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Evaluating the outcomes of a community-based health literacy intervention for hypertension and diabetes in Harare, Zimbabwe: a cluster randomized controlled trial

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Abstract

Introduction Health literacy interventions delivered by community health workers-(CHWs) can significantly improve lifestyle modification and medication adherence for non-communicable diseases. This study evaluated the outcomes of a CHW-led health literacy intervention among diabetes and hypertension patients in Harare, Zimbabwe.

Methods A cluster randomized controlled trial was conducted across six clinics. The intervention included four structured education sessions and monthly home visits and was delivered over six months. Primary outcomes were adherence to lifestyle modifications and medication adherence; secondary outcomes were blood pressure and blood glucose control. Data analysis was done under the intention to treat principle. Differences between groups were compared using chi-square and t-tests.

Results Six hundred and forty-three (643) participants were recruited (intervention = 321; control = 322). At follow-up, adherence to lifestyle modifications was significantly higher in the intervention compared to the control group for weight management (70% vs. 40%,); low-salt diet (65% vs. 36%); low-fat diet (60% vs. 30%); physical activity (80% vs. 50%); alcohol moderation (85% vs. 70%); and fruit/vegetable intake (75% vs. 45%). Medication adherence (59% vs. 36%) and blood pressure control (62% vs. 41%) were higher in intervention compared to control group, but there were no significant differences in blood glucose control and adherence to non-smoking.

Conclusion The CHW-led health literacy intervention was associated with improvements in adherence to recommended lifestyle modifications, medication adherence, and blood pressure control. These findings support the integration of CHWs into NCD care models in urban Zimbabwe and other low resource settings.

Keywords Community health workers, Health literacy, Hypertension and Diabetes, Lifestyle modification, Cluster randomized controlled trial, Zimbabwe

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Introduction

Non-communicable diseases (NCDs) are a major global health and development challenge worldwide [1, 2]. The burden is disproportionately higher in low- and middle-income countries (LMICs), where 85% of premature NCD-related deaths occur. Adults in LMICs face nearly double the risk of dying prematurely from NCDs compared to those in high-income countries [1–4]. Zimbabwe reflects this global trend, with NCDs accounting for up to 31% deaths nationally. Despite the growing burden, public health programming in Zimbabwe historically prioritized communicable diseases. The Ministry of Health and Child Care (MoHCC) National Strategy for 2016–2020 acknowledged that NCDs have received limited attention in terms of funding, policy development, and implementation [5, 6].While the subsequent National Health Strategy 2021–2025 recognises NCDs as an emerging public health priority and calls for strengthened prevention, surveillance, and management, including the establishment of a dedicated NCD unit, implementation challenges and resource constraints persist [5, 6].

National efforts to address modifiable risk factors such as tobacco use, harmful alcohol consumption, physical inactivity, and unhealthy diets remain fragmented. This gap, coupled with rapid urbanization and lifestyle changes, has contributed to the rising prevalence and impact of NCDs, particularly hypertension and diabetes [7, 8]. Effective control of diabetes and hypertension requires sustained lifestyle modification (LM) and adherence to medication. However, poor adherence remains a major barrier, often driven by limited health literacy. Many patients struggle to understand medical advice, adopt healthy behaviours, and engage meaningfully with health systems [9]. In LMICs, where human resources and health system are constrained, patient–provider communication is limited, and thus the challenge of low health literacy is even more pronounced.

To address health worker constraints in chronic disease management, community health workers (CHWs) have emerged as key facilitators for health literacy interventions [10–16]. Their close ties to communities, cultural competence, and ability to deliver tailored education position them to bridge critical gaps in health worker shortages. Evidence from several LMICs shows that CHW-led programs can improve patient knowledge, treatment adherence, and clinical outcomes [16–20]. However, in Zimbabwe, particularly in urban settings limited studies have rigorously evaluated the impact of CHW-led interventions on hypertension and diabetes outcomes. This study assessed the outcomes of a CHW-led health literacy intervention on lifestyle modification among patients with hypertension and diabetes in Harare, Zimbabwe.

