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Enhancing hypertension education of community health extension workers in Nigeria's federal capital territory: the impact of the extension for community healthcare outcomes model on primary care, a quasi-experimental study

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Abstract

Background Healthcare workers (HCWs) including community health extension workers (CHEWs) in the Federal Capital Territory, Nigeria participated in a hypertension training series following the Extension for Community Healthcare Outcomes (ECHO) model which leverages technology and a practical peer-to-peer learning framework to virtually train healthcare practitioners. We sought to evaluate the patient-level effects of the hypertension ECHO series.

Methods HCWs from 12 of 33 eligible primary healthcare centers (PHCs) in the Hypertension Treatment in Nigeria Program (NCT04158154) were selected to participate in a seven-part hypertension ECHO series from August 2022 to April 2023. Concurrent Hypertension Treatment in Nigeria Program patient data were used to evaluate changes in hypertension treatment and control rates, and adherence to Nigeria's hypertension treatment protocol. Outcomes were compared between the 12 PHCs in the ECHO program and the 21 which were not.

Results Between July 2022 and June 2023, 16,691 PHC visits were documented among 4340 individuals (ECHO: $n=1428$ [33%], non-ECHO: $n=2912$ [67%]). Patients were on average (SD) 51.5 (12.0) years old, and one-third were male ($n=1372$, 32%) with no differences between cohorts in either characteristic ($p \geq 0.05$ for both). Blood pressures at enrollment were higher in the ECHO cohort compared to the non-ECHO cohort (systolic $p<0.0001$ and diastolic $p=0.0001$), and patients were less likely to be treated with multiple medications ($p<0.0001$). Treatment rates were similar at baseline (ECHO: 94.0% and Non-ECHO: 94.7%) and increased at a higher rate (interaction

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$p = 0.045$) in the ECHO cohort over time. After adjustment for baseline and within site variation, the difference was attenuated (interaction $p = 0.37$). Over time, control rates increased and medication protocol adherence decreased, with no differences between cohorts. Staffing levels, adult patient visits, and rates of hypertension screening and empanelment were similar between ECHO and non-ECHO cohorts ($p \geq 0.05$ for all).

Conclusions The ECHO series was associated with moderately increased hypertension treatment rates and did not adversely affect staffing or clinical capacity among PHCs in the Federal Capital Territory, Nigeria. These results may be used to inform strategies to support scaling hypertension education among frontline HCWs throughout Nigeria, and use of the ECHO model for CHEWs.

Trial Registration The Hypertension Treatment in Nigeria Program was prospectively registered on November 8, 2019 at www.clinicaltrials.gov (NCT04158154; https://clinicaltrials.gov/ct2/show/NCT04158154).

Keywords Hypertension, Implementation, Qualitative, Primary care, Education

Introduction

Nigeria is projected to be one of the five most populous countries in the world by 2100, with a population that is projected to simultaneously age and experience growth in gross domestic product [1]. Demographic and economic changes have already resulted in epidemiologic shifts. Cardiovascular diseases are now the leading cause of mortality in Nigeria, accounting for at least 10% of deaths [2, 3]. Recent studies estimate that high blood pressure, a leading cause of cardiovascular disease, is prevalent in an estimated 25–40% of Nigerian adults [4–6]. Care for non-communicable diseases, including hypertension, has traditionally occurred within secondary and tertiary care centers [7].

In order to adequately support its aging and growing population, Nigeria's health system will require major growth and restructuring, particularly for non-communicable diseases which require lifetime management by healthcare workers (HCWs) and by patients themselves. Implementation of hypertensive services within primary healthcare centers (PHCs) and task shifting to community health extension workers (CHEWs) are both supported by the Nigerian Federal Ministry of Health and the Nigerian National Primary Health Care Development Agency [8]. Steps have recently been taken to increase the availability of hypertension services at the community level through the addition of hypertension medications in 2019 to standing orders based on the national hypertension protocol, allowing non-physician health care workers (CHEWs as well as community nurses) to prescribe these medications to patients [7]. While legally supported to diagnose, treat, and manage hypertension, HCWs at PHCs may receive only limited formal training in management of chronic diseases [9].

In 2020, the Hypertension Treatment in Nigeria Program was initiated within 60 PHCs in the Federal Capital Territory of Nigeria with the aim to improve the cascade of hypertension care among selected PHCs [10]. Primary healthcare centers were selected through a multi-stage stratified random sample, the methods for which have been previously described [10]. Formative work identified that frontline HCWs had substantial need for initial and ongoing professional training in order to implement and adopt hypertension services, which has also been identified in similar assessments [11–14]. HCWs at each of the 60 selected sites participated in baseline and refresher training during the Hypertension Treatment in Nigeria Program. The baseline training focused primarily on appropriate methods for diagnosing hypertension, the Nigeria hypertension treatment protocol, and completion of paper and electronic data capture, and was administered through a two-hour didactic overview and an in-depth six- to eight-hour session on cardiovascular disease, measurement of blood pressure, and appropriate treatment [10]. Each site was also visited approximately quarterly throughout the entire study period by research team staff for supportive supervision which included review of case load, appropriate technique for blood pressure measurement, an audit of paper- and electronic case report forms, medication, and equipment inventory. Targeted in-person and hands-on retraining was provided as needed based on findings from each supervision visit.

In preparation for scaling and sustainability, we sought to evaluate the feasibility, implementation, and effects of a supplemental online hypertension education program for CHEWs following the Extension for Community Healthcare Outcomes (ECHO) model. Healthcare workers (71% CHEWs) from 12 PHCs in the Hypertension Treatment in Nigeria Program were engaged to inform adaptation of the ECHO model. A seven-part ECHO series focused on hypertension was subsequently delivered between August 2022 and April 2023, to which all HCWs at the selected 12 PHCs were invited to participate [15]. In this study, we report on the patient-level outcomes of the hypertension ECHO series through evaluation of concurrent data collected in the Hypertension Treatment in Nigeria Program registry.

