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Received: 27 October 2025

Accepted: 23 June 2026

Published online: 04 July 2026

Cite this article as: Ntaganda E., El-Khatib Z., Gafrita J. *et al.* Driving NCD screening at scale: outcomes of a digital, CHW-led hypertension surveillance program in rural Rwanda. *BMC Public Health* (2026). <https://doi.org/10.1186/s12889-026-28330-z>

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Driving NCD Screening at Scale: Outcomes of a Digital, CHW-Led Hypertension Surveillance Program in Rural Rwanda

Evariste Ntaganda^{1,3*}, Ziad El-Khatib², James Gafirita¹, Judith Mukamurigo¹, Francois Uwinkindi³, Jacob Masai⁴, Mylene Manirakiza⁴, Alexandre Dukundane⁵, Albert Tuyishime³, Jesse Njunguru⁴, Sharonmercy Okemwa⁴, Simon Pierre Niyonsenga³, Jean Uwayezu⁴, Oren Ombiro⁴, Richard Kalisa¹

¹ School of Public Health, College of Medicine and Health Sciences, University of Rwanda, Kigali, Rwanda

² Department of Global Public Health, Karolinska Institutet, Stockholm, Sweden

³ Division of Non-Communicable Diseases, Rwanda Biomedical Center (RBC), Kigali, Rwanda

⁴ Medtronic LABS, Kigali, Rwanda

⁵Health Builders, Kigali, Rwanda

*Corresponding author: Evariste Ntaganda. School of Public Health, College of Medicine and Health Sciences, University of Rwanda, Kigali, Rwanda. crisntaganda@gmail.com

Authors emails:

EN : crisntaganda@gmail.com

ZEK : ziad.khatib@gmail.com

JG: jgafirita@gmail.com

JM: jmukama@nursph.org

FU: francois.uwinkindi@rbc.gov.rw

JM: jacob.masai@medtroniclabs.org

MM: mylene.manirakiza@medtroniclabs.org

AD: alexandre@healthbuilders.org

AT: albert.tuyishime@rbc.gov.rw

JN: jesse.njunguru@medtroniclabs.org

SO: sharon.okemwa@medtroniclabs.org

SPN: niyonsengasp@rbc.gov.rw

JU: jean.uwayezu@medtroniclabs.org

OO: oren.ombiro@medtroniclabs.org

RK: kalichard@gmail.com

Abstract

Background

Hypertension is the leading risk factor for cardiovascular diseases, with the greatest burden in low- and middle-income countries where access to care and infrastructure for prevention and management is limited. In Rwanda, community health workers (CHWs) have long played a critical role in improving access to health services. In 2023, the Turambe ('Live Longer') program integrated digitally enabled hypertension screening into Rwanda's community health program across three districts, equipping CHWs with blood pressure monitors and mobile devices loaded with the mUzima mobile application. This study aimed to assess the CHW-led screening process, evaluate the screening cascade from CHW identification to diagnosis confirmation, and determine the factors associated with hypertension diagnosis.

Methods

Data was extracted and socio-demographic and clinical characteristics were analyzed using frequencies and percentages. Chi-square tests assessed associations between diagnosis and patient characteristics, and logistic regression identified factors associated with hypertension diagnosis following referral.

Results

The program supported the screening of 499,475 community members representing 55.9% of the population aged 15 years and above. The majority of those screened were female (54.5%) and most were aged 35–44 years (29.6%). Of those screened, 63,291 (12.7%) individuals were found to have elevated blood pressure and were referred to health facilities. Among these referrals, 4,537 (7.2%) completed the referral by visiting a health facility and 2,873 (63.3%) of them were confirmed to have hypertension; 2,218 (48.9%) were newly diagnosed and 655 (14.4%) with a prior diagnosis. Among those who completed referral to health facilities, the proportion of those confirmed to have hypertension increased with age, reaching 71.0% among individuals aged above 65 years. Multivariable analysis showed that increasing age was strongly associated with a hypertension diagnosis, with those aged ≥ 65 years having 3.91 times higher odds (aOR: 3.91; 95% CI: 2.06–7.43) compared to those aged 25–34 years. Male sex was associated with 15% reduced odds (aOR: 0.85; 95% CI: 0.75–0.98) compared to females.