Methods and materials

This study was part of a mixed methods study which was conducted in two phases. Phase 1 focused on developing a culturally relevant health literacy intervention through a desk review and stakeholder consultations. Phase 2 involved evaluation of the intervention's outcomes through a cluster randomised controlled trial (cRCT) and assessment of its acceptability through qualitative assessments. This paper reports the results of the cRCT. Qualitative findings have been published separately [21]. The study was conducted and reported in accordance with CONSORT guidelines for cluster randomised trials.

Study design and setting

A cluster randomised controlled trial (cRCT) with a 6-month follow-up period was conducted in six City of Harare Primary Health Care (PHC) clinics in Harare, Zimbabwe. The trial consisted of one intervention arm and one control arm, with three clinics allocated to each arm. Cluster randomisation was selected to minimise contamination between intervention and control participants within the same health facility.

Selection of clinics and randomisation

At the time of the study, there were 12 PHC clinics located in high-density suburbs. Six clinics were purposively selected based on predefined criteria, including provision of routine hypertension and diabetes management services, comparable patient volumes, and absence of concurrent NCD-focused interventions. The selected clinics served similar catchment populations (approximately 80,000–100,000 residents) and were considered operationally comparable.

The six selected PHC clinics were randomly allocated to intervention or control arms in a 1:1 ratio using simple randomisation with computer-generated random numbers. Randomisation was performed by an independent official who was not involved in the study implementation to ensure allocation concealment. Each clinic was assigned a unique identification number, and three clinics were allocated to each arm. The allocation sequence was generated and finalised prior to participant recruitment to minimise the risk of selection bias.

Inclusion and exclusion criteria

All adults (aged ≥ 18 years) with a known diagnosis of hypertension and/or diabetes, who were currently taking prescribed medication and residing within the catchment areas of the targeted health facilities, and who were able to provide written informed consent, were eligible for enrolment. No minimum duration of treatment was required for inclusion, as the intervention aimed to improve adherence to lifestyle and medication recommendations irrespective of time since diagnosis or

treatment initiation. Exclusion criteria were: (i) individuals with hypertension- or diabetes-related complications; (ii) individuals who were pregnant or planning to become pregnant during the course of the trial; (iii) individuals who were unable to remain within the clinic catchment area for the duration of the study; and (iv) individuals unable to provide informed consent for any reason, including severe mental health disorders.

Sample size

A total of 680 participants were required for the study. The sample size was based on recommendations for trials with a fixed number of clusters [22].The calculation was informed by parameters drawn from a review of the literature, including a study power of 80%, an effect size of 0.5, and a standard deviation of 1 [23]. To account for the clustered design, a coefficient of variation of 0.05 was incorporated, and the sample size was adjusted by 20% for potential loss to follow-up.

Recruitment of participants

Participant mobilisation was conducted both within the community catchment areas and at the participating clinics. Community health mobilisers informed potentially eligible individuals about the study during community outreach activities and encouraged them to attend the clinic for screening. In addition, patients presenting at the clinics for routine services during the recruitment period were informed about the study. All interested individuals were screened for eligibility at the clinic, where recruitment and enrolment took place. Clinical measurements, including blood pressure and blood glucose assessments, were conducted at the clinic to confirm eligibility and collect baseline data. Recruitment was conducted consecutively by trained research assistants over a three-week period at both intervention and control clinics until the required sample size was achieved. All individuals meeting the eligibility criteria during the recruitment period were invited to participate.

Study outcomes

The primary study outcome was adherence to recommended lifestyle modifications and medication, consistent with the health literacy focus of the intervention. Blood pressure (BP) and fasting blood glucose control were assessed as secondary outcomes to evaluate the potential downstream physiological effects of improved adherence behaviours. All participants were required to be receiving prescribed medication at enrolment; however, no minimum duration of treatment was specified, as the intervention aimed to improve adherence behaviours irrespective of time since diagnosis or treatment initiation. Duration of treatment was recorded at baseline as a clinical characteristic but was not used as an inclusion criterion or covariate in the primary analysis. Outcome evaluation was based on data collected at baseline and at 6-month post-intervention follow-up.