Methods

ADAPT-ITT framework

The ECHO model was prospectively selected as an evidence-based intervention for delivery of hypertension training to CHEWs in the Federal Capital Territory of Nigeria. Adaptation, implementation, and evaluation of health worker outcomes of the hypertension ECHO program followed the ADAPT-ITT framework and has been previously described [15, 16]. In this quasi-experimental study, we report on differences in service- and patient-level outcomes between PHCs supported through the Hypertension Treatment in Nigeria Program which were selected to participate in the hypertension ECHO series and those which were not. These analyses support the results domain (level 4) of the Kirkpatrick framework which was selected a priori for overall evaluation of the hypertension ECHO training program [17]. Results focused on the reaction, learning, and behavior domains, as well as implementation outcomes will be published separately.

Study setting, design, and sampling

The Hypertension Treatment in Nigeria (NCT04158154) Program is a prospective longitudinal type 2 hybrid implementation research study which aims to evaluate a system-level hypertension program based on the Kaiser Permanente Northern California and World Health Organization HEARTS models within 60 primary healthcare centers in the Federal Capital Territory, Nigeria using an interrupted time series design [10]. Formative work, baseline assessment, and methods for the Hypertension Treatment in Nigeria Program have been previously described [10, 18, 19]. Registration in the pre-implementation phase started in January 2020; this study was embedded within the implementation phase which began in December 2020. Among the 60 PHCs participating in the Hypertension Treatment in Nigeria Program, sites were eligible to participate in the ECHO program if their median number of patient visits per month was 25 or higher at the time of selection in November, 2021, and if the site was not selected to participate in the home blood pressure monitoring arm of the program. Among the 33 eligible PHCs, a random sample of 12 were selected, stratified by government area council [15].

Power calculations were performed with SAS v9.4 (Cary, NC) glmpower and a linear exponent autoregressive correlation structure [20]. Power calculations, based on registry data through September 2021, assumed alpha of 5%, 2000 patient-visits per month, standard deviation of 0.3%, and variable allocation ratios. We determined 80% power to detect a 2.5% point difference in control rate between groups at six-months. Among 33 eligible sites, 12 were selected for the ECHO program based on an approximate 1:2 allocation ratio and stratification by local government council area. Random selection was used where possible, however in one council area, only two PHCs were eligible to participate and therefore both were selected. The analyses evaluate differences between the 12 PHCs selected to participate in the ECHO program and 21 that were not using an intent to treat approach.

Hypertension ECHO program

Seven ECHO sessions were held approximately monthly between August 2022 and April 2023 (Additional File 1). Healthcare workers at participating sites, including the CHEWs, previously assented to receive information about the Hypertension Treatment in Nigeria Program through WhatsApp, email, and phone communications. All HCWs at the 12 sites selected for the ECHO program were invited by WhatsApp message and email to register and participate in each training session. Extension for community health outcomes sessions were additionally advertised broadly on social media, and all registrants were allowed to participate. A parallel mixed-methods evaluation was used to assess reaction, learning, and behavior (Kirkpatrick levels 1 to 3) and implementation outcomes of the ECHO series, and will be separately reported [17]. All HCWs, including CHEWs, at the 12 selected PHCs participated in at least one ECHO session, though participation was variable.

Study population

Primary healthcare centers were instructed to empanel all adults (≥18 years) with hypertension as part of the Hypertension Treatment in Nigeria Program. Patients were included in the analytic cohort if they had complete baseline data, including date of birth, gender, weight, and date of registration, and were not known to be pregnant as well as met clinical criteria for hypertension based on the Nigerian national treatment protocol [21]. Hypertension was defined as: (1) a history of hypertension, (2) persistently (measured on two occasions) elevated systolic blood pressure of 140 mm Hg or above, (3) persistently elevated diastolic blood pressure of 90 mm Hg or above, or (4) use of blood pressure-lowering medication [10]. Blood pressure measurement followed a guideline-based approach including use of appropriate equipment, a resting period, and duplicate measurement [10, 22]. We included all clinic visits from eligible patients between July 2022 and June 2023, inclusive of the seven-part ECHO series. Patient visits included documentation of blood pressure, weight, prescription of medication, counseling, and referrals, and documentation of side effects and adverse events. We additionally used data from site supervision visits, which occurred quarterly as a component of the Hypertension Treatment in Nigeria

Program, to evaluate changes over time in patient case load, medication and supply stocks, healthcare worker staffing, accurate blood pressure measurement observed by trained supervisors, and re-training.

Data management

All participant information relating to the Hypertension Treatment in Nigeria Program were captured on paper-based treatment cards at the PHC. Data were subsequently abstracted to an electronic database in REDCap housed at the University of Abuja Teaching Hospital [23, 24]. Data were locked on September 15, 2023, for this analysis.

Outcomes

Outcomes were mapped to domains of the hypertension ECHO series based on information that was captured through the existing Hypertension Treatment in Nigeria Program (Additional File 1). Our a priori primary outcome was the difference in hypertension treatment rates between sites which were selected to participate in the ECHO series and those which were not. Secondary outcomes included hypertension control rates and adherence to the Nigeria hypertension treatment protocol. Treatment was defined as a new or ongoing prescription by a HCW of any blood pressure lowering medication at the time of the patient visit. Control was defined as blood pressure < 140/90 mm Hg measured during the patient visit. Appropriate treatment was defined as prescriber adherence to the national treatment protocol (Additional File 2) [21]. Secondary outcomes include evaluation of the clinic-level effects on staffing and site capacity, evaluated as patient case load, proportion of adult patients screened for high blood pressure, and proportion of hypertensive patients registered.

Our seven-part ECHO series included two sessions specifically oriented around gestational hypertension management and management of patients with concomitant diabetes. Per the Hypertension Treatment in Nigeria Program protocol, no pregnant women were enrolled during the study time period, nor did any empaneled patients become pregnant, so we were unable to evaluate any outcomes related to gestational hypertension management. To evaluate differences in treatment, control, and appropriate medication between ECHO cohorts among patients with and without diabetes, we performed a subgroup analysis.