Conclusion

This digital community-based hypertension screening program achieved substantial population coverage and a relatively high diagnostic yield among those who completed referral, demonstrating the potential of leveraging CHW networks and mobile technology for large-scale NCD detection and monitoring. However, low referral-to-care linkage limits inference on CHW diagnostic accuracy at the population level. Strengthened referral systems and further research into barriers to linkage are needed to translate community screening into timely diagnosis and management.

Keywords: Community health workers, digital health, hypertension,

Background

Globally 43 million deaths were linked to non-communicable diseases (NCDs) in 2021, with 18 million of those being premature deaths (under 70 years) and 82% of them occurred in low and middle-income countries (LMICs) ¹. Cardiovascular diseases account for most NCD-related deaths, with hypertension being a significant driver of the burden ². The prevalence of hypertension doubled from 650 million in 1990 to 1.3 billion in 2019, disproportionately affecting people in LMICs, where nearly three in four individuals with hypertension live ³.

Hypertension is largely asymptomatic in early stages, and therefore, early detection through screening could reduce mortality and morbidity ⁴. In the STEPwise survey, hypertension was defined as systolic blood pressure (SBP) greater than or equal to 140 mmHg or diastolic blood pressure (DBP) greater than or equal to 90 mmHg ⁵. According to the 2022 Rwanda WHO STEPwise survey, 16.8% of the adult population in Rwanda are living with hypertension, with the prevalence increasing with age, reaching 43.2% in the 60-69 age group, where half of the females in this age group have the condition ⁵. Despite this, 52.1% of adults aged between 18 and 69 years in Rwanda have never had their blood pressure measured, with a higher proportion in males (65.0%) than females (38.3%)⁵ showing disparities in health seeking behaviour and overall underutilization of early detection strategies such as screening.

Preventing and managing hypertension requires comprehensive strategies that include community-based interventions to expand access, especially in rural settings ⁶. To address the shortage of skilled health professionals, CHWs have emerged as a cost-effective and sustainable solution to bridge the gap between communities and health facilities. The effectiveness of CHWs is based on them forming the largest proportion of the health workforce and

their routine households contact, helping close the gap in health equity, especially in countries with low density of skilled health workers such as Rwanda ⁶. Previous studies have shown that CHWs can significantly contribute to reduction in the burden of blood pressure as a risk factor for premature death ⁷. Given their proven effectiveness and accessibility, CHWs represent a scalable approach to improving hypertension outcomes.

Community health workers form an important part of Rwanda's health workforce, and are credited for gains in reducing mortality, increasing access to maternal and child health care, and reducing the burden of infectious diseases ⁸. However, despite their extensive reach, they often face operational challenges such as inadequate documentation, delayed referrals, and limited tools for follow-up. To address these challenges, digital tools can improve service delivery and enable real-time referrals by CHWs. In 2023, Medtronic LABS in collaboration with the Ministry of Health and Rwanda Biomedical Center supported the enhancement and deployment of the mUzima-openMRS application to support CHWs in community-based screening and referral for hypertension and diabetes ⁹.

While studies assessing screening programs in Rwanda exist, there is limited evidence on CHW-led, digitally enabled screening-to-diagnosis cascade for hypertension. This study aimed to (1) describe individuals screened for hypertension, referred to health facilities for further assessment, and those confirmed to have hypertension by a health worker, (2) assess the association between socio-demographic characteristics and confirmation of diagnosis, and (3) determine the factors associated with confirmation of diagnosis at the health facility.

Methods

Country context

Rwanda is a low-income country administratively divided into four provinces and 30 districts ¹⁰. The East African country has an estimated population of 14.1 million with a predominantly younger population (median age of 21 years) ¹¹. Rwanda's healthcare system is organized into three hierarchical levels: primary, secondary, and tertiary care. The primary care level is provided at community level by community health workers (CHWs), and health posts and health centers by nurses. More specialized care is provided at district, provincial and referral hospitals by doctors and nurses ^{12,13}. To fill the gap of skilled health professionals, the Ministry of Health invested in community health programming to expand access to healthcare for rural

populations. Rwanda has over 55,000 CHWs, comprising three elected CHWs per village of approximately 50 to 150 households ¹³. They primarily focus on health promotion, community screening and referral activities.

