The Effect of Home-Based Hypertension Screening on Blood Pressure Change Over Time in South Africa: A Population-Based Regression Discontinuity Study

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Abstract

There is considerable policy interest in population wide home-based screening campaigns for hypertension in many low- and middle-income countries (LMICs). However, it is unclear whether such efforts will result in long-term population-level blood pressure improvements without more comprehensive interventions that strengthen the entire hypertension care continuum. Using multiple waves of the South African National Income Dynamics Study, we use the quasi-experimental regression discontinuity design to evaluate the effect of home-based hypertension screening on two-year change in blood pressure. We find that the home-based screening intervention results in important reductions in systolic blood pressure for women and younger men. We do not find evidence of an effect on systolic blood pressure for older men or on diastolic blood pressure for either sex. Our results suggest that home-based hypertension screening may be a promising strategy for reducing high blood pressure in LMICs, but additional research and policy efforts are needed to understand how to ensure that such strategies have maximum reach and impact.

Introduction

High blood pressure, or hypertension, is a main cause of stroke and cardiovascular disease and carries a substantial health and economic burden globally.[1–5] Hypertension is a growing problem in South Africa, where more than 25% of adults over the age of 35 are hypertensive, and hypertension-related causes of death are estimated to make up three of the top ten causes of death.[6–8] If detected, diagnosed, and treated effectively, the health and mortality consequences of hypertension can be reduced substantially.[9,10] Unfortunately, among South African adults with hypertension, only 28% are aware of their condition and just 9% have their blood pressure under control.[11]

Home-based screening for hypertension has the potential to result in large population-wide improvements in blood pressure control in South Africa and other low- and middle-income countries (LMICs). First, hypertension screening is a relatively straightforward and low-cost process. Second, home-based screening may result in greater population coverage than health facility-based screening by capturing individuals who would not have gone to health facilities. Despite the considerable enthusiasm for home-based screening,[12,13] broad community- and home-based screening efforts may not result in blood pressure improvements if individuals who are screened at their home and identified as potentially hypertensive do not confirm their diagnosis at a health facility, or if individuals who are aware that they are hypertensive do not initiate and adhere to treatment. To date, there is a dearth of evidence on whether home-based hypertension screening will result in long-term blood pressure improvements without more comprehensive interventions that strengthen the entire hypertension care continuum.

In this study, we evaluate the real-world effect of home-based hypertension screening on two-year change in blood pressure among a nationally representative cohort of South African adults. We employ a novel application of the regression discontinuity design that takes advantage of the fact that the activities of the fieldworker team as part of this cohort study closely mimic those of a home-based

hypertension screening campaign but were administered based on a clear discrete blood pressure threshold. Our results aim to directly inform researchers and policy makers seeking to identify the most effective ways to reduce rising levels of cardiovascular disease in South Africa and other LMICs.

Data and methods

National Income Dynamics Study

We use data from the 2008, 2010-2011, 2012, 2014-2015, and 2017 waves of the National Income Dynamics Study (NIDS).[14] The NIDS is a nationally representative longitudinal survey of approximately 28,000 individuals from 7,300 households across South Africa. The NIDS contains a wide array of social, economic, demographic, and health information for both individuals and households.

We provide detailed information on the sampling procedures and survey activities in **eAppendix II**. Briefly, the NIDS used a two-stage cluster probability sample with the Statistics South Africa primary sampling units as the first stage and dwellings within each primary sampling unit as the second stage. If there were multiple households in a dwelling, each household was assigned a unique identifier. If a member of the household agreed to be interviewed, the household was included in the sample and all individuals in the household were interviewed. In total, 7,305 out of 10,642 households agreed to participate in the baseline survey for a 69% baseline response rate. All individuals identified in the baseline survey were treated as panel respondents and efforts were made to locate and re-interview these individuals at each of the subsequent waves. New household members were interviewed in subsequent waves but only followed longitudinally if they were present in the household again in the follow-up waves of data collection. Our analysis only longitudinally follows individuals for one pair of waves; e.g., if an individual was interviewed in 2008, we only need information on this

individual from the 2010 wave. The between-wave loss to follow up was 26% -- **eAppendix I** provides more details on missing data and loss to follow up.

