Original Research Article

Effect of a Nurse-Led Intervention on Knowledge of the Modifiable Risk Behaviors of Cardiovascular Disease: A Randomized Controlled Trial

SAGE Open Nursing
Volume 9: 1–14

DOI: 10.1177/23779608231201044
journals.sagepub.com/home/son
Sage

Okubatsion Tekeste Okube, PhD[1,2], Samuel T. Kimani, PhD[1] and Waithira Mirie, PhD[1]

Abstract

Introduction: Cardiovascular disease (CVD) has disproportionately burdened the low- and middle-income countries where awareness and detection rates remain very low. Interventions directed to promote the community's awareness of CVD may help reduce the public's exposure to behavioral risk factors. However, the effectiveness of interventions implemented through a nurse on knowledge of the modifiable behavioral risk factors and preventive measures of CVD has not been determined in Kenya.

Objective: To establish the effect of a nurse-led intervention on knowledge of the modifiable risk behaviors of CVD in adults with metabolic syndrome (MetS) attending a mission-based hospital in Kenya.

Methods: A two-armed parallel-group randomized controlled trial design was conducted among 352 adults aged 18–64 years with MetS. The participants were recruited from a faith-based hospital in Nairobi, Kenya and randomly allocated to either a nurse-led lifestyle intervention or a control group. The intervention group received a comprehensive health education intervention using the World Health Organization (WHO) guideline recommendations for CVD control and prevention. Individuals in the control group were exposed to the usual CVD care according to hospital protocol. The duration of the intervention was 12 months. The primary outcome measure was a change in levels of knowledge on the modifiable risk factors and preventive measures of CVD. Outcome measures were assessed at baseline and at 15 months postintervention. Pre- and postintervention difference in the level of knowledge between the two groups was determined using the chi-square test of independence.

Results: The knowledge level of CVD risk factors and preventive measures was very low in both groups at baseline without significant difference. A significant improvement in the level of knowledge on CVD risk factors (78.2% vs. 30.4%, $p < .001$) and preventive measures (74.4% vs. 29.0%, $p < .001$) was observed in the intervention group relative to the control at the end-line.

Conclusions: The nurse-led lifestyle intervention significantly improved participants' level of knowledge on CVD risk factors and preventive measures. It is highly recommended that nurses incorporate routine health education interventions for patients with cardio-metabolic abnormalities.

Keywords

cardiovascular diseases, knowledge, preventive measures, risk factors

Received 6 August 2022; accepted 27 August 2023

Introduction

Background

Globally, more than three-quarters (80%) of adult deaths result from four major noncommunicable diseases (NCDs) namely: cardiovascular disease (CVD), type-2 diabetes, cancers and chronic pulmonary diseases, of which CVD

[1]School of Nursing Sciences, University of Nairobi, Nairobi, Kenya
[2]School of Nursing, The Catholic University of Eastern Africa, Nairobi, Kenya

Corresponding Author:
Okubatsion Tekeste Okube, School of Nursing Sciences, University of Nairobi, Nairobi, Kenya, 19676-00202.
Email: tokube@cuea.edu

contributes to half of these deaths (WHO, 2022). More than 75% of deaths caused by CVD occur in lower and middle-income countries (LMIC), where a majority of people with these diseases remain undiagnosed (WHO, 2019). For many people in these countries, detection is often late in the course of the disease and people die at a younger age from CVD often in their most productive years (WHO, 2019). In Kenya, CVD is responsible for much of the NCD burden, accounting for approximately a quarter (26%) of all NCD-related deaths (Wekesah et al., 2020).

The mortality rate caused by CVD has markedly decreased over the past two to three decades in developed countries following the implementation of population-based awareness creation and prevention approaches to CVD (Jagannathan et al., 2019). In contrast, deaths from CVD have sharply increased in the LMICs specifically in the sub-Saharan Africa (SSA) region over the same period (WHO, 2021). Moreover, the burden of CVD in SSA is expected to double by 2030 due to a lack of awareness and adoption of unhealthy lifestyles (Roth et al., 2015; Yuyun et al., 2020).

Evidence indicates that major lifestyle risk factors of CVD are: insufficient physical activity (Bull et al., 2020; Ofori-Asenso & Garcia, 2016), intake of unhealthy diets and excessive alcohol, and cigarette smoking (Hamid et al., 2019; Roth et al., 2015), and obesity (Ofori-Asenso & Garcia, 2016), and all are increasing in the SSA leading to an epidemic of CVD (Mensah et al., 2015). Likewise, increased consumption of unhealthy foods such as processed/fast foods, sugar-sweetened beverages, inadequate fruits, and vegetables associated with high blood pressure (BP) and obesity are well documented in Kenya (Hulzebosch et al., 2015; Kimani et al., 2019; Okube et al., 2020).

According to the WHO (2019), about 80% of CVD can be prevented through the adoption of healthy diets, adequate physical activity, and cessation of alcohol misuse and smoking. Adoption of healthy lifestyles is also the first-line treatment for CVD management (Rosas et al., 2016). However, the adoption of a healthy lifestyle requires an adequate level of knowledge of the modifiable risk factors and recommended preventive measures for CVD. Indeed, a lack of adequate knowledge of the risks and preventive actions for CVD exists in SSA. A systematic review in the SSA region revealed that most of the studies reported critically low levels of knowledge of the major risk factors of CVD (Boateng et al., 2017). For example, studies in the SSA region reported that below 30% of the study population mentioned excessive alcohol intake as a major risk factor for CVD (Temu et al., 2015; Wahab et al., 2015). In a study conducted in Nigeria among hypertensive and/or diabetic patients, only 4.5% of the participants reported excessive alcohol consumption as a risk factor for CVD (Wahab et al., 2015). A study conducted among Kenyan adults reported an acceptable low level of knowledge of CVD with a mean score of 1.3 out of 10 points (Temu et al., 2015). An estimated 75% of Kenyans who live with hypertension (HTN) do not know they suffer from it, and of those who are aware, only 4% are able to control their BP (Kenya Ministry of Health, 2018).

The epidemic of CVDs in the SSA is due to a lack of awareness of the major lifestyle risk factors, implying that primary prevention of CVD is lacking (Boateng et al., 2017). For example, evidence from Kenya shows that community awareness about CVD is low (Wekesah et al., 2019), with most individuals living with HTN being diagnosed late when complications have already set in (Mohamed et al., 2018). Poor public knowledge of CVD is the reflection of the unavailability of national programs for NCD prevention (Boateng et al., 2017). To reduce the burden of CVD, behavioral change interventions are urgently required in the SSA. Promotion of public awareness of CVD is an important first step for people to make the recommended behavioral changes (Azahar et al., 2017). Health education interventions focusing on specific lifestyle recommendations would inform the public to make healthier choices (McKenzie et al., 2022), which can lead to better prevention and control of CVD (Aminde et al., 2017; Fottrell et al., 2019). People with an adequate level of knowledge of CVD are more likely to identify the risks of the disease and adopt healthy lifestyles (Muhihi et al., 2020; Ng et al., 2014). In contrast, a lack of knowledge of CVD-related risks and preventive measures is a key barrier to the prevention of CVD (Azahar et al., 2017; Ignatowicz et al., 2020). Approaches aimed at improving population knowledge of CVD have significant public health importance by reducing both the health and economic burden of CVD in the population (Mensah et al., 2017) than treatment-oriented programs in settings with limited health resources (Checkley et al., 2014).

Nurses can significantly contribute to improving communities' awareness required for effective prevention and control of CVD (Hayman et al., 2015). A systematic review has shown the effectiveness of nurses in reducing the burden of CVD in LMICs (Khetan et al., 2017). The effectiveness of nurses in the control measures of CVD is due to their accessibility to and rapport with community members, and their scope of practice to deliver evidence-based patient-centered care (Checkley et al., 2014; Hill et al., 2017; Khetan et al., 2017). Hence, this study aimed to establishing the effect of a nurse-led health education intervention on knowledge of the modifiable risk factors and prevention measures of CVD among adults with MetS in Kenya.

