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ORIGINAL RESEARCH

Enhancing Public Knowledge of Risk Factors and Warning Signs for Stroke and Heart Attack Through Home-Based Community Health Worker Interventions: A Cluster Randomized Trial

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Purpose: Enhancing community knowledge about risk factors and warning signs for stroke and heart attack is important for effective prevention and control. This study evaluated the effects of home-based health education and healthy lifestyle interventions delivered by community health workers (CHWs) on knowledge of risk factors and warning signs for stroke and heart attack.

Patients and Methods: We conducted a 1:1 cluster-randomized trial in twelve villages in rural Morogoro, Tanzania. Participants in the intervention received monthly home-based health education and healthy lifestyle promotion from CHWs for 6 months, followed by bi-monthly follow-up visits until 12 months. Participants in the control group followed the standard of care. Knowledge regarding risk factors and warning signs for stroke and heart attack was assessed through two independent cross-sectional surveys, one before and another after the intervention. The analyses were adjusted for baseline factors.

Results: Both intervention and control groups experienced an increase in mean knowledge scores between baseline and evaluation survey, with a significant increase in the intervention group. Mean knowledge for risk factors increased by 4.0 (SD 2.7) in the intervention compared to 2.5 (SD 3.1) in the control group. That of warning signs increased by 3.1 (SD 2.4) in the intervention group compared to 2.4 (SD 2.8) in the control group. Overall, mean knowledge of risk factors and warning signs increased by 7.1 (SD 4.3) in the intervention group and by 4.9 (SD 5.3) in the control group. After adjusting for selected baseline characteristics, participants in the intervention group experienced a 2.1 greater increase in mean knowledge of risk factors and warning signs [difference in differences 2.1 (95% CI, 1.4 to 2.8)].

Conclusion: CHWs' home-delivered health education and healthy lifestyle promotion interventions resulted in a significant enhancement in knowledge of risk factors and warning signs for stroke and heart attack. These findings provide insight into the potential of CHW-led interventions in the prevention and control of stroke and heart attacks in Tanzania.

Clinical Trial Registration: Pan African Clinical Trial Registry (PACTR201801002959401).

Keywords: community health workers, health education, knowledge, stroke, heart attack

Introduction

Cardiovascular diseases (CVDs), including stroke and heart attack, have continued to pose a significant public health challenge globally.[1] In 2019, CVDs accounted for about one-third of all deaths worldwide.[2] In Africa, nearly 40% of

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deaths related to non-communicable diseases (NCDs) were due to CVDs.[3] Unlike many developing countries, where CVD rates have declined,[4,5] Africa has experienced close to a 50% increase in CVD burden in recent decades.[6] Projections indicate that deaths attributable to CVDs could reach as high as 35.6 million by 2050.[7] This alarming trend is exacerbated by rapid urbanization, aging populations, and unhealthy lifestyles, including smoking, excessive alcohol consumption, lack of physical activity, and poor diets rich in processed and calorie-dense foods.[8,9]

Although hypertensive strokes have been the primary cause of CVD-related mortality in Africa,[3] there is a growing incidence of heart attacks.[10] Stroke and heart attacks represent medical emergencies that necessitate timely recognition of symptoms and immediate intervention. Unfortunately, health systems in most African countries, particularly in rural areas, often lack adequate resources and infrastructure for effective diagnosis and timely management.[11] As a result, reliance on facility-based care alone is insufficient, especially in rural areas where access is limited and delayed care is common.[11]

In sub-Saharan Africa, awareness of risk factors associated with stroke and heart attack is notably low.[9,12] Around 50% of the population lacks adequate knowledge of these factors.[12] In Tanzania, recent studies conducted in urban areas of Dar es Salaam and Dodoma highlighted significant gaps in understanding the risk factors and warning signs associated with stroke and heart attack.[13,14] Raising the community's awareness of risk factors and warning signs for stroke and heart attack is crucial to developing effective prevention and control strategies. It also improves health-seeking behavior, enables early detection, and consequently improves overall health.[15]

Initiatives that focus on community-based strategies are essential, as they can enhance access to healthcare, promote health literacy, encourage physical activity, and foster healthier dietary practices at the community level.[16,17] Although low- and middle-income countries (LMICs) bear a significant economic and social burden from stroke and heart attack, only a few studies have been conducted to explore simple and affordable community-based interventions in these settings.[18–21] Guided by the Health Belief Model, we conducted a cluster-randomized trial to evaluate the impact of home-based health education and healthy lifestyle interventions delivered by community health workers (CHWs) on knowledge of risk factors and warning signs for stroke and heart attack in rural Morogoro, Tanzania. The health education messages focused on modifiable CVD risk factors, their deleterious effects on health, and how to reduce or prevent them. It was important for CHWs to understand people's beliefs and perceptions to provide tailored discussions that effectively motivate individuals to engage in healthier behaviors.

Materials and Methods

Study Design and Setting

We implemented a community-based, parallel-group, 1:1 cluster-randomized, non-blinded controlled trial with evaluations before and after the CHWs' intervention. The study was conducted in 12 villages in Kilombero and Ulanga districts of Morogoro, Tanzania.