Digitally enabled community-based hypertension screening

Training and digital kitting

The Turambe (Live Longer') program was implemented in three of the 30 districts: Rusizi and Nyamasheke in the Western Province and Kamonyi in the Southern Province from April 2023. The program trained a total of 5,883 CHWs; 2,347 in Nyamasheke, 1,263 in Kamonyi and 2,273 in Rusizi. The CHWs were kitted with a blood pressure machine, glucometer and a mobile device loaded with the mUzima-openMRS digital application. However, due to resource constraints, only 2,900 CHWs (50%) were equipped with digital devices and diagnostics. In addition, these 2,900 CHWs had to share the digital devices (smartphones) across two villages each to support and document screening activities.

mUzima-OpenMRS is a mobile and web-based platform used in Rwanda to facilitate the screening, enrollment, and follow-up of patients with hypertension and diabetes supporting both offline and online modes. The functionality allows for continuity of care even in rural areas with limited connectivity with all records automatically synchronized to a central database once internet connectivity is re-established. Internet connectivity was provided through partnership with MTN network service provider.

Community screening

Blood pressure was measured according to the recommendations of the NCDs management guidelines in Rwanda ¹⁴. CHWs measured blood pressure in a quiet room with the patient seated and relaxed for 3-5 minutes and bare arm resting on a table. Three readings were taken with one-minute interval between the readings and the average of the last two measurements used to assess patient status. A referral was triggered based on threshold from the guidelines (systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg) ¹⁴. The community platform was linked with the facility electronic medical records (EMR) that allowed the program to track the patients who visited the facility after referral.

Study design

This cross-sectional study was a secondary analysis of programmatic data collected between April 2023 and May 2025 from a community screening program implemented in three districts in Rwanda.

Data collection tools and procedure

The dataset was extracted from the OpenMRS database in comma-separated values (csv) format. All individuals screened had a unique identifier, and their demographic data (age, sex, district) and clinical characteristics (blood pressure, weight, height, and body mass index-BMI) documented.

Measures

Table 1 below shows how the study variables were operationalized.

Table 1: Operational definition of study variables

Variable	Definition
Hypertension	SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg
Hypertension grade	Systolic and diastolic blood pressure were classified into grades based on the 2024 European Society of Hypertension clinical practice guidelines ¹⁵ : Normal: SBP < 140 mmHg and/or DBP < 90 mmHg Grade 1: SBP 140-159 mmHg and/or DBP 90-99 Grade 2: SBP 160-179 mmHg and/or DBP 100-109 Grade 3: SBP $\geq$ 180 mmHg and/or DBP $\geq$ 110 mmHg
Hypertension type	Isolated systolic: SBP $\geq$ 140 mmHg and DBP < 90 mmHg
	Isolated diastolic: SBP < 140 mmHg and DBP $\geq$ 90 mmHg
	Systo-diastolic: SBP $\geq$ 140 mmHg and DBP $\geq$ 90 mmHg
Age categories	Individuals age at screening in years stratified into 10-year age groups and above 65 years. 15-24, 25-34, 35-44, 45-54, 55-64, $\geq$ 65 years
District	District of residence at screening: Kamonyi, Rusizi, Nyamasheke
Body mass index	Calculated by dividing an individual's weight in kilograms by their height in meters squared. Underweight: < 18.5 Kg/m ² Normal: 18.5-24.99 Overweight: 25.0-29.99 Obese: $\geq$ 30