Literature Review

CVD was the chief cause of disease burden accounting for 18.6 million global deaths in 2019 (Roth et al., 2020). Lifestyle risk factors including dietary habits, alcohol

consumption, tobacco use and level of physical activity greatly determine the occurrence of CVD (Silverman et al., 2019). Knowledge of behavioral and metabolic hazards is essential to adopt healthy lifestyles (Imes & Lewis, 2014). Despite this evidence, knowledge and awareness related to CVD is still low in the SSA population (Boateng et al., 2017). Nonetheless, the gap presents a window of opportunity for initiating preventive strategies that could be anchored on partnership and collaboration between health and community systems for awareness creation to promote early detection, diagnosis, and management of CVD.

Improving an individual's knowledge level related to CVD is a crucial component of CVD prevention and control approaches (Albarqouni et al., 2016; Imes & Lewis, 2014). The burden of CVD can be reduced in the entire community using community-based interventions aiming at improving CVD knowledge (Mensah et al., 2017). According to Fottrell et al. (2019) and Aminde et al. (2017), a community-based awareness creation strategy for CVD could be effective in the prevention and control of diseases, as knowledge empowers communities to practice the recommended health behaviors. Systematic reviews have indicated that nurses could be effective in promoting healthcare-seeking behaviors and tackling the burden of CVD in LMICs (Khetan et al., 2017). The effectiveness of nurses could be attributed to their wider reach in many areas, rapport with community members, and their scope of practice to deliver holistic care (Hill et al., 2017; Khetan et al., 2017). Hence, this study aimed at determining the effect of a nurse-led intervention on knowledge of the modifiable risk behaviors of CVD in adults with MetS attending a mission-based hospital in Kenya.

Methods and Materials

Study Setting

Recruitment of the study participants was carried out at St. Mary's Mission Hospital in Nairobi, while follow-up took place in the community. The baseline health education intervention was provided at the hospital after the participants were recruited and randomized. Then, at 9 and 15 months postintervention, the participants were called back to the hospital and provided with health education interventions.

The hospital is a Christian faith-based health organization dedicated to providing affordable inpatient and outpatient services to the informal settlements of Kibera, Mukuru-Kwa-Njenga, and Kuwinda. Kibera is the largest and poorest slum in Africa with an average monthly income of 39 U.S. dollar (USD) per household. It is home to more than a million people who live in extreme conditions, making less than 1$ per day (Desgroppes & Taupin, 2011). Locals live in small shacks built with mud, which can often house up to eight or more people. High levels of poverty, unemployment and lack of social amenities, including limited access to quality primary health care are typical characteristics of the Kibera slum. The study was focused on the urban low-income people because they are disproportionately at increased risk of behavioral and metabolic risk factors of CVD. Evidence suggests that such populations fare worse than their non-slum counterparts on most health measures including high prevalence of CVD and low levels of awareness, treatment and control of CVD (Van de Vijver et al., 2015).

Study Design and Participants

A two-arm parallel-group randomized controlled trial design was conducted among adults aged 18–64 years with MetS. Eligible participants were randomized into two groups. The control group received the usual CVD care. In addition to the usual care, the intervention group received a 12-months nurse-led comprehensive health education intervention (Appendix I).

Participants were eligible if they were adults aged 18–64 years, those with central obesity (waist circumference of $\geq$94 cm for men and $\geq$80 cm for women), plus at least two of the following four cardio-metabolic risk factors: (1) raised level of Triglycerides (TGs) $\geq$ 1.7 mmol/L, (2) reduced level of high-density lipoprotein cholesterol (HDL-C) < 1.03 mmol/L in males and <1.29 mmol/L in females, (3) raised BP-systolic BP $\geq$ 130 mm Hg and/or diastolic BP $\geq$ 85 mm Hg or previously diagnosed HTN, and (4) elevated fasting blood glucose (FBG) level of $\geq$5.6 mmol/L or known type-2 diabetes (Alberti et al., 2009).

Lactating and pregnant mothers and those with terminal diseases such as physical disability, CV events, cancer, and psychiatric illness were excluded from the study. The status of CV events was determined by asking the participants whether they were informed by a physician that they ever experienced CV events such as stroke, myocardial infarction, and so on.

Methods of Screening and Sampling. **Step 1:** Adults aged 18–64 years who attended the hospital during the baseline survey were screened for abdominal obesity. **Step 2:** Individuals with abdominal obesity (waist circumference [WC] $\geq$ 94 cm in men and WC $\geq$ 80 cm in women) were further screened for the other components of MetS. **Step 3**: Individuals with three or more components of MetS were re-consented and recruited for the study. **Step 4:** Eligible participants were divided into 22 blocks, with an average of 16 subjects in each block. **Step 5:** Subjects from each block were randomly allocated to either usual care control ($n = 176$) or nurse-led lifestyle intervention groups ($n = 176$) by picking a paper written "IG" or "CG" for intervention and control groups, respectively.

The total study duration from recruitment to the evaluation phase took 15 months, with each participant followed for 12 months to determine adherence to the recommended

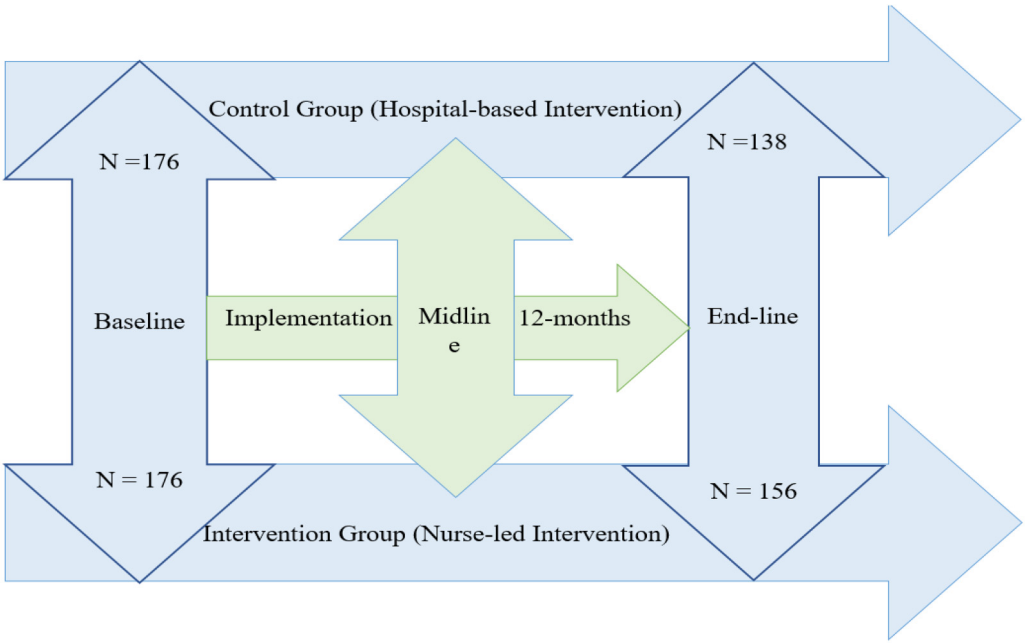

Figure 1. Implementation time frame for the study.

lifestyle practice and level of knowledge of CVDs-related lifestyle preventive measures. Data on adherence to the recommended lifestyle practice was fully described in the team's previously published works (Okube et al., 2022).

The study was structured into three phases; baseline, midline and, end-line. The baseline phase involved screening, recruitment, and allocation of participants into two groups during which baseline data was collected (Figure 1). During the baseline data collection, socio-demographic information, knowledge of risk factors and prevention measures of CVD, lifestyle characteristics and metabolic biomarkers (BP, FBG, TGs, HDL-C) were measured. The intervention phase involved the provision of lifestyle changes to the intervention group. The phase involved face-to-face delivery of verbal and written individualized health education interventions targeting the major modifiable risk factors of CVD in the intervention arm. The intervention phase ran for 12 months with midline data collection conducted at 9 months. During the midline, the metabolic biomarkers (BP, FBG, TGs, HDL-C) were measured. The end-line phase was conducted at month 15. This involved the collection of data on knowledge and lifestyle practices toward CVD prevention measures and metabolic biomarkers. Thereafter, face-to-face health education as well as written health education package messages were provided to both the groups as conclusion of the study.

