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Effect of a Community Health Worker–Led Multicomponent Intervention on Blood Pressure Control in Low-Income Patients in Argentina
A Randomized Clinical Trial

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IMPORTANCE Despite extensive knowledge of hypertension treatment, the prevalence of uncontrolled hypertension is high and increasing in low- and middle-income countries.

OBJECTIVE To test whether a community health worker–led multicomponent intervention would improve blood pressure (BP) control among low-income patients with hypertension.

DESIGN, SETTING, AND PARTICIPANTS A cluster randomized trial was conducted in 18 centers for primary health care within a national public system providing free medications and health care to uninsured patients in Argentina. A total of 1432 low-income adult patients with uncontrolled hypertension were recruited between June 2013 and April 2015 and followed up to October 2016.

INTERVENTIONS Nine centers (743 patients) were randomized to the multicomponent intervention, which included a community health worker–led home intervention (health coaching, home BP monitoring, and BP audit and feedback), a physician intervention, and a text-messaging intervention over 18 months. Nine centers (689 patients) were randomized to usual care.

MAIN OUTCOMES AND MEASURES The coprimary outcomes were the differences in systolic and diastolic BP changes from baseline to the end of follow-up of patients with hypertension. Secondary outcomes included the proportion of patients with controlled hypertension (BP <140/90 mm Hg). Three BP measurements were obtained at each of 2 baseline and 2 termination visits using a standard protocol, the means of which were used for analyses.

RESULTS Of 1432 participants (mean age, 55.8 years [SD, 13.3]; 772 women [53.0%]), 1357 (94.8%) completed the trial. Baseline mean systolic BP was 151.7 mm Hg for the intervention group and 149.8 mm Hg for the usual care group; the mean diastolic BP was 92.2 mm Hg for the intervention group and 90.1 mm Hg for the usual care group. Systolic BP reduction from baseline to month 18 was 19.3 mm Hg (95% CI, 17.9-20.8 mm Hg) for the intervention group and 12.7 mm Hg (95% CI, 11.3-14.2 mm Hg) for the usual care group; the difference in the reduction was 6.6 mm Hg (95% CI, 4.6-8.6; $P < .001$). Diastolic BP decreased by 12.2 mm Hg (95% CI, 11.2-13.2 mm Hg) in the intervention group and 6.9 mm Hg (95% CI, 5.9-7.8 mm Hg) in the control group; the difference in the reduction was 5.4 mm Hg (95% CI, 4.0-6.8 mm Hg; $P < .001$). The proportion of patients with controlled hypertension increased from 17.0% at baseline to 72.9% at 18 months in the intervention group and from 17.6% to 52.2% in the usual care group; the difference in the increase was 20.6% (95% CI, 15.4%-25.9%; $P < .001$). No adverse events were reported.

CONCLUSIONS AND RELEVANCE Low-income patients in Argentina with uncontrolled hypertension who participated in a community health worker–led multicomponent intervention experienced a greater decrease in systolic and diastolic BP than did patients who received usual care over 18 months. Further research is needed to assess generalizability and cost-effectiveness of this intervention and to understand which components may have contributed most to the outcome.

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Hypertension is a leading global modifiable risk factor for cardiovascular disease and premature death.[1,2] Despite extensive knowledge of hypertension prevention and treatment, the global prevalence of hypertension is high and increasing, while the proportion of controlled hypertension is low, especially in low- and middle-income countries.[3] It was estimated that 31.1% of the world's adults had hypertension in 2010, and 75% of those with hypertension lived in low- and middle-income countries. Of those, only 7.7% of patients with hypertension had their blood pressure (BP) controlled to less than 140/90 mm Hg.[3] Therefore, developing and implementing effective, affordable, and sustainable programs for hypertension control is a public health priority in low- and middle-income countries.

Barriers at the health care system, physician, patient, and community levels hinder BP control.[4,5] Strategies for overcoming these barriers, including pharmacist-led and nurse-led interventions, were shown to improve BP control in patients with hypertension.[6,7] For example, pharmacist-led interventions were associated with a 7.6-mm Hg reduction in systolic BP (95% CI, 6.3-9.0 mm Hg) and nurse-led interventions were associated with a 3.5-mm Hg reduction in systolic BP (95% CI, 1.1-5.9 mm Hg) in previously published meta-analyses.[6,7] However, there are limited data on effective intervention strategies for hypertension control in low- and middle-income countries.[8,9] Furthermore, the effect of community health worker–led interventions, a more affordable and sustainable approach for low-income settings, has not been well tested in randomized trials.

The Hypertension Control Program in Argentina (HCPIA) was a cluster randomized trial aiming to test whether implementation of a community health worker–led multicomponent intervention over 18 months lowered systolic and diastolic BP and improved hypertension control among low-income patients with uncontrolled hypertension in Argentina.

Key Points

Question Can a community health worker–led multicomponent intervention improve blood pressure control among low-income patients with hypertension?

Findings In this cluster randomized trial involving 1432 low-income, uninsured patients with hypertension in Argentina, the community health worker–led multicomponent intervention significantly reduced systolic blood pressure by 6.6 mm Hg and diastolic blood pressure by 5.4 mm Hg compared with usual care over 18 months.

Meaning A community health worker–led multicomponent intervention may improve hypertension control in low-income populations.

Methods

Study Design and Oversight

This was a cluster randomized trial involving 18 centers for primary health care within a national public system (Remediar+Redes Program) in Argentina (trial protocol in Supplement 1). Details of the trial's design and analysis plan have been published.[9] The institutional review boards of Tulane University and Hospital Italiano de Buenos Aires in Argentina approved the study. Informed consent was signed by all participants during screening.