Participants and Inclusion Criteria

We first conducted a baseline survey to evaluate knowledge and prevalence of risk factors for stroke and heart attack. Eligible participants for the baseline survey included adults (25–64 years old) who were permanent residents and had signed a written informed consent form. Individuals who were bedridden, experiencing severe mental illness, or were unable or unwilling to sign an informed consent were excluded. Participants identified as hypertensive during the baseline survey enrolled in the randomized trial.

Intervention Group

Trained CHWs conducted home visits to provide health education and promote a healthy lifestyle, aiming at increasing awareness of risk factors and warning signs for stroke and heart attack, and encouraging the adoption of healthier behaviors. These behaviors included maintaining healthy body weight, quitting smoking, limiting alcohol consumption, reducing salt intake, increasing consumption of fruits, vegetables, and whole grains, and use of vegetable-based cooking oil. CHWs assisted participants in setting realistic, achievable short-term behavior change goals tailored to their

individual needs. Home visits occurred monthly for the first 6 months, then every 2 months through the end of the 12-month intervention period. At each visit, CHWs followed a structured intervention guide to ensure consistent, high-quality care.

Control Group

Participants in the control group followed the standard of care, which involved referral to a local health facility for evaluation and management of hypertension. They did not benefit from home-based health education, healthy lifestyle promotion, or blood pressure monitoring during the study.

Sample Size and Power Calculation

Sample sizes were calculated separately for the baseline cross-sectional survey and for the intervention trial. For the baseline survey, calculations were based on the WHO STEP-wise approach to surveillance of risk factors for chronic disease,[22] using a 95% confidence interval, a 5% margin of error, and a 25.9% national prevalence of hypertension.[23] We applied a design of 1.2 to account for clustering, along with a 10% attrition rate. The target population was stratified by sex into four groups, yielding a final sample of 3,145. All participants identified as hypertensive during the baseline survey were subsequently enrolled in the cluster-randomized controlled trial.

For the intervention trial, the sample size was calculated to ensure 80% power to detect a minimum difference of 6.5 mmHg in mean systolic blood pressure between intervention and control groups, at a 5% significance level. The calculation assumed a standard deviation of 15 mmHg, an intra-cluster correlation of 0.03, and a 20% anticipated attrition rate, resulting in a requirement of 258 participants per arm, totaling 516 participants across the 12 villages. We included all participants with elevated baseline blood pressure. Thus, 848 participants were included, representing 164% of the sample size.

Sampling Procedures

We deployed a multi-stage sampling method, with villages serving as the primary sampling units. We stratified villages by district and, for each selected village, randomly selected 262 households. We used the next-birthday method to select one eligible adult from each household for an interview. Research assistants listed all eligible individuals aged 25–64 by their birth month in ascending order, from January to December, and picked the first person on the list.

Randomization and Blinding

The unit of randomization was a village. We randomly selected 12 villages (6 from each district) from a list of 38 villages with active CHWs. Within each district, villages were further grouped into two sets of three villages based on population size, type of health facility serving the village (health center or dispensary), and physical proximity. Simple randomization by coin flip was used to assign one set of villages to the intervention arm and another set to the control arm. Randomization was done by a statistician who was not involved in field activities. Both assessors and participants were blinded to intervention allocation at baseline, but not at follow-up.

Baseline Data Collection

A baseline cross-sectional survey was conducted to gather data on sociodemographic characteristics, knowledge, and prevalence of risk factors and warning signs for stroke and heart attack. Baseline data collection was conducted by an independent team of trained and experienced research assistants.

Sociodemographic Information

Collected sociodemographic data included age, gender, marital status, education level, and occupation. These variables were selected based on their prior use in population surveys in Tanzania.[24,25] Household-level data included asset ownership, housing characteristics, sources of water for domestic use and drinking, sources of fuel for cooking and lighting, and sanitation facilities.[25] We constructed a household wealth index using principal component analysis,[25] and categorized into quintiles to reflect relative socioeconomic status.

Assessment of Knowledge

We assessed knowledge using a questionnaire consisting of questions on knowledge of risk factors (10 items) and knowledge of warning signs for stroke and heart attack (9 items). The risk factors and warning signs assessed are summarized in Supplementary Table 1. Knowledge scores were assigned a value of 1 for a correct response and 0 for an incorrect response.

We summed the knowledge scores for each category. Based on total scores, the knowledge of risk factors was classified into four categories: good knowledge (7–10 points), moderate knowledge (4–6 points), poor knowledge (1–3 points), and not knowledgeable (0 points). Similarly, for warning signs, knowledge was classified into four categories: good knowledge (7–9 points), moderate knowledge (4–6 points), poor knowledge (1–3 points), and not knowledgeable (0 points). Adequate knowledge was defined as a combination of good and moderate knowledge categories. Cronbach's alpha test yielded coefficients of 0.826 for knowledge of risk factors and 0.782 for knowledge of warning signs, indicating that both scales were strongly reliable.[26]

Overall knowledge was analysed by summing total scores for risk factors and warning signs, with a maximum total score of 19 points. It was classified as good knowledge (≥14 points), moderate knowledge (8–13 points), poor knowledge (1–7 points), and not knowledgeable (0 points).

Behavioural CVD Risk Factors

Data on behavioral risk factors, including smoking, alcohol drinking, and unhealthy dietary habits, were collected using questions adapted from the WHO STEP-wise data collection tool, previously used in Tanzania.[24] Participants were asked about current and past smoking and alcohol consumption. The dietary assessment included consumption of fruits, vegetables, and whole grains, as well as the use of table salt and vegetable oil for cooking.