Intervention

Usual Care. The usual CVD care was the routine care provided by the hospital healthcare providers according to the hospital protocol. This included laboratory investigations, drug treatments, patient counseling, and discharge general health education. For example, if an individual develops high BP, the person receives anti-hypertensive medication and general lifestyle advice. No specific health education intervention was provided on the recommended dietary intake patterns (salt, sugar, fat, fruits, vegetables, etc.), alcohol consumption and physical activity to the control group at baseline and mid-line. However, after the evaluation phase, participants in the control group received comprehensive and specific lifestyle modification interventions accompanied by brochures and a health education intervention package (Appendix I).

Lifestyle Modification Intervention. In addition to the usual care, participants in the intervention group received comprehensive individualized and group-based health education intervention at three time points (baseline, midline, and end-line). The intervention was targeting the major behavioral risk factors of CVDs. According to the WHO (2019) guidelines, participants in the intervention group were educated about the recommended intake of sugar, salt, fruits, vegetables, legumes, and nuts. The intervention group was advised to restrict salt intake to less than 1 teaspoon (5 g) and sugar intake to less than 5 teaspoons (25 g) per day as well as to avoid or limit processed/fast foods and saturated fats intake. As per the Dietary Approaches to Stop Hypertension (DASH) diet, the recommended portions of protein, carbohydrate, and vegetable/fruit intake were demonstrated using a well-labeled diagram and emphasized its importance in the prevention of CVD (Onvani et al., 2015).

The intervention group received specific information on the recommended standard drinks and frequency of alcohol consumption as well as the negative effect of excessive alcohol drinking on CVD. Participants in the intervention group were also educated to engage in an adequate level of physical activity (≥150 min of moderate or ≥75 min of vigorous-intensity physical activity in a week; Mensah et al., 2015). The health education intervention was accompanied by brochures including the DASH diet flip charts (Onvani et al., 2015), the Kenya diabetes and HTN prevention flip charts (Kenya Diabetes Prevention Brochure, 2015) and the health education intervention package (Appendix I).

During the 12-month intervention period, there were 3 face-to-face intervention contacts with each session lasting for 30–40 min and at least 2 online interventions (email/SMS/WhatsApp or direct telephone call). The health education intervention was administered by a registered nurse with over 7 years of working experience.

Study Outcome

The study outcome included changes in levels of knowledge on the modifiable risk factors and preventive measures of CVD.

Data Collection

Respondents' level of knowledge of the main risk factors and control measures of CVD was assessed before and after the intervention. The data was collected using pretested questionnaires adopted from the WHO STEPwise approach to NCD risk factor surveillance (STEPS; WHO, 2017). The knowledge level on modifiable risk factors of CVD was assessed using seven variables, including knowledge of risk factors of high BP and type-2 diabetes, CVDs-related health consequences of tobacco smoking, intake of excessive salt, sugar and alcohol, eating junk foods, and being overweight/obese.

The knowledge level of CVD preventive measures was assessed using six variables. The variables included: knowledge on whether HTN and diabetes are preventable, preventive measures of HTN and diabetes, daily recommended intake of salt and sugar, frequency and servings of fruits and vegetables intake and their importance in CVD prevention. Data were collected by two trained nurse research assistants who were blinded to the study groups.

Scoring System of Participants' Level of Knowledge

Respondents who answered at least three correct responses for each of the major risk factors of CVD and recommended preventive measures, scored "three." Those respondents who identified two correct responses scored "two." Respondents who identified only one correct response, or incomplete or incorrect answer, scored "one." The scores for each response were added to determine the total knowledge score. Then, the total score was expressed in percentages. Accordingly, a score of < 50% was considered as low level of knowledge; between 50% and 74% was a moderate level of knowledge, and, a score ≥ 75% was considered a high level of knowledge (Appendix II).

Validity and Reliability of the Study Tool

The WHO STEPS questionnaire (WHO, 2017) was utilized to gather the data. The validity of the tools in terms of content was revised by experts in the field of CVD, and their recommendations were included in the final questionnaire. To measure the reliability of the questionnaire, a test–retest technique was carried out after three weeks. Cohen's kappa coefficient was employed to determine the degree of agreement between the two results. The repeated questions produced a 0.91 kappa value which was considered reliable.

Data Analysis

The Statistical Package for the Social Sciences software (SPSS Version 22) was employed to analyze the data. Frequencies and percentages were obtained for categorical variables. Pre- and postintervention difference in the level of knowledge on lifestyle-related risk factors and prevention measures of CVD between the two groups was determined using the chi-square test of independence.

Allocation and Follow-up of the Study Participants

A total of 404 adults with central obesity were screened for MetS using the International Diabetes Federation (IDF) diagnostic criteria, of which 352 were found to have MetS. Participants with MetS were randomized to receive either usual CVD care or a nurse-led lifestyle intervention for a duration of 15 months. Of the 352 participants, 294 (intervention = 156 and control = 138) completed the study period, with a response rate of 83.5%. Of the participants, 58 (intervention = 20, control = 38) dropped out. The most common reasons for dropout included a loss of follow-up and poor compliance. A small number of the participants dropped out due to relocation of residence, and travel to other counties, and two women became pregnant. At baseline, they did not differ in terms of age, level of education, and level of knowledge of the modifiable risk factors of CVD from those who completed the follow-up period (figure 2).

Results

Socio-Demographic Information of the Study Subjects

After excluding attritions, the data for 294 subjects were used for the final analysis (Figure 2). The mean age for the

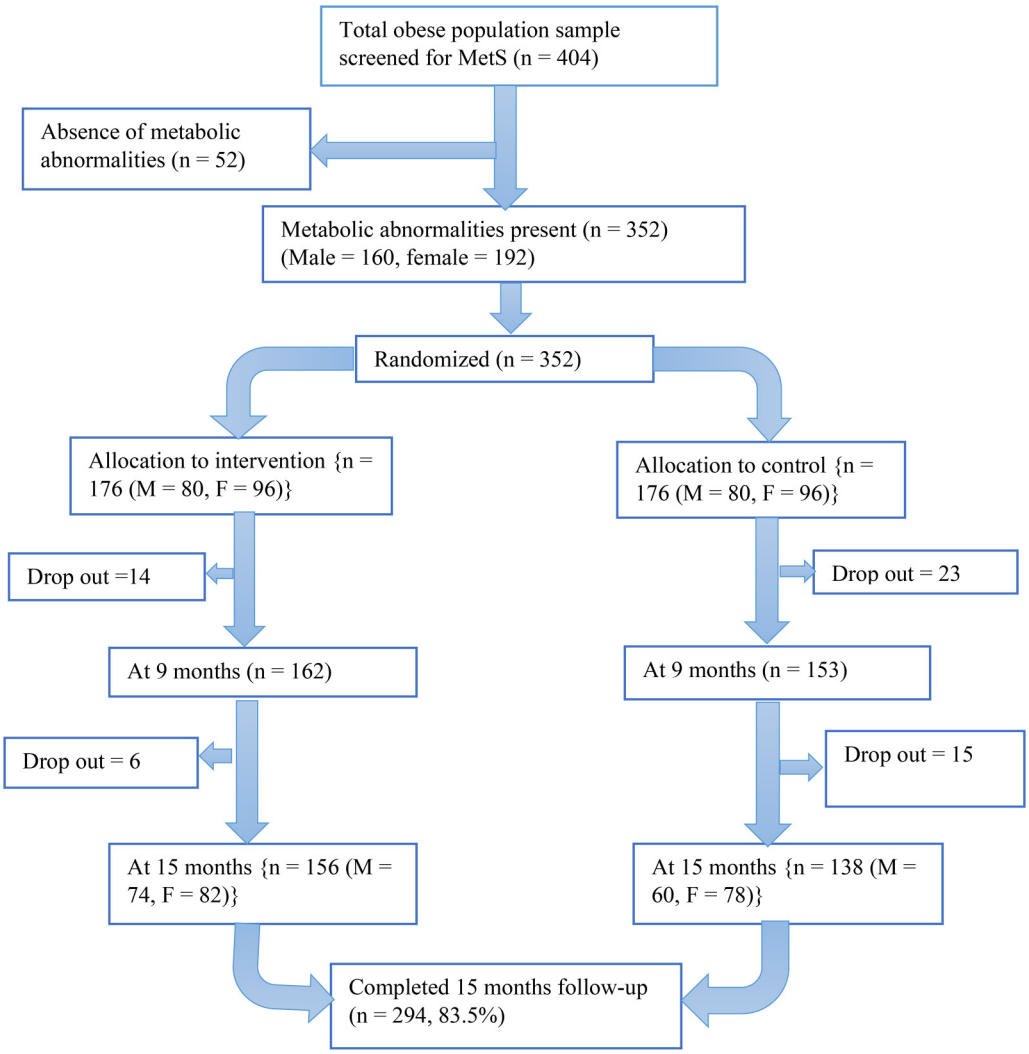

Figure 2. Consort flow diagram of the study participation.

intervention and control groups was 44.2 (±10.6) and 44.5 (±10.7) years, respectively. Most of the respondents were females (54.4%), married (77.9%), belonged to the Christian Protestant faith (60.2%), self-employed (52.7%), and reported a monthly family income of 100–500 USD (75.6%). Approximately one-half (46.6%) had attained a secondary level of education. Further analyses revealed there were no significant differences between the two groups in terms of sociodemographic characteristics at baseline (Table 1).

