception results in late diagnosis and detection of CVD, leading to higher rates of premature deaths: deaths occurring among individuals aged below 70 years.

Assessing absolute cardiovascular risk is a proven clinically sound guide to prevent and promote adherence to treatment strategies for CVD [8, 9]. It is a useful tool in risk communication for primary prevention [10]. By calculating a patient's absolute risk for CVD, a health care provider can identify individuals at increased risk for CVD and recommend mitigation strategies [11-13]. Absolute risk assessments and communication to the affected individuals have been used in raising CVD awareness, and in motivating adherence to lifestyle modifications and/or treatment in the developed world [14].

A number of multivariable CVD risk assessment algorithms (risk scores) that incorporate known and novel risk factors for CVD have been developed and are in use globally [15-23]. Majority of these risk scores were however developed in predominantly Caucasian populations, and may not be applicable to other populations, especially African. For instance, an earlier analysis reported that the Framingham-based scores had poor calibration when applied to certain ethnic groups and socioeconomically deprived populations in underestimating risk [24].

Few of the CVD risk scores are modified for use in screening populations in SSA. The current study assesses the performance of the newly released 2018 Pooled Cohort Equations (PCE) risk score for atherosclerotic cardiovascular diseases (ASCVD) as compared to the original (2013) PCE and the Framingham risk scores (laboratory- and non-laboratory based) for CVD risk stratification in an urban low resource population. We aimed to assess the level of agreement between and among the functions, and their transportability and potential application in CVD risk assessment in under-resourced settings.

Data sources

We used data collected in 2015 from the AWI-Gen (Africa, Wits-INDEPTH Partnership for GENomic studies) study in the Nairobi Urban Health and Demographic Surveillance System (NUHDSS). The study involved 2003 participants (922 (46.03%) male) aged between 35 and 67 years old. (The AWI-Gen study investigates the genetic, genomic and environmental risk factors associated with obesity and CVD in African populations [25]. The study is concurrently conducted in four other demographic surveillance sites in Western (Burkina Faso and Ghana), Eastern (Kenya) and Southern Africa (South Africa) rural and urban populations. For the current analysis forty-three individuals with incomplete records were excluded from this analysis. The number included one individual diagnosed with stroke and 42 individuals with missing values on the key variables useful for the current analysis (i.e. blood glucose, blood cholesterol and blood pressure values, diagnosis and treatment for diabetes and hypertension and height and weight values).

DEFINITIONS

Pooled cohort equations

Pooled cohort equations were developed in the United States for CVD risk assessment and to address concerns with existing risk scores for being non-representative or developed from older cohorts, of limited ethnic diversity, and accommodating narrowly defined endpoints (usually coronary heart disease). The 2013 PCE were developed to estimate first hard atherosclerotic cardiovascular disease (ASCVD) events for endpoints that included CHD death, nonfatal myocardial infarction, and fatal or nonfatal stroke [26].

Race- and sex-specific PCE were recommended for use in non-Hispanic African Americans and non-Hispanic whites, 40 to 79 years of age. The 2013 PCE have been criticized for overestimating risk by between 20% and 150% across risk groups and in different

populations [27]. Overestimation of risk was particularly a problem with the black race [28]. The 2018 PCE were developed to address this criticism. To derive the revised PCE function the same set of factors like the 2013 PCE (shown in Table 1) was used applying newer data and novel statistical methodology. Updating these equations is said to have improved accuracy among the race and sex subgroups and reduced the number of persons considered to be at high risk [28].

Table 1: Factors and outcomes for pooled cohort equations to assess 10-year ASCVD risk and Framingham risk functions for 10-year CHD outcomes

	2013 PCE	2018 PCE	Framingham laboratory score	Framingham non-laboratory score
Predictors	Age, total cholesterol, HDL-cholesterol, systolic blood pressure, (treated or untreated), diabetes, and current smoking status	Age, total cholesterol, HDL-cholesterol, systolic blood pressure, (treated or untreated), diabetes, race, and current smoking status	Age, systolic blood pressure, anti-hypertensive medication use, current smoking, diabetes, HDL-cholesterol	Age, systolic blood pressure, anti-hypertensive medication use, current smoking and diabetes, body-mass index
Age group	40-79	40 – 79	30 - 75	30 – 75
Outcomes	Nonfatal myocardial infarction (MI), death from coronary heart disease, or fatal or nonfatal stroke	Nonfatal myocardial infarction (MI), death from coronary heart disease, or fatal or nonfatal stroke	Coronary heart disease, cerebrovascular, and peripheral artery disease and heart failure	Coronary heart disease, cerebrovascular, and peripheral artery disease and heart failure
Estimates	Sex-and race-specific	Sex-specific	Sex-specific	Sex-specific

The Framingham cardiovascular disease risk score

The Framingham cardiovascular risk score (FRS) [19, 29] is perhaps the best known and widely used function in CVD risk assessment globally. This sex-specific risk score is used to predict the occurrence of coronary heart disease events, as well as cerebrovascular, and peripheral artery disease and heart failure events within 10 years of baseline risk assessment [19]. The main criticism of the FRS (Framingham Wilson 1998), however, is that since it was developed predominantly in a white middle-aged population, it may not

be applicable to racially/ethnically diverse and elderly populations [24]. The function has nevertheless been adapted, recalibrated and validated for use in many settings globally [30, 31]. The non-laboratory Framingham risk score replaces HDL-Cholesterol with body mass index. When checked against the laboratory-based score, it performed reasonably well and was recommended for use in under-resourced settings where laboratory tests may be unavailable or expensive to carry out [19].

Other measurements and definitions

Raised blood pressure was defined as systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg. Hypertension was based on self-report of a previous diagnosis by a clinician, and/or current use of antihypertensive medication. Blood pressure (BP) was measured using an automated digital blood pressure device (OMRON™). Using appropriate cuff sizes for each individual, three readings were taken on the left arm from an individual in a seated position, at one minute intervals. The mean of the second and third measurements were used for the current analysis.

Raised blood glucose was classified based on plasma glucose concentration of ≥ 11.1 mmol/L or fasting plasma glucose of 7.0 mmol/L. A drop of blood from a finger prick was used to test for glucose using the ACCU-CHEK™ Glucose, Cholesterol and Triglycerides (GCT) digital meter. Diabetes was based on self-report of a previous diagnosis by a clinician and or current use of medication. A drop of blood from a finger prick was used to test for blood cholesterol using ACCU-CHEK™ GCT. Total blood cholesterol levels were categorized either as ideal or high (cut-off 5.2 mmol/L). Current cigarette smoking, previous diagnosis with stroke and/or heart attack were self-reported. Height was measured in centimeters using SECA™ height boards while the individual stood on a flat surface. Body weight was taken in kilograms using calibrated SECA™ weighing scales.

ANALYSIS

Pooled cohort risk equations for Africans (2013 and 2018) and the Framingham risk scores (laboratory and non-laboratory) were applied and for each individual a risk score for developing ASCVD and CHD within a 10-years following the baseline risk assessment was computed. Risk was categorized into low (<10%) intermediate (10–20%) and high (>20%) respectively.

The agreement between any two functions was measured using a kappa-statistic, with the scores interpreted as guided by McHugh [32]: no agreement (0 - 20); minimal agreement (0.21 - 0.39); weak agreement (0.40 - 0.59); moderate agreement (0.60 - 0.79); strong agreement (0.80 - 0.90); and almost perfect agreement (0.91 - 1.00). Correlation between any two functions was assessed using Spearman's correlation co-efficient. The Spearman correlation coefficient, r_s , can take values from -1 to +1, with +1 indicating a perfect association, 0 indicating no association and -1 indicating a perfect negative association. The closer the r_s values are closer to zero, the weaker the association.

Ethical considerations

The Awi-Gen Kenya study received ethics approval from the Ethics and Scientific Review Committee of the African Medical Research Foundation in Kenya (Ref #P114/2014). Individual written informed consent was sought from all participants who were informed that their participation in the study was voluntary and they could discontinue their participation in the study whenever they chose to. Participants diagnosed with raised blood pressure/glucose were referred for care.

RESULTS

A total of 1960 records were included in the analysis. Men (mean age 49.19 ± 6.02 years) were slightly older than women (48.51 ± 5.59 years). More men (91.0%) were in a marital union i.e. living together, cohabiting or married compared to women (45.7%). Fewer men (4.0%) compared to women (10.9%) possessed no formal education, while more men (45.0%) than women (26.2%) possessed secondary school level education or higher. Still fewer men (3.1%) compared to women (8.4%) were unemployed, while self-employment was more prevalent among women (58.8% vs 34.1%). More women (30.9% & 32.4%) compared to men (19.3% & 5.6%) were overweight and obese. Underweight was three times as much common in men (11.6%) compared to women (3.8%). Tobacco use and smoking was prevalent among men (23.7%) compared to 2.6% among women. Overall, there were sex-differences on each key factor except on the high-density lipoprotein (HDL)-cholesterol levels, mean diastolic blood pressure (DBP), overall raised blood pressure levels, and on the proportion currently or previously on treatment for hypertension. Other characteristics of the study population are summarized in Table 2.

Table 2: Characteristics of the study population (N = 1960)

Factor	Overall (N=1960)	Women n=1060	Men n=900
Age (years)Mean (SD)	48.8 (5.8)	48.5 (5.6)	49.2 (6.0)
Total cholesterol (mg/ml), Mean (SD)	167.1 (41.2)	170.4 (41.3)	163.1 (40.8)
SBP (mean mmHg), Mean (SD)	120.16 (21.0)	117.9 (21.6)	122.6 (20.0)
DBP (mean mmHg), Mean (SD)	78.3 (12.7)	78.4 (13.2)	78.3 (12.1)
HDL (mg/ml), Mean (SD)	48.9 (18.1)	48.5 (17.1)	49.3 (19.2)
Education, N (%)			
No schooling	151 (07.7)	115 (10.9)	36 (4.0)
Primary school education	1126 (57.5)	667 (62.9)	459 (51.0)
Secondary school and higher	683 (34.9)	278 (26.2)	405 (45.0)
Marriage, N (%)			
In Union	1303 (66.5)	484 (45.7)	819 (91.0)
Not in union	657 (33.5)	576 (54.3)	81 (9.0)
Occupation, N (%)			
Self-employed	930 (47.5)	623 (58.8)	307 (34.1)
Formal employment	305 (15.6)	67 (6.3)	238 (26.4)
Informal, casual employment	608 (31.0)	281 (26.5)	327 (36.3)
Unemployed	117 (6.0)	89 (8.4)	28 (3.1)
Current smoker, N (%)	241 (12.3)	28 (2.6)	213 (23.7)
Blood pressure (140/90 mmHg), N (%)	389 (19.9)	208 (19.6)	181 (20.1)
Diagnosed with hypertension, N (%)	319 (16.3)	231 (21.8)	88 (9.8)
Treatment for hypertension, N (%)	251 (78.7)	190 (82.3)	61 (69.3)
Diagnosed with diabetes (Yes), N (%)	62 (3.2)	44 (4.2)	18 (2.0)
Treatment for diabetes (Yes), N (%)	48 (77.4)	33 (75.0)	15 (83.3)
Body mass index (Kg/m²)			
Underweight (<18.5 Kg/m ²)	145 (7.4)	41 (3.9)	104 (11.6)
Normal weight (18.5 – 24.9 Kg/m ²)	920 (46.9)	348 (32.8)	572 (63.6)
Overweight (25 - <30 Kg/m ²)	502 (25.6)	328 (30.9)	174 (19.3)
Obesity (≥30 Kg/m ²)	393 (20.1)	343 (32.4)	50 (5.6)

Classification of 10-year risk for CVD morbidity/mortality

Comparative classification of 10-year CVD risk by the PCE and Framingham risk functions is shown in Figure 1. The proportion of individuals classified in the high risk group (>20% probability of developing CVD in 10 years) were highest (10.3%) in PCE 2013, and lowest (0.4%) in the PCE 2018; was 2.9% in Framingham and 3.6% in Framingham non-laboratory scores. Low risk category (<10% probability of developing CVD in 10 years) was lowest (62.2%) in PCE 2013, and highest (95.6%) in PCE 2018. The proportion of low risk was 84.0% and 80.1% in Framingham and Framingham non-laboratory scores, respectively.