Study Participants

After the 1998-2002 economic depression, a large proportion of the Argentine population did not have health insurance, and health care for the uninsured was provided by an overloaded national network of public clinics and hospitals.[10,11] In response, the Remediar+Redes Program was funded by the Argentina Ministry of Health to provide free medications and health care to low-income, uninsured patients.[12] Over the past decade, the program has evolved to become the main public primary health care network in Argentina, covering almost all provinces and municipalities with almost 7000 centers for primary health care across the country (>90% of all public clinics).

The main eligibility criteria for centers for primary health care were an affiliation with the Remediar+Redes Program, location in a poor urban area, and employment of community health workers in addition to general practitioners and nurses. A total of 204 centers from Buenos Aires, Misiones, Tucuman, Corrientes, and Entre Ríos were screened for potential participation (study protocol is available in Supplement 1). Among centers that met the eligibility criteria, 18 were selected based on recommendations from the Remediar+Redes Program (**Figure 1**). Cluster randomization was stratified by geographic region and conducted at the data coordinating center at Tulane University. The randomization schedules were generated using PROC PLAN in SAS software (SAS Institute Inc).

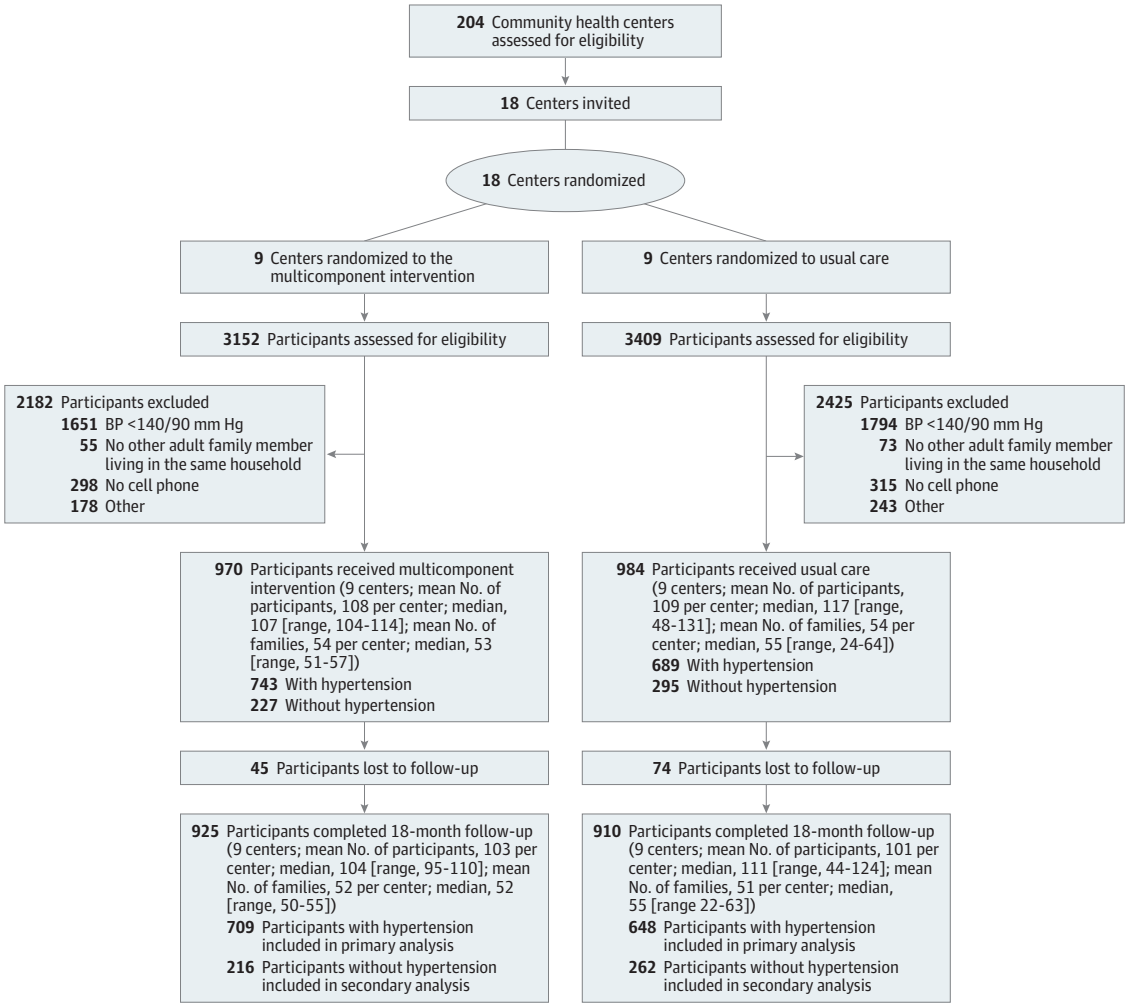
The main eligibility criteria for index participants were uncontrolled BP (systolic ≥140 mm Hg, diastolic ≥90 mm Hg, or both, measured on at least 2 separate screening visits), 21 years or older, uninsured and receiving primary care from the participating centers, spouses with or without hypertension, or adult family members (≥21 years) with hypertension living in the same household who were willing to participate in the study. The study nurses reviewed the clinic appointment schedules daily and identified all patients with hypertension. Two screening visits at least 1 day apart were conducted to assess patients' eligibility. Eligible index participants, their spouses with or without hypertension, and adult family members with hypertension were recruited for the study between June 2013 and April 2015. To avoid selection bias, participants remained eligible for the study if they received antihypertensive treatment after the screening visits and their BP was less than 140/90 mm Hg at the baseline examination.