Respondents' Level of Knowledge on Lifestyle Risk Factors of CVD

Table 2 presents respondents' level of knowledge on lifestyle risk factors of CVD before and after the intervention. Before the intervention, the level of knowledge on lifestyle risk factors of CVD was low. Of the respondents, only 15.4% of the intervention and 7.2% of the control group had a high level of knowledge of risk factors for type-2 diabetes and high BP. The majority of the respondents in each group had low levels of knowledge of tobacco smoking, excessive intake of salt and sugar, consumption of alcohol and processed/fast foods, and being overweight/obese as CVD risk factors at the baseline.

The group who received the intervention significantly ($p < .001$) improved and scored a higher level of knowledge in all the lifestyle risk factors of CVD than the control at the end-line. The percentage of people who scored high levels of knowledge on risk factors of high BP and type-2 diabetes (60.3% vs. 13.0%), risk factors of CVD namely: tobacco smoking (74.4% vs. 37.0%), consumption of processed foods (65.4% vs. 33.3%), excessive alcohol (70.5% vs. 47.8%), salt (58.3% vs. 21.7%), and sugar (61.5% vs. 31.9) intake as well as being overweight/obese (67.3% vs. 35.5%) was substantially ($p < .001$) higher in the intervention relative to the control arm at the end-line. The overall level of

Table 1. End Line Socio-Demographic Information of the Respondents by Group (*n*, %).

Characteristic	Intervention	Control	Total	Chi ($\chi 2$)	df	*p*-value
Mean age (SD)	44.2 (10.6)	44.5 (10.7)	44.3 (10.6)	0.235	292	.814*
Age group in years				0.008	2	.996
< 30	14 (9.0)	12 (8.7)	26 (8.8)			
30–50	99 (63.5)	88 (63.8)	187 (63.6)			
> 50	43 (27.6)	38 (27.5)	81 (27.6)			
Total	156 (100)	138 (100)	294 (100)			
Sex				0.462	1	.497
Male	74 (47.4)	60 (43.5)	134 (45.6)			
Female	82 (52.6)	78 (56.5)	160 (54.4)			
Total	156 (100)	138 (100)	294 (100)			
Marital status				0.096	2	.953
Married	121 (77.6)	108 (78.3)	229 (77.9)			
Single	21 (13.5)	19 (13.8)	40 (13.6)			
Divorced/separated/widowed	14 (9.0)	11 (8.0)	25 (8.5)			
Total	156 (100)	138 (100)	294 (100)			
Religion				1.104	2	.576
Protestant	90 (57.7)	87 (63.0)	177 (60.2)			
Catholic	52 (33.3)	42 (30.4)	94 (32.0)			
Muslim	14 (9.0)	9 (6.5)	23 (7.8)			
Total	156 (100)	138 (100)	294 (100)			
Education				0.875	2	.646
None—primary level	31 (19.9)	33 (23.9)	64 (21.8)			
Secondary level	76 (48.7)	61 (44.2)	137 (46.6)			
Tertiary level	49 (31.4)	44 (31.9)	93 (31.6)			
Total	156 (100)	138 (100)	294 (100)			
Employment status				1.572	3	.666
Government employee	7 (4.5)	5 (3.6)	12 (4.1)			
Nongovernment employee	47 (30.1)	34 (24.6)	81 (27.6)			
Self-employed	80 (51.3)	75 (54.3)	155 (52.7)			
Unemployed	22 (14.1)	24 (17.4)	46 (15.6)			
Total	156 (100)	138 (100)	294 (100)			
Income (USD)				2.226	2	.329
< 100	9 (6.0)	14 (10.9)	23 (8.2)			
100–500	117 (78.0)	94 (72.9)	211 (75.6)			
> 500	24 (16.0)	21 (16.3)	45 (16.1)			
Total	150 (100)	129 (100)	279 (100)			

knowledge on risk factors of CVD was significantly (78.2% vs. 30.4%; $p < .001$) higher in the intervention relative to the control group at the end-line (Table 2).

Respondents' Level of Knowledge of CVD-Related Lifestyle Preventive Measures

At the baseline, most (intervention = 88.5%, control = 91.3%) of the respondents believed that HTN and type-2 diabetes were preventable. However, the majority (intervention = 61.5%, control = 68.8%) scored a low level of knowledge on preventive measures for HTN and diabetes. Knowledge regarding the WHO recommended amount of salt and sugar intake was very low in both groups at baseline. Only 21.2% of the intervention and 12.3% of the control groups knew the daily recommended amount of salt intake. With regard to sugar intake, only 1.3% of the intervention and 5.1% of the control group knew the daily recommended amount of sugar intake at baseline. Furthermore, the majority of the respondents in each group had a low level of knowledge of the benefits of fruit and vegetable intake and physical activity toward CVD prevention. The overall level of knowledge on CVD-related preventive measures was not substantially ($p = .785$) different between the two groups at baseline.

The level of knowledge of preventive measures of CVD significantly ($p < .001$) improved among individuals in the intervention group compared to those in the control arm at the end-line. The overall level of knowledge of CVD-related preventive measures was significantly (74.4%

Table 2. Respondents' Level of Knowledge of CVDs Risk Factors Before and After the Intervention (*n*, %).

	Baseline					End-line				
Variables	Intervention	Control	X^2 value	*df*	*p*-value	Intervention	Control	X^2 value	*df*	*p*-value
Knowledge of risk factors for hypertension and type-2 diabetes										
High	24 (15.4)	10 (7.2)	4.76	2.00	.092	94 (60.3)	18 (13.0)	73.51	2.00	.000
Moderate	33 (21.2)	33 (23.9)				27 (17.3)	33 (23.9)			
Low	99 (63.5)	95 (68.8)				35 (22.4)	87 (63.0)			
Knowledge of tobacco smoking as CVD risk factor										
High	45 (28.8)	28 (20.3)	5.94	2.00	.051	116 (74.4)	51 (37.0)	54.66	2.00	.000
Moderate	32 (20.5)	44 (31.9)				27 (17.3)	27 (19.6)			
Low	79 (50.6)	66 (47.8)				13 (8.3)	60 (43.5)			
Knowledge of excessive alcohol consumption as CVD risk factor										
High	46 (29.5)	38 (27.5)	6.17	2.00	.046	110 (70.5)	66 (47.8)	38.67	2.00	.000
Moderate	21 (13.5)	34 (24.6)				26 (16.7)	10 (7.2)			
Low	89 (57.1)	66 (47.8)				20 (12.8)	62 (44.9)			
Knowledge of excessive salt intake as CVD risk factor										
High	16 (10.3)	9 (6.5)	1.59	2.00	.452	91 (58.3)	30 (21.7)	71.88	2.00	.000
Moderate	65 (41.7)	64 (46.4)				46 (29.5)	28 (20.3)			
Low	75 (48.1)	65 (47.1)				19 (12.2)	80 (58.0)			
Knowledge of excessive sugar intake as CVD risk factor										
High	26 (16.7)	28 (20.3)	0.71	2.00	.701	96 (61.5)	44 (31.9)	41.88	2.00	.000
Moderate	37 (23.7)	33 (23.9)				32 (20.5)	20 (14.5)			
Low	93 (59.6)	77 (55.8)				28 (17.9)	74 (53.6)			
Knowledge of the consumption of processed/fast/junk foods as CVD risk factor										
High	31 (19.9)	17 (12.3)	3.79	2.00	.150	102 (65.4)	46 (33.3)	35.18	2.00	.000
Moderate	42 (26.9)	47 (34.1)				36 (23.1)	43 (31.2)			
Low	83 (53.2)	74 (53.6)				18 (11.5)	49 (35.5)			
Knowledge of being overweight/obese as CVD risk factor										
High	35 (22.4)	32 (23.2)	0.11	2.00	0.945	105 (67.3)	49 (35.5)	65.65	2.00	.000
Moderate	48 (30.8)	40 (29.0)				32 (20.5)	11 (8.0)			
Low	73 (46.8)	66 (47.8)				19 (12.2)	78 (56.5)			
Overall level of knowledge of CVD lifestyle risk factors										
High	8 (5.1)	5 (3.6)	0.48	2.00	.785	122 (78.2)	42 (30.4)	76.83	2.00	.000
Moderate	65 (41.7)	59 (42.8)				22 (14.1)	30 (21.7)			
Low	83 (53.2)	74 (53.6)				12 (7.7)	66 (47.8)			