Statistical analysis

Data was processed in Microsoft Excel, and imported into Stata version 18 (StataCorp, College Station, TX, USA) for analysis. Descriptive analyses were conducted to identify patients in each category across the cascade (screening, referral, completed referral, and diagnosis). Socio-demographic and clinical characteristics were categorized and summarized as frequencies and percentages. Cross-tabulations with Chi-square tests of association were used to examine relationships between confirmation of diagnosis and patient characteristics. Bivariable and multivariable logistic regression analyses were performed to identify factors associated with a hypertension diagnosis following completion of referral from the community. Before fitting the multivariable model, multicollinearity among covariates was assessed using the variance inflation factor (VIF) and tolerance (inverse of VIF), with multicollinearity assumed when the VIF exceeded 10¹⁶ (see table 5). Variables included in the multivariable model (age, sex, BMI, residence, and hypertension type and severity grade) were selected based on clinical relevance. Model calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test, which yielded a p-value of 0.1502, indicating adequate fit ($p > 0.05$)¹⁷ (see table 6). Results from logistic regression analyses are reported as crude and adjusted odds ratios (ORs) with corresponding 95% confidence intervals (CIs).

Results

Table 2 below shows the demographic and clinical characteristics of individuals who were screened and those who completed the referral and diagnosis cascade. By the end of May 2025, the hypertension screening program had reached 449,475 people, covering 55.9% of the population aged 15 years and above across the three districts. Most of those screened were women (54.5%), in the 35–44-year age group (29.6%), from Kamonyi district (42.1%), and had a normal body mass index (77.7%). During screening, 63,291 people, constituting 12.7% of the total screened, were found to have elevated BP and were referred to health facilities for further assessment. The proportion of those with elevated BP was higher among women (14.0%), people over 65 years old (19.9%), and residents of Nyamasheke district (18.4%). However, only 4,537 people (7.2%) of those referred attended a health facility for confirmation. Attendance was highest among residents of Kamonyi district (9.3%), those aged over 65 years (9.7%), and women (7.9%). At the facilities, further assessment confirmed that 2,218 people (48.9%) were newly diagnosed with hypertension, 655 people (14.4%) already had a known diagnosis, and 1,664 people (36.7%) were found not to be hypertensive.

Table 2 Demographic and Clinical Characteristics of Individual Screened, Referred and Completed Referral

Variable	Population screened ≥ 15 years n (%)	Elevated BP and referred n (%)	Visited Facility After Referral n (%)	Hypertension Newly Diagnosed n (%)	Known Hypertension n (%)
	499,475	63,291 (12.7)	4,537 (7.2)	2,218 (48.9)	655 (14.4)
Sex					
Female	272,073 (54.5)	38,420 (14.0)	3,042 (7.9)	1,505 (49.5)	468 (15.3)
Male	227,402 (45.5)	24,871 (10.9)	1,495 (6.0)	713 (47.7)	187 (12.6)
Age categories					
15-24 years	553 (0.1)	38 (6.9)	1 (2.6)	0 (0)	0 (0)
25-34 years	10,408 (2.1)	820 (7.9)	49 (6.0)	13 (26.5)	2 (4.1)
35-44 years	147,885 (29.6)	11,709 (7.9)	523 (4.5)	223 (42.6)	45 (8.6)
45-54 years	133,159 (26.7)	14,731 (11.1)	821 (5.6)	369 (45.0)	93 (11.3)
55-64 years	100,225 (20.1)	14,657 (14.6)	1,064 (7.3)	517 (48.6)	135 (12.6)
≥ 65 years	107,245 (21.5)	21,336 (19.9)	2,079 (9.7)	1,096 (52.7)	380 (18.3)
Population screening coverage					
Kamonyi	210,357 (42.1)	18,891 (9.0)	1,756 (9.3)	824 (46.9)	306 (17.3)
Nyamasheke	133,382 (26.7)	24,471 (18.4)	1,574 (6.4)	650 (41.3)	210 (13.3)
Rusizi	155,736 (31.2)	19,929 (12.8)	1,207 (6.1)	744 (61.6)	139 (11.3)
BMI categories					
Underweight	46,715 (9.4)	10,347 (22.2)	1,000 (9.7)	503 (50.3)	119 (11.7)