Analysis

Continuous variables are summarized with means and standard deviations or medians and interquartile ranges dependent on normality. Categorical variables are summarized as frequencies and percentages. Differences in patient demographics and clinical patterns between sites selected to participate in the ECHO program and those not participating, were evaluated with two sample-test, chi-squared test, or Fishers exact test.

The effect of the hypertension ECHO series on site-level treatment, control, and appropriate stepped treatment was estimated through sequential models which accounted for complexity of the intervention, background study, and baseline imbalances between groups. We used generalized linear models to evaluate the overall effects of time (in months from July 2022), the ECHO intervention, and a time and intervention interaction effect. We used linear mixed models with fixed effects for baseline (July 2022) rates, time (in months from July 2022), intervention, a time and intervention interaction effect, and random site effects to account for within-site variation. We finally performed logistic mixed effects models at the patient level with fixed effects for baseline status (treatment, control, or appropriate treatment), time (in days from July 1, 2022), and intervention, and random effects for to account for within-subject variation. Subgroup analyses among patients with and without diabetes were performed following the same methods.

Statistical significance was declared at 2-sided 5% alpha level, with no adjustments for multiplicity. All analyses were performed using SAS v 9.4 (SAS Institute, Inc.), and R v 4.0.3 (R Foundation for Statistical Computing) was used to create figures.

Ethics and reporting

The protocol for this analysis was reviewed and approved by the Ethics Committee of the University of Abuja (UATH/HREC/PR/2021/011/015) and determined to be exempt by the Northwestern University Institutional Review Board (STU00216041). The overall Hypertension Treatment in Nigeria Program was reviewed and approved by the Ethics Committee of the University of Abuja and the Northwestern University Institutional Review Board. Ethical oversight of the Nigeria Hypertension Treatment in Nigeria Program was provided by the University of Abuja Teaching Hospital Health Research Ethics Committee, which waived patient informed consent based on the Common Rule. This study was performed in accordance with relevant guidelines and regulations in the Declaration of Helsinki.

Results

Patients

Between July 2022, and June 2023, there were 32,101 patient visits reported in the Hypertension Treatment in Nigeria Program of which 16,691 happened within the 33 sites eligible for participation in the ECHO program (Table 1). There were 4340 unique individuals who had one or more site visits, 1428 (33%) within the 12 primary healthcare centers in the ECHO cohort and 2912 (67%)

Table 1 Patients' sociodemographic and clinical characteristic and blood pressure overall and by group

Characteristic, No. (%)	No. Reported	Overall (*n* = 4340)	Group		*P*-value[1]
			ECHO (*n* = 1428)	Non-ECHO (*n* = 2912)	
Age, mean (SD), years	4340	51.5 (12.0)	51.2 (11.8)	51.7 (12.0)	0.18
Body Mass Index, mean (SD), kg/m^2	4313	27.0 (6.1)	26.7 (6.2)	27.2 (6.0)	0.014
Male	4340	1372 (32)	474 (33)	898 (31)	0.12
Education level	4333				0.15
Never attended school		1476 (34)	517 (36)	959 (33)	
Primary school		889 (21)	289 (20)	600 (21)	
Secondary school		866 (20)	268 (19)	598 (21)	
High school or more		1058 (24)	342 (24)	716 (25)	
Other[2]		44 (1)	10 (1)	34 (1)	
Medical History[3]					
Hypertension	4329	2403 (55)	777 (55)	1626 (56)	0.40
Diabetes	4334	166 (4)	42 (3)	124 (4)	0.033
Heart Failure	4334	14 (0)	7 (0)	7 (0)	0.17
Stroke	4333	43 (1)	15 (1)	28 (1)	0.78
Heart attack	4334	17 (0)	6 (0)	11 (0)	0.84
Smoking	4334	78 (2)	24 (2)	54 (2)	0.68
Alcohol use	4334	212 (5)	79 (6)	133 (5)	0.17
SBP, mean (SD), mm Hg[4]	4340	143.9 (22.4)	146.4 (23.1)	142.7 (21.9)	< 0.0001
DBP, mean (SD), mm Hg[4]	4340	89.4 (14.3)	90.6 (14.6)	88.9 (14.2)	0.0001
Heart rate, mean (SD), beats per min[3]	4340	80.9 (13.2)	82.0 (13.9)	80.3 (12.8)	< 0.0001
Council Area	4340				< 0.0001
Abaji		1023 (24)	220 (15)	803 (28)	
AMAC		994 (23)	135 (9)	859 (30)	
Bwari		535 (12)	319 (22)	216 (7)	
Gwagwalada		1186 (27)	285 (20)	901 (31)	
Kuje		443 (10)	310 (22)	133 (5)	
Kwali		159 (4)	159 (11)	0 (0)	
Treatment Step at First Visit[4]	4340				< 0.0001
No Treatment		278 (7)	95 (7)	192 (7)	
Other		750 (17)	251 (18)	499 (17)	
Step 1		1582 (36)	559 (39)	1023 (35)	
Step 2		1375 (32)	379 (27)	996 (34)	
Step 3		258 (6)	93 (7)	165 (6)	
Step 4		88 (2)	51 (4)	37 (1)	
No. Clinic Visits by the Patient During the Study Period, median (IQR)	4340	3 (1, 6)	2 (1–5)	3 (1–6)	0.07
Newly Registered During the Study Period	4340	1086 (25)	442 (31)	644 (22)	< 0.0001

Abbreviations: AMAC, Abuja Municipal Area Council; DBP, Diastolic Blood Pressure; ECHO, Extension for Community Healthcare Outcomes; HCTZ, Hydrochlorothiazide; IQR, Interquartile Range; SD, Standard Deviation; SBP, Systolic Blood Pressure