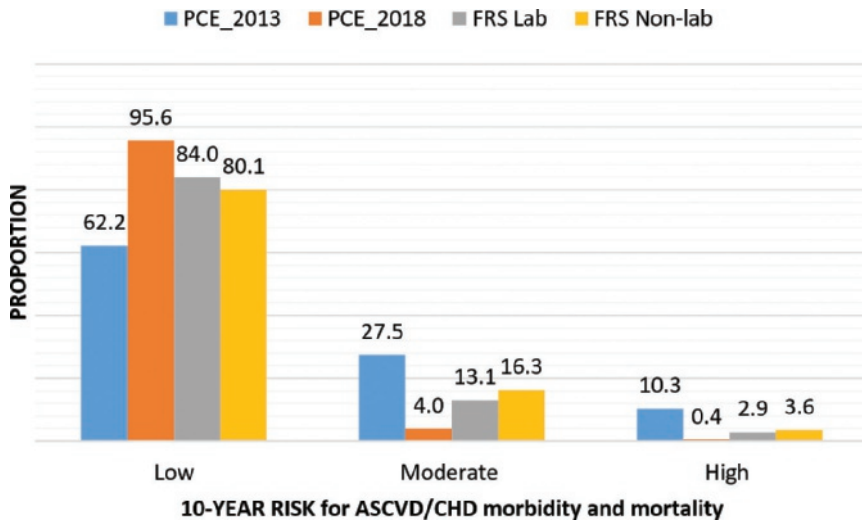


Figure 1: CVD risk classification of population in low resource settings in Nairobi

Comparative risk classification

We checked the agreement and the correlation between any two of the four functions when applied in this population. The PCE 2013 when compared to PCE 2018, the kappa statistic (kappa) was lowest at 0.05 (95% CI 0.04 - 0.06), indicating no agreement between the scores. The Spearman's correlation, r_s , was also low at 0.39. There was a moderate agreement between the pair of Framingham functions (kappa = 0.64, 95% CI 0.59 - 0.68) and a better correlation ($r_s = 0.71$). The agreement between the revised 2018 PCE and Framingham laboratory function was low (kappa = 0.29, 95% CI 0.24 - 0.34), as well as the correlation ($r_s = 0.46$). Likewise, there was minimal agreement and correlation between PCE 2018 and Framingham non-laboratory functions (kappa = 0.25, 95% CI 0.20 - 0.30, $r_s = 0.41$). Detailed information on the agreement and correlation in the functions is shown in Table 3.

Table 3: Agreement and correlation in cardiovascular risk classification among Framingham and pooled cohort equations

	Pooled Cohort Equations 2013				Framingham laboratory				Framingham non-laboratory			
	Low n (%)	Interme- diate n (%)	High n (%)	Total	Low n (%)	Interme- diate n (%)	High n (%)	Total	Low n (%)	Interme- diate n (%)	High n (%)	Total
Pooled Cohort Equations 2018												
Low	1220 (65.1)	0 (0.0)	0	1220	1639 (99.6)	209 (81.3)	26 (45.6)	1874	1563 (99.6)	266 (83.1)	45 (63.4)	1874
Intermediate	537 (28.7)	1 (1.3)	0	538	7 (0.4)	48 (18.7)	24 (42.1)	79	6 (0.4)	54 (16.9)	19 (26.8)	79
High	117 (6.2)	78 (98.7)	7 (100)	202	0 (0.0)	0 (0.0)	7 (12.3)	7	0 (0.0)	0 (0.0)	7 (9.8)	7
Total	1874	79	7	1960	1646	257	57	1960	1569	320	71	1960
Kappa (95% CI)	0.05 (0.04 - 0.06)				0.292 (0.24 - 0.34)				0.248 (0.20 - 0.30)			
p-value	<0.001				<0.001				<0.001			
Spearman's r _s	0.39**				0.46**				0.41**			
Framingham non-laboratory												
Low	1104 (70.4)	115 (35.9)	1 (1.4)	1220	1517 (96.7)	125 (39.1)	4 (5.6)	1646				
Intermediate	410 (26.1)	114 (35.6)	14 (19.7)	538	51 (3.3)	182 (56.9)	24 (33.8)	257				
High	55 (3.5)	91 (28.4)	56 (78.9)	202	1 (0.1)	13 (4.1)	43 (60.6)	57				
Total	1569	320	71	1960	1569	320	71	1960				

Pooled Cohort Equations 2013									
			Framingham laboratory			Framingham non-laboratory			
	Low n (%)	Interme- diate n (%)	High n (%)	Total	Low n (%)	Interme- diate n (%)	High n (%)	Total	Total
Kappa (95% CI)		0.23 (0.20 - 0.30)				0.64 (0.59 - 0.68)			
p-value		<0.001				<0.001			
Spearman's r _s		0.41**				0.71**			
Framingham laboratory									
Low	1189 (72.2)	31 (12.1)	0 (0.0)	1220					
Intermediate	404 (24.5)	129 (50.2)	5 (8.8)	538					
High	53 (3.2)	97 (37.7)	52 (91.2)	202					
Total	1646	257	57	1960					
Kappa (95% CI)		0.31 (0.28 - 0.35)							
p-value		<0.001							
Spearman's r _s		0.54**							

Kappa statistic: a measure of agreement between a pair of items across the different levels. Ranges from 0 (agreement equivalent to chance) to 1 (perfect agreement).

Spearman's correlation r_s: a statistical measure of strength and direction of association between two ordinal/ranked variables. +1 indicating a perfect association, 0 indicating no association an -1 indicating a perfect negative association

DISCUSSION

The proportion classified in the high risk (>20% probability of developing ASCVD/CHD within 10-years of risk assessment) ranged from as low as 0.4% to as high as 10.3% while it ranged from 4.0% to 27.5% for the moderate risk classification. Overall, a larger proportion of the community were classified in the low risk (<10% probability of developing ASCVD/CHD within 10-years of risk assessment), the range from 62% to 95.0%.

When compared with the 2018 PCE, the 2013 PCE classified relatively more individuals into the high and in the intermediate classes. This tendency to 'over-classify' was highlighted by the developers of the 2018 PCE functions when they set out to revise them [28]. The current findings on risk classification seem consistent with this attribute of overestimation for intermediate and high risk categories by 2013 PCE. Consistently therefore, if used in clinical practice in these settings, the PCE 2013 has the potential to misclassify individuals as high or in intermediate risk groups, and by so doing erroneously add to the number of individuals needed to treat for CVD risk as high risk candidates [12], or even worse, needlessly alarming persons with low risk for CVD [19].

Our findings did not observe any substantial/strong agreement or correlation between any pair among the four functions considered in this analysis to warrant substitution in their use for screening in the urban slum community. The 'best of the rest' agreement was recorded between the Framingham functions indicating a moderate agreement, with a positive but moderate correlation while no agreement as seen between the pair of PCE functions.

The performance of the PCE and the Framingham functions has been investigated mostly in high income countries and in Asia [33-35]. However, Boateng et al [36] recently compared PCE 2013 and Framingham laboratory and non-laboratory functions among rural and urban Ghanaians in Ghana, and migrant Ghanaians living in Europe and the United Kingdom. In this study, PCE and Framingham non-laboratory scores posted better agreement in Ghanaian populations in Ghana as opposed to those residing in Europe and the UK. In China, the results of a comparative performance between PCE 2013 and Framingham risk scores showed substantial agreement between Framingham non-laboratory and Framingham laboratory functions at levels similar to our own findings, but there was a moderate agreement between PCE and Framingham laboratory, and a fair agreement between PCE 2013 and Framingham non-laboratory [34].

A comparison of the FRS laboratory and the 2013 PCE in the incidence of metabolic syndrome in a Korean population reported a 1.7 times (70%) increase (overestimation) in the high risk group by the PCE function [35]. The three cases quoted above could demonstrate that the performance of existing CVD risk functions may be influenced by the population differences and contexts in which they are applied [37]. It is true that CVD risk functions developed in and for specific population groups will misestimate (overestimate or underestimate) risk when used on other populations, evidently due to different baseline risks, owing to secular, cultural, contextual and epigenetic differences [38, 39].

Since the Framingham non-laboratory function was developed as an alternative to the laboratory function and was proposed as an alternative for use in resource constrained settings where laboratory tests may be unavailable or expensive to carry out, anything less than an almost perfect agreement in their performance makes its use very limited. Transportability and use of functions in populations in which they were not created is evidently therefore a problematic matter. Each context may require its own function developed by recalibrating the existing functions by adding context specific variables to the ones specified in the original functions [40]. This approach in recalibrating existing functions is less costly, and can improve the reclassification of individuals at intermediate risk as either being above or below a chosen intervention threshold.

A more robust approach, however, in developing appropriate context-specific risk scores is use of prospective data e.g. from cohort studies with a longer follow-up. Such cohort data is missing in SSA majorly due to the costs of setting them up, follow-up and ascertainment of outcomes. If available, cohort data can support the development of simpler non-laboratory measures with similar sensitivity and specificity when compared to the laboratory measures for use in primary health care settings. For SSA, CVD risk scores can incorporate socioeconomic variables like socioeconomic status and education which have been linked to CVD morbidity and mortality.

Our analysis faces some limitations. Data used in this analysis was from a cross-sectional study conducted in an urban slum community, and findings may therefore not be generalizable to the general population in Kenya. Without outcome data on fatal and non-fatal CVD events to validate the observed from expected outcomes, this study cannot comment on the appropriateness of any of the four functions for use in these settings. Our aim was limited to demonstrating their comparative performance in risk stratification in

an underserved African population, and to lend a voice to the opinion on transportability and applicability of existing CVD risk functions across diverse populations.

The absolute risk approach can promote CVD prevention and enhance adherence to treatment when accompanied by effective risk communication in high risk individuals. Thus, beyond the development of appropriate risk functions, it is pertinent that they are disseminated to health care providers in primary health care settings, who should be sensitized about their general use in primary health care settings. Emphasis should be laid on the benefits of risk stratification and effective communication that go beyond the identification of individuals at high-risk, but encompasses the motivation and promotion of adherence to risk mitigation [14]. Combining risk assessment with innovative approaches like the use of community health workers to screen, identify and follow up high risk individuals [41] and use of mobile phone health technology to promote messages to motivate risk mitigation [42] can deliver impressive results in CVD risk prevention in under-resourced settings, and can help to lower the incidence and the burden of CVD [14].

ACKNOWLEDGEMENTS

Authors acknowledge advice on the approach for analysis by Dr Damazo Kadengye of the African Population and Health Research Center (APHRC).

Funding

FMW received the Global Health Support Award for PhD from University Medical Center, Utrecht. The Awigen Collaborative Center is funded by the National Human Genome Research Institute (NHGRI), the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and Office of the Director (OD) of the National Institutes of Health (NIH) of the United States of America (Grant #U54HG006938), as part of the H3Africa Consortium.

Conflict of interest

The authors have no conflict of interest to declare.