Note. CVD = cardiovascular disease.

vs. 29.05; $p < .001$) higher in the intervention arm relative to the control at the end-line (Table 3).

Discussion

The study determined the effect of a nurse-led health education intervention on knowledge of the modifiable risk factors and preventive measures of CVD in adults with MetS. Participants in the intervention group showed significant improvements in their level of knowledge on the major behavioral risk factors and preventive measures of CVD.

Baseline Respondents' Level of Knowledge on Modifiable Risk Factors and Preventive Measures of CVDs

The level of knowledge on lifestyle-related risk factors and preventive measures for CVD was low in both groups at baseline. Only 15.4% of the intervention and 7.2% of the control group knew the major modifiable risk factors of CVD. Most of the respondents in each group had a low level of knowledge of tobacco smoking, excessive salt, sugar, and alcohol intake, consumption of processed/fast foods, and being overweight/obese as CVD risk factors at baseline. Although most of the respondents believed that CVD was preventable, the majority had a low level of knowledge of the specific preventive measures of CVD. Most did not know the recommended daily intake of salt and sugar. Furthermore, the majority of the respondents in each group had a low level of knowledge of the benefits of fruit and vegetable intake and physical activity for CVD prevention. Overall, most of the respondents had a low level of knowledge of the risk factors and preventive measures of CVD at the baseline.

The baseline findings underscore an overwhelming lack of awareness of CVD risk factors and prevention measures in

Table 3. Respondents' Level of Knowledge of CVDs-Related Lifestyle Preventive Measures before and after the Intervention (*n*, %).

	Baseline					End-line				
Variables	Intervention	Control	X^2 value	*df*	*p*-value	Intervention	Control	X^2 value	*df*	*p*-value
Knowledge of whether CVDs (hypertension and diabetes) are preventable										
Yes	138 (88.5)	126 (91.3)	0.65	1.00	.422	152 (97.4)	126 (91.3)	5.35	1	.021
No	18 (11.5)	12 (8.7)				4 (2.6)	12 (8.7)			
Knowledge of preventive measures for CVDs (hypertension and diabetes)										
High	31 (19.9)	9 (6.5)	11.44	2.00	.003	121 (77.6)	25 (18.1)	103.54	2	.000
Moderate	29 (18.6)	34 (24.6)				13 (8.3)	44 (31.9)			
Low	96 (61.5)	95 (68.8)				22 (14.1)	69 (50.0)			
Knowledge of the daily recommended amount of salt intake (teaspoons)										
Correct response	33 (21.2)	17 (12.3)	4.05	1.00	.044	104 (66.7)	18 (13.0)	86.73	1	.000
Wrong response	123 (78.8)	121 (87.7)				52 (33.3)	120 (87.0)			
Knowledge of the daily recommended amount of sugar intake (teaspoons)										
Correct response	2 (1.3)	7 (5.1)	3.55	1.00	.060	114 (73.1)	25 (18.1)	88.74	1	.000
Wrong response	154 (98.7)	131 (94.9)				42 (26.9)	113 (81.9)			
Knowledge of the importance of fruits and vegetables consumption toward CVD prevention										
High	28 (17.9)	20 (14.5)	0.77	2.00	.682	114 (73.1)	55 (39,9)			
Moderate	29 (18.6)	29 (21.0)				22 (14.1)	12 (8.7)	51.21	2	.000
Low	99 (63.5)	89 (64.5)				20 (12.8)	71 (51.4)			
Knowledge of benefits of participating in physical activity toward CVD prevention										
High	18 (11.5)	24 (17.4)	2.11	2.00	.349	96 (61.5)	49 (35.5)	31.16	2	.000
Moderate	44 (28.2)	38 (27.5)				38 (24.4)	31 (22.5)			
Low	94 (60.3)	76 (55.1)				22 (14.1)	58 (42.0)			
Overall level of knowledge on CVD lifestyle preventive measures										
High	10 (6.4)	5 (3.6)	0.48	2.00	.785	116 (74.4)	40 (29.0)	71.83	2	.000
Moderate	62 (39.7)	62 (44.9)				28 (17.9)	32 (23.2)			
Low	84 (53.8)	71 (51.4)				12 (7.7)	66 (47.8)			

Note. CVD = cardiovascular disease.

the studied population. A low level of awareness of CVDs has negative consequences on the outcome of a disease. For example, across Kenya, people's awareness involving CVD is very low. The majority of patients with HTN are being diagnosed too late when multiple organs are affected (Mohamed et al., 2018). This makes interventions less effective leading to a poor outcome of the diseases (Kitt et al., 2019). Certainly, this is an indication that prevention and early detection of CVDs are lacking and points to the need for designing targeted educational programs to increase the public's awareness of CVDs.

The baseline findings of the current study are consistent with several local and regional reports. Studies have shown that although CVDs are more common in many SSA countries, awareness and control measures remain critically low (Ataklte et al., 2015). A local study among HIV-positive patients found a low level of knowledge (mean score of 1.3 out of 10 points) on the major risk factors of CVDs (Temu et al., 2015). A cross-sectional study conducted in the informal settlements of Nairobi reported that the majority of respondents did not know excessive alcohol intake, smoking, and insufficient physical activity as risk factors for CVDs (Wekesah et al., 2019). Likewise, Hulzebosch et al. (2015) reported a low level of awareness of the control measures of HTN and type-2 diabetes in low-resourced settings in Nairobi, Kenya. Studies carried out in the semi-urban community in South Africa (Steyn et al., 2015), Cameroon (Aminde et al., 2017), Nigeria (Ikpeama et al., 2016), and a systematic review in the SSA (Boateng et al., 2017), reported that the majority of the studied population had a low level of knowledge on risk factors and preventive measures of CVDs. To reduce the burden of CVD and achieve better health outcomes in the SSA, population-based lifestyle interventions are highly recommended.

Effects of a Nurse-Led Intervention on Knowledge of the Modifiable Risk Factors and Preventive Measures of CVDs

There was a marked improvement in the level of knowledge of CVDs in favor of the intervention. The proportion of

people who scored a high level of knowledge on lifestyle-related risk factors of CVDs including tobacco smoking, consumption of processed/fast foods, taking excessive alcohol, salt, and sugar as well as being overweight/obese was significantly improved in the intervention relative to the control group at the end-line. Furthermore, the intervention group substantially scored a higher level of knowledge on the recommended lifestyle practices than the control group. For example, knowledge of the major modifiable CVD risk factors including tobacco smoking (from 28.8% to 74.4%), excessive alcohol consumption (from 29.5% to 70.5%), excessive salt (from 10.3% to 58.3%) and sugar (from 16.7% to 61.5%) intake, consumption of processed foods (from 19.9% to 65.4%), and knowledge on being overweight/obese (from 22.4% to 67.3%) significantly ($p < .001$) improved in intervention group at the end-line compared to the baseline.