[1]Two sample t-test, Chi-squared test, or Fishers Exact test as appropriate

[2]Includes religious and trade schools

[3]Reported at baseline and up until June 30, 2023

[4]At the first visit on or after July 1, 2022. Treatment step is defined by the Nigeria Hypertension Guidelines (**Step 1**: Amlodipine 5 mg; **Step 2**: Amlodipine 5 mg + Losartan 50 mg *or* Amlodipine 5 mg + Amiloride 2.5 mg + HCTZ 25mg; **Step 3**: Amlodipine 10 mg + Losartan 100 mg *or* Amlodipine 10 mg + Amiloride 2.5 mg + HCTZ 25mg; **Step 4**: Amlodipine 10 mg + Losartan 100 mg + HCTZ 25 mg)

in the 21 primary healthcare centers in the non-ECHO cohort. Patients were on average (SD) 51.5 (12.0) years old, and one-third were male (n = 1372, 32%). A slightly higher proportion of patients in the non-ECHO cohort had diabetes (n = 124, 4%) compared to the ECHO cohort (n = 42, 3%; p = 0.033). Systolic and diastolic blood pressure – based on the first recorded visit during the study period – was higher among patients in the ECHO cohort (146.4 [23.1] mm Hg and 90.6 [14.6] mm Hg, respectively) compared to the non-ECHO cohort (142.7 [21.9] mm Hg and 88.9 [14.2] mm Hg, respectively; $p \leq 0.0001$ for both). There was no significant difference in the median (IQR) number of clinic visits each patient made at ECHO (2 [1–5]) and at non-ECHO sites (3 [1–6]; p = 0.07).

One-quarter of the patients who visited the clinics during the study time frame were new, and a greater proportion of patients at ECHO sites (31%) were newly empaneled compared to non-ECHO sites (22%; $p<0.0001$). Similar demographics and patterns were observed among subgroups of previously registered and newly registered participants between ECHO groups (Additional File 3).

Treatment, control, and appropriate medication rates

In July 2022, the treatment rates across both ECHO (94.0%) and non-ECHO (94.7%) sites were high and remained so through June 2023 (97.5% and 93.3%, respectively; Table 2; Fig. 1). Treatment rates increased at a significantly higher rate during the hypertension ECHO series among selected sites (interaction p-value=0.045) compared to sites in the non-ECHO cohort. However, after adjustment for baseline and accounting for within site variation, no differences were observed between cohorts in either the overall treatment rate ($p=0.57$) or the rate of increase ($p=0.37$). Baseline treatment rate was deterministic ($p<0.0001$) of follow up treatment rates.

At baseline, the control rates at both ECHO (51.9%) and non-ECHO (54.3%) sites were moderate and increased slightly through June 2023 (55.8% and 55.9%, respectively). A greater increase in overall control rates from baseline was observed among sites which participated in the ECHO program compared to those who did not; however, there was no difference (interaction $p=0.32$) in the slope of the control rates between groups. Medication protocol adherence rates were moderate and similar (chi-squared p-value=0.17) within ECHO (58.3%) and non-ECHO (61.7%) sites at baseline. Adherence to the medication protocol based on prescriber data decreased over time; during the last month of the study period 48.7% of patients among centers in the ECHO cohort and 50.9% of patients in the non-ECHO cohort were treated according to the national protocol. No differences (interaction $p=0.30$) were observed in the slope of the medication protocol adherence rates between groups. Similar to

Table 2 Association of the extension for community healthcare outcomes program with rates of hypertension treatment, control, and adherence to the medication protocol

Outcome	Observed Rates		Linear Model[1]		Linear Mixed Model[2]		Logistic Mixed Model[3]	
	July 2022	June 2023	Adjusted Beta (95% CI)	*P*-value	Adjusted Beta (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Treatment[4]								
Group				0.19		0.57		0.14
ECHO	94.02	97.45	0.84 (-0.45, 2.13)		-0.59 (-2.68, 1.49)		7.06 (0.54, 92.64)	
Non-ECHO	94.68	93.34	Referent		Referent		Referent	
Time			-0.01 (-0.15, 0.13)	0.87	-0.07 (-0.20, 0.06)	0.30	1.01 (1.002, 1.018)	0.017
Group * Time			0.20 (0.01, 0.40)	0.045	0.11 (-0.13, 0.34)	0.37		
Baseline					1.04 (0.98, 1.09)	< 0.0001	> 999	< 0.0001
Control[5]								
Group				0.053		0.94		0.30
ECHO	51.86	55.81	-3.68 (-7.41, 0.06)		-0.33 (-8.27, 7.61)		0.93 (0.81, 1.07)	
Non-ECHO	54.31	55.87	Referent		Referent		Referent	
Time			0.25 (-0.16, 0.65)	0.22	0.14 (-0.28, 0.57)	0.51	1.002 (1.001, 1.002)	< 0.0001
Group * Time			0.28 (-0.29, 0.86)	0.32	-0.04 (-0.79, 0.70)	0.91		
Baseline					0.78 (0.47, 1.09)	< 0.0001	36.83 (31.35, 43.27)	< 0.0001
Appropriate Medication[6]								
Group				0.22		0.82		0.26
ECHO	58.32	48.73	-3.48 (-9.16, 2.21)		0.71 (-5.57, 6.99)		0.91 (0.78, 1.07)	
Non-ECHO	61.66	50.91	Referent		Referent		Referent	
Time			-0.56 (-1.18, 0.06)	0.07	-0.46 (-0.88, -0.04)	0.031	0.998 (0.998, 0.999)	< 0.0001
Group * Time			0.44 (-0.43, 1.32)	0.30	0.13 (-0.59, 0.86)	0.72		
Baseline					0.68 (0.46, 0.89)	< 0.0001	92.84 (75.79, 113.71)	< 0.0001

Abbreviations: CI, Confidence Interval; ECHO, Extension for Community Healthcare Outcomes; OR, Odds Ratio

[1]Rate = Time (months from July 2022) + ECHO Group + ECHO Group * Month

[2]Rate = Time (months from July 2022) + ECHO Group + ECHO Group * Month + Baseline Rate (July 2022) + Random Site Effect. The ICC values for treatment, control, and adherence were 0.23, 0.36, and 0.21 respectively