Intervention

The intervention we study is field workers informing individuals at the household that their blood pressure is high, that high blood pressure can have adverse health consequences if left uncontrolled, and that they should seek further care. This intervention occurred as part of routine data collection for the NIDS. Specifically, field workers collected two blood pressure measurements on each adult member of the household using an Omron digital blood pressure monitor and entered these blood pressure readings into a Health Information Sheet (attached as **eAppendix XII**). If either of the two readings had a systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg, field workers marked a box that read (in the participant's native language), "Your blood pressure readings are higher than normal. High blood pressure is dangerous because it makes the heart work too hard. High blood pressure increases the risk of heart disease and stroke. High blood pressure can also cause other problems, such as heart failure, kidney disease, and blindness. You can control high blood pressure by taking action." Based on the level of blood pressure, additional boxes were highlighted to suggest how soon the participant should seek medical care. The field workers then verbally conveyed this information to the participants and provided the filled-out Health Information Sheet to the individual in their native language.

Outcome

Our primary outcome of interest is between-wave change in blood pressure. For example, for an individual who had their blood pressure measured in 2008 and again in 2010/2011, we would estimate the impact of the intervention in 2008 on their change in systolic and diastolic blood pressure

(separately) between 2008 and 2010/2011. We use the average of the two blood pressure measurements recorded in each wave of the data. Since we use information from five waves of data with approximately two years between each wave, the outcome corresponds on average to a two-year change in blood pressure.

Causal identification strategy

We use the quasi-experimental regression discontinuity design (RDD) to evaluate the effect of home-based hypertension screening on blood pressure change over time. (We provide detailed information on the study design and estimation procedure in **eAppendix III.**) In comparison to other observational study designs, the RDD is thought to be particularly appealing for estimating causal effects because it relies on relatively weak assumptions that can be partially verified empirically.[15–17] Indeed, recent studies find that RDD estimates come close to those estimated from randomized clinical trials.[18,19]

The RDD design takes advantage of the fact that the screening intervention was only administered to individuals if they had a measured systolic blood pressure ≥ 140 mmHg (or diastolic blood pressure ≥ 90 mmHg). Intuitively, the main assumption of the RDD is that individuals just above this blood pressure cutoff are comparable with those just below the cutoff on all factors related to blood pressure change over time. The only difference between these two groups is that those above the 140 mmHg systolic (or 90 mmHg diastolic) cutoff received the intervention. Therefore, the effect of the intervention is estimated by comparing the average two-year change in blood pressure for individuals just above a systolic blood pressure ≥ 140 mmHg (or diastolic blood pressure ≥ 90 mmHg) –- who were administered the intervention and thus form the intervention group -- to those with a measured blood pressure just below 140 mmHg systolic (or 90 mmHg diastolic) –- who were just shy of receiving the intervention. In practice the RDD is estimated with slightly weaker assumptions (the

potential outcome in the absence of treatment is a continuous function of the running variable [blood pressure]. We discuss the full estimation procedure in detail in **eAppendix III)**.

The main assumption for the RDD is that other characteristics related to our outcome -- two-year change in blood pressure -– do not have a discontinuous change at the cutoff point of 140 mmHg systolic blood pressure (or 90 mmHg diastolic blood pressure) used by field workers to determine which individuals should receive the intervention. There are few reasons to believe that other characteristics related to the outcome change substantially between those with a blood pressure just shy of the 140/90 mmHg cutoff and those just above it. First, blood pressure monitors measure blood pressure with a degree of random measurement error and blood pressure varies randomly over time within individuals.[20] Therefore, whether individuals recorded a blood pressure just above or below the cutoff at the time of the survey is effectively random. Second, the field workers did not use the cutoff to provide any other interventions, such that the effect of the screening intervention would not be confounded with other programs. Third, the 140mmHg/90mmHg cutoff does not represent an underlying pathophysiological phenomenon that occurs at this precise level of blood pressure.[21] Therefore, there are no reasons to believe that individuals just above and below the cutoff are biologically different in ways that would also affect their blood pressure change over time. Lastly, we empirically test whether individual characteristics are substantially different above and below the 140mmHg/90mmHg cutoff (**eAppendix VI**), which is similar to the balance test routinely done in clinical trials.[22] We do not find consistent evidence of differences in any of the pre-intervention variables that we tested at the 140/90 mmHg cutoff. We conducted several additional robustness and validity checks described later in the results sections.

This analysis was pre-registered on ClinicalTrials.gov (NCT03762304) and exempt from Institutional Review Board approval because it uses publicly available de-identified secondary data.