Knowledge level on preventive measures of CVD including daily recommended amount of salt (from 21.2% to 66.7%) and sugar (from 1.3% to 73.1%) intake, importance of fruit and vegetable consumption (from 17.9% to 73.1%), and benefits of engaging in an adequate level of physical activity (from 11.5% to 61.5%) substantially improved in the intervention group at the end of the intervention relative to the baseline. Whereas, in the control group, there were no significant changes observed in the level of knowledge of CVD risk factors and preventive measures at the end-line compared to the baseline. The overall level of knowledge on the modifiable risk factors (78.2% vs. 30.4%; $p < .001$) and preventive measures (74.4% vs. 29.05; $p < .001$) of CVDs were markedly improved among individuals in the intervention group relative to those in the control arm at the end-line.

The end-line findings demonstrate that the nurse-led health education interventions were effective in improving participants' levels of knowledge of the risks and preventive measures of CVD. The improvement of the knowledge level of CVD risk factors and their preventive actions in the intervention group may provide a basis for the feasibility and effectiveness of community-based approaches as an effective measure of CVD risk reduction. Establishing a community's level of knowledge of CVD is a crucial step in designing prevention approaches to curb the rising burden of the disease. Hence, there is an immediate need to implement population-based health educational interventions to promote public awareness of risk factors and preventive actions for CVD. Implementation of population-based awareness creation strategies will encourage the public to achieve better CV health outcomes.

In line with our end-line findings, studies carried out in Egypt (Ibrahim et al., 2017) and Brazil (Fonseca et al., 2019) regarding dietary changes in adults found that the intervention group significantly scored a higher level of knowledge than the controls at the end-line relative to the baseline. Similarly, a community-based health education intervention on nutrition in adults with diabetes observed a significantly higher level of knowledge in the treatment group than in the controls (Vasconcelos et al., 2019). Likewise, a systematic review of community-based interventions for CVD prevention in LMICs showed a significant improvement in the population's knowledge of CVD risk factors and preventive practices (Ndejjo et al., 2021).

The Strength and Limitations of This Study

This study is strengthened by its randomized controlled trial design in which the findings are attributed to the nurse-led health education intervention and not by chance. This is the first study in Kenya that determined the effect of a nurse-led lifestyle intervention on knowledge of CVD risk factors and prevention measures in adults with MetS. This is a novel finding that can have a huge implication for the prevention and early management of cardio-metabolic disorders through nurses' and community health workers' involvement at the community level. However, the findings should be interpreted with some limitations. All the participants were recruited from Nairobi, the capital city of Kenya. Given the difference in socioeconomic and demographics, the findings may have limitations in generalizing to other communities. For future studies, a multicentered study design is recommended.

Implications for Nursing Practice

Given the increasing prevalence of CVDs and associated adverse effects, creating public awareness of the modifiable risk factors and prevention measures of CVD is crucial in nursing practice. The findings of the current study revealed that the level of knowledge of the modifiable risk factors and prevention measures of CVD markedly improved in adults with MetS. The health education package delivered was simple and appropriate to apply in nursing practice. The team recommends that nurses abreast themselves on current guidelines of CVD prevention and apply them in routine care for patients with cardio-metabolic abnormalities.

Conclusion

The level of knowledge regarding risks and preventive actions of CVD was very low at the baseline. The nurse-led health education intervention successfully improved the level of knowledge on CVD risk factors and preventive measures. There was a marked improvement in the level of knowledge on CVD risk factors and prevention measures in favor of the nurse-led health education intervention. The findings demonstrate the feasibility and effectiveness of a nurse-led intervention as a proactive strategy for the prevention and control of CVD in low-income settings. Population-based awareness creation strategy on the modifiable risks of CVD such as

intake of unhealthy diets, harmful use of alcohol, smoking and sedentary lifestyle, is highly recommended.

Acknowledgments

We sincerely appreciate all the participants of the study for their time, patience and cooperation during the data collection and follow-up period. Further appreciation goes to the management of St Mary's Mission Hospital for granting us to conduct the research.

Authors' Contributions

OT and SK conceived and designed the study protocol as well as did a literature review. OT participated in data acquisition, data analysis and drafting of the manuscript. SK and WM reviewed and revised the manuscript. All the authors read and approved the final manuscript.

ORCID iD

Okubatsion Tekeste Okube https://orcid.org/0000-0001-5225-4836

Data Availability

The data used to produce this manuscript is available. The corresponding author can be contacted for any queries.

Ethical Consideration

The study was approved by the University of Nairobi-Kenyatta National Hospital Ethical Review Committee (Approval number: P430.07/2017). A permit to conduct this research was granted from the National Commission for Science, Technology and Innovation (NACOSTI; Permit No. NACOSTI/P/18/09156/22152). Permission was granted by the administration of the hospital where the study was conducted. All the participants provided their consent prior data collection.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

References

Albarqouni, L., Smenes, K., Meinertz, T., Schunkert, H., Fang, X., Ronel, J., & Ladwig, K. H. (2016). Patients' knowledge about symptoms and adequate behaviour during acute myocardial infarction and its impact on delay time: Findings from the multicentre MEDEA study. *Patient Education and Counseling*, *99*(11), 1845–1851. https://doi.org/10.1016/j.pec.2016.06.007

Alberti, K. G., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., & Smith, S. C. Jr (2009). Harmonizing the metabolic syndrome: A joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. *Circulation*, *120*(16), 1640–1645. https://doi.org/10.1161/CIRCULATIONAHA.109.192644

Aminde, L. N., Takah, N., Ngwasiri, C., Noubiap, J. J., Tindong, M., Dzudie, A., & Veerman, J. L. (2017). Population awareness of cardiovascular disease and its risk factors in Buea, Cameroon. *BMC Public Health*, *17*, 1–10. https://doi.org/DOI 10.1186/s12889-017-4477-3

Ataklte, F., Erqou, S., Kaptoge, S., Taye, B., Echouffo-Tcheugui, J. B., & Kengne, A. P. (2015). Burden of undiagnosed hypertension in sub-Saharan Africa: A systematic review and meta-analysis. *Hypertension*, *65*(2), 291–298. https://doi.org/10.1161/HYPERTENSIONAHA.114.04394

Azahar, N. M. Z. M., Krishnapillai, A. D. S., Zaini, N. H., & Yusoff, K. (2017). Risk perception of cardiovascular diseases among individuals with hypertension in rural Malaysia. *Heart Asia*, *9*(2), 1–4. https://doi.org/10.1136/heartasia-2016-010864

Boateng, D., Wekesah, F., Browne, J. L., Agyemang, C., Agyei-Baffour, P., Aikins, A. D. G., & Klipstein-Grobusch, K. (2017). Knowledge and awareness of and perception towards cardiovascular disease risk in sub-Saharan Africa: A systematic review. *PloS One*, *12*(12), e0189264. https://doi.org/10.1371/journal.pone.0189264

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., & Friedenreich, C. M. (2020). World health organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955

Checkley, W., Ghannem, H., Irazola, V., Kimaiyo, S., Levitt, N. S., Miranda, J. J., & of Excellence, C. (2014). Management of NCD in low- and middle-income countries. *Global Heart*, *9*(4), 431–443. https://doi.org/10.1016/j.gheart.2014.11.003

Desgroppes, A., & Taupin, S. (2011). Kibera: The biggest slum in Africa? *Les Cahiers D'Afrique de L'Est/The East African Review*, *44*, 23–33. https://doi.org/10.4000/eastafrica.521

Fonseca, L. G., Bertolin, M. N. T., Gubert, M. B., & da Silva, E. F. (2019). Effects of a nutritional intervention using pictorial representations for promoting knowledge and practices of healthy eating among Brazilian adolescents. *PLoS One*, *14*(3), e0213277. https://doi.org/10.1371/journal.pone.0213277

Fottrell, E., Ahmed, N., Morrison, J., Kuddus, A., Shaha, S. K., King, C., & Azad, K. (2019). Community groups or mobile phone messaging to prevent and control type 2 diabetes and intermediate hyperglycaemia in Bangladesh (DMagic): A cluster-randomised controlled trial. *The Lancet Diabetes & Endocrinology*, *7*(3), 200–212. https://doi.org/https://doi.org/10.1016/S2213-8587(19)30001-4

Hamid, S., Groot, W., & Pavlova, M. (2019). Trends in cardiovascular diseases and associated risks in sub-Saharan Africa: A review of the evidence for Ghana, Nigeria, South Africa, Sudan and Tanzania. *The Aging Male*, *22*(3), 169–176. https://doi.org/10.1080/13685538.2019.1582621