REFERENCES

1. World Health Organisation. *Cardiovascular diseases (CVDs)*. 2017 17 May 2017 [cited 2019 12/06]; Available from: [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)).
2. World Health Organisation. *Noncommunicable diseases*. 1 June 2018 [cited 2019 17 June]; Available from: <https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases>.
3. Mensah, G.A., et al., *Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: a systematic analysis of data from the Global Burden of Disease Study 2013*. *Cardiovascular Journal of Africa*, 2015. **26**(2 Suppl 1): p. S6-10.
4. Mokdad, A.H., et al., *Global, regional, national, and subnational big data to inform health equity research: perspectives from the Global Burden of Disease Study 2017*. *Ethnicity & Disease*, 2019. **29**(Suppl 1): p. 159-172.
5. Peters, D.H., et al., *Poverty and access to health care in developing countries*. *Annals of the New York Academy of Sciences*, 2008. **1136**(1): p. 161-171.
6. Avis, N.E., K.W. Smith, and J.B. McKinlay, *Accuracy of perceptions of heart attack risk: what influences perceptions and can they be changed?* *American Journal of Public Health*, 1989. **79**(12): p. 1608-12.
7. Weinstein, N.D., *Optimistic biases about personal risks*. *Science*, 1989. **246**(4935): p. 1232-1234.
8. World Health Organization., *Prevention of cardiovascular disease: pocket guidelines for assessment and management of cardiovascular risk:(WHO/ISH cardiovascular risk prediction charts for the European Region)* 2007, World Health Organization Geneva.
9. Cooney, M.T., A.L. Dudina, and I.M. Graham, *Value and limitations of existing scores for the assessment of cardiovascular risk: a review for clinicians*. *Journal of the American College of Cardiology*, 2009. **54**(14): p. 1209-1227.
10. Petr, E.J., et al., *Perceived lifetime risk for cardiovascular disease (from the Dallas Heart Study)*. *The American Journal of Cardiology*, 2014. **114**(1): p. 53-8.
11. Hayman, L.L., et al., *A life course approach to cardiovascular disease prevention*. *European Journal of Cardiovascular Nursing*, 2011. **10**(2 suppl): p. S20-S31.
12. Lloyd-Jones, D.M., *Cardiovascular risk prediction basic concepts, current status, and future directions*. *Circulation*, 2010. **121**(15): p. 1768-1777.
13. Goff, D.C., et al., *2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines*. *Journal of the American College of Cardiology*, 2014. **63**(25 Part B): p. 2935-2959.
14. Kariuki, J.K., et al., *Evaluation of the performance of existing non-laboratory based cardiovascular risk assessment algorithms*. *BMC Cardiovascular Disorders*, 2013. **13**(1): p. 1-13.

15. Woodward, M., P. Brindle, and H. Tunstall-Pedoe, *Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC)*. Heart, 2007. **93**(2): p. 172-176.
16. Hippisley-Cox, J., et al., *Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2*. BMJ, 2008. **336**(7659): p. 1475-1482.
17. Assmann, G., P. Cullen, and H. Schulte, *Simple scoring scheme for calculating the risk of acute coronary events based on the 10-year follow-up of the prospective cardiovascular Münster (PROCAM) study*. Circulation, 2002. **105**(3): p. 310-315.
18. Mendis, S., 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*. Journal of Hypertension, 2007. **25**(8): p. 1578-1582.
19. D'Agostino, R.B., et al., *General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study*. Circulation, 2008. **117**(6): p. 743-753.
20. Conroy, R.M., et al., *Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project*. European Heart Journal, 2003. **24**(11): p. 987-1003.
21. Gaziano, T.A., et al., *Laboratory-based versus non-laboratory-based method for assessment of cardiovascular disease risk: the NHANES I Follow-up Study cohort*. The Lancet, 2008. **371**(9616): p. 923-931.
22. Yusuf, S., et al., *Cardiovascular Risk and Events in 17 Low-, Middle-, and High-Income Countries*. New England Journal of Medicine, 2014. **371**(9): p. 818-827.
23. Ridker, P.M., et al., *Development and validation of improved algorithms for the assessment of global cardiovascular risk in women: the Reynolds Risk Score*. Jama, 2007. **297**(6): p. 611-9.
24. Beswick, A., et al., *A systematic review of risk scoring methods and clinical decision aids used in the primary prevention of coronary heart disease*. Royal College of General Practitioners [GRA], 2008: p. 4-105.
25. Ramsay, M., et al., *African partnerships through the H3Africa Consortium bring a genomic dimension to longitudinal population studies on the continent*. International Journal of Epidemiology, 2015.
26. Goff, C.D., et al., *2013 ACC/AHA Guideline on the Assessment of Cardiovascular Risk: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines*. Circulation, 2014. **129**(25_suppl_2 Suppl 1): p. S49-S73.
27. Cook, N.R. and P.M. Ridker, *Calibration of the Pooled Cohort Equations for Atherosclerotic Cardiovascular Disease: An Update Calibration of the Pooled Cohort Equations for ASCVD*. Annals of Internal Medicine, 2016. **165**(11): p. 786-794.
28. Yadlowsky, S., et al., *Clinical implications of revised pooled cohort equations for estimating atherosclerotic cardiovascular disease risk*. Annals of Internal Medicine, 2018. **169**(1): p. 20-29.

29. Cooney, M.T., et al., *Cardiovascular risk-estimation systems in primary prevention: do they differ? Do they make a difference? Can we see the future?* *Circulation*, 2010. **122**(3): p. 300-10.
30. D'Agostino, R.B., Sr, et al., *Validation of the Framingham Coronary Heart Disease Prediction Scores: Results of a Multiple Ethnic Groups Investigation.* *JAMA*, 2001. **286**(2): p. 180-187.
31. Marrugat, J., et al., *Validity of an adaptation of the Framingham cardiovascular risk function: the VERIFICA study.* *Journal of Epidemiology and Community Health*, 2007. **61**(1): p. 40.
32. McHugh, M.L., *Interrater reliability: the kappa statistic.* *Biochemia Medica*, 2012. **22**(3): p. 276-282.
33. Topel, M.L., et al., *Comparisons of the Framingham and Pooled Cohort Equation Risk Scores for Detecting Subclinical Vascular Disease in Blacks Versus Whites.* *The American Journal of Cardiology*, 2018. **121**(5): p. 564-569.
34. Wang, H., et al., *Evaluation of the Framingham risk score and pooled cohort risk equation for prediction of cardiovascular risk in low resource areas: Insights from Asian rural population.* *International Journal of Cardiology*, 2018. **265**: p. 237.
35. Oh, J., et al., *Comparison of pooled cohort risk equations and Framingham risk score for metabolic syndrome in a Korean community-based population.* *International Journal of Cardiology*, 2014. **176**(3): p. 1154-1155.
36. Boateng, D., et al., *Cardiovascular disease risk prediction in sub-Saharan African populations — Comparative analysis of risk algorithms in the RODAM study.* *International Journal of Cardiology*, 2018. **254**: p. 310-315.
37. Boateng, D., et al., *Cardiovascular disease risk prediction in low income settings: A call for context specific risk equations.* *International Journal of Cardiology*, 2018. **265**: p. 239.
38. Brindle, P., et al., *Accuracy and impact of risk assessment in the primary prevention of cardiovascular disease: a systematic review.* *Heart*, 2006. **92**(12): p. 1752-1759.
39. Hense, H.-W., *Risk factor scoring for coronary heart disease.* *BMJ*, 2003. **327**(7426): p. 1238.
40. Damen, J.A., et al., *Performance of the Framingham risk models and Pooled Cohort Equations for predicting 10-year risk of cardiovascular disease: a systematic review and meta-analysis.* *BMC Medicine*, 2019. **17**(1): p. 109.
41. Gaziano, T.A., et al., *An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study.* *The Lancet Global Health*, 2015. **3**(9): p. e556-e563.
42. Surka, S., et al., *Evaluating the use of mobile phone technology to enhance cardiovascular disease screening by community health workers.* *International Journal of Medical Informatics*, 2014. **83**(9): p. 648-654.

Part 4

Mortality due to cardiovascular diseases in the
slums of Nairobi

Chapter 8

Determinants of mortality from cardiovascular disease in the slums of Nairobi, Kenya

Frederick M. Wekesah, Kerstin Klipstein-Grobusch, Diederick E. Grobbee,
Damazo Kadengye, Gershim Asiki, Catherine K. Kyobutungi

Submitted

ABSTRACT

Background: Cardiovascular diseases (CVD) comprise eighty percent of non-communicable disease (NCD) burden in low- and middle-income countries and are increasingly impacting the poor inequitably. Traditional and socioeconomic factors were analyzed for their association with CVD mortality over 10 years of baseline assessment in an urban slum of Nairobi, Kenya.

Methods and results: A 2008 survey on CVD risk factors was linked to cause of death data collected between 2008 and 2018. Cox proportional hazards on relative risk of dying from CVD over 10 years following assessment of cardiovascular disease risk factors were computed. Population attributable fraction (PAF) of incident CVD death was estimated for key risk factors. 4,290 individuals, 44.0% female, mean age 48.4 years in 2008 were included in the present analysis. Diabetes and hypertension was 7.8% and 24.9% respectively in 2008. Of 385 deaths recorded between 2008 and 2018, 101 were caused by CVD. Age (hazard ratio (HR) 1.119; 95% confidence interval (CI) 1.03-1.20, $p = 0.005$) and hypertension (HR 2.19, 95% CI 1.44-3.33, $p < 0.001$) were positively associated with CVD mortality. Primary school education or higher (HR 0.57, 95% CI 0.33-0.99, $p = 0.044$) and formal employment (HR 0.22, 95% CI 0.06 - 0.75, $p = 0.015$) were inversely associated with CVD mortality. If hypertension was fully controlled, CVD deaths would be averted by 27% (95% CI 9%-42%, $p = 0.004$). Attainment of primary school level education for every member of the community and eradicating unemployment would avert 39% (95% CI 5% - 60%, $p = 0.026$), and 17% (95% CI 5% - 27%, $p = 0.030$), respectively, of CVD deaths.

Conclusions: Socioeconomic factors influence prevention and treatment-adherence for CVD, and should be addressed in the broader context of social determinants of health at the policy, population and individual level to enhance prevention and treatment for CVD.

Key words: Cardiovascular risk, mortality, social determinants of health, education, employment.

INTRODUCTION

Cardiovascular diseases (CVD) which comprise coronary heart disease (CHD), cerebrovascular disease (e.g. stroke), and ischemic heart attacks occurring in low- and middle-income countries (LMICs) are estimated at 80% of the global burden [1, 2]. Sub-Saharan Africa (SSA) accounted for 5.5% of global CVD deaths (nearly one million deaths) in 2013 [3], a number that is expected to increase in the coming decade due to ageing, population growth, and epidemiologic transition being experienced in the region [3, 4].

The SSA region is recording rapid urbanization, which has been linked to the increasing CVD burden [5, 6]. The UN-Habitat estimates that about half of the population in SSA currently lives in urban areas, the number projected to double by the year 2050 [7]. A majority of the urban dwellers live in informal settlements or in slum-like environments which are characterized by poverty, lack of basic water and sanitation infrastructure and rampant crime [8]. Most slum residents are classified as poor (relative to the general population) and are disproportionately exposed to poor health and disease, and enhanced risk for CVD [9, 10]. Urban environments have been known to predispose populations to CVD risk factors because the environments promote unhealthy diets [11], sedentary lifestyles, increased smoking and harmful alcohol consumption [5, 12].

Residents of slums also suffer from high blood pressure, obesity, high blood cholesterol and diabetes [13]. There is emerging evidence from LMICs that socioeconomic factors including education, wealth and employment correlate with CVD risk [14]. Socioeconomic status (SES) can influence behavioral risk factors, which in turn influence physiological risk factors that increase the risk for developing CVD [6, 15]. Other studies have also shown that psychosocial stress, anger, anxiety and depression are associated with CVD in some settings in SSA [16]. In sum, different risk factors and exposures work together in an intricate fashion to cause CVD in individuals [17].

Previous research in low-resourced settings in Nairobi has shown a relatively higher prevalence of CVD risk factors when compared to the overall urban and rural populations in Kenya. In 2010, raised blood glucose/diabetes and raised blood pressure/hypertension among individuals aged 18 years and older was estimated at 5.3% and 22.8% respectively, with diabetes doubling to 10.5% among individuals aged between 45 and 54 years [18, 19]. In studies conducted between 2008 and 2012 in informal settlements in Nairobi, central obesity, hypercholesterolemia, and hypertriglyceridemia was 12.3%, 10.3%, and 17.3%,

respectively [20], while unhealthy diet, insufficient physical activity, harmful alcohol consumption and tobacco use were 57.2%, 14.4%, 10.1%, and 12.4%, respectively [21, 22]. The accompanying level of awareness, treatment and control of diabetes and hypertension in these settings was low [22]. Perception towards CVD risk and risk factors was also varied, yet perception has been shown to influence the way individuals seek for, and adhere to treatment in such, and other communities in SSA [23-25].