Assessment of outcomes

Patients' adherence to recommended lifestyle modifications was assessed using a self-reported tool adapted from the Hypertension Self-Care Activity Level Effects (H-SCALE) Scale) [24]. The adapted tool underwent expert review for face and content validity prior to use in the study. Patient's hypertension and diabetes control were assessed by BP and fasting blood glucose measurements. Blood pressure measurements were conducted at the clinic by a trained nurse using a calibrated automated sphygmomanometer, following standard measurement procedures. Participants were seated comfortably with their back supported and feet flat on the floor and rested for at least five minutes prior to measurement. The arm was supported at heart level. Three BP readings were taken at 2–3 min intervals, and the average of the last two readings was used for analysis, in line with standard clinical and epidemiological practice to minimise the influence of transient elevations, including potential white coat effects.

Hypertension was classified as uncontrolled if the averaged systolic BP was ≥ 140 mmHg and/or diastolic BP was ≥ 90 mmHg. Fasting blood glucose measurements were obtained at the clinic by trained nursing staff using standardised glucometers in accordance with manufacturer guidelines. A fasting blood glucose level ≥ 7.0 mmol/L was classified as uncontrolled diabetes. Medication adherence was assessed using the 8-item Morisky Medication Adherence Scale (MMAS-8) [25], a validated self-reported measure widely used in chronic disease research. Permission to use the MMAS-8 was obtained from the copyright holders prior to study implementation. Objective measures of adherence (such as pill counts, pharmacy refill records, or electronic monitoring) were not feasible within the primary health care setting; therefore, adherence assessment relied on the validated self-report instrument. The same measurement protocol was applied at both baseline and 6-month follow-up across intervention and control clinics to ensure consistency and reduce measurement bias. Further details on assessment of outcomes are available in study protocol [26].

Data collection and management

Recruitment of participants began in June 2023. Baseline data were collected during participant enrolment, and follow-up data were obtained in January 2024. Data were gathered using paper-based questionnaires, and all records were stored in a password-protected computer system. Each participant was assigned a unique

identification number at baseline, which was used for follow-up data collection to ensure consistency and confidentiality. Prior to data collection, research assistants received training on the study protocol and completed an online Good Clinical Practice (GCP) certification.

Data analysis

Data analyses were performed using the Epi-info Software (version 7.2.6). The analysis was conducted under the principle of intention-to-treat. Between group differences were compared using chi-square($\chi 2$) for categorical variables and t -test for continuous variables. Within group differences were assessed using the McNemar's test.

Study fidelity and bias mitigation

Several measures were implemented to ensure study fidelity and minimise bias. Clusters (clinics) were randomly allocated by an independent official using computer-generated random numbers to prevent allocation bias. Participant mobilisation was conducted both in the community and at clinic level; however, enrolment and baseline assessment were completed at the clinic to ensure standardised clinical measurements. Data collectors underwent standardised training prior to study implementation to ensure uniform procedures across all sites. Validated instruments (the H-SCALE and the MMAS-8) were used to enhance measurement reliability. Due to the nature of the behavioural intervention, blinding of participants and intervention providers was not feasible. However, outcome assessors were blinded to group allocation at baseline, making this a single-blind trial. Standardised measurement protocols were applied across both arms to further reduce detection bias. To minimise attrition in the control group, participants received reminder phone calls at months 2 and 4 during the follow-up period. These calls were limited to retention purposes only and did not include lifestyle or medication adherence counselling. The intervention group did not receive these reminder calls, as they were already engaged in structured follow-up activities as part of the intervention. The cluster randomised design was selected to minimise cross-contamination between study arms. Randomisation occurred at clinic level to prevent interaction between intervention and control participants within the same facility. The selected clinics operated independently, with separate health care staff and service delivery structures, reducing the likelihood of co-intervention bias. Intervention activities were delivered only within designated intervention clinics, and study materials were not shared across facilities. Participants were recruited from their respective clinic catchment areas, further limiting cross-exposure between arms.

Results

Participant flow and retention

Screening for eligibility was conducted at the participating clinics by trained research assistants following community mobilisation and clinic-based recruitment. A total of 720 individuals presented for screening. Of these, 77 were excluded: 45 did not meet the inclusion criteria (primarily due to not being on prescribed medication), and 32 declined to participate after receiving study information.