Normal	385,928 (77.7)	39,031 (10.1)	2,618 (6.7)	1,305 (49.9)	393 (15.1)
Overweight	50,663 (10.2)	9,829 (19.4)	663 (6.7)	294 (44.3)	107 (16.1)
Obese	13,261 (2.7)	3,499 (26.4)	256 (7.3)	116 (45.3)	36 (14.1)
BMI $\geq$ 25 kg/m²					
Yes	63,924 (12.9)	13,328 (20.9)	919 (6.9)	410 (44.6)	143 (15.1)
No	432,643 (87.1)	49,378 (11.4)	3,618 (7.3)	1,808 (50.0)	512 (14.1)
Hypertension type					
Normal	N/A	-	-	-	-
Isolated systolic	N/A	17,793 (28.1) *	1,446 (8.1)	634 (43.8)	240 (16.1)
Isolated diastolic	N/A	21,848 (34.5) *	532 (2.4)	159 (28.9)	46 (8.7)
Systo-diastolic	N/A	23,650 (37.4) *	2,559 (10.8)	1,425 (55.7)	369 (14.1)
Hypertension grade					
Normal	N/A	-	-	-	-
Grade 1	N/A	43,423 (68.6) *	2,140 (4.9)	820 (38.3)	300 (14.1)
Grade 2	N/A	13,293 (21.0) *	1,524 (11.5)	850 (55.8)	222 (14.1)
Grade 3	N/A	6,575 (10.4) *	873 (13.3)	548 (62.8)	133 (15.1)

**Proportions are presented as column percentages; NA-Not Applicable; Estimated population (894,060)*

Association between confirmation of diagnosis and patient characteristics

Table 3 below shows the association between confirmation of diagnosis and patient characteristics. Among the 4,537 patients who completed referral to a health facility, 2,873 (63.3%) were confirmed to have hypertension. Sex,

age, district, hypertension grade, and hypertension type were all significantly associated with confirmation of a hypertension diagnosis.

Table 3 Association between confirmation of diagnosis and patient characteristics

Variable	Visited Facility n (%)	Confirmed Hypertensive n (%)	P-value *
Hypertension status	4,537 (7.2)	2,873 (63.3)	
Sex			
Female	3,042 (7.9)	1,973 (64.9)	
Male	1,495 (6.0)	900 (60.2)	0.002
Age categories			
15-24 years	1 (2.6)	0 (0)	
25-34 years	49 (6.0)	15 (30.6)	
35-44 years	523 (4.5)	268 (51.2)	
45-54 years	821 (5.6)	462 (56.3)	
55-64 years	1,064 (7.3)	652 (61.3)	
≥ 65 years	2,079 (9.7)	1,476 (71.0)	<0.001
District			
Kamonyi	1,756 (9.3)	1,130 (64.4)	
Nyamasheke	1,574 (6.4)	860 (54.6)	
Rusizi	1,207 (6.1)	883 (73.2)	<0.001
BMI categories			
<18.5	1,000 (9.7)	622 (62.2)	
18.5-24.9	2,618 (6.7)	1,698 (64.9)	
25-29.9	663 (6.7)	401 (60.5)	
≥30	256 (7.3)	152 (59.4)	0.065
BMI ≥25.0			
Yes	919 (6.9)	2,320 (64.1)	
No	3,618 (7.3)	553 (60.2)	0.027
Hypertension grade			
Grade 1	2,140 (4.9)	1,120 (52.3)	
Grade 2	1,524 (11.5)	1,072 (70.3)	
Grade 3	873 (13.3)	681 (78.0)	<0.001
Hypertension type			

Isolated Systolic	1,446 (8.1)	874 (60.4)	
Isolated Diastolic	532 (2.4)	205 (38.5)	
Systo-Diastolic	2,559 (10.8)	1,794 (70.1)	<0.001
<i>*p-value computed using chi-square test of association</i>			

Multiple logistic regression

The odds of a confirmed diagnosis increased with age. Males were 15% less likely to be diagnosed compared to females (aOR = 0.85, 95% CI: 0.75–0.98). Patients with grade 3 hypertension were 2.42 times more likely to receive a diagnosis compared to those with lower grades (aOR = 2.42, 95% CI: 1.97–2.96), while those with systo-diastolic hypertension were 23% more likely to be diagnosed than patients with isolated systolic or diastolic hypertension (aOR = 1.23, 95% CI: 1.06–1.43). Table 4 below shows the factors associated with a diagnosis of hypertension.