Physical Measurements

Blood pressure was measured using a digital BP machine (OMRON HEM-712C). For participants with high blood pressure, confirmatory measurements were taken on the following day. Participants with confirmed hypertension were referred to a local health facility for evaluation and treatment. Hypertension was defined as average systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg and/or current treatment with antihypertensive medications.[27] We measured body weight using a digital SECA scale to the nearest 0.1kg. We measured height using a portable stadiometer and recorded to the nearest 0.1cm. We then calculated body mass index (BMI) by dividing body weight by the square of height (kg/m^2). Overweight was defined as BMI ≥25kg/m^2 but <30kg/m^2, and obesity as BMI ≥30kg/m^2.[28]

Follow-up Survey

An independent team of data collectors conducted a follow-up survey at the end of the intervention to assess changes in prevalence and knowledge, thereby evaluating the effect of the CHWs' interventions. The participant flow from baseline to follow-up surveys is presented in Figure 1.

Study Monitoring and Quality Control

Given the nature of the study, a data safety monitoring board (DSMB) was not required. However, several quality control measures were put in place, including thorough training of the research staff and routine data quality checks. At each visit, CHWs followed a structured intervention guide to ensure consistent, high-quality delivery of the intended intervention. Routine spot checks and supervised visits were also conducted to ensure quality.

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics (SPSS Inc., Chicago, IL, USA) version 30 for Windows. Descriptive statistics were used to summarize participant characteristics, with continuous and categorical variables presented appropriately. Differences in participant characteristics for those who did not complete the follow-up survey were examined using an independent-samples *t*-test for continuous variables and a chi-square ($\chi 2$) test for categorical

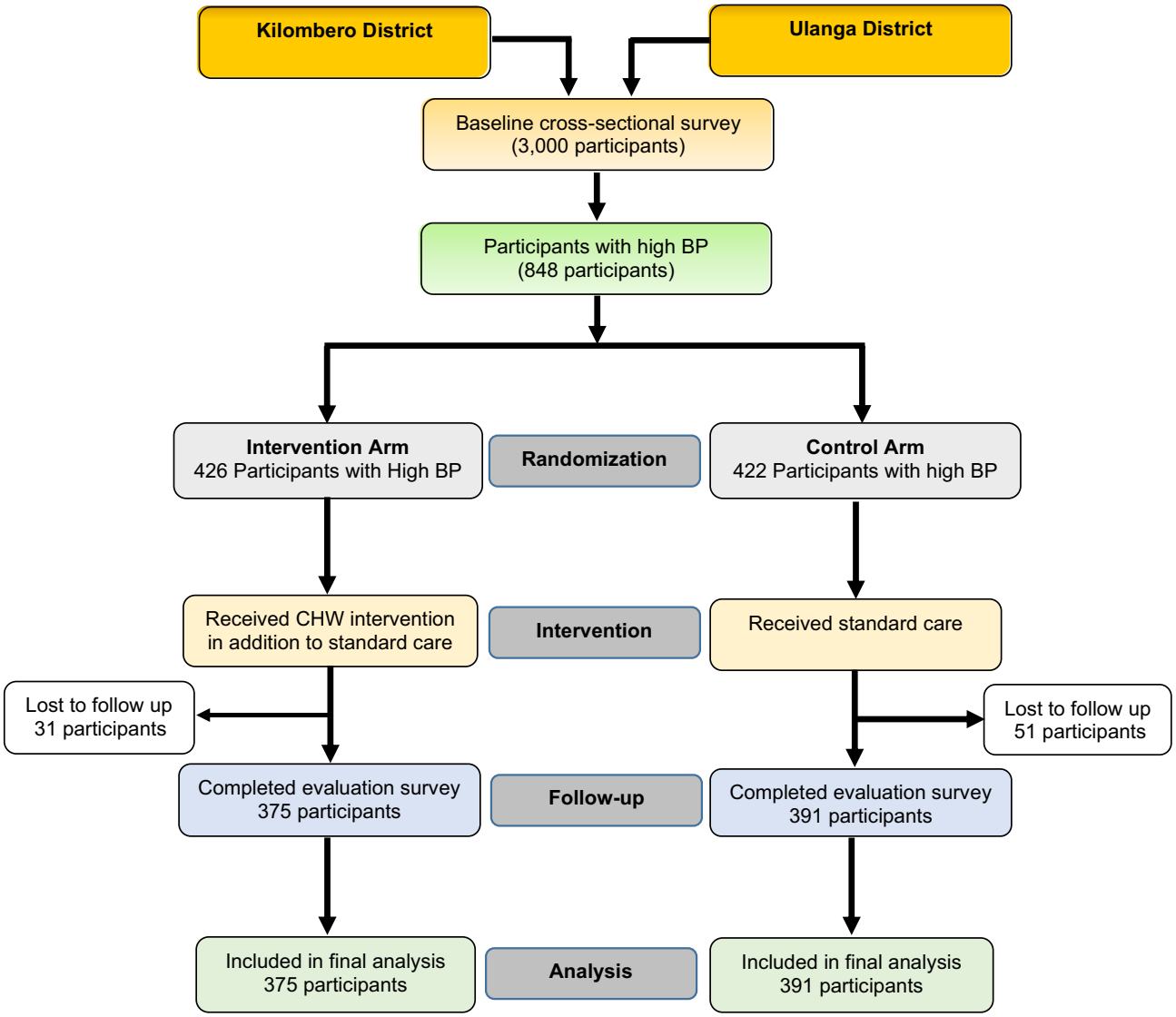

Figure 1 Flow diagram of the trial participants.

variables. Statistical analyses followed the intention-to-treat principle, in which participants were analysed in the groups to which they were assigned, regardless of whether they received the intervention.