A SES gradient exists with respect to CVD with the poor being the worst affected [26], yet little is known about the contribution of specific socioeconomic factors like education and employment to CVD mortality in this community. These individual-level socioeconomic factors may reveal differences in the disease burden among urban slum dwellers, as informed by emerging evidence from LMICs [27] and evidence in developed countries [28].

The current study investigated the contribution of physiological, behavioral and socioeconomic determinants to CVD mortality in an underserved community living in the slums of Nairobi over a 10-year period (2008-2018) using data from a demographic surveillance system and verbal autopsy cause of death. Evidence from this study may help in the design of strategies and programs for CVD prevention and control at policy, population and individual levels by identifying and addressing key determinants of CVD mortality.

METHODS

Data source and study setting

Data was obtained from the Nairobi Urban Health and Demographic Surveillance System (NUHDSS), operated by the African Population and Health Research Center (APHRC) since 2002. About 82,000 people resident in 33,000 households were part of the NUHDSS at the end of 2018. Additional details on the NUHDSS is published [29].

For each resident in the NUHDSS, a record is kept and updated three times annually during household visits (the frequency of household visits has been reduced to twice since 2015) on demographic events related to births, out-migration and in-migration, and death. Other household data include living arrangement and property ownership. Data on 'residency' of individuals in the community offers us the opportunity to conduct event-history analysis

for each individual for the period they spend in the NUHDSS. Death, as an event, is also recorded if the individual dies in the NUHDSS, and the case is confirmed.

In 2008, a cross-sectional study was conducted in the NUHDSS to assess the linkages between socioeconomic and socio-cultural factors, and perceived personal risk for CVD and health behavior in a slum setting (CVD 2008 study). The cross-sectional study provides baseline measures for the current analysis. The CVD study adopted a stratified random sampling based on the World Health organization (WHO) STEPwise protocol [30] targeting 250 respondents in each of the following strata: sex (men and women), age-group (18-29, 30-39, 40-49, 50-59, 60 years and over), and slum of residence (Korogocho and Viwandani). A total of 5,470 individuals (3,018 men and 2,452 women) aged 18 years and older participated in the study.

Measurements

Self-reported measurements

Tobacco smoking, physical activity and disease history were self-reported. Individuals that reported engaging in 150 minutes/week moderate- and 75 minutes/week vigorous-intensive activities were considered physically active. Sedentary behavior and physical inactivity was classified as sitting or sleeping for long hours each day, and not walking or riding a bicycle.

Physical measurements

Height was measured in centimeters using SECA™ height boards while the individual stood in an upright position on a flat surface. Body weight was measured in kilograms using calibrated SECA™ weighing scales.

High blood pressure and hypertension

Blood pressure (BP) was measured using automated digital blood pressure devices (OMRON™). Using appropriate cuff sizes, three readings were taken on the left arm with the individual in a seated position, at one minute intervals. The mean of the second and third measurement was used for the current analysis. Raised blood pressure was defined as systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg. Hypertension was self-reported on a previous diagnosis by a physician, and if the individuals were previously or currently on treatment.

Raised blood glucose, diabetes and hypercholesterolemia

A drop of blood from a finger prick was used to test for glucose and total cholesterol levels using the combined ACCU-CHEK™ Glucose, Cholesterol and Triglycerides (GCT) digital meter. In addition, fasting blood glucose and oral glucose tolerance tests were conducted. Raised blood glucose were based on WHO criteria for random capillary blood glucose ≥ 11.1 mmol/L, oral glucose tolerance test 2-hour post-load of ≥ 11.1 mmol/L, or fasting blood glucose of 7.0 mmol/L [31].; Total cholesterol levels were based on optimal levels and classified as ideal or high based on a cut-off of 5.2 mmol/L [32]. Individuals reported a previous diagnosis by a physician of diabetes, and if they were previously or currently on treatment.

Cause of death data

Cause of death data were derived from verbal autopsies. Verbal autopsy (VA) is an indirect method of ascertaining cause of death from information on symptoms, signs and circumstances preceding the death, obtained from primary caregivers and close relatives of the deceased [33]. Every case of death occurring in the NUHDSS is identified and recorded via VA. InterVA-4 software uses a probabilistic approach to generate cause of death. The software has been used in different settings in Africa and Asia, and the details on the development, validation and use for determining cause of deaths is described in other publications [34-36]. Notably, InterVA-4 follows the cause of death codes defined in the WHO 2012 verbal autopsy instrument corresponding ICD-10 categories [33]: In this case the specific ICD-10 codes for acute cardiac disease (I20-I25), stroke (I60-I69), and other unspecified cardiac diseases (I00-I09; I10-I15; I26-I52; I70-I99) including rheumatic diseases were used.

Exclusion criteria

The CVD 2008 study, NUHDSS residency data, cause of death data datasets were merged. Individuals aged below 30 years (1,164) were excluded from the current analysis given low risk for CVD mortality among such individuals, i.e. no CVD death was recorded from individuals aged 18-30 over the 10-year study period.

Data analysis

Imputation of missing height and weight data

Multiple imputation was carried out on 106 out of 4290 records (about 2.5%) with missing height and weight values. Multivariate normal imputation (MVNI) method in Stata (Stata Corporation, College Station, Texas). The assumption was that the variables with missing

data followed a multivariate normal distribution and the missing data was completely random i.e. missing-ness was not related to the outcome of interest. Age, sex and marital status were used in the imputation. After imputation, we compared the distribution of BMI (created from height and weight variables) in individuals with and without missing data and confirmed that they were not any different.

Descriptive and advanced analysis

We describe the distribution of sociodemographic and CVD risk factors in the population, stratifying by CVD death or not. Using survival analysis, a multivariable regression approach, we evaluated association of the important prognostic baseline factors with CVD mortality within 10 years of baseline risk assessment. Using Cox proportional-hazards models, we estimated the hazard ratio (HR) or the relative risk of dying from a CVD outcome from physiological and behavioral risk factors, and socioeconomic factor measured at baseline (2008). Model 1, adjusted for age and sex, included physiological risk factors diabetes mellitus, hypertension, total blood cholesterol, overweight and obesity, together with behavioral risk factors current smoking, and physical activity. Education and employment, the two individual-level variables for socioeconomic status that were collected in the survey were added in model two. At every step, variables that were not statistically significant at $p\text{-value} < 0.20$ were excluded. Hazard ratios (HR) together with the 95% confidence intervals (95% CI) are reported.

Attributable risk in a population is a function of the prevalence of risk factor and the strength of its association (relative risk) with the outcome (in this case CVD mortality).

$$\text{PAR} = P_e (\text{RR}_e - 1) / [1 + P_e (\text{RR}_e - 1)],$$

where P_e is the prevalence of the risk factor, and RR_e is the relative risk of mortality due to that risk factor.

We estimated post-Cox regression the reduction in incidence of the event (death from CVD over a 10-year period) that would result if the prognostic baseline risk factor was completely eliminated from the population, relative to a situation when the risk factor was present, or simply put, the population attributable fraction (PAF). We included factors that were significantly associated with a death from CVD Cox regression model. The adjusted PAF represents the reduction in incident CVD deaths if the risk factor was eliminated from

the population while adjusting for the effect of the other risk factors. Data were analyzed using Stata 15.1 (Stata Corporation LP, College Station, TX).

Ethical considerations

The Scientific and Ethics Review Unit of the Kenya Medical Research Institute (KEMRI) approved the CVD study (SERU/NON-SSC 339). Individual informed consent was sought from all participants. Participants were made aware of their voluntary participation, and the freedom to withdraw consent at any point during their participation in the study. The NUHDSS is approved by the Government of Kenya and ethical responsibilities are overseen by KEMRI.

RESULTS

Characteristics of study participants

The mean age of the 4290 individuals (44% female) was 48.4 years in 2008. More than half (55.8%) possessed primary school level education or higher. The prevalence of diabetes and hypertension was 7.8% and 24.9% respectively. Of the 9.7% individuals who were obese based on body mass index cut-off of $>30 \text{ kg/m}^2$, the majority (84.5%) was female. Of the 12.2% who were currently smoking, nearly all (98%) were men.

Table 1: Baseline characteristics of study participants

	Overall	CVD death = 0	CVD death = 1
Variables	N=4290	N=4189	N=101
Age \pm SD	48.4 \pm 12.5	48.1 \pm 12.2	64.0 \pm 14.9
Female	1887 (44.0)	1832 (97.1)	55 (2.9)
Male	2403 (56.0)	2537 (98.1)	46 (1.9)
Ideal blood cholesterol	3318 (77.3)	3246 (97.8)	72 (2.2)
High blood cholesterol ($>5.2 \text{ mmol/L}$)	972 (22.7)	943 (97.0)	29 (3.0)
Normal weight ($18.5 - 24.9 \text{ kg/m}^2$)	2606 (60.8)	2547 (97.7)	59 (2.3)
Underweight ($<18.5 \text{ kg/m}^2$)	325 (7.6)	313 (96.3)	12 (3.7)
Overweight (BMI $25-29.9 \text{ kg/m}^2$)	949 (22.1)	931 (98.0)	19 (2.0)
Obese (BMI $\geq 30 \text{ kg/m}^2$)	409 (9.5)	398 (97.3)	11 (2.7)
Diabetes mellitus	333 (7.8)	317 (95.2)	16 (4.8)
No diabetes mellitus	3957 (92.2)	3872 (97.8)	85 (2.2)

	Overall	CVD death = 0	CVD death = 1
Hypertension	1068 (24.9)	1013 (94.8)	55 (5.2)
No hypertension	3222 (75.1)	3176 (98.6)	46 (1.4)
Currently smoking	524 (12.2)	515 (98.3)	9 (1.7)
Not currently smoking	3766 (87.8)	3674 (97.6)	92 (2.4)
Insufficient physical activity	762 (17.8)	724 (95.0)	38 (5.0)
Sufficient physical activity	3528 (82.2)	3465 (98.2)	63 (1.8)
Low level and no education	1895 (44.2)	1814 (95.7)	81 (4.3)
Primary school education and higher	2395 (55.8)	2375 (99.2)	20 (0.8)
Unemployed	473 (11.0)	441 (93.2)	32 (6.8)
Informal employment	3188 (74.3)	3122 (97.9)	66 (2.1)
Formal employment	629 (14.7)	626 (99.5)	3 (0.5)

CVD death = 0: did not die from a CVD/alive; CVD death = 1: died from a CVD; diabetes mellitus: previous diagnosis by health care professional and currently or previously on medication, random plasma glucose ≥ 11.1 mmol/L or fasting plasma glucose ≥ 7.0 mmol/L; hypertension: previous diagnosis by healthcare professional and currently or previously on medication, systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg; insufficient physical activity: based on self-report of less than 150 minutes/week moderate and 75 minutes/week vigorous intensive activities.

Of the 385 deaths recorded during the 10-year follow-up period (2008-2018), 101 (26.2%) resulted from a CVD. Deaths from CVD happened more often among older individuals (mean age 64.0 vs 48.1 years), and among women (2.9% vs 1.9%). Individuals diagnosed with diabetes (4.8% vs 2.2%), and hypertension (5.2% vs 1.4%), those who possessed low levels of or no education (4.3% vs 1.0%) were observed to die from CVD. Deaths from CVD were also prevalent among the unemployed (6.8%) when compared to the self-employed (2.1%) and the formally employed (0.5%). Among the physically inactive, 5.0% died from a CVD compared to 1.8% among the physically active. Additional differences in the individuals that died from CVD based on baseline characteristics are summarized in Table 1.

Determinants for mortality from cardiovascular diseases

Table 2 reports estimates for determinants of CVD mortality within 10 years of baseline assessment of the factors. A one-unit increase in age of the individual increased the hazard ratio (the relative risk for CVD mortality) by eleven percentage points (HR 1.11; 95% CI 1.03 -1.20, $p = 0.005$). Hypertension more than doubled the risk of death from CVD (HR 2.19, 95% CI 1.44 - 3.33, $p < 0.001$). Overweight (HR 0.59, 95% CI 0.35 - 1.00, $p = 0.044$) when compared to normal weight was associated with decreased risk of CVD death as was

primary school-level education (HR 0.57, 95% CI 0.33 - 0.99, $p = 0.044$) and formal (salaried) employment (HR 0.22, 95% CI 0.06 - 0.75, $p=0.015$) by 41%, 43% and 78% respectively. Table 2 summarises these findings.