Table 4 Bivariate and multivariable logistic regression

Variable	Confirmed Hypertension n (%)	cOR (95% CI)	p-value	aOR (95% CI)	p-value
Sex					
Female	1,973 (64.9)	Ref		Ref	
Male	900 (60.2)	0.82 (0.72,0.93)	0.002	0.85 (0.75,0.98)	0.023
Age groups					
25-34 years	15 (30.6)	Ref		Ref	
35-44 years	268 (51.2)	2.38 (1.27,4.48)	0.007	2.15 (0.12,4.15)	0.022
45-54 years	462 (56.3)	2.92 (1.56,5.44)	0.001	2.40 (1.26,4.59)	0.008
55-64 years	652 (61.3)	3.59 (1.93,6.67)	<0.001	2.68 (1.41,5.11)	0.003
≥ 65 years	1,476 (71.0)	5.55 (3.00,10.26)	<0.001	3.91 (2.06,7.43)	<0.001
District					
Kamonyi	1,130 (64.4)	Ref		Ref	
Nyamasheke	860 (54.6)	0.67 (0.58,0.77)	<0.001	0.62 (0.53,0.72)	<0.001

Rusizi	883 (73.2)	1.51 (1.29,1.77)	<0.001	1.09 (0.91,1.29)	0.345
BMI categories					
18.5-24.9	1,698 (64.9)	Ref		Ref	
<18.5	622 (62.2)	0.89 (0.77, 1.04)	0.132	0.76 (0.64, 0.89)	0.001
25-29.9	401 (60.5)	0.83 (0.70, 0.99)	0.035	0.87 (0.73, 1.05)	0.154
≥30	152 (59.4)	0.79 (0.61, 1.03)	0.079	0.80 (0.60, 1.05)	0.111
Hypertension grade					
Grade 1	1,120 (52.3)	Ref		Ref	
Grade 2	1,072 (70.3)	2.16 (1.88,2.49)	<0.001	1.69 (1.44,1.97)	<0.001
Grade 3	681 (78.0)	3.23 (2.69,3.87)	<0.001	2.42 (1.97,2.96)	<0.001
Hypertension type					
Isolated Systolic	874 (60.4)	Ref		Ref	
Isolated Diastolic	205 (38.5)	0.41 (0.33,0.50)	<0.001	0.57 (0.46,0.71)	<0.001
Systo-Diastolic	1,794 (70.1)	1.54 (1.34,1.76)	<0.001	1.23 (1.06,1.43)	0.008

Discussion

Community-based interventions, including home-based screening and awareness campaigns, have proven to be effective modalities for controlling hypertension in sub-Saharan Africa, with community-based screening showing potential to reach high-risk populations¹⁸. This study evaluated the outcomes of a digital community-based screening program in Rwanda and examined factors associated with hypertension diagnosis following community screening. Cumulatively, the program screened 55.9% of the population aged 15 years and above across three districts, identified and referred 63,291 (12.7%) with elevated BP to health facilities, and enrolled 2,128 new hypertension patients from the community. Female sex, older age,

and higher BP were significantly associated with a confirmed hypertension diagnosis.

Population coverage and reach

More than half of individuals aged 15 years and above accessed blood pressure measurement during the program period, a substantial improvement on the 47.9% reported in the 2022 STEPS survey as having ever had their blood pressure measured⁵. The gains were more evident in higher-risk groups with individuals aged over 40 years accounted for more than 65% of those screened. This reach reflects the combined strength of Rwanda's community health infrastructure and the digital tools supporting it. The network of approximately 55,000 community health workers (CHWs) screened individuals directly in their households, removing transportation barriers that typically constrain facility-based services. Each CHW was equipped with a smartphone running the application that captures and manages community-level healthcare activities, including hypertension and diabetes screening and follow-up.