[3]Status = Time (days from 1 July 2022) + ECHO Group + Baseline Status (First Visit in the Study Period) + Random Intercept

[4]Defined as a hypertension medication prescribed or otherwise being taken at the time of the patient visit

[5]Defined as SBP < 140 mm Hg and DBP < 90 mm Hg measured at the patient visit

[6]Defined as appropriate prescription or continuation of therapy following the Nigeria Hypertension Medication Protocol

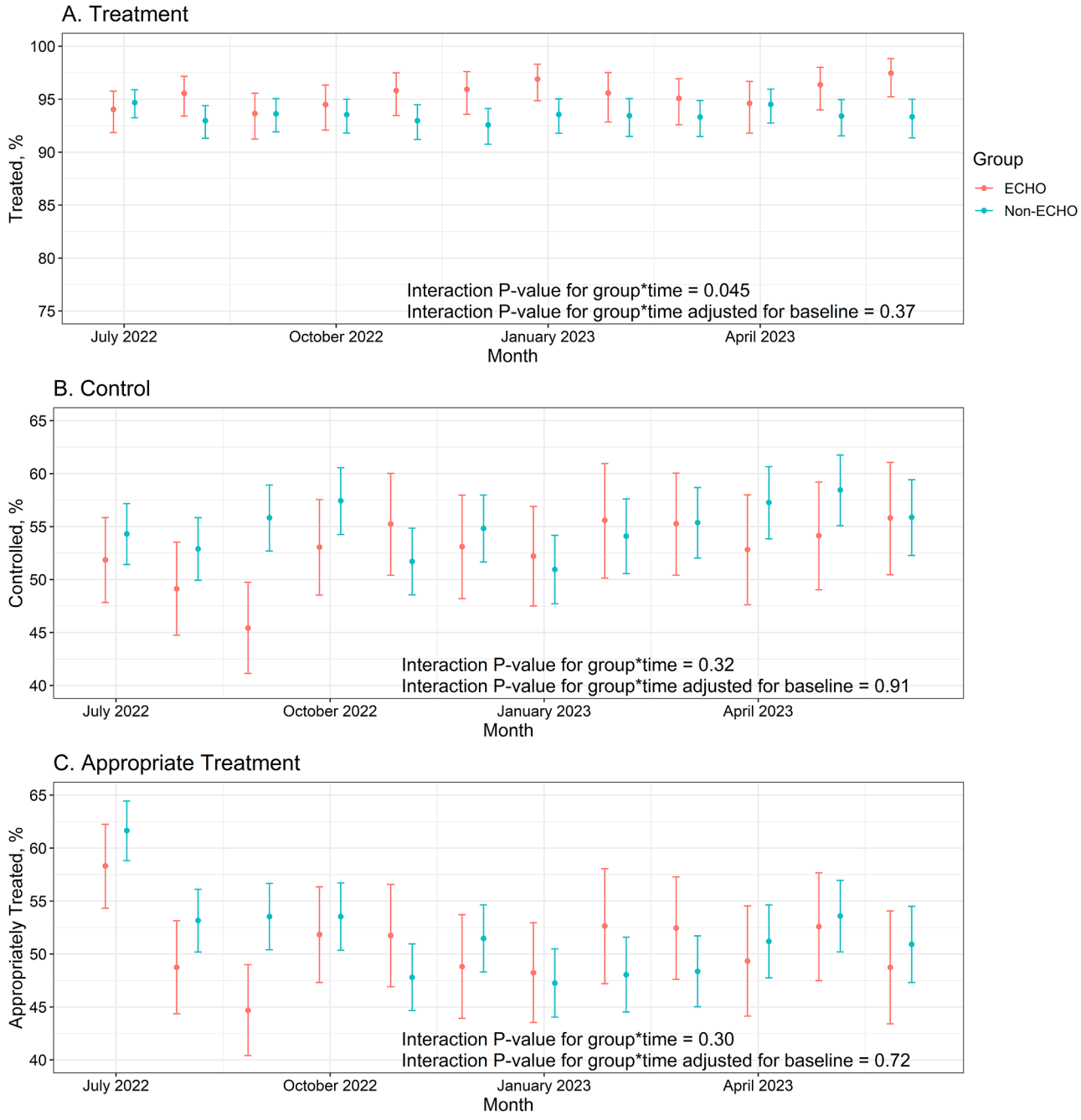

Fig. 1 Observed Treatment (**A**), Control (**B**), and Medication Protocol Adherence (**C**) Rates and 95% Confidence Intervals Over Time by Extension for Community Healthcare Outcomes Group. The proportion of empaneled patients who were treated, controlled, and prescribed medications following the Nigeria hypertension protocol are shown based on the timing of their visits to 12 primary healthcare centers which were selected to participate in the Extension for Community Healthcare Outcomes program and 21 which were not. Results are shown as a proportion and accompanying 95% confidence interval using patient level data from the Nigeria Hypertension Treatment Program registry

treatment results, baseline control ($p<0.0001$) and medication protocol adherence ($p<0.0001$) were highly predictive of follow-up rates.

Similar results were observed in treatment, control, and protocol adherent medication when data were analyzed at a patient level through logistic mixed effects models. The baseline treatment, control, and protocol adherent medication status were generally deterministic of an individual patients' follow up status. When subset to patients who were untreated ($n=181$), uncontrolled ($n=1623$), and not treated according to the national treatment protocol ($n=1205$) at their index visit and who had at least

one follow up visit, results were similar and reinforced the deterministic effect of the patients' baseline status.

Subgroup analyses

Among 4340 patients with one or more visits in the study time frame, 166 had a history of diabetes, and no patients were diagnosed with new onset diabetes during the study timeframe. Of the 166 patients with diabetes, 132 were already empaneled prior to the study period (Additional File 4). While overall differences were observed in the rate of empanelment among patients with diabetes, there were no differences observed between cohorts in empanelment rates among newly registered patients. The median (IQR) number of clinic visits for each patient with diabetes made was similar at ECHO (3 [1–5]) and at non-ECHO sites (3 [1–6]; $p=0.46$). Patients with diabetes among the ECHO sites were more likely to be treated for hypertension at their baseline visit ($p=0.02$) than those at non-ECHO sites. No differences were observed in treatment, control, or appropriate medication between cohorts among patients with diabetes (Additional File 5).