Population attributable fraction

A 29% reduction in the incident CVD deaths (95% CI 11% - 42%, $p = 0.002$) would be achieved if hypertension was fully controlled in this community. Adjusting for the effect of other risk CVD factors included in the final regression model, 27% (95% CI 9%-42%, $p= 0.004$) of deaths from CVD in this community would be eliminated. Further, if members of this population attained at least primary school level education, a 39% reduction (95% CI 5 - 60%, $p = 0.026$) in CVD mortality would be achieved after adjusting for the effect of the other factors included in the final regression model. On the other hand, if unemployment was eradicated, deaths from CVD would decrease by 17% (95% CI 5% - 27%).

DISCUSSION

In the slums of Nairobi, older age and hypertension were associated with increased relative risk for CVD mortality, while overweight and favorable socioeconomic indicators, such as being employed and attained primary school level education or higher were associated with decreased risk of CVD mortality. In line with global trends [37, 38], hypertension was associated with increased risk for CVD mortality in this community. The population attributable fraction of CVD mortality arising from hypertension was 29%.

Behavioral risk factors, notably smoking, sedentary behavior, insufficient physical activity, alcohol consumption, and insufficient fruit and vegetable intake have been linked to increased risk for CVD morbidity and mortality globally [39-41]. We did not find in our analysis an association between tobacco smoking (whose prevalence was skewed to males at 98% among those that smoked tobacco), insufficient physical activity and insufficient fruit and vegetable intake with CVD mortality. Members of the urban slum community are generally physically active (only about 17% reported insufficient physical activity), while insufficient fruit and vegetable intake was highly prevalent (up to 74%). The lack of association between tobacco smoking and CVD mortality observed in our analysis can possibly be attributed to underreporting, as is the case with behaviors that are considered socially undesirable (a concept known as social desirability bias) [42], specifically among female participants [43].

Table 2: Determinants of mortality from CVD within 10 years of assessment of risk

Factor	Model 1			Model 2			Final Model		
	HR (95% CI)	p-value		HR (95% CI)	p-value		HR (95% CI)	p-value	
Age	1.11 (1.04 - 1.20)	0.003		1.11 (1.03 - 1.19)	0.006		1.11 (1.03 - 1.20)	0.005	
Male	0.77 (0.49 - 1.20)	0.245		0.97 (0.62 - 1.51)	0.878		0.94 (0.61 - 1.45)	0.777	
Diabetes	1.35 (0.77 - 2.35)	0.290							
Hypertension	2.09 (1.37 - 3.20)	0.001		2.11 (1.43 - 3.32)	<0.001		2.19 (1.44 - 3.33)	<0.001	
Underweight	1.20 (0.63 - 2.27)	0.580							
Overweight	0.56 (0.33 - 0.96)	0.034		0.59 (0.34 - 1.00)	0.049		0.59 (0.35 - 1.00)	0.051	
Obesity	0.70 (0.35 - 1.39)	0.307							
High cholesterol	1.17 (0.75 - 1.82)	0.484							
Current smoking	0.99 (0.48 - 2.05)	0.986							
Insufficient physical activity	1.36 (0.87 - 2.13)	0.178		1.20 (0.75 - 1.90)	0.452				
Primary school education and higher				0.57 (0.33 - 0.99)	0.045		0.57 (0.33 - 0.99)	0.044	
Informal employment				0.63 (0.38 - 1.04)	0.072		0.60 (0.37 - 0.97)	0.039	
Formal/salaried employment				0.23 (0.07 - 0.80)	0.021		0.22 (0.06 - 0.75)	0.015	

Although previous research has established that in the general population, excess weight is associated with a significantly increased risk of CVD morbidity and mortality, these results indicate that overweight decreased the risk of death from CVD mortality in this population. Similar findings, based on the obesity paradox have been reported elsewhere. The obesity paradox associates overweight with decreased mortality risk compared with normal weight. Another plausible explanation could be because the urban slum dwellers are generally physically active and that could offset the effect of obesity and overweight on CVD mortality [44, 45].

Individuals who possessed primary school level education or higher, or were in informal or formal employment had lower relative risk of death from CVD. If every member in this community attained at least primary school level education, about 39% of deaths from CVD would be averted. Previous research has shown that individual-level financial, occupational, and educational circumstances can attenuate CVD risk [46, 47]. Low levels of education are associated with misperception of CVD risk, and can consequently affect the acceptance of, and adherence to medical treatment for CVD [48, 49]. This situation can be explained by health belief models of disease risk and mitigation behavior that posit that individuals who perceive themselves to be at a higher risk of developing CVD are more likely to make lifestyle adjustments to mitigate risk factors for CVD and consequently reduce their risk of developing CVD, when they encounter appropriate cues for action [49, 50].

It has been established from high income countries that a socioeconomic gradient exists for CVD risk [51]. Emerging research from SSA and in Asia confirms this. The Prospective Urban and Rural Epidemiology (PURE) study has reported widely, on the differential distribution of CVD risk factors across levels of SES, education and employment, and in urban and rural populations [52]. For instance, findings from South Africa show substantial differences between rural and urban populations with regard to CVD, with the urban areas recording the highest prevalence. Education of the urban and rural populations did not however influence the distribution of the risk factors in the country [53], a finding that went contrary to what was reported in another study in the same population of men and women with secondary school education and higher having lower BMIs, and women specifically having lower blood pressure and lipid levels, and practicing healthier diets compared to those with low levels of education [54].

Poverty promotes disparities in CVD prevention in LMIC countries such as in SSA and Asia. Inequality, a direct consequence of poverty, rural residence and low levels of education

were shown to affect secondary prevention of CVD by impacting on uptake and adherence to drug treatment among patients with coronary heart disease (CHD) and stroke in the two world regions [55, 56]. Elsewhere in China, low levels of education and income were positively associated with an increase in acute myocardial infarction (AMI) risk [57], and were likewise implicated in smoking or tobacco use, low physical activity and the clustering of major cardiovascular risk factors in India [58].

The results of our study are not without some limitations. Data from self-report suffers from underreporting with respect to socially undesirable practices. The observed no association between tobacco smoking and CVD deaths in this population could have come about as a result of such underreporting. The CVD study on risk factors conducted in 2008 was cross-sectional, and some of the behavioral risk factors collected during the study may have changed over the 10 years. Additionally, residents of urban slums are a highly mobile population and some of the individuals that out-migrated may have died from CVD outside of the NUHDSS. We could only include in our analysis cardiovascular-related deaths occurring within the slum. A sub-group analysis of the individuals that out-migrated showed that they were not systematically different from those that remained in the study area.

Our analysis combines a baseline survey for CVD risk factors with follow-up data on residency in the NUHDSS and records of individual-level events that include deaths and their causes, and migration. This type of surveillance data supports time-to-event analysis and is appropriate for estimation, with confidence, the strength of association of several baseline factors with mortality outcomes. Availability of such data is rare in SSA. Additionally, the cause of death data generated by verbal autopsies (VA) are a useful and the only available method for determining cause of death in settings where vital registration and clinically certified cause-of-death data are missing, are incomplete or inaccurate [59, 60], as is the case with this community.

CONCLUSIONS

Kenya is rapidly urbanizing, and will continue experiencing a net positive migration of individuals from rural to urban areas, and consequently the growth of informal settlements that will provide a conducive environment for the thriving of CVD risk factors. Populations living in slums are generally classified as poor and socioeconomically disadvantaged, and

are likely to face a disproportionately higher burden of CVD morbidity and mortality compared to rural populations.

The inverse relationship between socioeconomic factors, most importantly education and employment, with the risk for mortality from CVD in urban poor communities highlights the important role socioeconomic factors play for CVD prevention, and the need to urgently address them in the broader context of the social determinants of health at the policy, population and individual levels. Addressing literacy, education, employment and livelihood opportunities can enhance primordial prevention of CVD, generating high returns on investment for CVD prevention and control. Additionally, adequate prevention and management (treatment and effective control) of hypertension through drug and non-drug therapies is a key intervention for CVD morbidity and mortality in this community.

Author contributions

FMW, KKG, DDG & CKK conceptualized the study and drafted the plan of analysis. FMW conducted the analysis, supported by DK and GA, and wrote the manuscript. KKG reviewed and gave feedback on the analysis and early drafts of the manuscript. All authors reviewed and gave input to the manuscript, read the final version and approved its submission.

ACKNOWLEDGEMENTS

Authors acknowledge support provided in extracting and preparing analytic datasets, and in actual analysis by Ms. Marylene Wamukoya, data manager for the NUHDSS; and Ms. Sylvia Onchanga and Mr. Elvis Wambiya, both data analysts at the African Population and Health Research Center (APHRC) for ideas and support in analysis.

Funding

FMW is supported by a Global Health Support Scholarship of the UMC Utrecht. Funding for the 'Cardiovascular disease risk perception and risk factors' study came from the Wellcome Trust (Grant # WT092775MA), while APHRC receives core support from various funders such as The William and Flora Hewlett Foundation, Sida and the Rockefeller Foundation.

Conflict of interest

The authors have no conflict of interest to declare in regard to the research, authorship and publication of this article.

Data availability statement

Data can be accessed following a reasonable request to the APHRC through the Microdata portal.

REFERENCES

1. Roth, G.A., et al., *Global and regional patterns in cardiovascular mortality from 1990 to 2013*. *Circulation*, 2015. **132**(17): p. 1667-1678.
2. Strong, K., et al., *Preventing chronic diseases: How many lives can we save?* *The Lancet*, 2005. **366**(9496): p. 1578-1582.
3. Mensah, G.A., et al., *Mortality from cardiovascular diseases in sub-Saharan Africa, 1990-2013: a systematic analysis of data from the Global Burden of Disease Study 2013*. *Cardiovascular Journal of Africa*, 2015. **26**(2 Suppl 1): p. S6-10.
4. Roth, G.A., et al., *Demographic and epidemiologic drivers of global cardiovascular mortality*. *New England Journal of Medicine*, 2015. **372**(14): p. 1333-41.
5. Assah, F.K., et al., *Urbanization, Physical Activity, and Metabolic Health in Sub-Saharan Africa*. *Diabetes Care*, 2011. **34**(2): p. 491.
6. Sodjinou, R., et al., *Obesity and cardio-metabolic risk factors in urban adults of Benin: relationship with socio-economic status, urbanisation, and lifestyle patterns*. *BMC Public Health*, 2008. **8**(1): p. 84.
7. UNHABITAT., *The state of African Cities 2014: re-imagining sustainable urban transitions*. United Nations Human Settlements Programme: Nairobi, Kenya, 2014.
8. UN Habitat., *Urbanization and development: emerging futures; world cities report 2016, in UN-Habitat*. 2016, UN-Habitat: Nairobi, Kenya.
9. Sliwa, K., et al., *Impact of Socioeconomic Status, Ethnicity, and Urbanization on Risk Factor Profiles of Cardiovascular Disease in Africa*. *Circulation*, 2016. **133**(12): p. 1199-208.
10. Kaplan, G.A. and J.E. Keil, *Socioeconomic factors and cardiovascular disease: a review of the literature*. *Circulation*, 1993. **88**(4): p. 1973-1998.
11. Waxman, A., *Why a global strategy on diet, physical activity and health?*, in *Nutrition and Fitness: Mental Health, Aging, and the Implementation of a Healthy Diet and Physical Activity Lifestyle*. 2005, Karger Publishers. p. 162-166.
12. Doulougou, B., et al., *Differences in hypertension between informal and formal areas of Ouagadougou, a sub-Saharan African city*. *BMC Public Health*, 2014. **14**: p. 893.
13. Yusuf, S., et al., *Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study*. *The Lancet*, 2004. **364**(9438): p. 937-952.
14. Bobak, M., et al., *Socioeconomic status and cardiovascular risk factors in the Czech Republic*. *International Journal of Epidemiology*, 1999. **28**(1): p. 46-52.
15. Kivimäki, M., et al., *Socioeconomic position in childhood and adult cardiovascular risk factors, vascular structure, and function: cardiovascular risk in young Finns study*. *Heart*, 2006. **92**(4): p. 474.