In total, 643 participants were enrolled across six clinics, with three clinics allocated to the intervention arm ($n = 321$) and three to the control arm ($n = 322$). At the end of the 6-month follow-up period, 32 participants (5%) were lost to follow-up due to relocation outside the clinic catchment area, deaths and inability to be contacted. Deaths were recorded as they occurred during the study period. Two deaths were documented, occurring in the second and fifth months in the intervention and control groups, respectively. For other participants lost to follow-up, the exact timing of attrition could not be determined, as loss was identified during attempts to conduct the scheduled 6-month endline assessment.

All enrolled participants ($N = 643$) were included in the final analysis under the intention-to-treat principle. Figure 1 summarises the recruitment and retention of participants.

Baseline characteristics

Table 1 shows the baseline socio-demographic and clinical characteristics of participants in both arms. There were no differences in the groups on recruitment.

Effects of intervention on adherence to recommended lifestyle modifications

Baseline adherence to recommended lifestyle modifications was comparable between the intervention and control groups. Approximately one-third of participants in both groups reported adherence to weight management, low-salt, and low-fat diets, while a similar proportion engaged in regular physical activity. Most participants were non-smokers (about 87%), and adherence to fruit and vegetable intake was low (around 25%). No statistically significant differences were observed between the two groups across all lifestyle domains (Table 2).

At six-month follow-up, participants in the intervention group demonstrated significantly higher adherence to most recommended lifestyle modifications compared to those in the control group. Adherence to weight management, low-salt and low-fat diets, physical activity, alcohol moderation, and fruit and vegetable intake was markedly higher among intervention participants. The only lifestyle modification without a significant difference between groups was smoking status, with high adherence