Site outcomes

No differences were observed between sites in the ECHO cohort and those not in the ECHO cohort in their staffing levels either immediately prior to the ECHO series or during the series (Table 3). No differences were observed either in staffing levels over time (p for trend ≥ 0.05 for all). The median number of adult patients per day based on site registers was stable over the study time frame, and no differences were observed between cohorts. Nearly all adult patients presenting at both the ECHO and non-ECHO sites were screened for blood pressure, and nearly all patients who were diagnosed with hypertension were empaneled in the Nigeria Hypertension Treatment registry (Fig. 2).

Working blood pressure apparatuses were present in all facilities at the supervision visit prior to the ECHO series and were available during all concurrent visits with the exception of one visit at an ECHO site. Functional weighing scales and at least one or more 30-day supplies of hypertension medications were similarly nearly always available, and measuring tapes for recording height which

Table 3 Site Supervision results in extension for community healthcare outcomes and non-extension for community healthcare outcomes cohorts

Site Characteristic, median (IQR)	Immediate Prior Supervision Visits		*P*-value[1]	Supervision Visits During the Study Period		*P*-value[1]	*P*-value[2]	
	ECHO (*n* = 12)	Non-ECHO (*n* = 21)		ECHO (*n* = 48)	Non-ECHO (*n* = 83)		ECHO	Non-ECHO
Staff								
Number of full-time staff	5 (3–6)	5 (3–7)	0.66	4 (3–7)	5 (3–7)	0.23	0.83	0.89
Number of part-time staff	6 (3–9)	3 (2–6)	0.21	5 (3–9)	4 (2–7)	0.013	0.73	0.73
Number of doctors	0 (0–0)	0 (0–0)	0.72	0 (0–0)	0 (0–0)	0.13	1	0.82
Number of CHEWs[3]	3 (1–4)	2 (1–4)	0.95	2 (1–4)	3 (1–5)	0.56	0.53	0.94
Patient Flow								
Number of adult patients, per day	6 (5–10)	6 (4–9)	0.63	6 (4–10)	5 (3–9)	0.06	0.29	0.26
Proportion of adults with blood pressure checked	100 (100–100)	100 (85–100)	0.65	100 (100–100)	100 (100–100)	0.26	0.95	0.67
Proportion of adults with high blood pressure	28 (5–55)	24 (17–48)	0.61	11 (0–27)	13 (0–33)	0.22	0.30	0.40
Proportion registered	100 (100–100)	100 (100–100)	0.62	100 (100–100)	100 (100–100)	0.63	0.11	0.021
Functional Supplies Present, N (%)								
Blood pressure apparatus	12 (100)	21 (100)	NA	47 (98)	83 (100)	0.19	NE	NE
Adult weighing scale	10 (83)	19 (90)	0.55	45 (94)	78 (94)	0.96	0.13	0.10
Measuring tape	12 (100)	20 (95)	0.44	48 (100)	83 (100)	NA	NE	NE
Hypertension medications[4]	10 (83)	21 (100)	0.054	46 (96)	78 (94)	0.65	0.26	0.18
Observation and Retraining, N (%)								
Blood pressure measured correctly[5]	10 (100)	13 (72)	0.07	40 (89)	67 (87)	0.76	0.85	0.41
Data captured correctly[5]	7 (58)	11 (52)	0.74	34 (71)	50 (60)	0.22	0.57	0.70
Retraining was provided[5]	10 (91)	19 (90)	0.97	43 (90)	77 (93)	0.53	0.53	0.73

Abbreviations: CHEWs, Community Health Extension Workers; ECHO, Extension for Community Healthcare Outcomes; IQR, Interquartile Range

[1]Wilcoxon Sign Rank test, Chi-squared test, or Fishers Exact test as appropriate, comparing independent samples between each cohort

[2]P-value for trend evaluated through linear or logistic regression

[3]Includes "Junior Community Health Extension Workers"

[4]Defined as availability of one or more 30-day supplies of any hypertension medications on the day of assessment