Interventions

An 18-month multicomponent intervention program, including a community health worker–led home-based intervention (health coaching and home BP monitoring and audit), physician education, BP feedback, and weekly text messaging was implemented in the intervention clinics.

The community health workers were trained to coach patients and their family members on lifestyle modification,

Figure 1. Flow Diagram of Trial Participants



Participants who did not have hypertension were the spouses of patients with hypertension (<140/90 mm Hg) and did not use antihypertensive medications. Although many centers met the eligibility criteria, 18 were recommended based on their geographic distribution, their willingness to participate, and their previous experience collaborating with the coordinating center. The centers were not randomly selected.

home BP-monitoring, and medication adherence during a 2-day interactive training session followed by onsite field testing and certification. They were also trained to function as case managers for the patients and their families by coordinating intervention activities and facilitating patient care. They visited participants' homes monthly for the first 6 months and every other month thereafter. The family-based intervention started with an initial 90-minute home visit at a time when all family members in the household were available to discuss general knowledge about hypertension prevention and treatment. During subsequent 60-minute monthly or bimonthly follow-up visits, the community health workers provided tailored counseling to participants and their families on lifestyle modification, home BP monitoring, and medication adherence skills. They reviewed specific strategies for lifestyle modification—such as weight loss, dietary sodium reduction, physical activity increase, alcohol moderation, and the DASH (Dietary Approaches to Stop Hypertension) diet use—with patients and their families. Patients were encouraged to adopt lifestyle modification strategies that were the most suitable for their individual needs. All patients with hypertension in the intervention group were given an automatic home BP monitor and log and were trained to record their BP weekly. Additionally, they were provided 7-day pill organizers and counseled on techniques for improving medication adherence. Home visits also focused on goal setting, problem solving, social support, and maintaining motivation during challenging situations. Community health workers helped patients schedule appointments with primary care physicians and delivered antihypertensive medications to patients' homes if they did not have access to transportation.

Primary care physicians took part in an online education course on hypertension management followed by an onsite, in-person, half-day intensive training and certification. The physician training program focused on standard treatment algorithms for stepped-care BP management based on clinical

guidelines.[13,14] In addition, annual online hypertension management courses were provided for recertification. Feedback was given to primary care physicians, based on home BP monitoring data collected by community health workers, to encourage medication adjustment when needed.

Individualized text messages to promote lifestyle changes and reinforce medication adherence were sent out weekly to participants' mobile phones by an eHealth platform at the Institute for Clinical Effectiveness and Health Policy in Buenos Aires, Argentina. Messages were based on hypertension status and perceived barriers to behavioral change identified during home visits and consisted of motivational statements and behavioral change techniques to reinforce in-person education interventions. The community health workers also collected information on participants' receipt of text messages.

Usual Care Control

In the centers randomized to the control group, neither physicians nor community health workers were trained to conduct study interventions. Additionally, participants did not receive home visits, home BP monitors, or text messages. Participants were encouraged to follow the clinical visit schedule of the Remediar+Redes Program: monthly among patients after pharmacological treatment initiation and every 3 to 6 months among patients who had controlled BP.

Blinding

Study physicians, community health workers, and participants were not blinded to the intervention assignment. However, study outcomes were collected by nurses who were not involved in the intervention (Figure 1).

Outcomes

The coprimary outcomes were the differences between the intervention and control groups in mean systolic and diastolic BP changes from baseline to the end of follow-up in patients with hypertension. Secondary outcomes included the proportion of patients who had controlled hypertension, adhered to antihypertensive medication by self-report, and intensified their antihypertensive medication (via titration or added another medication); the cost per additional percentage of hypertension controlled; and the change in weight over the 18-month study. Secondary outcomes also included changes in systolic and diastolic BP among the participants who did not have hypertension.

Trained and certified research nurses who did not engage in the intervention collected all study data at baseline and at 6, 12, and 18 months of follow-up in participants' homes using standard questionnaires and measurement methods. Two visits between 1 and 14 days apart at baseline and at 18 months were conducted to obtain repeated BP measurements. Three BP measurements were obtained at each data collection visit, and the mean of all measurements at each time point was used for analysis. Blood pressure was measured according to a standard protocol recommended by the American Heart Association[15] and was measured with participants in a seated position after 5 minutes of quiet rest. In addition, participants were required to avoid alcohol, cigarettes, coffee, tea, and exercise for at least 30 minutes before their BP measurement. An auto-BP cuff (Intellisense Digital BP Monitor; Omron HEM 907 XL, Omron Healthcare) was used, and 1 of 4 cuff sizes (pediatric, regular adult, large, or thigh) was chosen based on each participant's arm circumference. Patient adherence to antihypertensive medication was quantified using the 8-item Morisky Medication Adherence Scale.[16] Intensification of antihypertensive medications, including titration or addition of a new medication, was assessed by questionnaire and medical records. Intensification was used as an indicator of primary care physician adherence to the intervention program and related clinical guidelines. Adverse events, such as hypotension, syncope, and injurious falls, were queried during the nurse visits.

Costs related to the intervention (ie, program coordination, community health worker salaries, physician training, home visits, BP monitors, and eHealth platform programming) were recorded at each clinic or study coordinating center. Costs related to health care (ie, drug expenditures, laboratory tests, physician office visits, and hospitalizations) were collected from patients, clinics, and hospitals using standard questionnaires. (See eAppendix in Supplement 2 for detailed methods.)