Baseline knowledge comparisons between intervention and control groups were performed using Pearson's Chi-square test. Similar comparisons of knowledge between intervention and control groups were conducted again at follow-up. We calculated the mean knowledge scores for risk factors and warning signs in both the intervention and control groups. The effect of the CHWs' interventions on knowledge was assessed using the difference-in-differences (DID) method. We conducted a multilevel analysis using mixed-effects regression models to examine changes in mean knowledge scores. The base model included terms for the treatment group (intervention or control), the survey period (baseline or follow-up), and the treatment group-time interaction. The interaction term assessed whether the post-intervention difference between the intervention and control groups was significantly different from the pre-intervention difference. We included age, sex, education level, smoking status, use of raw table salt, baseline mean systolic BP, and baseline mean diastolic BP as fixed factors. In contrast, the village was included as a random effect. The intervention effect is reported as mean differences in knowledge scores with the corresponding 95% confidence intervals. We used a complete case analysis, excluding participants with missing data on the key outcome variables. We chose this

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approach because the proportion was so small and was assumed to be missing completely at random. Statistical significance was considered at a p-value of ≤0.05.

Results

Baseline Characteristics of the Study Participants

A total of 3,000 participants were surveyed at baseline, of whom 848 were identified as being hypertensive and subsequently enrolled in the cluster-randomized trial. During the follow-up survey, 766 participants with hypertension were contacted and included in the analysis of the effect of the CHWs' intervention on knowledge. A total of 82 participants (51 in the intervention and 31 in the control group) were lost to follow-up. The main reason for loss to follow-up in the evaluation survey was being temporarily away (moved to the farming area). Characteristics of participants lost to follow-up for the intervention and control groups are summarized in Supplementary Table 2.

A description of the participants analyzed is summarized in Table 1. The median age of participants was 46, and approximately 25% were aged 55 or older. A significant majority were females (73.4%), married (70.8%), had primary education (80.7%), and had farming as their main income-generating activity (93.2%). More than half (54.2%) were either overweight or obese. The mean systolic and diastolic BP were 150.8 mmHg and 98.5 mmHg, respectively. Only one-third of participants were aware of their hypertension status (32.0%), and among those aware, only 28.6% were taking antihypertensive medications.

Knowledge of Risk Factors

Knowledge of risk factors is displayed in Table 2 and Figure 2. At baseline, both intervention and control groups had relatively low levels of knowledge. At least a quarter (26.1% for intervention and 27.6% in the control) demonstrated a good

Table 1 Baseline Characteristics of Study Participants (N = 766)

Variable	Total (N=766)	Intervention (n = 375)	Control (n = 391)	*p*-value
Age (years) [median (IQR)]	46.0 [38.0–54.0]	46.0 [38.0–54.0]	46.0 [39.0–54.0]	0.848
Age Group (years), n (%)				
25-34	117 (15.3)	64 (17.1)	53 (13.6)	0.276
35-44	228 (29.8)	101 (26.9)	127 (32.5)	
45-54	232 (30.3)	118 (31.5)	114 (29.2)	
55-64	189 (24.7)	92 (24.5)	97 (24.8)	
Sex, n (%)				
Females	562 (73.4)	277 (73.9)	285 (72.9)	0.760
Marital Status, n (%)				
Married	542 (70.8)	256 (68.3)	286 (70.8)	0.138
Education Level, n (%)				
Primary Education	618 (80.7)	304 (81.1)	314 (80.7)	0.790
Occupation, n (%)				
Peasant	714 (93.2)	349 (93.1)	365 (93.4)	0.876
Current Smoker, n (%)				
Yes	46 (6.0)	21 (5.6)	25 (6.4)	0.644

(*Continued*)

Table 1 (Continued).

Variable	Total (N=766)	Intervention (n = 375)	Control (n = 391)	*p*-value
Current Alcohol Drinker, n (%)				
Yes	171 (22.3)	101 (26.9)	70 (17.9)	0.005
Adding Raw Salt to Cooked Food				
Always	131 (17.1)	81 (21.6)	50 (12.5)	<0.001
Blood Pressure (mmHg), mean (SD)				
Systolic BP	150.8 (20.30)	151.1 (19.64)	150.5 (20.94)	0.712
Diastolic BP	98.5 (10.82)	98.7 (11.03)	98.3 (10.63)	0.711
Aware of Hypertension Status, n (%)				
Yes	245 (32.0)	122 (49.8)	123 (50.2)	0.750
On Treatment for Hypertension, n (%) ‡				
Yes	70 (28.6)	29 (23.8)	41 (33.3)	0.098
Overweight or obese				
Yes	415 (54.2)	200 (53.3)	215 (55.0)	0.646
Socioeconomic Status				
Poorest	168 (21.9)	85 (22.7)	83 (21.2)	0.031
Poor	125 (16.3)	47 (12.5)	78 (19.9)	
Middle	142 (18.5)	65 (17.3)	77 (19.7)	
Rich	165 (21.5)	86 (22.9)	79 (20.2)	
Richest	166 (21.7)	92 (24.5)	74 (18.9)	