Prior to the nationwide rollout, a standardized 10-day training curriculum was developed and delivered to CHWs by trained facilitators from their respective health centers. The training focused on building practical competencies in using the application for data entry, reporting, and client follow-up. Implementation was further reinforced through continuous mentorship and supportive supervision conducted by health center staff to ensure sustained data quality.

Prevalence of elevated blood pressure

Our findings revealed that among the 499,475 community members screened, 63,291 (12.7%) had elevated blood pressure readings. This figure is lower than the 21.2% reported in a previous rural Rwanda campaign¹⁹, as well as the 15.3% (2012) and 16.8% (2022) prevalence rates from the Rwanda STEPS surveys^{5,20}. However, the results align closely with the 12% prevalence found in the Mata Sector screening program in Rwanda²¹. Additionally, community-based screening may capture different segments of the population compared to household surveys. The population coverage for this program starts at a younger age (15 years) compared to most surveys that look at older populations.

Linkage to diagnosis and care

Despite achieving extensive screening coverage, only 7.2% of individuals with suspected hypertension attended health facilities after referral, consistent

with broader patterns of low linkage to care across sub-Saharan Africa. This rate is however notably lower than Malawi (60.9%)²², Kenya (31%)²³, and another CVD screening program in Rwanda (54.7%)²⁴. However, this comparison should be interpreted with caution, as majority of the cited studies benefited from research-controlled environments, while our data reflects real-world program conditions without dedicated resources for patient follow-up. Contributing factors likely include transportation and geographical barriers, shortages of trained healthcare workers, and limited health system infrastructure, challenges that are well-documented in the region's health system^{24,25}. The higher rates of referral completion among individuals with grade 2 and grade 3 hypertension suggest that those with more severe readings likely perceived their condition as more serious and themselves as more susceptible to health consequences, potentially outweighing perceived barriers such as costs and geographical barriers²⁶.

Previous studies demonstrated that higher perceived disease severity and treatment benefit were key drivers of health-seeking behavior among individuals with hypertension²⁷ suggesting that those who perceive their condition as mild may be less motivated to complete referral visits. Interventions should seek to develop risk-stratified education materials that communicate personalized risk based on blood pressure readings and individual risk factors to address these challenges. Evidence from high income countries show that risk communication strategies that employ personalized and visual evidence of current cardiovascular health status are more likely to promote action to reduce risk²⁸. Further, integration of follow-up visits from CHWs and tailored behavioral communication in routine screening programs has also been shown to improve linkage to diagnosis and care²⁹.

Facility-based assessment outcomes

Among those who attended a health facility after referral, 63.3% were confirmed to be hypertensive, which means nearly two-thirds of those identified by CHWs, demonstrating relatively high diagnostic accuracy of CHW-led screening. The diagnostic yield was higher among those aged ≥ 65 years (71%), those with grade 3 range readings (78%) and those with systo-diastolic hypertension range readings (70.1%). The significantly higher odds of diagnosis for individuals with higher risk suggests CHWs are particularly effective at identifying more severe cases requiring immediate attention. These findings suggest that with appropriate training, mentorship,

standardized protocols and digital tools, CHWs can serve as a reliable first point of contact for hypertension detection ³⁰.

Contrary to findings from previous studies reporting an association between increase in BMI and hypertension ^{31,32}, this study found no association between BMI categories and a diagnosis of hypertension after adjusting for other variables. This finding should, however, be interpreted with caution. The analysis was restricted to the 7.2% of referred individuals who completed facility visits, limiting the generalizability of the associations, including BMI. Post-hoc power analysis revealed that the study achieved only 42% power to detect a difference in hypertension confirmation between the normal BMI and obese group, considerably below the 80% threshold ³³. Given that only 256 individuals were classified as obese, the wide confidence intervals observed also suggest association may exist but was not detected. Our findings are consistent with a community screening campaign in Kirehe District, Rwanda, which similarly reported an inconsistent relationship between elevated blood pressure and BMI categories, attributing their findings to the sample sizes across cells ¹⁹. Additionally, BMI as a measure of general adiposity may be insufficient to capture hypertension risk in this population as evidence from Tanzania demonstrated that central adiposity, independent of BMI, is a contributor of hypertension³⁴. Future community-based NCD screening programs in Rwanda should consider incorporating waist circumference alongside BMI and ensure sufficient sample sizes with subgroups to allow powered analyses.