Statistical Analysis

The trial was designed to provide 80% statistical power to detect a 4.0-mm Hg or more reduction in systolic BP at a significance level of .05 using a 2-tailed test.[6,7] Eighteen centers (9 in each group) with an average cluster size of 62 patients with hypertension, an 85% follow-up rate, an intercluster correlation of 0.06, and a standard deviation of 10.0 mm Hg were assumed. The cluster design was taken into consideration in the power calculation.[17,18]

The intention-to-treat principle was used for all analyses. Only patients with hypertension were included in the primary analysis, according to the study protocol, because we aimed to test the effect of the community health worker–led multicomponent intervention on BP control among patients with hypertension.[9] A mixed-effects regression analysis, in which participants were nested in families, which were nested in centers, which were further nested in randomization groups, was used to estimate difference in the changes of BP from baseline to 6, 12, and 18 months, separately. In addition, the mean difference in the changes of BP during the intervention period were estimated. In these models, participants, families, and centers were assumed to be random effects, and the intervention was assumed to be a fixed effect. An autoregressive correlation structure was selected for these repeated measures. In addition, generalized estimating equations were used to compare baseline variables and the proportions of binary outcomes at 6, 12, and 18 months. Cluster effects were accounted for by assuming a compound-symmetry covariance structure, and standard errors were estimated using a robust variance estimator. In secondary analyses, important covariables were adjusted, and predefined subgroup analyses were conducted. In these analyses, pairwise deletion of missing data was used to preserve all information observed. Additionally, multiple imputation for missing data in the multivariable analyses was conducted using the Markov chain Monte Carlo method. PROC GLIMMIX and PROC GENMOD of SAS

Table 1. Baseline Characteristics of Participants With Hypertension

Characteristics[a]	Intervention (n = 743)	Control (n = 689)	*P* Value
Age, mean (SD), y	56.1 (13.6)	55.5 (13.0)	.45
Women, No. (%)	394 (52.6)	378 (53.4)	.53
Currently smoking, No. (%)	144 (19.2)	134 (19.2)	.99
Weekly alcohol drinking, No. (%)	247 (33.4)	208 (30.1)	.19
Physical activity, median (IQR), MET/wk	8 (0, 24)	9 (0, 28)	.30
Medical history, No. (%)			
Major CVD[b]	93 (12.7)	62 (9.0)	.03
Hypercholesterolemia	313 (42.4)	254 (36.8)	.04
Diabetes	175 (23.7)	146 (21.1)	.26
BMI, mean (SD)	31.8 (6.6)	31.5 (6.5)	.36
Blood pressure, mean (SD), mm Hg[c]			
Systolic	151.7 (16.8)	149.8 (15.5)	.03
Diastolic	92.2 (12.2)	90.1 (12.9)	.002
Use of antihypertensive medications, No. (%)	639 (86.0)	575 (83.5)	.18
Morisky score, mean (SD)[d]	6.3 (1.9)	6.3 (2.0)	.69

Abbreviations: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared; CVD, cardiovascular disease; IQR, interquartile range.

[a] Generalized estimating equations were used to compare baseline variables accounting for cluster effects from families and clinics.

[b] Major CVD includes myocardial infarction and stroke.

[c] Mean blood pressure from screening and baseline visits.

[d] Eight-item Morisky Medication Adherence Scale scores range from 0 to 8 with low adherence defined as a score of less than 6, medium adherence as scores of 6 or 7, and high adherence with a score of 8.

Table 2. Effects of the Multicomponent Intervention on Secondary Outcomes Among Participants With Hypertension

	Intervention		Control		Net Difference in Percentage Points (95% CI)	*P* Value	Adjusted Net Difference (95% CI)[a]	*P* Value
	No. of Patients	No. (%) [95% CI]	No. of Patients	No. (%) [95% CI]				
Proportion With Controlled Hypertension[b]								
Baseline	743	127 (17.0) [14.4 to 20.0]	689	122 (17.6) [15.0 to 20.7]	−0.6 (−4.6 to 3.4)	.77	1.9 (−1.1 to 5.0)	.22
Month measured								
6	722	333 (46.1) [42.5 to 50.0]	682	277 (40.4) [36.8 to 44.4]	5.7 (0.4 to 11.0)	.04	8.0 (2.9 to 13.1)	.002
12	719	439 (61.0) [57.3 to 64.8]	654	288 (43.9) [40.2 to 47.9]	17.1 (11.7 to 22.5)	<.001	18.4 (13.2 to 23.6)	<.001
18	709	517 (72.9) [69.6 to 76.3]	648	340 (52.2) [48.4 to 56.4]	20.6 (15.4 to 25.9)	<.001	22.1 (17.1 to 27.2)	<.001
Proportion With High Adherence in Patients Taking Antihypertensive Medications[c,d]								
At baseline	620	197 (31.3) [27.6 to 35.6]	570	223 (38.0) [34.0 to 42.5]	−6.7 (−12.6 to −0.9)	.03	−6.3 (−12.1 to −0.5)	.03
Month measured								
6	627	309 (48.3) [44.2 to 52.8]	575	237 (41.2) [37.0 to 45.7]	7.1 (1.0 to 13.2)	.02	8.2 (2.4 to 14.0)	.005
12	633	353 (54.5) [50.4 to 58.9]	550	280 (49.6) [45.3 to 54.4]	4.9 (−1.4 to 11.1)	.13	6.0 (−0.1 to 12.1)	.05
18	629	422 (66.1) [62.2 to 70.4]	542	292 (53.0) [48.7 to 57.7]	13.1 (7.0 to 19.2)	<.001	14.9 (8.8 to 20.9)	<.001
Proportion With Intensification of Antihypertensive Treatment From Baseline[e]								
Month measured								
6	722	248 (34.5) [31.1 to 38.2]	683	177 (26.0) [22.9 to 29.5]	8.5 (3.7 to 13.4)	<.001	7.8 (3.0 to 12.7)	.001
12	719	339 (47.2) [43.8 to 51.0]	655	244 (37.3) [33.7 to 41.3]	9.9 (4.7 to 15.2)	<.001	8.9 (3.7 to 14.2)	<.001
18	709	407 (57.6) [54.1 to 61.3]	648	276 (42.8) [39.0 to 47.0]	14.8 (9.4 to 20.2)	<.001	13.7 (8.3 to 19.1)	<.001

[a] Adjusted for age, sex, history of major cardiovascular disease, history of hypercholesterolemia, alcohol drinking, physical activity, baseline body mass index, and systolic (or diastolic) blood pressure.