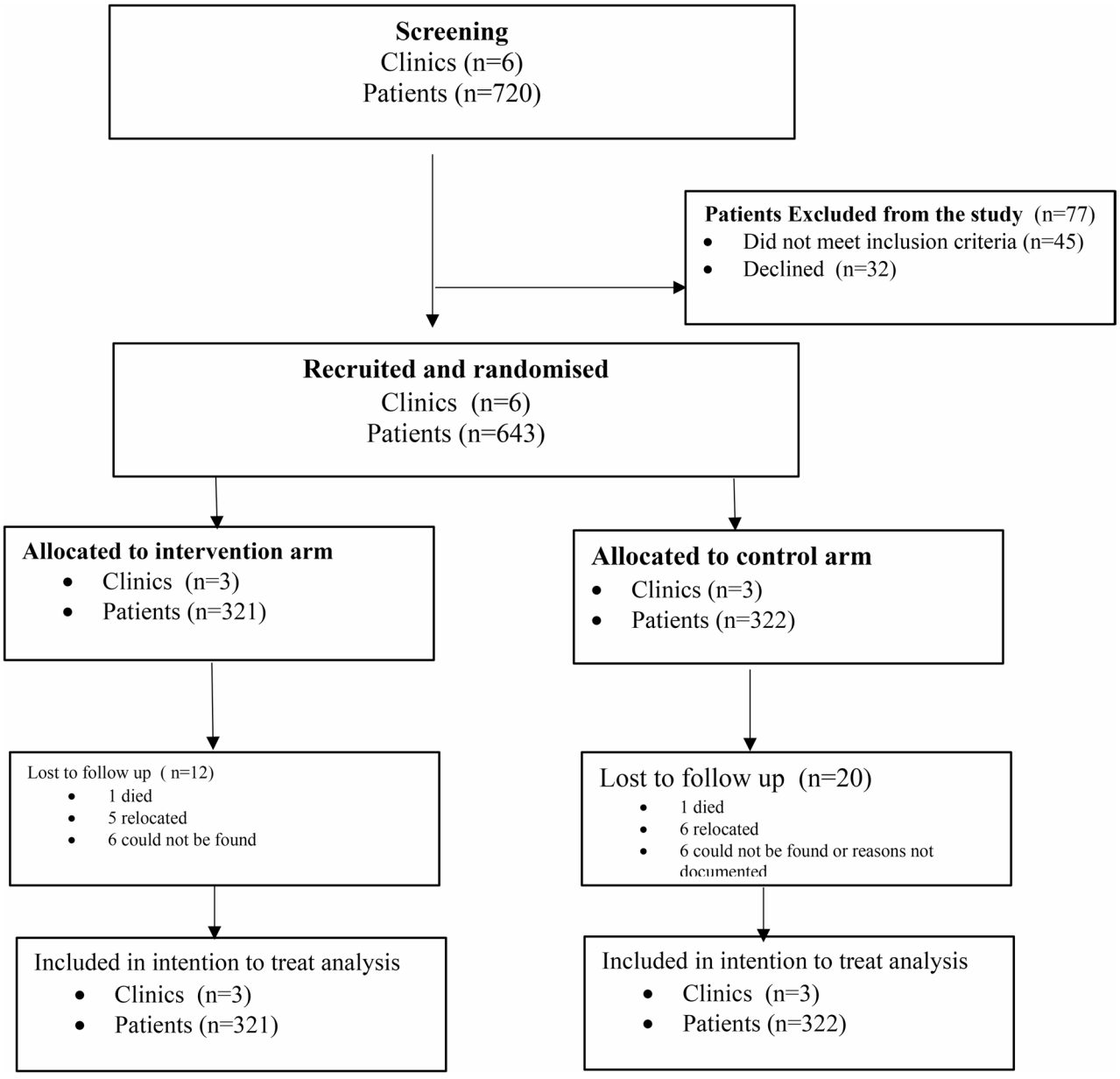

Fig. 1 Participant recruitment and flow diagram

observed in both groups. Detailed results are presented in Table 3.

Effect of intervention on adherence to medication

At six-month follow-up, overall medication adherence differed significantly between the intervention and control groups ($p < 0.001$), (Table 4). Based on the Morisky Medication Adherence Scale (MMAS-8), 59% of participants in the intervention group achieved high adherence (score = 8) compared to 36% in the control group. Medium adherence (scores 6–7) was observed in 30% of intervention participants and 37% of controls, while low adherence (scores < 6) was lower in the intervention group (11%) than in the control group (27%).

Effects of intervention on blood pressure and blood glucose control

At 6-month follow-up, 62% of participants in the intervention arm had controlled blood pressure (< 140/90 mmHg) compared to 41% in the control arm ($p < 0.001$). Fasting blood glucose levels below 7.0 mmol/L (controlled blood glucose levels) were observed in 58% of intervention participants compared to 56% in the control group ($p = 0.071$). As shown in Table 5, within-group differences show that the intervention group experienced

Table 1 Participants Baseline Characteristics

Variable	Intervention Group (*n* = 321)	Control Group (*n* = 322)	*p*-value
Sex			0.284
Male	150 (47%)	139 (43%)	
Female	171 (53%)	183 (57%)	
Education			0.621
None	51 (16%)	45 (14%)	
Primary	100 (31%)	93 (29%)	
Secondary	125 (39%)	132 (41%)	
Tertiary	45 (14%)	52 (16%)	
Employment:			0.482
Not employed	84 (26%)	77 (24%)	
Formally employed	125 (39%)	132 (41%)	
Informally employed	112 (35%)	113 (35%)	
Religion			0.729
Christianity	221 (69%)	229 (71%)	
Muslim	32 (10%)	29 (9%)	
Apostolic sect	29 (9%)	32 (10%)	
Traditional/None	38 (12%)	32 (10%)	
Condition			0.537
Hypertension only	129 (41%)	126 (39%)	
Diabetes only	93 (29%)	100 (31%)	
Both conditions	96 (30%)	96 (30%)	
Age (Median, IQR)	55 (50–60)	56 (52–61)	0.815
Mean Systolic BP	135 mmHg	134 mmHg	0.652
Mean Diastolic BP	85 mmHg	83 mmHg	0.421
Mean Blood Glucose	150 mg/dL	148 mg/dL	0.739

Table 2 Baseline Adherence to Lifestyle Modification

Lifestyle Modification	Adherence in Intervention Group (%) (*N* = 321)	Adherence in Control Adherence (%) (*N* = 321)	*p*-value
Weight management	40.1	38.1	0.605
Low salt diet	35.4	34.3	0.102
Low fat diet	30.3	27.6	0.350
Physical activity	32.8	33.2	0.222
Alcohol moderation	38.2	40.1	0.851
Non-smoking	87.3	86.8	0.703
Fruit & vegetable intake	25.4	23.0	0.671