Implications for program design and policy

This digital community-based screening program illustrates the potential of leveraging extensive CHW networks for large-scale NCD screening and case identification. The integration of mobile technology enabled real-time data capture and offers opportunities for improved referral tracking and follow-up. However, the critical weakness lies in referral-to-care linkage, with fewer than 1 in 10 referred individuals completing facility visits. Given their screening accuracy and their position within the community, expanding CHW's roles to include risk communication, personalized communication and structured follow-up, could help translate the investment in screening and case detection into timely diagnosis and treatment ³⁵. Effective screening programs must therefore be supported by robust referral systems and context-specific strategies to overcome barriers to care-seeking.

Strengths and limitations

The large population coverage across three districts provided a substantial sample size for subgroup comparisons, adding to evidence on the role of CHWs and digital tools in community hypertension screening. However, the cross-sectional design without a control group limits causal inference regarding the effectiveness of these approaches. Additionally, the low referral completion rate (7.2%) introduces potential selection bias, as individuals who sought care may differ systematically from those who did not, potentially over- or underestimating true hypertension confirmation rates and the factors associated with confirmed diagnosis.

Conclusion

This digital community-based hypertension screening program in Rwanda achieved substantial population coverage and relatively high diagnostic yield, demonstrating the potential of leveraging CHW networks and mobile technology for large-scale NCD surveillance. However, the low referral-to-care linkage remains a critical gap, highlighting the need for strengthened referral systems to ensure timely diagnosis and management. These findings provide valuable lessons for scale up in Rwanda and similar programs in sub-Saharan Africa aiming to improve early detection of hypertension. Future implementation research should evaluate whether CHW-delivered risk communication, structured follow-up, and integrated referral coordination can close the screening-to-care gap and improve linkage rates in Rwanda.

Declarations

Approvals

This research was conducted by respecting ethical standards according to Declaration of Helsinki (1964). Ethical approval to conduct this study was obtained from the Rwanda National Research Ethics Committee (RNEC) [RNEC 115/2025]. All community members screened gave informed verbal consent for blood pressure measurement and collection of demographic data. All data collected during program implementation was stored in a password protected database and was only accessible to people involved in the implementation.

Availability of data and materials

The dataset used in this study is owned by the Rwanda Biomedical Centre (RBC). Researchers who meet the criteria for access to confidential data may request access by contacting the Non-Communicable Diseases Division at info@rbc.gov.rw.

Conflict of interest

Authors declare no conflict of interest.

Authors' Contribution

Conceptualization, methodology, and data collection: EN, JG, FU, N, JK, OO, MM, ZEK, and RK, CM, Data analysis: SO, EN, UF, JM, OO, MM, JN, ZEK, and RK, Original draft preparation, SO, EN, UF, JM, OO, ZEK, and RK Review and editing: EN, JU, RK, AT, ZEK, BI, GTA, OO, JM, SO, SPN, NG, AD and UJ. All Authors have read and recommended publishing this manuscript as the final version.

Acknowledgments

We would also like to extend our gratitude to the hospital director generals who granted permission to access the data and NCD nurses who supported data extraction from electronic medical records. We also recognize the RBC/NCD division to permit us access to the data from hospital records.

Funding

The TURAMBE program was jointly resourced by the Patrick J. McGovern Foundation, Medtronic Labs and the Rwanda Biomedical Center.

Consent to Publication

Not applicable

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Supplementary Materials

Assessment of multicollinearity among explanatory variables.

Table 5: Variance inflation factor

Variable	VIF	1/VIF
Sex	1.01	0.992
Age groups	1.09	0.922
District	1.08	0.927
BMI categories	1.06	0.945
Hypertension grades	1.28	0.781

Hypertension type	1.21	0.823
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Model post-estimation tests- Goodness of fit test after logistic model

Table 6: Results from the Hosmer-Lemeshow test

Number of observations	4,536
Number of groups	10
Hosmer-Lemeshow Chi2	12.02
P-value	0.1502