Results

Sample characteristics

Table 1 presents descriptive characteristics for the overall and analytic systolic and diastolic blood pressure samples (we provide an extended version of this table in **eAppendix IV**). The analytic samples are the individuals within the bandwidth around the blood pressure cutoff that are used to form the intervention and control groups. There are few important differences between the overall and analytic systolic blood pressure samples. The analytic systolic blood pressure sample is older for both men (49.5 years vs. to 46.8 years) and women (54.2 years vs. 47.6 year) compared to their respective overall systolic blood pressure samples. Additionally, women in the analytic systolic blood pressure sample are less likely to be have greater than secondary schooling (10% vs. 14%) and slightly more likely to report fair or poor self-rated health (25% vs. 20%). In contrast, we do not find any meaningful differences between the diastolic blood pressure samples for either men or women

Baseline maximum pressure and two-year blood pressure change

Figure 1 presents the relationship between baseline maximum blood pressure and two-year change in blood pressure for men. For men, there is little visual evidence of a discontinuity at the cutoff for either systolic or diastolic blood pressure. **Figure 2** presents these same results for women. In contrast to men, there is evidence of a downward jump at the 140-mmHg systolic blood pressure cutoff suggestive of an impact of the intervention on systolic blood pressure change over time. However, we do not observe evidence of a potential intervention effect on diastolic blood pressure among women.

Table 1: Characteristics for the systolic and diastolic blood pressure overall and analytic samples.

	Men		Women	
Variable, Systolic blood pressure	Overall % (N=6163)	Analytic sample % (N=2265)	Overall % (N=11396)	Analytic sample % (N=2802)
Mean Age (SD)	46.8 (13.1)	49.5 (14.0)	47.6 (13.5)	54.2 (13.5)
Urban	0.52	0.5	0.47	0.44
> Secondary schooling	0.16	0.14	0.14	0.10
Fair/poor SRH	0.16	0.17	0.20	0.25
Prior stroke	0.01	0.01	0.02	0.02
Prior diabetes	0.05	0.06	0.07	0.10
Prior heart attack	0.02	0.02	0.04	0.05
Smoker	0.42	0.41	0.08	0.09
Has health insurance	0.13	0.13	0.10	0.08
Variable, Diastolic blood pressure	Overall % (N=6405)	Analytic sample % (N=2699)	Overall % (N=12753)	Analytic sample % (N=8045)
Mean Age (SD)	45.3 (12.3)	44.8 (11.7)	46.1 (12.5)	46.6 (12.2)
Urban	0.53	0.55	0.48	0.48
> Secondary schooling	0.17	0.17	0.14	0.14
Fair/poor SRH	0.15	0.13	0.19	0.19
Prior stroke	0.01	0.01	0.02	0.02
Prior diabetes	0.04	0.04	0.06	0.07
Prior heart attack	0.02	0.02	0.04	0.04
Smoker	0.42	0.40	0.08	0.09
Has health insurance	0.13	0.15	0.10	0.10

Notes: The analytic sample is the sample within the bandwidth around the blood pressure cutoff used to estimate the effect of the intervention on two-year change in blood pressure.