[b] Controlled hypertension was defined as systolic blood pressure less than 140 mm Hg and diastolic blood pressure less than 90 mm Hg among patients with hypertension.

[c] High adherence was defined as a score of 8 in the 8-item Morisky Medication Adherence Scale. Medical nonadherence data were not collected from patients who were not taking antihypertensive medication.

[d] Adjusted for age, sex, history of major cardiovascular disease, history of hypercholesterolemia, alcohol drinking, physical activity, and baseline body mass index, systolic blood pressure, and 8-item Morisky Medication Adherence Scale score.

[e] Titration or addition of new antihypertensive medications since baseline.

version 9.4 to obtain point estimates and standard errors and to test for differences between randomization groups. A 2-sided *P* value of <.01 was considered statistically significant because 5 main study outcomes were compared (additional explanation of the cost analysis is available in Supplement 2).

The incremental cost per additional percentage of patients achieving hypertension control at 18 months was calculated using patient-level data.[19] Costs related to intervention and health care but not to the study data collection were included. Costs were documented in Argentine pesos and converted to US dollars as of May 2017 (1 US dollar = 15.8 pesos). The 95% CI of incremental cost-effectiveness ratio was estimated by bootstrapping 1000 replications of the main analysis.[20]

Results

From June 2013 to April 2015, 6561 patients with hypertension and their family members were screened, and 1954 who met eligibility criteria were enrolled (Figure 1; **Table 1**). Of them, 970 participants (743 hypertensive and 227 normotensive participants) were recruited from the 9 intervention centers, with a median 107 participants per center (range, 104-114), and 984 participants (689 hypertensive and 295 normotensive participants) from the 9 control centers, with a median 117 participants per center (range, 48-131). Among 1432 participants with hypertension, 1357 (94.8%) completed the 18-month follow-up.

The mean age of patients with hypertension was 55.8 years and 53.0% were women. In general, baseline characteristics of patients with hypertension were balanced between intervention and control groups (Table 1). However, the intervention group had a slightly higher proportion of individuals with self-reported major cardiovascular disease and hypercholesterolemia, as well as higher levels of mean systolic (151.7 vs 149.8 mm Hg) and diastolic (92.2 vs 90.1 mm Hg) BP than did the control group. Likewise, baseline characteristics of normotensive participants were balanced between intervention and control groups except for physical activity and diastolic BP, which were slightly lower in the intervention group than in the control group (eTable 1 in Supplement 2).

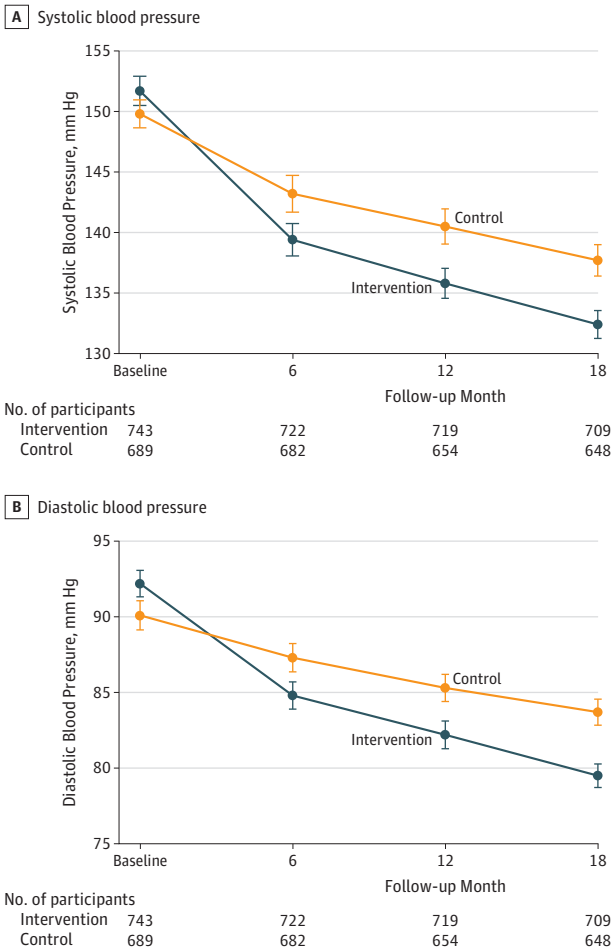
Implementation Indicators

During the 18-month intervention, community health workers completed 92.8% (8272 of 8916) of planned home-based interventions, and patients completed 84.2% (26342 of 31287) of anticipated home BP measurements. In addition, the eHealth platform sent out 91.2% of scheduled text-messages and 76.3% of participants reported receiving messages weekly. The proportion of high adherence to antihypertensive medication (Morisky score, 8) increased from 31.3% at baseline to 66.1% at 18 months in the intervention group and from 38.0% to 53.0% in the control group (**Table 2**). The difference in the proportion of high adherence to antihypertensive medication was 13.1% (95% CI, 7.0%-19.2%; $P < .001$) at 18 months. Proportions of medication intensification from baseline to 18 months were 57.6% in the intervention group and 42.8% in the control group ($P < .001$).