Notes: ‡Among those who were aware of their hypertension status.

understanding of risk factors. Stress (85.4%), obesity (67.6%), cholesterol (65.0%), and physical inactivity (60.7%) were the most frequently identified risk factors. At follow-up, the proportion of participants with good knowledge improved in both intervention and control groups (Figure 2). Except for stress and cholesterol, the proportion of participants who correctly identified risk factors at follow-up was significantly higher for intervention compared to control (p<0.001) (Table 2).

Knowledge of Warning Signs

Knowledge of warning signs is displayed in Table 2 and Figure 3. Knowledge of warning signs was also unsatisfactory at baseline for both intervention and control groups. Only one in five participants demonstrated good knowledge of warning signs. The frequently identified warning signs were shortness of breath (73.5%), loss of consciousness (64.5%), severe headache (64.4%), and dizziness (61.5%). The proportion of participants who correctly identified warning signs improved at follow-up (Figure 3). Except for sweating at rest and dizziness, which were not significant, knowledge of other warning signs improved significantly in the intervention group (p<0.05) (Table 2).

Effects of CHW Intervention on Knowledge

Finally, we compared changes in knowledge between the baseline and follow-up assessments to evaluate the impact of the CHW intervention on enhancing knowledge (Table 3). At baseline, the mean (standard deviation, SD) knowledge score for risk factors was 4.9 (2.5) in the intervention group and 4.4 (3.0) in the control group. At follow-up, the mean

Table 2 Knowledge of Risk Factors and Warning Signs for Cardiovascular Diseases Before and After Community Health Worker Intervention Among Participants with Hypertension (N = 766)

Identified Risk Factors for CVDs	Baseline		*p*-value	Follow-up		*p*-value
	Intervention	Control		Intervention	Control	
Old Age (n, %)	130 (34.7)	134 (34.3)	0.484	352 (93.9)	221 (56.5)	<0.001
Obesity (n, %)	260 (69.3)	258 (66.0)	0.181	366 (97.6)	359 (91.8)	<0.001
Hypertension (n, %)	150 (40.0)	154 (39.4)	0.460	339 (90.4)	257 (65.7)	<0.001
Diabetes Mellitus (n, %)	150 (40.0)	148 (37.9)	0.296	333 (88.8)	236 (60.4)	<0.001
Cholesterol (n, %)	259 (69.1)	239 (61.1)	0.013	347 (92.5)	368 (94.1)	0.231
Smoking (n, %)	94 (25.1)	120 (30.7)	0.049	295 (78.7)	175 (44.8)	<0.001
Alcohol Drinking (n, %)	104 (27.7)	111 (28.4)	0.452	313 (83.5)	193 (49.4)	<0.001
Physical Inactivity (n, %)	288 (76.8)	177 (45.3)	<0.001	367 (97.9)	336 (85.9)	<0.001
Family History of Stroke (n, %)	86 (22.9)	65 (16.6)	0.018	282 (75.2)	171 (43.7)	<0.001
Stress (n, %)	336 (89.6)	318 (81.3)	0.001	367 (97.9)	383 (98.0)	0.566
Good Knowledge of CVD Risk Factors (n, %)	98 (26.1)	108 (27.6)	0.684	347 (92.5)	231 (59.1)	<0.001
Identified Warning Signs for CVDs						
Severe Headache (n, %)	253 (67.5)	240 (61.4)	<0.001	361 (96.3)	345 (88.2)	<0.001
Chest Pain (n, %)	147 (39.2)	217 (55.5)	0.111	344 (91.7)	340 (87.0)	0.021
Shortness of Breath (n, %)	316 (84.3)	247 (63.2)	0.540	373 (99.5)	362 (92.6)	<0.001
Sweating While at Rest (n, %)	171 (45.6)	153 (39.1)	0.002	279 (74.4)	283 (72.4)	0.291
Vomiting (n, %)	33 (8.8)	53 (13.6)	0.234	225 (60.0)	99 (25.3)	<0.001
Pain in the Jaw or Neck (n, %)	43 (11.5)	53 (13.6)	0.162	262 (69.9)	86 (22.0)	<0.001
Pain in the Arms/Shoulder (n, %)	191 (50.9)	179 (45.8)	0.099	323 (86.1)	264 (67.5)	<0.001
Loss of Consciousness (n, %)	291 (77.6)	203 (51.9)	0.190	368 (98.1)	350 (89.5)	<0.001
Dizziness (n, %)	272 (72.5)	199 (50.9)	0.581	340 (90.7)	351 (89.8)	0.384
Good Knowledge of Warning Signs (n, %)	72 (19.2)	81 (20.7)	0.651	310 (82.7)	200 (51.2)	<0.001

knowledge score was 9.0 (1.5) for the intervention group and 6.9 (2.1) for the control group. The mean knowledge score for risk factors increased by 4.0 (2.7) among intervention participants and by 2.5 (3.1) among control participants. After adjusting for baseline confounders, participants in the intervention group experienced a 1.5 greater increase in mean knowledge score for risk factors than in the control group [difference in differences 1.5 (95% CI: 1.1 to 1.9)] (Table 3).