Table 3 Follow -Up Adherence to Lifestyle Modification

Lifestyle Modification	Adherence in Intervention Group (%) (*N* = 321)	Adherence in Control (%) (*N* = 321)	*p*-value
Weight management	70	40	< 0.001
Low salt diet	65	36	< 0.001
Low fat diet	60	30	< 0.001
Physical activity	80	50	< 0.001
Alcohol moderation	85	70	0.021
Non-smoking	90	88	0.153
Fruit & vegetable intake	75	45	0.032

Table 4 Adherence to medication at follow up

MMAS-8 Score Category	Intervention (*N* = 321)	Control (*N* = 322)	*p*-value
High adherence (score = 8)	189 (59%)	116 (36%)	< 0.001
Medium adherence (score = 6–7)	95 (30%)	120 (37%)	
Low adherence (score < 6)	37 (11%)	86 (27%)	

significant reductions in systolic blood pressure, diastolic blood pressure, and blood glucose levels from baseline to endline. The control group demonstrated only minimal within-group changes, which were not statistically significant.

Discussion

This study evaluated the effectiveness of a CHW–led health literacy intervention in improving adherence to recommended lifestyle modifications and treatment adherence among patients with hypertension and diabetes in Harare, Zimbabwe through a cRCT. The intervention demonstrated significant improvements across nearly all recommended lifestyle modifications, including weight management, healthier dietary practices, increased physical activity, and moderation of alcohol intake. It also led to higher medication adherence and better blood pressure control compared with usual care. Only smoking behaviour and blood glucose control showed no significant change. Overall, these findings confirm the effectiveness of CHW-delivered health literacy interventions in addressing key behavioural and clinical determinants of chronic disease control. The results highlight the potential of integrating CHWs into primary health care systems as a feasible and impactful strategy to improve non-communicable disease outcomes in resource-limited urban settings, thus consistent with a growing body of evidence that supports the role of community-based interventions in managing non-communicable diseases (NCDs), particularly in sub-Saharan Africa, where health systems are often under-resourced and physician shortages are acute [27–30].

The positive effects observed in this study may be attributed to the intervention's strong grounding in local knowledge and practices. For instance, to improve adherence to recommended dietary practices, the CHW-led sessions emphasized culturally relevant recommendations, focusing on locally available and affordable food options, which made dietary adjustments more feasible and acceptable for participants. This culturally responsive approach likely enhanced participant engagement, ownership, and adherence, thereby contributing to the overall effectiveness of the intervention. The integration of family support and individualized goal setting may also have reinforced behaviour change, as interpersonal and familial support are known to sustain lifestyle modifications

Table 5 Baseline and endline comparison of blood pressure and blood glucose levels between intervention and control groups

Variable	Baseline	Endline	*n*	Mean Change	*p*-value	Baseline	Endline	*n*	Mean Change	*p*-value
	Intervention					Control				
SBP (mmHg)	135	129	309	-6	0.001	134	132	302	-2	0.191
DBP (mmHg)	85	81	309	-4	0.008	83	82	302	-1	0.343
Glucose (mmol/L)	8.3	7.7	195	-0.6	0.009	8.21	7.94	190	-0.3	0.117

over time. Similar findings have been reported in studies by Jeet et al. and Gaziano et al., which demonstrated that CHW-led health interventions, when tailored to local contexts and community needs, are not only feasible but highly effective in improving adherence and clinical outcomes in non-communicable disease management [28, 31]. This alignment with previous evidence underscores the importance of designing community-based interventions that are contextually adapted and socially grounded.

While the intervention produced significant improvements in blood pressure control, no comparable changes were observed in blood glucose levels. This may reflect the relatively short follow-up period, as glycaemic control typically requires sustained adherence and longer-term behavioural or pharmacological interventions compared with blood pressure management [32, 33]. It may also indicate challenges in achieving dietary modifications specific to diabetes, such as regulating carbohydrate intake, which often demand more specialized education and individualized support. Similar difficulties in attaining optimal glycaemic control have been reported in other studies [34, 35], highlighting the need for longer and more intensive interventions to achieve sustained improvements in diabetes outcomes.