Coprimary Outcomes

The mean systolic BP was significantly reduced from 151.7 mm Hg (95% CI, 150.5-152.9 mm Hg) at baseline to 132.4 mm Hg (95% CI, 131.2-133.5 mm Hg) at 18 months in the intervention group and from 149.8 mm Hg (95% CI, 148.7-151.0 mm Hg) to 137.7 mm Hg (95% CI, 136.4-139.0 mm Hg) in the control group (**Figure 2**; eTable 2 in Supplement 2). Diastolic BP was reduced from 92.2 mm Hg (95% CI, 91.3-93.0 mm Hg) to 79.5 mm Hg (95% CI, 78.7-80.2 mm Hg) in the intervention group and from 90.1 mm Hg (95% CI, 89.1-91.1) to 83.7 mm Hg (95% CI, 82.9-84.6 mm Hg) in the control group. Difference in the reduction in systolic BP was 6.6 mm Hg (95% CI, 4.6-8.6 mm Hg; $P < .001$) and in diastolic BP was 5.4 mm Hg (95% CI, 4.0-6.8 mm Hg; $P < .001$) (**Table 3**). The intraclass correlation coefficients were 0.0768 and 0.0713 for changes in systolic and diastolic BP, respectively. Net reductions in systolic and diastolic BP were consistent by age, sex, cardiovascular risk (history of major cardiovascular disease, hypercholesterolemia, and diabetes), body mass index, and number of hypertensive family members in predefined subgroup analyses (**Figure 3**).

Figure 2. Mean Blood Pressure During Trial Follow-up in Intervention and Control Groups Among Patients With Hypertension



Six blood pressure measurements were taken at baseline and at 18 months during 2 visits and 3 blood pressure measurements were taken at 6 months and 12 months during 1 visit. The data points represent the mean blood pressure; error bars, 95% CIs.

Secondary Outcomes

The proportion of controlled hypertension increased from 17.0% at baseline to 72.9% at 18 months in the intervention group, and from 17.6% at baseline to 52.2% at 18 months in the control group. The difference in the increase in proportion of controlled hypertension was 20.6% (95% CI, 15.4%-25.9%; $P < .001$; Table 2). The intraclass correlation coefficient was 0.0415 for hypertension control. There were no significant differences in body weight or waist circumference changes between intervention and control groups (eTable 3 in Supplement 2).

Table 3. Effects of the Multicomponent Intervention on Primary Outcomes Among Participants With Hypertension

	Intervention		Control		Net Difference in Pecentage Points (95% CI)	P Value	Adjusted Net Difference in Percentage Points (95% CI)[a]	P Value
	No. of Patients	Mean (95% CI)	No. of Patients	Mean (95% CI)				
Coprimary Outcome: Change in Systolic Blood Pressure From Baseline, mm Hg								
Month measured								
6	722	−11.9 (−13.3 to −10.5)	682	−7.4 (−8.9 to −5.9)	−4.5 (−6.6 to −2.4)	<.001	−3.7 (−5.7 to −1.8)	<.001
12	719	−15.6 (−16.8 to −14.4)	654	−10.1 (−11.3 to −8.8)	−5.5 (−7.3 to −3.8)	<.001	−4.8 (−6.3 to −3.3)	<.001
18	709	−19.3 (−20.8 to −17.9)	648	−12.7 (−14.2 to −11.3)	−6.6 (−8.6 to −4.6)	<.001	−5.8 (−7.5 to −4.1)	<.001
Overall	722	−15.6 (−16.8 to −14.3)	682	−10.0 (−11.3 to −8.8)	−5.5 (−7.3 to −3.8)	<.001	−4.8 (−6.3 to −3.2)	<.001
Coprimary Outcome: Change in Diastolic Blood Pressure From Baseline, mm Hg								
Month measured								
6	722	−6.5 (−7.4 to −5.5)	682	−3.5 (−4.4 to −2.6)	−2.9 (−4.3 to −1.6)	<.001	−2.1 (−3.4 to −0.8)	.001
12	719	−9.4 (−10.2 to −8.5)	654	−5.2 (−6.0 to −4.4)	−4.2 (−5.3 to −3.0)	<.001	−3.3 (−4.3 to −2.4)	<.001
18	709	−12.2 (−13.2 to −11.2)	648	−6.9 (−7.8 to −5.9)	−5.4 (−6.8 to −4.0)	<.001	−4.6 (−5.7 to −3.4)	<.001
Overall	722	−9.3 (−10.2 to −8.5)	682	−5.2 (−6.0 to −4.4)	−4.1 (−5.3 to −3.0)	<.001	−3.3 (−4.3 to −2.3)	<.001

[a] Adjusted for age, sex, history of major cardiovascular disease, history of hypercholesterolemia, alcohol drinking, physical activity, baseline body mass index, and systolic (or diastolic) blood pressure.

There were no significant changes in BP in normotensive participants during the 18-month intervention (eTable 4 in Supplement 2). For example, differences in BP changes over 18 months were 0.6 mm Hg (95% CI, −1.6 to 2.7 mm Hg; $P = .60$) for systolic and 1.8 mm Hg (95% CI, 0.1 to 3.5 mm Hg; $P = .04$) for diastolic.

No adverse events were reported.