Regarding warning signs, the mean baseline knowledge score was 4.6 (2.2) in the intervention group and 3.9 (2.7) in the control group. At follow-up, the mean knowledge score increased to 7.7 (1.4) in the intervention group and to 6.3 (1.8) in the control group. The mean knowledge score increased by 3.1 (2.4) in the intervention group and by 2.4 (2.8) in the control group. Similarly, participants in the intervention group experienced a 0.7 greater increase in mean knowledge score for warning signs than in the control group [difference in differences 0.7 (95% CI: 0.3 to 1.0)] (Table 3).

Overall, the mean knowledge increased by 7.1 (4.3) points in the intervention group and by 4.9 (5.3) points in the control group. There was a 2.1 greater increase in mean knowledge score for participants who received CHW intervention compared to those who did not [difference in differences 2.1 (95% CI: 1.4 to 2.8)] (Table 3). We did not find significant differences in knowledge gains by age, gender, or education level.

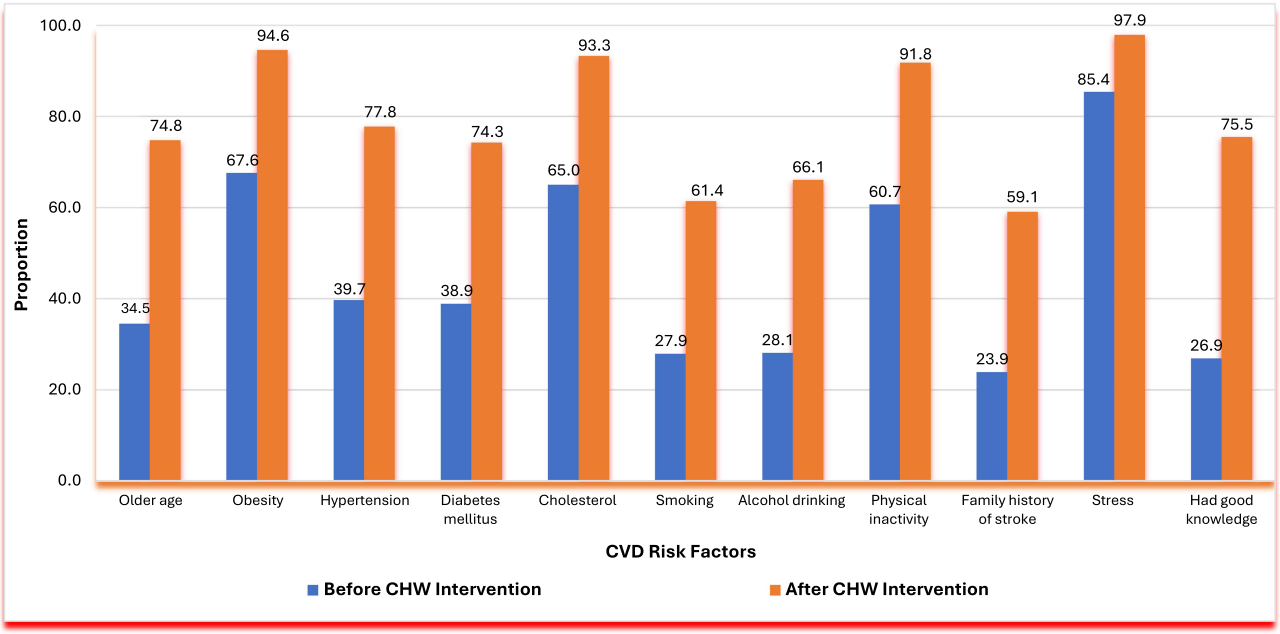

Figure 2 Knowledge of Risk Factors for Stroke and Heart Attack Before CHW Intervention (Baseline) and After CHW Intervention (Follow-up).