Hayman, L. L., Berra, K., Fletcher, B. J., & Houston Miller, N. (2015). The role of nurses in promoting cardiovascular health worldwide: The global cardiovascular nursing leadership forum. *Journal of the American College of Cardiology*, *66*(7), 864–866. https://doi.org/10.1016/j.jacc.2015.06.1319

Hill, J., Peer, N., Oldenburg, B., & Kengne, A. P. (2017). Roles, responsibilities and characteristics of lay community health

workers involved in diabetes prevention programmes: A systematic review. *PLoS One*, *12*(12), e0189069. https://doi.org/10.1371/journal.pone.0189069

Hulzebosch, A., van de Vijver, S., Oti, S. O., Egondi, T., & Kyobutungi, C. (2015). Profile of people with hypertension in Nairobi's slums: A descriptive study. *Globalization and Health*, *11*, 1–7. https://doi.org/10.1186/s12992-015-0112-1

Ibrahim, H. A. F., El Sayed, H. A. E., & Abd El-aal, E. M. (2017). Diet behavior modification of pregnant woman with iron deficiency anemia using construct of the trans-theoretical model: A theory-based study. *IOSR Journal of Nursing and Health Science*, *6*(3), 1–7. https://doi.org/10.9790/1959-0603067285

Ignatowicz, A., Odland, M. L., Bockarie, T., Wurie, H., Ansumana, R., Kelly, A. H., & Davies, J. (2020). Knowledge and understanding of cardiovascular disease risk factors in Sierra Leone: A qualitative study of patients' and community leaders' perceptions. *BMJ open*, *10*(12), e038523. https://doi.org/10.1136/bmjopen-2020-038523

Ikpeama, O. J., Onuzulike, N. O., & Ikpeama, C. A. (2016). Knowledge of risk factors and preventive measures of hypertension among adults in Sokoto metropolis. *Sokoto Journal of Medical Laboratory Science (SJMLS)*, *1*(2), 32–57.

Imes, C. C., & Lewis, F. M. (2014). Family history of cardiovascular disease, perceived cardiovascular disease risk, and health-related behavior: A review of the literature. *The Journal of Cardiovascular Nursing*, *29*(2), 108–129. https://doi.org/10.1097/JCN.0b013e31827db5eb

Jagannathan, R., Patel, S. A., Ali, M. K., & Narayan, K. M. V. (2019). Global updates on cardiovascular disease mortality trends and attribution of traditional risk factors. *Current Diabetes Reports*, *19*(7), 44. https://doi.org/10.1007/s11892-019-1161-2

Kenya Diabetes Prevention Brochure. (2015). Division of Non-Communicable Diseases. Ministry of Public Health and Sanitation. https://www.worlddiabetesfoundation.org/files/kenya-diabetes-prevention-brochure.

Kenya Ministry of Health. (2018). Accelerating Cardiovascular Health and Care in Kenya. Roadmap to Reducing Cardiovascular Mortality through Hypertension Management. A partnership of the World Heart Federation and Access Accelerated (AA) Report, 1-4. https://world-heart-federation.org/wp-content.

Khetan, A. K., Purushothaman, R., Chami, T., Hejjaji, V., Mohan, S. K. M., Josephson, R. A., & Webel, A. R. (2017). The effectiveness of community health workers for CVD prevention in LMIC. *Global Heart*, *12*(3), 233–243. https://doi.org/10.1016/j.gheart.2016.07.001

Kimani, S., Mirie, W., Chege, M., Okube, O. T., & Muniu, S. (2019). Association of lifestyle modification and pharmacological adherence on blood pressure control among patients with hypertension at Kenyatta National Hospital, Kenya: A cross-sectional study. *BMJ Open*, *9*(1), e023995. https://doi.org/10.1136/bmjopen-2018-023995

Kitt, J., Fox, R., Tucker, K. L., & McManus, R. J. (2019). New approaches in hypertension management: A review of current and developing technologies and their potential impact on hypertension care. *Current Hypertension Reports*, *21*, 1–8. https://doi.org/10.1007/s11906-019-0949-4

McKenzie, J. F., Neiger, B. L., & Thackeray, R. (2022). Planning a health promotion program. In Jones, & Bartlett Learning (Eds.), *Planning, implementing and evaluating health promotion programs* (8th ed., pp. 6–7, 25). Pearson. ISBN: 1284262375, 9781284262377.

Mensah, G. A., Sampson, U. K., Roth, G. A., Forouzanfar, M. H., Naghavi, M., Murray, C. J., & Feigin, V. L. (2015). 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*, *26*(2 H3Africa Suppl), S6–S10. https://doi.org/10.5830/CVJA-2015-036

Mensah, G. A., Wei, G. S., Sorlie, P. D., Fine, L. J., Rosenberg, Y., Kaufmann, P. G., Mussolino, M. E., Hsu, L. L., Addou, E., Engelgau, M. M., & Gordon, D. (2017). Decline in cardiovascular mortality: Possible causes and implications. *Circulation Research*, *120*(2), 366–380. https://doi.org/10.1161/CIRCRESAHA.116.309115

Mohamed, S. F., Mutua, M. K., Wamai, R., Wekesah, F., Haregu, T., Juma, P., & Ogola, E. (2018). Prevalence, awareness, treatment and control of hypertension and their determinants: Results from a national survey in Kenya. *BMC Public Health*, *18*(3), 1–10. https://doi.org/10.1186/s12889-018-6052-y

Muhihi, A. J., Anaeli, A., Mpembeni, R. N. M., Sunguya, B. F., Leyna, G., Kakoko, D., Kessy, A. T., Sando, M. M., Njelekela, M., & Urassa, D. P. (2020). Public knowledge of risk factors and warning signs for cardiovascular disease among young and middle-aged adults in rural Tanzania. *BMC Public Health*, *20*(1), 1832. https://doi.org/10.1186/s12889-020-09956-z

Ndejjo, R., Hassen, H. Y., Wanyenze, R. K., Musoke, D., Nuwaha, F., Abrams, S., Bastiaens, H., & Musinguzi, G. (2021). Community-based interventions for cardiovascular disease prevention in low-and middle-income countries: A systematic review. *Public Health Reviews*, *42*, 1604018. https://doi.org/10.3389/phrs.2021.1604018

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M., Achoki, T., AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., & Guzman, N. A., … E. Gakidou (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the global burden of disease study 2013. *Lancet (London, England)*, *384*(9945), 766–781. https://doi.org/10.1016/S0140-6736(14)60460-8

Ofori-Asenso, R., & Garcia, D. (2016). Cardiovascular diseases in Ghana within the context of globalization. *Cardiovascular Diagnosis and Therapy*, *6*(1), 67. https://doi.org/10.3978/j.issn.2223-3652.2015.09.02

Okube, O. T., Kimani, S., & Mirie, W. (2022). Community-based lifestyle intervention improves metabolic syndrome and related markers among Kenyan adults. *Journal of Diabetes & Metabolic Disorders*, *21*(1), 607–621. https://doi.org/10.1007/s40200-022-01023-1

Okube, O. T., Kimani, S., & Waithira, M. (2020). Association of dietary patterns and practices on metabolic syndrome in adults with central obesity attending a mission hospital in Kenya: A cross-sectional study. *BMJ Open*, *10*(10), e039131. https://doi.org/10.1136/bmjopen-2020-039131

Onvani, S., Haghighatdoost, F., & Azadbakht, L. (2015). Dietary approach to stop hypertension (DASH): Diet components may be related to lower prevalence of different kinds of cancer: A review on the related documents. *Journal of Research in*

Medical Sciences: The Official Journal of Isfahan University of Medical Sciences, *20*(7), 707–713. https://doi.org/10.4103/1735-1995.166233

Rosas, L. G., Lv, N., Xiao, L., Lewis, M. A., Zavella, P., Kramer, M. K., Luna, V., & Ma, J. (2016). Evaluation of a culturally-adapted lifestyle intervention to treat elevated cardiometabolic risk of Latino adults in primary care (Vida Sana): A randomized controlled trial. *Contemporary Clinical Trials*, *48*, 30–40. https://doi.org/10.1016/j.cct.2016.03.003