Cost-effectiveness of Intervention

Mean intervention cost per patient was $114.6 (95% CI, $113.7-$115.6) or $6.36 per patient per month. There were no significant differences in mean health care costs per patient between groups: $62.2 (95% CI, $44.6-$79.7) in the intervention group and $67.6 (95% CI, $41.9-$93.3) in the control group. The total cost per patient over the 18-month follow-up was $178.6 (95% CI, $161.0-$196.1) in the intervention group and $67.6 (95% CI, $41.9-$93.3) in the control group. The mean adjusted total cost difference was $102.7 (95% CI, $61.0-$144.4), and the incremental cost-effectiveness ratio was $464.7 per additional percentage of patients achieving hypertension control at 18 months (95% CI, $335.2-$771.7). (For further explanation about the cost analysis, see Supplement 2.)

Sensitivity Analysis

After multiple imputation for missing data, the difference in the reduction in BP over 18 months was 6.7 mm Hg (95% CI, 4.7-8.7 mm Hg; $P < .001$) for systolic and 5.1 mm Hg (95% CI, 3.8-6.5 mm Hg, $P < .001$) for diastolic (eTable 5 in Supplement 2). The difference in the increase in the proportion of controlled hypertension was 19.2% (95% CI, 14.1%-24.3%; $P < .001$).

Discussion

This cluster randomized trial indicated that a community health worker-led multicomponent intervention was effective in reducing systolic and diastolic BP and improving hypertension control among low-income, uninsured patients with hypertension in Argentina. The multicomponent intervention significantly increased patients' adherence to antihypertensive medication and physicians' adherence to treatment guidelines.

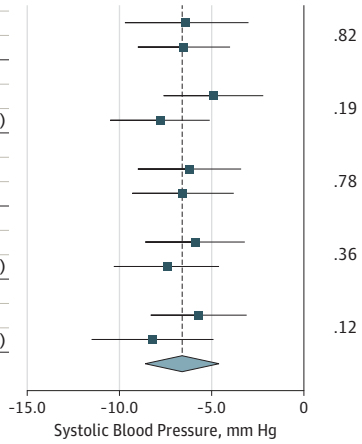
These findings may have public health significance. About 80% of all cardiovascular mortality occurs in low- and middle-income countries, where the greatest burden of hypertension is observed.[3,21] Although clinical trials have documented that BP lowering reduces the risk of cardiovascular disease and premature death, and affordable antihypertensive medications and lifestyle interventions are widely available, hypertension control rates continue to be low in low- and middle-income countries.[3,22-24] Lack of effective and sustainable strategies to overcome barriers is a major obstacle for hypertension control in underserved populations.[25] Therefore, widespread scaling-up of this proven effective intervention in low- and middle-income countries should result in a substantial reduction in uncontrolled hypertension and related cardiovascular disease.

Several strategies have been documented to improve BP control among patients with hypertension.[6,7,26] In addition, multicomponent interventions targeting health care systems, physicians, and patients have been shown to be more effective.[27,28] However, the effects of these intervention strategies have not been well studied in low-income settings. In a cluster randomized trial, Ogedegbe and colleagues[29] reported that a multicomponent intervention—including patient education, home BP monitoring, lifestyle counseling, physician education, and BP audit and feedback—did not improve BP control compared with usual care in African-American patients with hypertension receiving care in low-resource primary care practices. The HCPIA trial also involved low-income patients who received health care from a resource-limited public primary care system in Argentina. The major differences between the 2 trials are that the intervention in the

Figure 3. Mean Difference in the Changes of Systolic and Diastolic Blood Pressure Among Patients With Hypertension by Subgroups

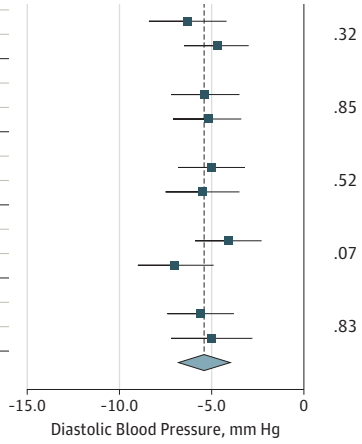
A Mean change in systolic blood pressure

	Intervention		Control			
	No. of Patients	Blood Pressure Change (95% CI)	No. of Patients	Blood Pressure Change (95% CI)	Net Difference (95% CI)	*P* Value for Homogeneity
Age, y						
≥60	267	-20.2 (-22.5 to -17.9)	254	-13.8 (-16.3 to -11.4)	-6.4 (-9.7 to -3.0)	.82
<60	442	-18.7 (-20.6 to -16.9)	394	-12.2 (-13.9 to -10.6)	-6.5 (-9.0 to -4.0)	
Sex						
Men	329	-17.3 (-19.2 to -15.4)	290	-12.4 (-14.4 to -10.5)	-4.9 (-7.6 to -2.2)	.19
Women	380	-20.6 (-22.5 to -18.7)	358	-12.8 (-14.7 to -10.9)	-7.8 (-10.5 to -5.1)	
Cardiovascular risk[a]						
High	394	-19.2 (-21.1 to -17.3)	322	-13.0 (-15.1 to -10.9)	-6.2 (-9.0 to -3.4)	.78
Not high	315	-19.2 (-21.2 to -17.3)	326	-12.7 (-14.6 to -10.8)	-6.6 (-9.3 to -3.8)	
Body mass index						
≥30	400	-19.1 (-21.0 to -17.2)	358	-13.2 (-15.1 to -11.3)	-5.9 (-8.6 to -3.2)	.36
<30	308	-19.4 (-21.4 to -17.3)	288	-11.9 (-13.9 to -9.9)	-7.4 (-10.3 to -4.6)	
No. of hypertensive family members						
≥2	494	-18.2 (-20.0 to -16.4)	410	-12.5 (-14.4 to -10.6)	-5.7 (-8.3 to -3.1)	.12
1	215	-21.4 (-23.8 to -19.0)	238	-13.2 (-15.5 to -10.9)	-8.2 (-11.5 to -4.9)	
Overall	709	-19.3 (-20.8 to -17.9)	648	-12.7 (-14.2 to -11.3)	-6.6 (-8.6 to -4.6)	