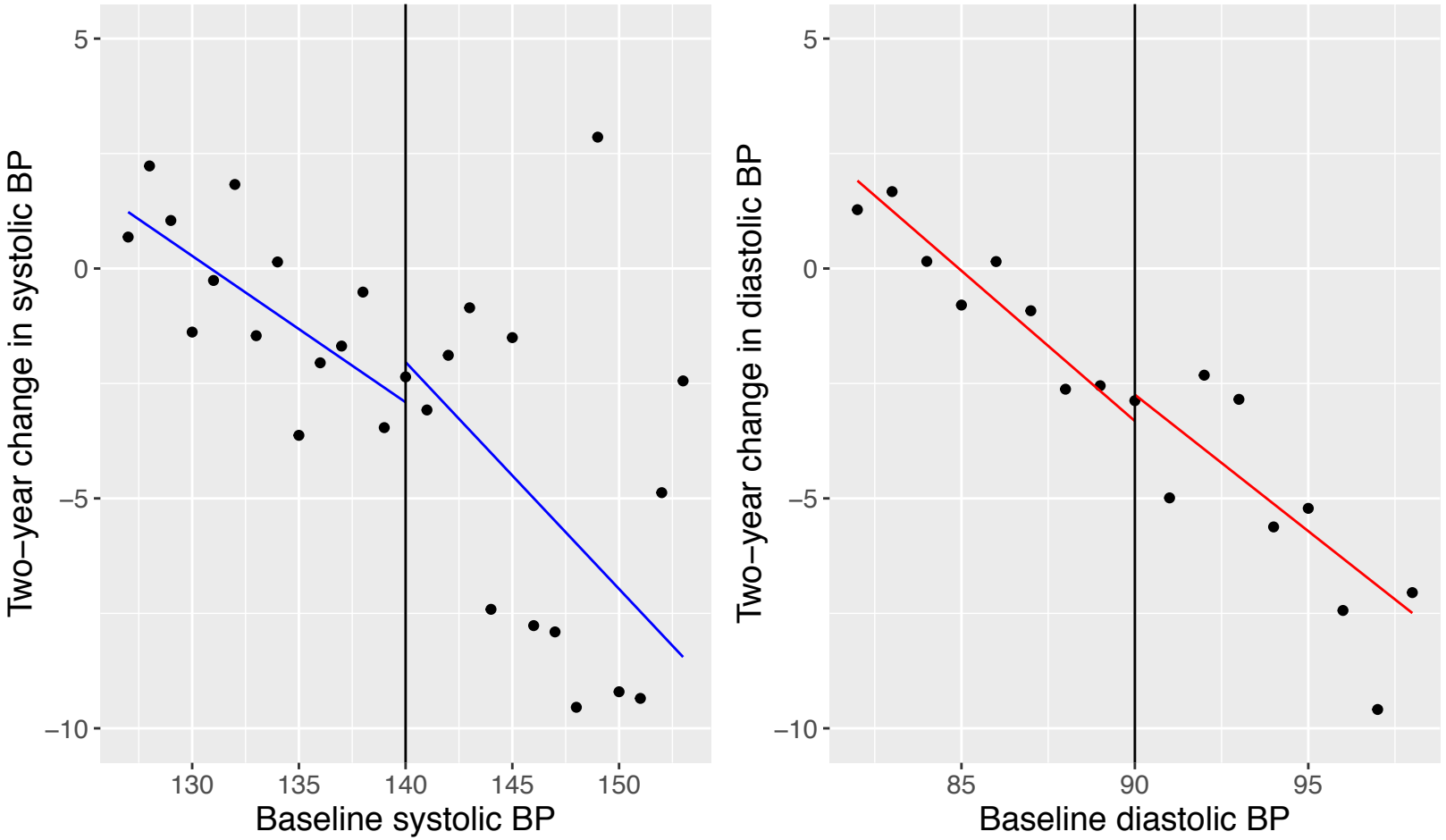

Figure 1: Relationship between baseline maximum and two-year change in blood pressure, South African men ages 30+, National Income Dynamics Study, 2008-2017. *Notes:* The vertical line is the cut-off point after which the intervention was administered; each point is the average two-year change for single-unit blood pressure bins; the blue and red lines represent a local linear fit separately on each side of the cutoff.