16. Suls, J. and J. Bunde, *Anger, anxiety, and depression as risk factors for cardiovascular disease: the problems and implications of overlapping affective dispositions*. Psychological Bulletin, 2005. **131**(2): p. 260.
17. D'Agostino, R.B., et al., *General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study*. Circulation, 2008. **117**(6): p. 743-753.
18. Ayah, R., et al., *A population-based survey of prevalence of diabetes and correlates in an urban slum community in Nairobi, Kenya*. BMC Public Health, 2013. **13**(1): p. 371.
19. Joshi, M.D., et al., *Prevalence of hypertension and associated cardiovascular risk factors in an urban slum in Nairobi, Kenya: A population-based survey*. BMC Public Health, 2014. **14**(1): p. 1177.
20. Haregu, T.N., et al., *Interlinkage among cardio-metabolic disease markers in an urban poor setting in Nairobi, Kenya*. Global Health Action, 2016. **9**.
21. Haregu, T.N., et al., *Co-occurrence of behavioral risk factors of common non-communicable diseases among urban slum dwellers in Nairobi, Kenya*. Global Health Action, 2015. **8**: p. 28697.
22. Oti, S.O., et al., *The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya: results from a cross-sectional survey*. Tropical Medicine & International Health, 2013. **18**(12): p. 1520-1530.
23. Haregu, T.N., et al., *The connection between non-communicable disease risk factors and risk perception among urban slum dwellers in Nairobi, Kenya*. African Population Studies, 2016. **30**(3): p. 3094-3102.
24. Boateng, D., et al., *Knowledge and awareness of and perception towards cardiovascular disease risk in sub-Saharan Africa: A systematic review*. PLoS One, 2017. **12**(12): p. e0189264.
25. Wekesah, F.M., et al., *Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi*. BMJ Open, 2019. **9**(6): p. e026852.
26. Kawada, T., *Socioeconomic status and cardiovascular disease*. International Journal of Cardiology, 2019. **274**: p. 378.
27. Janković, S., et al., *Association of socioeconomic status measured by education, and cardiovascular health: a population-based cross-sectional study*. BMJ Open, 2014. **4**(7): p. e005222.
28. Winkleby, M.A., et al., *Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease*. American Journal of Public Health, 1992. **82**(6): p. 816-820.
29. Beguy, D., et al., *Health & Demographic Surveillance System Profile: The Nairobi Urban Health and Demographic Surveillance System (NUHDSS)*. International Journal of Epidemiology, 2015. **44**(2): p. 462-471.
30. World Health Organization., *World Health Organization STEPwise approach to chronic disease risk factor surveillance (STEPS) instrument*. 2007, World Health Organization: Geneva.

31. International Diabetes Federation Working Group., *IDF clinical practice recommendations for managing type 2 diabetes in primary care*. 2017, International Diabetes Federation Brussels, Belgium
32. Nantsupawat, N., et al., *Appropriate Total cholesterol cut-offs for detection of abnormal LDL cholesterol and non-HDL cholesterol among low cardiovascular risk population*. *Lipids in Health and Disease*, 2019. **18**(1): p. 28-28.
33. Soleman, N., D. Chandramohan, and K. Shibuya, *Verbal autopsy: current practices and challenges*. *Bulletin of the World Health Organization*, 2006. **84**: p. 239-245.
34. Byass, P., H. Dao Lan, and M. Hoang Van, *A probabilistic approach to interpreting verbal autopsies: methodology and preliminary validation in Vietnam*. *Scandinavian Journal of Public Health*, 2003. **31**(62_suppl): p. 32-37.
35. Oti, S.O. and C. Kyobutungi, *Verbal autopsy interpretation: a comparative analysis of the InterVA model versus physician review in determining causes of death in the Nairobi DSS*. *Population Health Metrics*, 2010. **8**(1): p. 21.
36. Byass, P., et al., *Refining a probabilistic model for interpreting verbal autopsy data*. *Scandinavian Journal of Public Health*, 2006. **34**(1): p. 26-31.
37. Yusuf, S., et al., *Global Burden of Cardiovascular Diseases: Part I: General Considerations, the Epidemiologic Transition, Risk Factors, and Impact of Urbanization*. *Circulation*, 2001. **104**(22): p. 2746-2753.
38. Yusuf, S., S. Hawken, and S. Ounpuu, *Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study*. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 2005. **25**(1): p. 56-57.
39. Erhardt, L., *Cigarette smoking: An undertreated risk factor for cardiovascular disease*. *Atherosclerosis*, 2009. **205**(1): p. 23-32.
40. Williams, P.T., *Physical fitness and activity as separate heart disease risk factors: a meta-analysis*. *Medicine and Science in Sports and Exercise*, 2001. **33**(5): p. 754.
41. Li, J. and J. Siegrist, *Physical Activity and Risk of Cardiovascular Disease—A Meta-Analysis of Prospective Cohort Studies*. *International Journal of Environmental Research and Public Health*, 2012. **9**(2): p. 391.
42. *Social Desirability Bias*, in *Wiley International Encyclopedia of Marketing* 2010.
43. Addo, J., L. Smeeth, and D. Leon, *Smoking patterns in Ghanaian civil servants: changes over three decades*. *International Journal of Environmental Research and Public Health*, 2009. **6**(1): p. 200-208.
44. McAuley, P.A. and S.N. Blair, *Obesity paradoxes*. *Journal of Sports Sciences*, 2011. **29**(8): p. 773-782.
45. Curtis, J.P., et al., *The Obesity Paradox: Body Mass Index and Outcomes in Patients With Heart Failure*. *JAMA Internal Medicine*, 2005. **165**(1): p. 55-61.

46. Pollitt, R.A., K.M. Rose, and J.S. Kaufman, *Evaluating the evidence for models of life course socioeconomic factors and cardiovascular outcomes: a systematic review*. BMC Public Health, 2005. **5**(1): p. 7.
47. Tyroler, H.A., *The Influence of Socioeconomic Factors on Cardiovascular Disease Risk Factor Development*. Preventive Medicine, 1999. **29**(6): p. S36-S40.
48. Katz, M., et al., *Calculated and perceived cardiovascular risk in asymptomatic subjects submitted to a routine medical evaluation: The perception gap*. Eur J Prev Cardiol, 2015. **22**(8): p. 1076-82.
49. Webster, R. and E. Heeley, *Perceptions of risk: understanding cardiovascular disease*. Risk Management and Healthcare Policy, 2010. **3**: p. 49-60.
50. Lundborg, P. and B. Lindgren, *Do they know what they are doing? Risk perceptions and smoking behaviour among Swedish teenagers*. Journal of Risk and Uncertainty, 2004. **28**(3): p. 261-286.
51. de Mestral, C. and S. Stringhini, *Socioeconomic status and cardiovascular disease: an update*. Current Cardiology Reports, 2017. **19**(11): p. 115.
52. Teo, K., et al., *The Prospective Urban Rural Epidemiology (PURE) study: Examining the impact of societal influences on chronic noncommunicable diseases in low-, middle-, and high-income countries*. American Heart Journal, 2009. **158**(1): p. 1-7.e1.
53. Egbujie, B.A., E.U. Igumbor, and T. Puoane, *A cross-sectional study of socioeconomic status and cardiovascular disease risk among participants in the Prospective Urban Rural Epidemiological (PURE) Study*. South African Medical Journal, 2016. **106**(9).
54. Pisa, P.T., et al., *Social drift of cardiovascular disease risk factors in Africans from the North West Province of South Africa: the PURE study*. Cardiovascular Journal of Africa, 2012. **23**(7): p. 371-e388.
55. Gupta, R., et al., *Socioeconomic factors and use of secondary preventive therapies for cardiovascular diseases in South Asia: The PURE study*. European Journal of Preventive Cardiology, 2014. **22**(10): p. 1261-1271.
56. Murphy, A., et al., *Inequalities in the use of secondary prevention of cardiovascular disease by socioeconomic status: evidence from the PURE observational study*. The Lancet Global Health, 2018. **6**(3): p. e292-e301.
57. GUO, J., et al., *Influence of socioeconomic status on acute myocardial infarction in the Chinese population: the INTERHEART China study*. Chinese Medical Journal, 2012. **125**(23): p. 4214-4220.
58. Gupta, R., et al., *Association of Educational, Occupational and Socioeconomic Status with Cardiovascular Risk Factors in Asian Indians: A Cross-Sectional Study*. PLOS One, 2012. **7**(8): p. e44098.
59. Fottrell, E., *Dying to count: mortality surveillance in resource-poor settings*. Global Health Action, 2009. **2**(1): p. 1926.
60. Byass, P., et al., *Strengthening standardised interpretation of verbal autopsy data: the new InterVA-4 tool*. Global Health Action, 2012. **5**(1): p. 19281.

Chapter 9

General discussion



Social deprivation and poverty lead to disparities in access and utilization of health care

Urban slum populations live in a chronic state of social deprivation, where social challenges they face greatly contribute to their poor health, a situation that is compounded by a glaring disparity and inequality in access and utilization of health care. Our research shows that there is widespread low level of awareness for cardiovascular disease and its risk factors (even among individuals who were diagnosed and are aware of their condition). The community is exposed to unreliable and misleading information on the disease and lacks opportunities for screening and access to essential treatment for CVD [1-4].

Risk perception and the prevention, care seeking and adherence to treatment for cardiovascular diseases

One key barrier for the acceptance of and adherence to medical treatment in CVD management is misperception of cardiovascular disease risk in an individual [5, 6]. Many individual patients have been shown to misperceive their risk: in many instances individuals display optimistic bias, defined as the “underestimation, after self-assessment, of own risk of developing and dying from CVD” [7]. An appropriate example of this phenomena was reported in recent findings from a randomized trial in the Netherlands that showed that nearly four in five high-risk patients displayed over-optimism when their perceived risk for CVD was compared to the estimated risk [8].

When risk misperception is adequately addressed, the performance and effectiveness of programs for prevention and treatment of CVD can be enhanced [9]. This theory is based on the health belief model which states that individuals are more likely to make lifestyle adjustments to mitigate risk factors for CVD and consequently reduce their risk of developing CVD if and when they perceive themselves to be at risk of a disease and are presented with the right cues to action [6, 10-13]. For appropriate assessment of personal risk for conditions such as CVD, individuals require “information about the nature and likelihood of potential ill-effects (of the condition in question), information about the risk factors that modify one’s susceptibility, and information about the ease or difficulty of avoiding harm” [14].

Cardiovascular disease risk assessment and communication to enhance treatment adherence

Assessment of absolute CVD risk, and communicating the same effectively to individuals at high risk is needed to raise awareness, and to motivate the adoption of risk mitigation

through lifestyle adjustments and drug therapy [15]. The incidence and the burden of CVD in resource-constrained countries like Kenya can be lowered through the adoption of such a proactive CVD risk prevention strategy [15]. Combining risk assessment with innovative approaches like the use of community health workers to screen, identify and follow up high risk individuals [16] and use of mobile phone health technology to promote messages to motivate risk mitigation [17] can deliver impressive results in CVD risk prevention in under-resourced settings.

A number of CVD risk assessment functions have been developed in the last four decades following the Framingham risk score for use in specific communities [18-24]. No prospective data from SSA has been used to develop existing and widely used risk scores, thus none is appropriate for CVD risk screening in the region. The INTERHEART risk score came close to creating an appropriate function for SSA, but it has been criticized for its case-control design method used in its development [24]. Region-specific functions by the WHO exist, but they suffer from insufficiency of robust country-specific data used to create them [23]. This is a big gap for CVD prevention efforts in the region that needs to be filled. To support the efforts to make screening for CVD risk more practical in SSA, we propose to recalibrate existing risk scores taking newer cohort-based data from SSA into consideration or to develop algorithms including key context-specific variables to enhance the performance of the functions for use in risk assessment in SSA.