B Mean change in diastolic blood pressure

	Intervention		Control			
	No. of Patients	Blood Pressure Change (95% CI)	No. of Patients	Blood Pressure Change (95% CI)	Net Difference (95% CI)	*P* Value for Homogeneity
Age, y						
≥60	267	-11.7 (-13.1 to -10.2)	254	-5.4 (-6.9 to -3.9)	-6.3 (-8.4 to -4.2)	.32
<60	442	-12.6 (-13.9 to -11.2)	394	-7.8 (-9.0 to -6.6)	-4.7 (-6.5 to -3.0)	
Sex						
Men	329	-11.1 (-12.4 to -9.8)	290	-5.7 (-7.0 to -4.4)	-5.4 (-7.2 to -3.5)	.85
Women	380	-13.0 (-14.3 to -11.7)	358	-7.7 (-9.0 to -6.5)	-5.2 (-7.1 to -3.4)	
Cardiovascular risk[a]						
High	394	-11.7 (-13.0 to -10.4)	322	-6.7 (-8.0 to -5.4)	-5.0 (-6.8 to -3.2)	.52
Not high	315	-12.5 (-14.0 to -11.0)	326	-7.0 (-8.4 to -5.7)	-5.5 (-7.5 to -3.5)	
Body mass index						
≥30	400	-11.3 (-12.5 to -10.0)	358	-7.2 (-8.5 to -6.0)	-4.1 (-5.9 to -2.3)	.07
<30	308	-13.2 (-14.8 to -11.7)	288	-6.3 (-7.7 to -4.9)	-7.0 (-9.0 to -4.9)	
No. of hypertensive family members						
≥2	494	-11.9 (-13.2 to -10.7)	410	-6.4 (-7.6 to -5.1)	-5.6 (-7.4 to -3.8)	.83
1	215	-12.8 (-14.4 to -11.2)	238	-7.8 (-9.3 to -6.3)	-5.0 (-7.2 to -2.8)	
Overall	709	-12.2 (-13.2 to -11.2)	648	-6.9 (-7.8 to -5.9)	-5.4 (-6.8 to -4.0)	



Mean differences in systolic and diastolic blood pressure changes from baseline to the 18-month follow-up between the intervention and control groups. Data markers indicate mean difference in the changes; error bars, 95% CIs.

[a] High cardiovascular risk subgroup includes participants with a history of coronary heart disease, heart failure, stroke, hypercholesterolemia, or diabetes. Those without these risk factors are considered not at high risk.

HCPIA trial was led by community health workers and conducted at patients' homes. In another cluster randomized trial, Jafar and colleagues[30] reported that community health worker-led home health education or general practitioner training alone did not reduce BP. However, the combination of home health education and practitioner training led to a significant 5.0-mm Hg reduction in systolic BP among patients with hypertension in Pakistan.[30] These results support community health worker–led multicomponent interventions for BP control in low-income settings. In many low- and middle-income countries, community health workers are already employed within the public primary care system for infectious disease control and maternal and child health care. Training and engaging them in hypertension management may provide an effective, affordable, and sustainable approach for BP control in low- and middle-income countries.

This study showed that community health workers can play an important role in hypertension control among low-income communities. They provided health coaching to patients and families about lifestyle modification and medication adherence; trained and tracked patients' home BP monitoring; served as mediators between patients and the health care system and physicians; arranged physicians' appointments and delivered medications when needed; and

listened to patients and their family members, motivated them, and provided social support.[31]

A significant BP reduction among patients from control centers was also observed. In the Remediar+Redes Program, only 11.6% of patients with hypertension had their BP controlled.[32] In this study, 52.3% of patients achieved hypertension control at 18 months in the usual care group. Patients received repeated BP measurements every 6 months and were interviewed about behaviors related to antihypertensive medication adherence, which might have contributed to improvement in medication adherence and treatment intensification, and eventually, BP reduction. In addition, intervention contamination could have occurred and contributed to the findings observed in the control group. Furthermore, BP reduction in patients might be partially due to regression to the mean because participants with elevated BP were selected.

Limitations

This study has several limitations. It used a cluster randomized trial design because the multilevel and multicomponent interventions were implemented at the primary care center level. It was not practical to recruit all participants prior to randomization. Therefore, selection bias could have occurred. However, patients with hypertension and their family members were systematically recruited to avoid selection bias.[33] Important covariables were also adjusted to limit potential confounding effects. Another limitation is that intervention contamination, if any occurred, might have diluted the observed effect. In addition, the incremental cost-effectiveness ratio for quality-adjusted life-years saved was not calculated because extensive assumptions were necessary for modeling, which was beyond the scope of this report. Therefore, the cost-effectiveness of this community health worker–led multicomponent intervention for BP control could not be directly compared with other interventions for various outcomes.[23]

Conclusions

Among low-income patients with uncontrolled hypertension in Argentina, a community health worker–led multicomponent intervention compared with usual care resulted in a greater decrease in systolic and diastolic BP over 18 months. Further research is needed to assess generalizability and cost-effectiveness of this intervention and to understand which components may have contributed most to the outcome.

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