The intervention achieved significant reductions in harmful alcohol consumption, but no meaningful change was observed in smoking behaviour. The improvement in alcohol moderation highlights the ability of CHWs to influence sensitive lifestyle practices. Similar results have been reported in other LMIC contexts, where CHW-led interventions have successfully reduced alcohol-related NCD risks by framing moderation in ways that resonate with local social norms and daily realities [12, 36]. In contrast, the lack of significant change in smoking prevalence may reflect several factors. First, baseline adherence to non-smoking was already high in both groups, creating a ceiling effect that limited the scope for measurable improvement. Second, smoking behaviour in many communities is often more addictive than alcohol use, making it less responsive to short-term interventions. This suggest that while CHWs are well-positioned to facilitate behaviour change alcohol moderation, their impact on smoking cessation may require more intensive, longer-term, or specialized interventions.

The intervention also resulted significant improvements in medication adherence among participants in the intervention group compared to controls. This finding is particularly important, as consistent use of antihypertensive and antidiabetic medications is a cornerstone of effective chronic disease management, yet adherence remains a major challenge in many low-resource settings [37]. By providing regular follow-up, reminders, and peer support, CHWs likely played a crucial role in addressing common barriers such as forgetfulness, and misconceptions about treatment.

Overall, the findings from this study suggest that CHW-led health literacy interventions may represent a feasible approach to improving adherence to recommended lifestyle modifications and medication among patients with hypertension and diabetes in urban, resource-limited settings. By leveraging trusted community figures, such interventions may help bridge gaps between patients and the formal health system, strengthen self-management capacity, and support continuity of care. Integrating CHWs into primary health care systems could therefore enhance the reach of NCD services, particularly in contexts facing workforce shortages and limited access to specialist care.

This study has several methodological and contextual strengths. The cluster randomized controlled trial design reduced the likelihood of contamination between study arms and enabled evaluation of the intervention within routine primary health care settings. Integrating the CHW-led health literacy intervention within existing public health structures enhanced contextual relevance, feasibility, and potential scalability. Data collection used validated instruments (H-SCALE and MMAS-8), and independent randomization, standardized data collection procedures, and blinding of data collectors helped reduce measurement bias.

Some limitations should be considered when interpreting the findings. First, the six-month follow-up period may have been insufficient to capture longer-term behavioural and clinical outcomes, particularly for glycaemic control. Lifestyle behaviours were assessed using self-reported measures, which may be subject to recall and social desirability bias. This study used a cluster randomized design in which clinics, rather than individual participants, were randomized, participants were recruited consecutively within each facility after cluster allocation. While this approach was appropriate to minimise contamination between study arms, it may introduce some potential for selection bias at the participant level. Blood glucose control was assessed using fasting blood

glucose measurements, which rely on participant adherence to fasting instructions that could not be independently verified. This introduces potential measurement bias, similar to other self-reported data. The use of glycated haemoglobin (HbA1c) would have provided a more objective and reliable measure of long-term glycaemic control over the follow-up period; however, this was not feasible within the resource constraints of the primary health care setting. Finally, as the clinics were purposively selected from urban primary health care facilities, the findings may not be fully generalizable to rural or other health system contexts.

Conclusions

The CHW-led health literacy intervention was associated with improved medication adherence, healthier lifestyle practices, and better blood pressure control among patients with hypertension and diabetes in Harare, Zimbabwe. These findings suggest that community health workers can play an important role in supporting chronic disease self-management within primary health care systems in resource-constrained settings. Integrating similar interventions into routine services may help strengthen ongoing efforts to address the growing burden of non-communicable diseases. However, further studies with longer follow-up periods are needed to assess the sustainability of behavioural and clinical outcomes. Future interventions may also benefit from incorporating more targeted diabetes education and evaluating applicability in rural and other diverse populations.

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Authors' contributions

NAK: conceptualisation of study, data collection, data analysis and drafting of first draft and subsequent drafts leading to the final manuscript; SR, SS, JM and GTF: Supervision, reviewing of study proposal, reviewing of initial manuscript and subsequent drafts. All authors read and approved the final manuscript.

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Data availability

The data sets generated from this study will be made available to the public upon request ensuring compliance with ethical standards and participant confidentiality.

Declarations

Ethics approval and consent to participate

In our study, all procedures involving human participants were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision). The research also complied with the requirements of the Joint Research Ethics Committee (JREC) of the University of Zimbabwe and Parirenyatwa Group of Hospitals and the Medical Research Council of Zimbabwe (MRCZ), from whom we obtained ethical approval.

Competing interests

The authors declare no competing interests.

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