Clarion call: addressing socioeconomic determinants of health will enhance prevention and treatment of cardiovascular diseases

Socioeconomic factors, key of which are literacy and employment (as a source of livelihood), contribute to the disparity in access and utilization of health care, and are key barriers in addressing morbidity and mortality from CVD in underserved communities like those living in the urban slums of Nairobi. As we have documented in this research, underlying the inequality in access to appropriate information on risk factors and for responsive and appropriate health care and treatment for CVD in urban slum communities, is widespread poverty, low levels of education (illiteracy) and few or total lack of opportunities for livelihoods. These are linked to the late diagnosis of CVD, and contribute to the high number of premature deaths from CVD seen in such populations.

Poverty forms a vicious cycle with CVD, and indeed any other disease. Poverty causes CVD because the poor are known to suffer a disproportionately higher burden of the risk factors, and are more likely to engage in behaviors that promote and exacerbate CVD, like

tobacco use, and unhealthy diets. On the other hand, the chronic nature of CVD conditions can lead to poverty of the patients and their families as a consequence of catastrophic and mostly out-of-pocket expenditure incurred during care-seeking and treatment for the conditions, as well as time taken off work due to illness and inability to engage in some strenuous activities due to ill-health.

Such key factors should be addressed in the broader context of the social determinants of health through innovative, collaborative and multi-sectorial policy and programmatic work on CVD prevention and treatment. A good place to start in optimizing cardiovascular health of the urban poor in SSA is to narrow the gap between knowledge and awareness of CVD and its risk factors with care-seeking and treatment adherence by educating the public on prevention and control of CVD. At the policy level, there is a need to develop new and/or reorient existing policies to the current realities of a growing burden of non-communicable diseases alongside persisting infectious diseases. Relevant technical capacity obstacles need to be identified and addressed requiring demonstrable renewed political will and commitment. In part, the impetus required is headed by the renewed calls for improved investments in universal health coverage as stipulated in the sustainable development goals, which forms a good basis for governments to address inequalities in the access to care for their people, including the underserved constituencies. The WHO has proposed cost-effective population- and individual level strategies to fight CVD, such as tobacco control and promotion of a healthy diet and physical activity that can be implemented through educating the public, and providing treatment for individual with established CVD; and treating risk factors such as blood pressure and blood lipids for high-risk individuals [25, 26].

The SSA region is rapidly urbanizing, a trend that will continue in the coming three decades, bringing with it new challenges in preventing and managing CVD. Locally-generated evidence is required on the contribution of the behavioral, physiological and socioeconomic factors to the burden of CVD, and to seize opportunities that exist for prevention and treating CVD, to inform the design of effective interventions and response strategies. Addressing misperceptions that act as barriers to the efforts to tackle CVD will be key. Policy actors and implementers need to understand and address the challenges with care-seeking and treatment continuum for CVD. In sum, much has been done, but a lot more remains to be done to fight NCDs and CVD in SSA.

We recommend that future research investigates and proposes strategies and sustainable and innovative approaches for addressing social determinants of health, including but not limited to multi-sectoral partnerships, and effective funding for the prevention and control of CVD along the lines proposed by the WHO 'best-buys' individual, population and policy level interventions.

REFERENCES

1. Van de Vijver, S.J., et al., *Prevalence, awareness, treatment and control of hypertension among slum dwellers in Nairobi, Kenya*. Journal of hypertension, 2013. **31**(5): p. 1018-1024.
2. Haregu, T.N., et al., *The connection between non-communicable disease risk factors and risk perception among urban slum dwellers in Nairobi, Kenya*. African Population Studies, 2016. **30**(3): p. 3094-3102.
3. Haregu, T.N., et al., *Co-occurrence of behavioral risk factors of common non-communicable diseases among urban slum dwellers in Nairobi, Kenya*. Global Health Action, 2015. **8**: p. 28697.
4. Oti, S.O., et al., *The magnitude of diabetes and its association with obesity in the slums of Nairobi, Kenya: results from a cross-sectional survey*. Tropical Medicine & International Health, 2013. **18**(12): p. 1520-1530.
5. Katz, M., et al., *Calculated and perceived cardiovascular risk in asymptomatic subjects submitted to a routine medical evaluation: The perception gap*. Eur J Prev Cardiol, 2015. **22**(8): p. 1076-82.
6. Webster, R. and E. Heeley, *Perceptions of risk: understanding cardiovascular disease*. Risk Management and Healthcare Policy, 2010. **3**: p. 49-60.
7. Avis, N.E., K.W. Smith, and J.B. McKinlay, *Accuracy of perceptions of heart attack risk: what influences perceptions and can they be changed?* American Journal of Public Health, 1989. **79**(12): p. 1608-12.
8. van der Weijden, T., et al., *Primary prevention of cardiovascular diseases in general practice: mismatch between cardiovascular risk and patients' risk perceptions*. Medical Decision Making, 2007. **27**(6): p. 754-61.
9. Awuah, R.B., et al., *Prevalence, awareness, treatment and control of hypertension in urban poor communities in Accra, Ghana*. Journal of Hypertension, 2014. **32**(6): p. 1203-1210.
10. Lundborg, P. and B. Lindgren, *Do they know what they are doing? Risk perceptions and smoking behaviour among Swedish teenagers*. Journal of Risk and Uncertainty, 2004. **28**(3): p. 261-286.
11. Rimal Rajiv N. and R. Kevin, *Perceived Risk and Efficacy Beliefs as Motivators of Change*. Human Communication Research, 2003. **29**(3): p. 370-399.
12. Rosenstock, I.M., *The health belief model and preventive health behavior*. Health education monographs, 1974. **2**(4): p. 354-386.
13. Pligt, J.v.d., *Risk Perception and Self-Protective Behavior*. European Psychologist, 1996. **1**(1): p. 34-43.
14. Weinstein, N.D., *What Does It Mean to Understand a Risk? Evaluating Risk Comprehension*. Journal of the National Cancer Institute Monographs, 1999. **25**: p. 15-20.

15. Kariuki, J.K., et al., *Evaluation of the performance of existing non-laboratory based cardiovascular risk assessment algorithms*. BMC Cardiovascular Disorders, 2013. **13**(1): p. 1-13.
16. Gaziano, T.A., et al., *An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study*. The Lancet Global Health, 2015. **3**(9): p. e556-e563.
17. Surka, S., et al., *Evaluating the use of mobile phone technology to enhance cardiovascular disease screening by community health workers*. International Journal of Medical Informatics, 2014. **83**(9): p. 648-654.
18. D'Agostino, R.B., et al., *General Cardiovascular Risk Profile for Use in Primary Care*. Circulation, 2008. **117**(6): p. 743.
19. Conroy, R., et al., *Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project*. European Heart Journal, 2003. **24**(11): p. 987-1003.
20. Woodward, M., P. Brindle, and H. Tunstall-Pedoe, *Adding social deprivation and family history to cardiovascular risk assessment: the ASSIGN score from the Scottish Heart Health Extended Cohort (SHHEC)*. Heart, 2007. **93**(2): p. 172-176.
21. Hippisley-Cox, J., et al., *Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2*. BMJ, 2008. **336**(7659): p. 1475-1482.
22. Assmann, G., P. Cullen, and H. Schulte, *Simple scoring scheme for calculating the risk of acute coronary events based on the 10-year follow-up of the prospective cardiovascular Münster (PROCAM) study*. Circulation, 2002. **105**(3): p. 310-315.
23. Mendis, S., 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*. Journal of Hypertension, 2007. **25**(8): p. 1578-1582.
24. Yusuf, S., et al., *Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study*. The Lancet, 2004. **364**(9438): p. 937-952.
25. World Health Organization., *World Health Report 2002: reducing risks, promoting healthy life*. . 2002, World Health Organization: Geneva, Switzerland
26. World Health Organization., *Integrated Management of Cardiovascular Risk*. 2002, World Health Organization: Geneva, Switzerland.

Chapter 10

Summary

Nederlandse samenvatting

Acknowledgements

Curriculum Vitae and list of publications

SUMMARY

The current research brought to the fore evidence on the cardiovascular disease risk profile of an urban slum population in Nairobi, Kenya, and in particular the role socioeconomic factors play in promoting and exacerbating CVD in among the urban poorest.

In chapter two and three, we analyze the co-occurrence and existence of multiple NCD risk factors in the Kenyan population using data from the national STEPs survey. We observed that three out of four Kenyan adults report between four and six of the conventional NCD risk factors (insufficient physical activity, smoking, harmful alcohol consumption, obesity, hypertension, and diabetes mellitus). These findings point to an emerging NCD epidemic in the Kenyan population. The pattern and distribution of the NCD risk factors in the Kenyan population was influenced by key sociodemographic factors that included age, sex, education and socioeconomic status.

In chapters four, five and six, we report on knowledge, understanding and perception towards NCD and CVD risk factors. In a systematic review conducted from studies across SSA, the main findings were that inadequate knowledge, misconceptions and cultural understanding of CVD and associated risk factors were important influencers of health-seeking behavior. In the urban slums of Nairobi (chapter five and six), we also found low levels of understanding regarding the conditions, their risk factors, and the mechanisms through which risk factors cause disease. Further, few and inadequately equipped public health facilities were a major barrier to care-seeking and adherence to treatment in this population.

Chapter seven presents the analysis on comparative performance of pooled cohort equations (PCE) and Framingham CVD risk assessment scores when used in risk stratification in Nairobi's slum population. The results show a large difference between the PCE 2013 and PCE 2018 functions, with the former classifying more people in the high-risk category and comparatively fewer in the low risk category when compared to the PCE 2018. The two functions had the lowest agreement/concordance ($\kappa = 0.05$, correlation = 0.39) of any pair in the classification of individuals into the three risk categories. Although there was a moderate agreement between the Framingham and Framingham non-laboratory functions ($\kappa = 0.64$, 95% CI 0.59 - 0.68) and a better correlation ($r_s = 0.71$) of any pair, the discrepancy in the proportion of individuals classified into high and intermediate risk categories show that the functions are not substitutable for use in this population.

The role of behavioral, physiological and socioeconomic factors in mortality from CVD in the urban slum population is presented in chapter eight. Our findings show that socioeconomic factors education and employment are attributable to CVD deaths, and investing in education and treating high blood pressure could avert up to four in 10 CVD deaths in the urban poor population. It follows, therefore, that a holistic approach of addressing social determinants of health can potentially result in huge gains in the primordial prevention of CVD, delivering high returns on investment on CVD treatment and management.

NEDERLANDSE SAMENVATTING

Dit onderzoek presenteert bewijs over het risicoprofiel van hart- en vaatziekten (HVZ) van een sloppenbevolking in de stad Nairobi, Kenia. In het bijzonder, in welke mate socio-economische factoren invloed hebben op het bevorderen en verergeren van HVZ in deze bevolking.

In hoofdstukken twee en drie hebben wij de aanwezigheid en combinatie van meerdere risicofactoren van niet-overdraagbare aandoeningen in de Keniaanse bevolking met behulp van gegevens uit de nationale STEPWise-enquête geanalyseerd. Hierbij hebben wij geconstateerd dat drie van de vier Keniaanse volwassenen tussen de vier tot zes van de niet overdraagbare risicofactoren (onvoldoende lichamelijke activiteit, roken, schadelijk alcoholgebruik, obesitas, hypertensie en diabetes mellitus) hebben gerapporteerd. Deze bevindingen wijzen op een opkomende epidemie van niet-overdraagbare aandoeningen/ziekten in de Keniaanse bevolking. Het patroon en de verdeling van de risicofactoren van niet-overdraagbare aandoeningen in de Keniaanse bevolking werden beïnvloed door belangrijke sociaal-demografische factoren zoals leeftijd, geslacht, opleiding en sociaal-economische status.

In hoofdstukken vier, vijf en zes rapporteren wij over de kennis, inzicht en perceptie van risicofactoren voor niet-overdraagbare ziekten en HVZ. Onze systematische review van literatuur uit Sub-Sahara Afrika heeft onvoldoende kennis, misvattingen en cultureel begrip van HVZ en de bijbehorende risicofactoren als belangrijke invloeden op gezondheidszoekend gedrag geïdentificeerd. In de sloppenwijken van Nairobi (hoofdstukken vijf en zes) hebben wij waargenomen dat participanten weinig inzicht hadden in niet overdraagbare aandoeningen/HVZ, de bijbehorende risicofactoren en de mechanismen die deze aandoeningen veroorzaken. Daarnaast vormden weinig en onvoldoende uitgeruste gezondheidsfaciliteiten een grote belemmering in het gezondheidszoekend gedrag en therapietrouw voor de bevolking van Nairobi's sloppenwijken.