Roth, G. A., Forouzanfar, M. H., Moran, A. E., Barber, R., Nguyen, G., Feigin, V. L., & Murray, C. J. (2015). Demographic and epidemiologic drivers of global cardiovascular mortality. *New England Journal of Medicine*, *372*(14), 1333–1341. https://doi.org/10.1056/NEJMoa1406656

Roth, G. A., Mensah, G. A., Johnson, C. O., Addolorato, G., Ammirati, E., Baddour, L. M., Barengo, N. C., Beaton, A. Z., Benjamin, E. J., Benziger, C. P., Bonny, A., Brauer, M., Brodmann, M., Cahill, T. J., Carapetis, J. R., Catapano, A. L., Chugh, S. S., Cooper, L. T., Coresh, J., & Wubishet, B. L. (2020). Global burden of cardiovascular diseases and risk factors, 1990-2019: Update from the GBD 2019 study. *Journal of the American College of Cardiology*, *76*(25), 2982–3021. https://doi.org/10.1016/j.jacc.2020.11.010

Silverman, A. L., Herzog, A. A., & Silverman, D. I. (2019). Hearts and minds: Stress, anxiety, and depression: Unsung risk factors for cardiovascular disease. *Cardiology in Review*, *27*(4), 202–207. https://doi.org/10.1097/CRD.0000000000000228

Steyn, K., Levitt, N., Surka, S., Gaziano, T. A., Levitt, N., & Everett-Murphy, K. (2015). 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 Journal of Primary Health Care and Family Medicine*, *7*(1), 1–8. https://hdl.handle.net/10520/EJC179195

Temu, T. M., Kirui, N., Wanjalla, C., Ndungu, A. M., Kamano, J. H., Inui, T. S., & Bloomfield, G. S. (2015). Cardiovascular health knowledge and preventive practices in people living with HIV in Kenya. *BMC Infectious Diseases*, *15*(1), 1–8. https://doi.org/10.1186/s12879-015-1157-8

Van de Vijver, S., Oti, S., Addo, J., de Graft-Aikins, A., & Agyemang, C. (2015). Review of community-based interventions for prevention of cardiovascular diseases in low- and middle-income countries. *Ethnicity & Health*, *17*(6), 651–676. https://doi.org/10.1080/13557858.2012.754409

Vasconcelos, C., Almeida, A., Cabral, M., Ramos, E., & Mendes, R. (2019). The impact of a community-based food education program on nutrition-related knowledge in middle-aged and older patients with type 2 diabetes: Results of a pilot randomized controlled trial. *International Journal of Environmental Research and Public Health*, *16*(13), 2403. https://doi.org/10.3390/ijerph16132403

Wahab, K. W., Kayode, O. O., & Musa, O. I. (2015). Knowledge of stroke risk factors among Nigerians at high risk. *Journal of Stroke and Cerebrovascular Diseases*, *24*(1), 125–129. https://doi.org/10.1016/j.jstrokecerebrovasdis.2014.07.053

Wekesah, F. M., Klipstein-Grobusch, K., Grobbee, D. E., Kadengye, D., Asiki, G., & Kyobutungi, C. K. (2020). Determinants of mortality from cardiovascular disease in the slums of Nairobi, Kenya. *Global Heart*, *15*(1), 33. https://doi.org/10.5334/gh.787

Wekesah, F. M., Kyobutungi, C., Grobbee, D. E., & Klipstein-Grobusch, K. (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. https://doi.org/10.1136/bmjopen-2018-026852

World Health Organization. (2017). *The WHO STEPwise approach to noncommunicable disease risk factor surveillance (STEPS)*. World Health Organization. https://iris.paho.org/handle/10665.2/56889

World Health Organization. (2019). *Cardiovascular diseases*. World Health Organization.Fact sheet. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

World Health Organization. (2022). *Non-communicable Diseases*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

World Health Organization regional committee for Africa. (2021). *Non-communicable Diseases*. World Health Organization. https://www.afro.who.int/health-topics/noncommunicable-diseases

Yuyun, M. F., Sliwa, K., Kengne, A. P., Mocumbi, A. O., & Bukhman, G. (2020). Cardiovascular diseases in sub-saharan Africa compared to high-income countries: An epidemiological perspective. *Global Heart*, *15*(1), 15. https://doi.org/10.5334/gh.403

Appendix I

Box 1. Health education intervention package on lifestyle modification for adults with MetS.

➢ **Diet**

- **Consider the DASH diet** to reduce portion sizes, calorie intake and increase vegetable and fruit intake. Fill half of your meal plate with vegetable and fruit, and the remaining half with carbohydrates and plant-based proteins like legumes, soy products, nuts, and seeds proteins.
- **Avoid processed/fast foods**: They are full of processed sugars, salt, refined carbohydrate, saturated fat and low in whole grains. Limit fatty foods, dairy fat, and cooking oil.
- **Reduce fat intake:** Use low-fat dairy products, vegetable oil, avoid fatty foods.
- **Reduce salt intake:** Restrict salt intake to less than 1 teaspoon (5grams) per day. Avoid adding salts on meals, read labels for salt content. Reduce salt when cooking, limit processed and fast foods.
- **Reduce sugar intake**: Restrict sugar intake to less 5 teaspoons in a day. Avoid sweetened-beverages**.** Replace soda with water or fresh juice.
- **Choose low glycemic index foods**: Consider whole grain cereals, brown bread and rice, legumes, fruit, vegetables.
- **Use vegetables or olive oils for cooking:** Use sunflower oil, soybean oil, olive oil.
- **Increase consumption of fruit and vegetable**: Consume 4-5 servings of fruit and vegetable every day. 1 serving is equivalent to 1 orange or apple or mango or banana or 3 tablespoons of cooked vegetables.
- **Increase fibre intake:** Consume 4-5 servings of legumes (beans, lentils, chickpeas, peas), and nuts a week to increase fibre intake.
- **Increase** time interval between taking dinner and sleeping, minimum of 2 hours.

➢ **Alcohol:** If you drink, limit it to a maximum of 1 standard drink for women and 2 for men in a day.

➢ **Physical activity**: Reduce periods of inactivity throughout the day. Participate for at least 150 minutes/week of moderate-intensity physical activity (brisk walking, digging, jogging, stairs climbing, cycling, housework) (5 days of 30 minutes a week). OR at least 75 minutes/week of vigorous-intensity physical activity (running, jogging, rope jumping, playing football/valley ball, digging, swimming) (3 days of 25 minutes a week).

➢ **Stop smoking!**

Appendix II

Overall score of knowledge on lifestyle risk factors of cardiovascular diseases

The following 7 elements were used to assess the overall score of knowledge on modifiable risk factors of CVDs. The scoring system was calculated as showing below.

- Knowledge on risk factors of **hypertension** and type 2 **diabetes** (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge on **tobacco smoking** as CVD risk factor (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge on **excessive alcohol consumption** as CVD risk factor (≤ 1 correct response $= 1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge on **excessive salt intake** as CVD risk factor (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge on **excessive sugar intake** as CVD risk factor (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge of **processed/fast** food consumption as CVD risk factor (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge of being **overweight/obese** as CVD risk factor CVDs (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$).

The maximum attainable total score was 21 and minimum score was 7. A percentage score was generated and classified as low (<50%), moderate (50–74%), and high (≥75%).

Overall score of knowledge on preventive practices of cardiovascular diseases.

Knowledge of the respondents toward CVD-related preventive measures was assessed using six variables.

- Knowledge of whether hypertension and diabetes are preventable (incorrect response $= 1$; correct response $= 2$)
- Knowledge on preventive measures of hypertension and diabetes (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge of daily recommended amount of salt intake (incorrect response $= 1$; correct response $= 2$)
- Knowledge of daily recommended amount of sugar intake (incorrect response $= 1$; correct response $= 2$)
- Knowledge of the importance of fruits and vegetables consumption toward CVD prevention (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)
- Knowledge of benefits of engaging in physical activities toward CVD prevention (≤ 1 correct response $=1$; 2 correct responses $= 2$; ≥ 3 correct responses $= 3$)

The maximum attainable total score was 15 and minimum score was 6. A percentage score was generated and classified as low (<50%), moderate (50–74%), and high (≥75%).