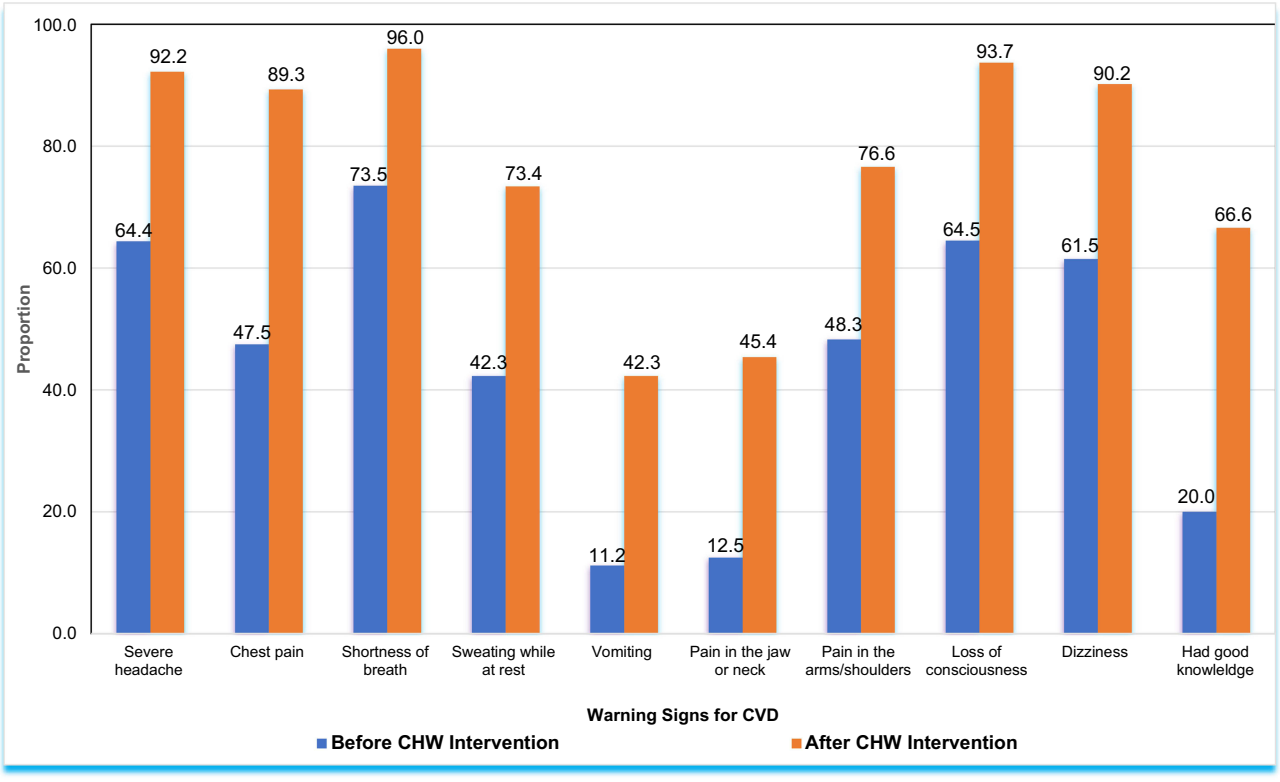

Figure 3 Knowledge of Warning Signs for Stroke and Heart Attack Before CHW Intervention (Baseline) and After CHW Intervention (Follow-up).

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Table 3 Changes in CVD Knowledge Scores Among Study Participants with Hypertension (N = 766)

CVD Knowledge	Intervention (n = 375)	Control (n = 391)	Intervention Effect (Difference-in-Differences for Mean Knowledge Scores)			
	Mean (SD)[†]	Mean (SD)[†]	Unadjusted	*p*-value	Adjusted[‡]	*p*-value
Knowledge of Risk Factors						
Mean Knowledge Score at Follow-up	9.0 (1.5)	6.9 (2.1)				
Mean Knowledge Score at Baseline	4.9 (2.5)	4.4 (3.0)				
Change in Knowledge Score	4.0 (2.7)	2.5 (3.1)	1.5 (1.1–1.9)	<0.001	1.5 (1.1–1.9)	<0.001
Knowledge of Warning Signs						
Mean Knowledge Score at Follow-up	7.7 (1.4)	6.3 (1.8)				
Mean Knowledge Score at Baseline	4.6 (2.2)	3.9 (2.7)				
Change in Knowledge Score	3.1 (2.4)	2.4 (2.8)	0.7 (0.3–1.1)	<0.001	0.7 (0.3–1.0)	<0.001
Knowledge of Risk Factors and Warning Signs						
Mean Knowledge Score at Follow-up	16.6 (2.2)	13.2 (3.5)				
Mean Knowledge Score at Baseline	9.5 (4.1)	8.4 (5.2)				
Change in Knowledge Score	7.1 (4.3)	4.9 (5.3)	2.2 (1.5–2.9)	<0.001	2.1 (1.4–2.8)	<0.001

Notes: [†]Within-group change over time. [‡]Adjusted mean difference (intervention minus control) with 95% CI between intervention and control group from baseline to 12 months; adjusted for age, sex, education level, smoking status, use of raw table salt, and baseline systolic and diastolic blood pressure in a linear mixed-effect model with a random effect for village.

Discussion

This cluster-randomized controlled trial aimed to address a critical gap in public knowledge regarding risk factors and warning signs for stroke and heart attack. Early recognition of warning signs is crucial for prompt health care-seeking, effective management, and potentially improved health outcomes. At baseline, participants in both groups demonstrated limited knowledge. This is consistent with prior studies in Tanzania, which have also reported limited public understanding of risk factors and warning signs for stroke and heart attack. For instance, Pallangyo et al reported that only 2.2% of the respondents in Dar es Salaam had satisfactory knowledge of risk factors.[13] Another study conducted in Dodoma found that only one-third of participants had adequate knowledge of risk factors.[14] Overall, the level of knowledge regarding risk factors and warning signs for stroke and heart attack has remained low in many LMICs.[29–31] In their totality, these findings underscore the necessity for interventions designed to enhance awareness as a primary prevention and control strategy in Tanzania and similar settings.

In our study, stress was the most identified risk factor. The proportion of participants who cited stress is much higher than that observed in other community-based studies.[32,33] In contrast, excessive alcohol consumption was the most reported risk factor among participants in Dodoma.[14] These findings indicate geographical variations in perceptions of stroke and heart attack risk factors. They highlight the need for health education interventions to be tailored to specific regions in Tanzania.