[5]In some supervision visits, these data were not recorded

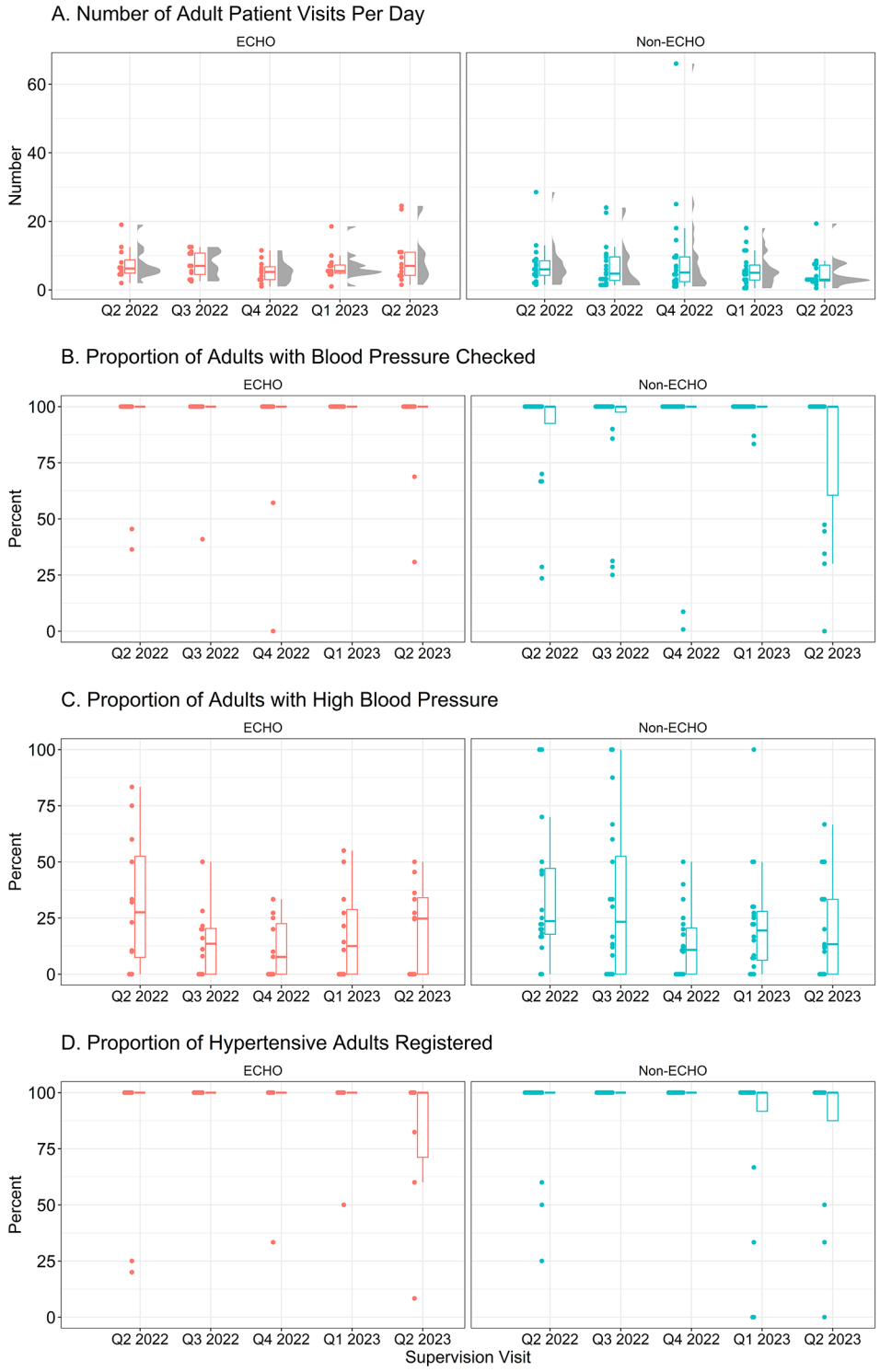

Fig. 2 Clinic Caseload (**A**) and Cascade of Hypertension Evaluation (**B**), Diagnosis (**C**), and Empanelment (**D**) based on Quarterly Supportive Supervision Visits. Site supervision data from the Nigeria Hypertension Treatment Program were used to summarize clinic caseload and hypertension services. Data are from the immediate prior quarter (Q2 2022) and each quarter during (Q3 2022 to Q2 2023) the hypertension Extension for Community Healthcare Outcomes program. The site supervision protocol included visiting each site once per quarter, and all visits occurred as planned except for one. During the visit, site registry information was used to calculate the number of adult patients visiting the clinic per day. The number of those adults who had their blood pressure checked was documented, along with the number of adults who had high blood pressure and the number who were newly registered in the Nigeria Hypertension Treatment Program

was used to calculate body mass index were slightly less frequently present. Direct observation of blood pressure measurement was performed during supervision visits, and no differences were found between ECHO and non-ECHO sites. Retraining was frequently performed with sites (≥90% of supervision visits) but focused primarily on data capture for the Hypertension Treatment in Nigeria registry.

Discussion

Despite higher absolute increases in the rates of hypertension treatment and control among ECHO sites compared to non-ECHO sites, and a significant interaction effect for treatment rates, the differences were not significant after adjustment for baseline rates and time. These findings were consistent when data were analyzed at a patient level, illustrating that minimal individual patient-level change in treatment, control, and medication prescription occurred during the study time frame.

The limited number of prior patient-level evaluations that include objective measures of treatment and disease control largely report positive outcomes associated with the ECHO program. One study focused on patients with poorly controlled diabetes (HbA1c>9%) reported significant reduction (mean [Standard Deviation] HbA1c improved from 10.2 [1.4]% to 8.4 [1.8]%; $p<0.001$) among a small ($n=39$) retrospective cohort following implementation of an ECHO program [25]. Another evaluation among patients with chronic liver disease demonstrated improved mortality (hazard ratio: 0.54, 95% confidence interval 0.36–0.81, $p=0.003$) among patients who received a virtual consultation associated with the ECHO model compared to patients who did not [26]. While several patient-level evaluations have been performed to assess indicators of treatment and control among Hepatitis C – the initial domain of the ECHO model – these have been performed as a comparison with outcomes at tertiary care centers in a non-inferiority framework, limiting understanding of the ECHO programs' effects [27, 28].

Our ability to detect an effect of the ECHO program may have been limited due to a ceiling effect of high treatment rates at baseline across all sites. At the start of the ECHO series, the PHCs had been participating in the Hypertension Treatment in Nigeria Program for over two and half years. At the time of ECHO delivery, healthcare workers at these sites had received substantial baseline training and ongoing support to provide hypertension services following a simplified treatment guideline, as well as monthly performance report, quarterly site supervision, and access to essential hypertension medicines and fixed dose combinations. Within this context, the ECHO series was offered as an add-on strategy, and the effects may be stronger if compared between sites that are not receiving as much support or as focused on hypertension patient outcomes.

We observed a marked reduction in medication protocol adherence rates over time. When the Hypertension Treatment in Nigeria Program transitioned to the implementation phase, hypertension medications following the Nigeria hypertension treatment protocol were offered at no cost to patients. In preparation for sustainment of the program, the free medication model transitioned at a systemwide level to a subsidized model, implemented as a drug revolving fund in June, 2022. Analyses of the drug revolving fund and its effects on availability of medications are in progress. It is notable that treatment rates rose among PHCs which participated in the ECHO program and slightly declined among those which did not during this timeframe.