Hoofdstuk zeven presenteert een vergelijkende analyse van de prestaties van gepoolde cohortvergelijkingen (PCE)- en Framingham HVZ- risicobeoordeling modellen bij risicostratificatie in Nairobi's sloppenwijken. De analyse constateerde dat er een groot verschil bestaat tussen de PCE 2013- en PCE 2018- risicoscores, waarbij de PCE 2013 meer mensen in de categorie met een hoog risico, en relatief weinig mensen in de categorie met laag risico classificeert in vergelijking met de PCE 2018. Deze twee functies hadden de

laagste overeenkomst ($\kappa = 0,05$, correlatie = 0,39) van ieder paar in de classificatie van individuen in de drie risicocategorieën. Er bestond een gematigde overeenkomst ($\kappa = 0,64$, 95% BI 0,59 - 0,68) en een sterkere correlatie ($r_s = 0,71$) tussen de niet-laboratoriumfuncties van Framingham en Framingham in vergelijking met andere paren. Desondanks zijn beide functies niet geschikt bevonden voor het gebruik in deze bevolkingsgroep gezien de discrepantie in het aandeel van personen, die waren ingedeeld in de hoog- en gemiddelde risicocategorie.

De rol van gedrags-, fysiologische en socio-economische factoren in HVZ sterfte in de stedelijke sloppenwijk bevolking is gepresenteerd in hoofdstuk acht. Onze bevindingen tonen aan dat socio-economische factoren, opleiding en werkgelegenheid bijdragen aan de HVZ-sterfte gevallen. Investerings in onderwijs en behandeling van hoge bloeddruk kunnen 4 op de 10 HVZ-sterftegevallen in de sloppenwijk bevolking voorkomen. Hieruit volgt dat een holistische benadering van het aanpakken van sociale determinanten kan leiden tot een enorme winst in de primaire preventie van HVZ. Dit impliceert een groot potentiaal voor winstbehoud met betrekking tot investeringen voor HVZ-behandelingen op korte en lange termijn.

ACKNOWLEDGEMENTS

"If I have seen further it is by standing on the shoulders of Giants."

Sir Isaac Newton, 1675

My heart is overjoyed, and filled with gratitude on this crowning moment and proudest occasion of my life. Getting this thesis published means the absolute world to me, and to my immediate and extended family. Earning this PhD is a culmination of an otherwise arduous journey, inspired by very special people that I have been very lucky to meet, work with, learn (even copy) from, and share my life with. These great people have shaped my thinking, beliefs and actions, and from them I have gladly accepted support, in word and in deed. To them I will remain eternally grateful.

First and foremost, my PhD mentors Prof. dr. Diederick Grobbee, Dr. Kerstin Klipstein-Grobusch and Dr. Catherine Kyobutungi. You have been very patient with me from the start to finish, as you watered and nurtured an idea that grew into a project, and now is set to be my life's purpose. I tapped into your deep knowledge about a subject I knew very little about, and applied your counsel every step of the way. The last four years you have transformed me from an unwrought stone in your academic kiln, to a *polished fine product* that I am today.

Rick, in very few but in no uncertain terms, you entreated that I keep focus, and demanded that I wrote concisely. Thank you for the overall guidance on the PhD, and for reading and improving the articles included in this thesis.

Kerstin, you were the ever-present and supportive supervisor that any PhD candidate could ever ask for. Your constant reminders and polite nudges successfully moved me forward, step by step. You demanded hard work from me, and were also encouraging and offered praise when I did something right. I will forever take your constant advice to take breaks from my work to have some fun and to re-strategize.

Catherine, you taught me in words and deed that nothing but the best is enough. From you CK, as we fondly call you, I have benefitted from a decade of invaluable mentorship, encouragement, constructive criticism and golden lessons. You have inspired me in every way possible.

Funding for PhD research came from UMC Utrecht Global Health Support scholarship. The African Population and Health Research Center (APHRC) has been my home for 14 years now. In transforming lives in Africa through research, you have also transformed me. I have received unwavering support in the pursuit of personal and professional growth while working at APHRC.

At APHRC I met brilliant colleagues turned friends, previous and present, who have inspired and supported me in various ways. I have received mentorship and models of excellence, hard work and purpose in Dr. Elizabeth Kimani-Murage and Dr. Chimaraoke Izugbara (currently at the International Center for Research on Women, Washington D.C.). Dr. Abdhalah Ziraba, Dr. Shukri Mohamed, Dr Maurice Mutisya and Dr. Tilahun Haregu (Australia) showed genuine interest in my PhD, and on many occasions offered words of encouragement and material support. Stephen van de Vijver (Tropical doctor, author and researcher), Dr. Samuel Oji Oti, Dr. Donatien Beguy, Dr. Eliya Zulu and Dr. Alex Ezeh are former colleagues at APHRC that played a big part in me getting here today. Sheila Mwero, may the good Lord richly bless you, Ma.

The enthusiastic team of Global Health researchers at Julius Global Health have provided me a powerful network. Dr. Daniel Boateng, Dr. Joyce Browne, and other current and previous PhD fellows at the University Medical Center Utrecht have given me friendship, peer support and encouragement to complete this PhD.

Melanie Pero, Anna Marza Florensa, Wout de Nooij, Coby and many more colleagues from Julius Center who provided administrative and logistical support for travel and accommodation during my trips to the Netherlands – you are all appreciated.

Goodarz Danaei (Harvard School of Public Health, USA) read and helped improve the language for the thesis. Remco Peters (Leeds University) translated the thesis summary to Dutch. For you Peter I wish you but the very best with your PhD research.

Thank you Dr. Bernard Lown for reminding me about our greatest mission on earth today – to organize and mobilize in one's own area for change!

Prof dr. Frank Visseren, Prof. dr. Yvonne vd Schouw, Prof. dr Joost de Laat, Prof. dr. John de Wit and Prof. dr. Marianne van der Sande, members of the thesis assessment committee; and Dr. Ilonca Vaartjes and Prof. dr. Josefien van Olmen who took the opponent's seat during my PhD defense – to you all, thank you.

And to you all, my profound gratitude. This is OUR success.

*

“Families are the compass that guide us. They are the inspiration to reach great heights, and our comfort when we occasionally falter.”

Brad Henry

A special mention is reserved for Caroline Kagwiria, my cherished wife and life partner. You have supported and encouraged me every step of the way during my PhD studies. Your constant reminder that I was a hard worker and that you were proud of me was the catalyst behind this achievement. When I forgot or could not pray, for one reason or the other, you knelt down and prayed, and interceded for me. I love you.

To my lovely children Jenny Prisca Nandako (10) and Patrice Mwanga (6): you warm my heart. You have taught me how to always be grateful, and why we should always count our blessings. I am so proud to be your father. This bar I have set for you is not high – I can picture you soaring above it and making me and mum proud.

Margaret and Lazarus Murunga Wekesa, my loving parents – I want the world to know that words alone are not enough to express my gratitude to you for what you have done and continue doing for me. You gave literally everything: blood, sweat and tears, for me to get an education when the odds were stacked against us. My assignment is clear: to give my best because you gave your utmost. Thank you for always praying for me. Thank you for protecting me. If I became half the parents you are to me to my own children, I will be very proud of myself. I love you.

My mother-in-law, Susana Kabaka – thank you for the prayers and blessings you keep sending my way. Your grateful and pure heart is rare. My late father-in-law - Julius Guantai Ikunyua - was a dear friend. We truly miss you. My siblings: Judy, Suleiman, Jerry, Daisy, Hezekiah and Ezra: this is also for you. We hunt as a pack.

Lastly, it is my sincere hope that this achievement inspires others from backgrounds with impossible written over it, to realize that impossibilities only exist in our minds, and that our origins do not determine our destinies. Hard work pays, and faith conquers mountains.

#Believe

CURRICULUM VITAE

Frederick Murunga Wekesah is an Epidemiologist and Researcher at the African Population and Health Research Center (APHRC - www.aphrc.org). Frederick conducts research in non-communicable diseases and in mental health. He has researched on cardiovascular diseases in the urban slums of Nairobi for the past 10 years and is fascinated by the concept of developmental origins of health and disease (DOHaD) and life course epidemiology. Frederick has identified childhood obesity and hyperglycemia in pregnancy (GDM) as further areas for his research.

Frederick possesses a wide range of qualitative and quantitative research and analytical skills. He has authored several scientific publications in peer reviewed journals, and is a co-investigator on several research projects.

Education and awards

Frederick holds a Master of Science degree in Medicine in Population-based Field Epidemiology from the University of the Witwatersrand, South Africa (2010). He received a Global Health Support award for PhD research from the University Medical Center Utrecht in September 2015. Frederick is a 2019 Bernard Lown Scholar in Cardiovascular Health at the Harvard TH. Chan School of Public Health, Harvard University, USA.

LIST OF PUBLICATIONS IN THIS THESIS

- 1) **Wekesah, F. M.**, L. Nyanjau, J. Kibachio, M. K. Mutua, S. F. Mohamed, D. E. Grobbee, K. Klipstein-Grobusch, C. Ngaruiya, T. N. Haregu, G. Asiki and C. K. Kyobutungi (2018). "Individual and household level factors associated with presence of multiple non-communicable disease risk factors in Kenyan adults." *BMC Public Health* 18(3): 1220.
- 2) Haregu, T. N., **F. M. Wekesah**, S. F. Mohamed, M. K. Mutua, G. Asiki and C. Kyobutungi (2018). "Patterns of non-communicable disease and injury risk factors in Kenyan adult population: a cluster analysis." *BMC Public Health* 18(3): 1225.
- 3) Boateng, D., **F. Wekesah**, J. L. Browne, C. Agyemang, P. Agyei-Baffour, A. d.-G. Aikins, H. A. Smit, D. E. Grobbee and K. Klipstein-Grobusch (2017). "Knowledge and awareness

of and perception towards cardiovascular disease risk in sub-Saharan Africa: A systematic review." PLOS ONE 12(12): e0189264.

- 4) Haregu, T. N., C. Kyobutungi, **F. M. Wekesah**, S. Oti and T. Egondi (2016). "The connection between non-communicable disease risk factors and risk perception among urban slum dwellers in Nairobi, Kenya." *African Population Studies* 30(3).
- 5) **Wekesah, F. M.**, C. Kyobutungi, D. E. Grobbee and K. Klipstein-Grobusch (2019). "Understanding of and perceptions towards cardiovascular diseases and their risk factors: a qualitative study among residents of urban informal settings in Nairobi." *BMJ Open* 9(6): e026852.
- 6) **Wekesah, F. M.**, K. Klipstein-Grobusch, D. E. Grobbee, D. Kadengye, G. Asiki, and C. Kyobutungi (2019). Determinants of mortality from cardiovascular disease in the slums of Nairobi, Kenya. *Manuscript under review* (Global Heart).
- 7) **Wekesah, F. M.**, M. K. Mutua, D. Boateng, D. E. Grobbee, G. Asiki, C. Kyobutungi and K. Klipstein-Grobusch (2019). Comparative performance of pooled cohort equations and Framingham risk scores in cardiovascular disease risk classification in a slum setting in Nairobi Kenya. *Manuscript submitted*.

Other publications

- 1) Vusirikala A, **Wekesah F**, Kyobutungi C, et al. Assessment of cardiovascular risk in a slum population in Kenya: use of World Health Organisation/International Society of Hypertension (WHO/ISH) risk reduction charts - secondary analyses of a household survey. *BMJ Open* 2019;0:e029304. doi:10.1136/bmjopen-2019-029304.
- 2) Mohamed, S. F., M. K. Mutua, R. Wamai, **F. Wekesah**, T. Haregu, P. Juma, L. Nyanjau, C. Kyobutungi and E. Ogola (2018). "Prevalence, awareness, treatment and control of hypertension and their determinants: results from a national survey in Kenya." *BMC Public Health* 18(3): 1219.