At follow-up, both intervention and control groups showed improvement in knowledge of risk factors and warning signs. However, participants who received CHW home-delivered interventions experienced significantly greater knowledge gains than those who received standard care alone. Our health education and healthy lifestyle promotion interventions were delivered through regular home visits, using a structured checklist. This ensured that CHWs consistently reinforced key health messages, which may have contributed to the observed improvements in participants' knowledge. Previous studies have also demonstrated the effectiveness of educational interventions in improving health literacy, promoting treatment adherence, and healthy lifestyles.[17,34,35]

Social, cultural, and gender related factors can shape knowledge acquisition.[36] In our study, we did not find significant differences in knowledge gains by age, gender, or education level. The improvements in public knowledge following CHW-led interventions are likely through several reinforcing mechanisms. As trusted members of the community, CHWs are likely to provide health information in a more culturally appropriate way and in a language that is easily understandable to community members. Repeated home visits allow for detailed feedback sessions tailored to individual needs and reinforce key messages over time. Collectively, these mechanisms can explain how CHW-led interventions increase public knowledge and sustain behavior change. Given the rising prevalence of stroke and heart attack, particularly in LMICs, expanding community-based health education interventions led by CHWs present a promising strategy to bolster increase community awareness, and reinforce prevention and control initiatives in Tanzania.

The method of delivering health education interventions is also critical in determining their effectiveness. While some studies suggest that group-based interventions tend to yield greater knowledge gains due to peer support,[37–39] our study demonstrated that individualized, home-delivered interventions are equally effective. One advantage of individual sessions is the opportunity for participants to engage in an open discussion and ask questions freely. Social pressure in a group setting can deter some individuals from asking or seeking clarification. Furthermore, the duration of intervention delivery has a significant influence on the outcome. Evidence suggests that interventions lasting between one and three years are more likely to result in improved knowledge.[17] Our 12-month intervention yielded a notable increase in mean knowledge scores in the intervention group. This indicates that even shorter-term interventions can have a substantial impact when implemented consistently. Although the link between knowledge and behavior change is promising, it requires longitudinal or behavioral studies to confirm it.

Our study is among the few that have evaluated the impact of home-based CHW interventions on enhancing knowledge of risk factors and warning signs. It achieved a higher retention rate (90.3%) compared to similar community-based interventions.[20,40] However, certain limitations should be noted. The study was conducted in rural Morogoro, with most participants being peasants. As a result, our findings may be ungeneralizable to the broader Tanzanian population. Additionally, the cluster-randomized design, while appropriate for this type of intervention, does not guarantee equal distribution of baseline characteristics and may lead to contamination of the intervention across clusters. While using the same questionnaire was good for comparing knowledge before and after intervention, it carries a risk of recall or learning effects. This may have overestimated the observed gains in knowledge among participants. It is also possible that participants reported favorably because CHWs were following them. The sample size was calculated for the primary effect, a 6.5 mmHg difference in systolic blood pressure between baseline and follow-up for the intervention and control groups. Thus, the study might be underpowered to assess changes in knowledge following the CHW interventions. Lastly, the intervention lasted 12 months, which may have been insufficient to capture longer-term changes in knowledge and behavior.

Conclusion

Health education and healthy lifestyle promotion interventions delivered by CHWs led to a 2.1-point increase in overall mean knowledge. These findings provide evidence that CHW-led interventions can play an important role in the prevention and control of stroke and heart attacks in Tanzania and similar resource-constrained settings. The 2021–2026 Tanzania national strategic plan for prevention and control of NCDs recognizes strengthening community infrastructure, including CHWs, as one of its strategic interventions. In the context of the rising burden of CVDs and the shortage of trained health professionals, particularly in rural settings, integrating CHW-led interventions into existing primary healthcare systems is a feasible, culturally appropriate, and scalable strategy to strengthen community-level prevention and control efforts.

To maximize impact, complementary health education initiatives should be implemented within healthcare facilities through audiovisual materials displayed at outpatient clinics and waiting areas. Mass media campaigns should be implemented to extend reach to the broader Tanzanian population. Future research should assess whether the observed gains in knowledge translate into sustained behavioral changes, appropriate attitudes and practices regarding risk factors and warning signs, and measurable clinical outcomes, such as blood pressure control and reduced CVD events. Since our study was conducted in rural Morogoro, future research should also assess the scalability of the intervention in other regions and urban settings.

Data Sharing Statement

Datasets used for this analysis can be obtained from the corresponding author at a reasonable request.

Ethics and Consent Statement

The study was conducted in accordance with the principles for medical research involving human participants as outlined in the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of Muhimbili University of Health and Allied Sciences (Ref #: MUHAS-REC-1-2017-070). Participants were provided with comprehensive information regarding the study objectives, data collection procedures, potential risks and benefits, confidentiality, and the voluntary nature of their participation. Before joining the study, each participant provided written informed consent, either by signature or thumbprint. Participants found to be hypertensive during the baseline survey in both intervention and control villages were referred to a nearby health facility for appropriate management per Tanzanian guidelines. The trial was prospectively registered at the Pan African Clinical Trials Registry on January 10, 2018. (PACTR201801002959401).

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Disclosure

The author(s) report no conflicts of interest in this work.

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