In our formative work, comorbid diabetes and gestational hypertension were identified by HCWs as domains for focused trainings. We observed results similar to our overall findings when analyses were carried out among patients with diabetes only, though the sample size was small. Gestational hypertension screening and referral are critical within primary care, particularly given the high prevalence of elevated blood pressure, risk factors, and unique barriers among women of reproductive age [6, 29]. We were unable to evaluate effectiveness within this population due to exclusion from the Hypertension Treatment in Nigeria Program. Future scaling of hypertension services and supportive training should incorporate additional follow up and evaluate quality of care among these special populations.

Participation in the hypertension ECHO program does not appear to have adversely affected clinical capacity to provide hypertension services. We found no adverse consequences on the sites' ability to provide patient care – evaluated as the hypertension treatment cascade – and no differences over time in staffing levels among ECHO sites which could indicate overly burdened HCWs. To our knowledge, ECHO program evaluations have not reported on potential adverse consequences of participation at clinic-levels, and these results support continued and broader use of the model.

This study adds to a limited, but growing body of evidence evaluating the effect of the ECHO program on patient level outcomes. Three systematic reviews have been performed to date focusing on patient-level outcomes of ECHO programs, which together describe the results of 23 unique studies [30–32]. Collectively, these three reviews narratively describe positive effects of the ECHO program on a variety of patient outcomes including objective biomarkers, access to clinical care, mortality, prescription patterns, cost, and referrals. Each of the 23 studies identified was performed in either the United States or Australia and none utilized a randomized

design. Our evaluation builds upon the literature within this space by incorporating random selection, performance within a diverse setting including rural locations, and evaluation with a rich patient registry to robustly quantify multiple patient-level effects of our hypertension ECHO program in a pragmatic setting.

Limitations

The power and sample size calculation did not account for within-site clustering or baseline imbalances; therefore, our study may have been underpowered to detect a difference between groups. While we randomly selected sites when there were enough eligible for participation in each area council, random selection at the PHC level did not translate to equivalent groups at the patient level. To account for differences, we adjusted for baseline rates in our analyses, which were highly predictive of follow up treatment, control, and protocol adherence rates both at patient- and site-levels. Our intervention and control groups both received substantial training and support through the Hypertension Treatment in Nigeria Program; similar evaluation of the ECHO model among sites which are less sensitized and focused on hypertension care may yield stronger effects.

A number of program evaluations within chronic pain management have evaluated and reported on significant reductions in opioid prescriptions associated with implementation of an ECHO program [33–35]. One of these studies found differential results between an intent-to-treat analysis and an as-treated analysis reflecting the importance of provider engagement in the ECHO program [35]. We performed our patient-level analyses following an intent-to-treat approach. An as-treated analysis accounting for dose of the intervention among individual HCWs could further explain differences in the patient-level effects. We were unable to perform this analysis as we did not track individual HCW participation during the ECHO series, or unique HCWs in the Hypertension Treatment in Nigeria Program registry. Finally, we did not specifically seek to evaluate cost as an outcome for this sub-study, which is underreported in ECHO program evaluations [36]. In administering the program, we did collect information on implementation cost, which will be reported in the future and used to inform decisions around national implementation.

Conclusion

Our results show that the hypertension ECHO program resulted in moderate, but not significant improvements on treatment rates among PHCs participating in the Hypertension Treatment in Nigeria Program and that participation in the ECHO series did not adversely affect staffing or clinical capacity. Establishing a correlation between patient-level outcomes and the ECHO training received by HCWs in this setting is challenging due to the numerous and multifaceted contextual factors. More research is needed to evaluate the effectiveness of individual HCW participation in ECHO trainings and the subsequent effects on patient care, particularly among populations of interest who could benefit from increased service availability within primary care. These results may be used to inform strategies for scaling hypertension services throughout Abuja and Nigeria, and implementation of the ECHO model for CHEWs in other geographies and focus areas.

Abbreviations

CHEW	Community Health Extension Worker
ECHO	Extension for Community Healthcare Outcomes
HCW	Healthcare Worker
PHC	Primary Healthcare Center
UATH	University of Abuja Teaching Hospital

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12875-024-02579-y.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

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Not Applicable.

Author contributions

ASB, LRH, and NRK designed the study and directed the analysis. ASB, DBO, and MDH secured funding for the study. ASB, BA, EO, IAO, GLS, and SO implemented the study. ASB wrote the first draft of the manuscript. ASB analyzed and interpreted data. AO, BA, DBO, EO, EJ, GI, GLS, IAO, JY, LNM, LRH, MDH, NRK, OB, and SO provided critical feedback on the manuscript. All authors read, provided feedback and edits, developed figures and tables, and approved the final manuscript.

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Data availability

The data used in this analysis will be made available through NHLBI BioLINCC upon conclusion of the Hypertension Treatment in Nigeria Program.

Declarations

Ethics approval and consent to participate

The study was reviewed and approved by the Ethics Committee at the University of Abuja Teaching Hospital (UATH/HREC/PR/2021/011/015) and the Institutional Review Board at Northwestern University (STU00216041). Ethical oversight of the Nigeria Hypertension Treatment in Nigeria Program was

provided by the University of Abuja Teaching Hospital Health Research Ethics Committee, which waived patient informed consent based on the Common Rule. The study was also reviewed by the Federal Capital Territory Ethics Committee and Northwestern University Institutional Review Board. The trial was prospectively registered at www.clinicaltrials.gov under NCT04158154 on November 8, 2019; https://clinicaltrials.gov/ct2/show/NCT04158154. This study was performed in accordance with relevant guidelines and regulations in the Declaration of Helsinki.

Consent for publication
Not Applicable.

Competing interests
MDH has received travel support from the World Heart Federation and consulting fees from PwC Switzerland. MDH has an appointment at The George Institute for Global Health, which has a patent, license, and has received investment funding with intent to commercialize fixed-dose combination therapy through its social enterprise business, George Medicines. MDH has pending patents for heart failure polypills. LRH served as a Guest Editor for 'The role of community health workers in primary care' Collection.

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