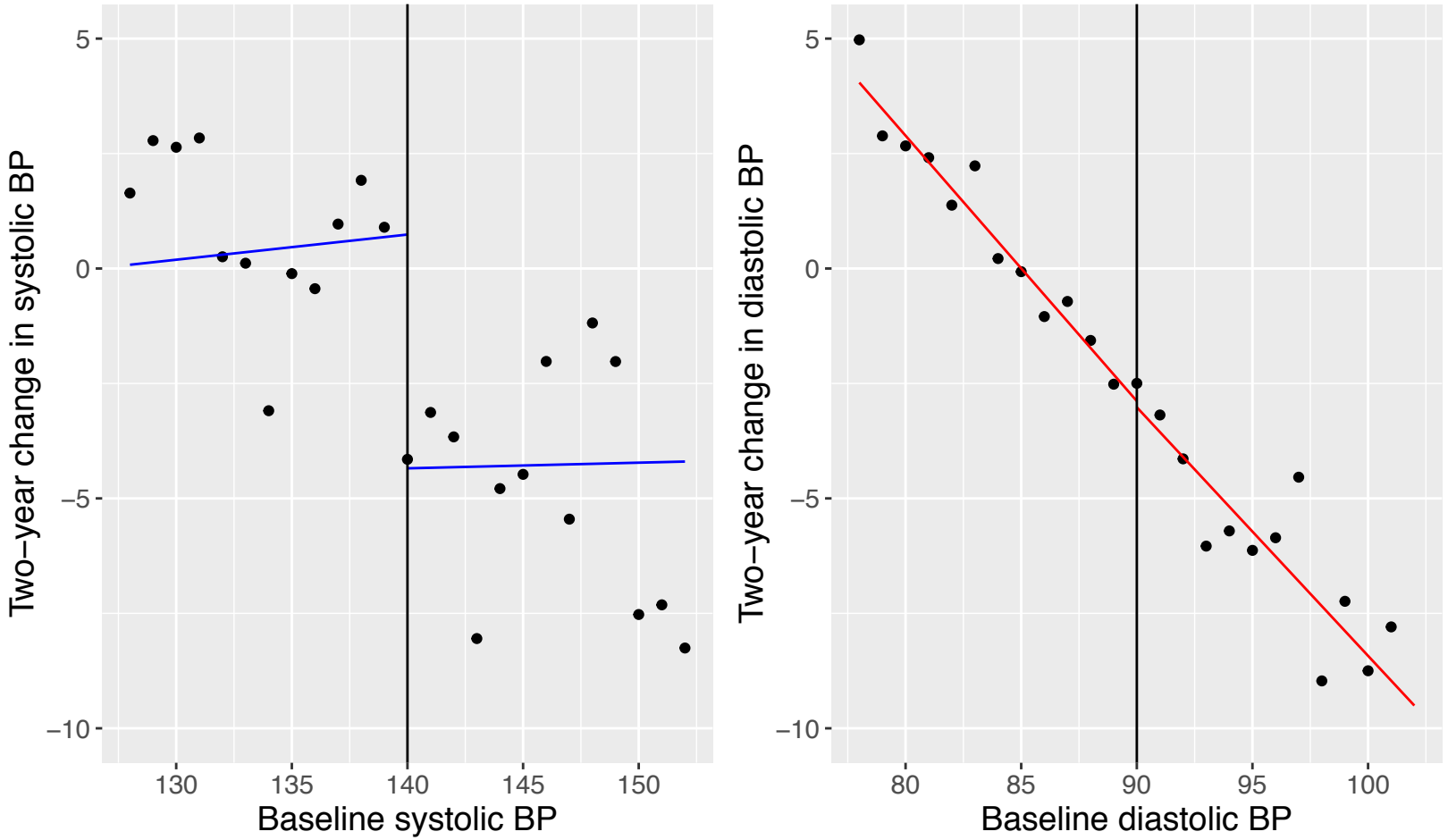

Figure 2: Relationship between baseline maximum and two-year change in blood pressure, South African women ages 30+, National Income Dynamics Study, 2008-2017. *Notes:* The vertical line is the cut-off point after which the intervention was administered; each point is the average two-year change for single-unit blood pressure bins; the blue and red lines represent a local linear fit separately on each side of the cutoff.

Effect of the intervention on two-year change in blood pressure

Table 2 presents the regression-discontinuity estimates of the effect of the intervention on two-year change in blood pressure. These estimates confirm the visual evidence presented in **Figures 1** and **2.** We find that the intervention results in a 4.7 mmHg systolic blood pressure reduction for women (95% CI: -12.6, -2.1, p = 0.006). In contrast, we do not find evidence that the intervention lowered diastolic blood pressure for women or either blood pressure outcome for men.

Table 2 Regression discontinuity estimates of the effect of household-based hypertension screening on two-year change in blood pressure, South African adults ages 30+, National Income Dynamics Study, 2008-2017.

	Men	Women
Systolic		
Estimated effect	0.9	-4.7
95% CI	(-5,5.8)	(-12.6,-2.1)
p-value	0.881	0.006
MSE-optimal bandwidth	13	12
Within-bandwidth observations	2265	2802
Diastolic		
Estimated effect	0.4	0.1
95% CI	(-2.5,2.9)	(-1.0,2.1)
p-value	0.887	0.485
MSE-optimal bandwidth	8	12
Within-bandwidth observations	2699	8045

Notes: Effects are estimated using a local linear specification with triangular weights; the regression function includes indicator variables for year of baseline survey; 95% CI and p-values are based on bias-corrected robust standard errors and are clustered at the individual level; we use a mean-squared error optimal bandwidth size that is empirically determined.

Heterogeneity analyses

Figure 3 plots the effect of the intervention on two-year change in blood pressure separately by age and schooling groups. We find evidence that the impact of the intervention on systolic blood pressure is more pronounced for younger adults between the ages of 30-45 relative to older age groups. For men between ages 30 and 45, the intervention resulted in a 7.0 mmHg (95% CI: -20.1, -1.6, p = 0.022) reduction in systolic blood pressure compared to essentially null effects for the other age groups. Similarly, for women, the intervention had the largest impact on systolic blood pressure for those between ages 30 and 45 (-9.1 mmHg, 95% CI: - 25.3, 1.7) although this effect is estimated with a very wide confidence interval. In contrast, we do not find evidence of heterogeneity in the impact of the intervention on systolic blood pressure by schooling groups or on diastolic blood pressure for any of the groups.

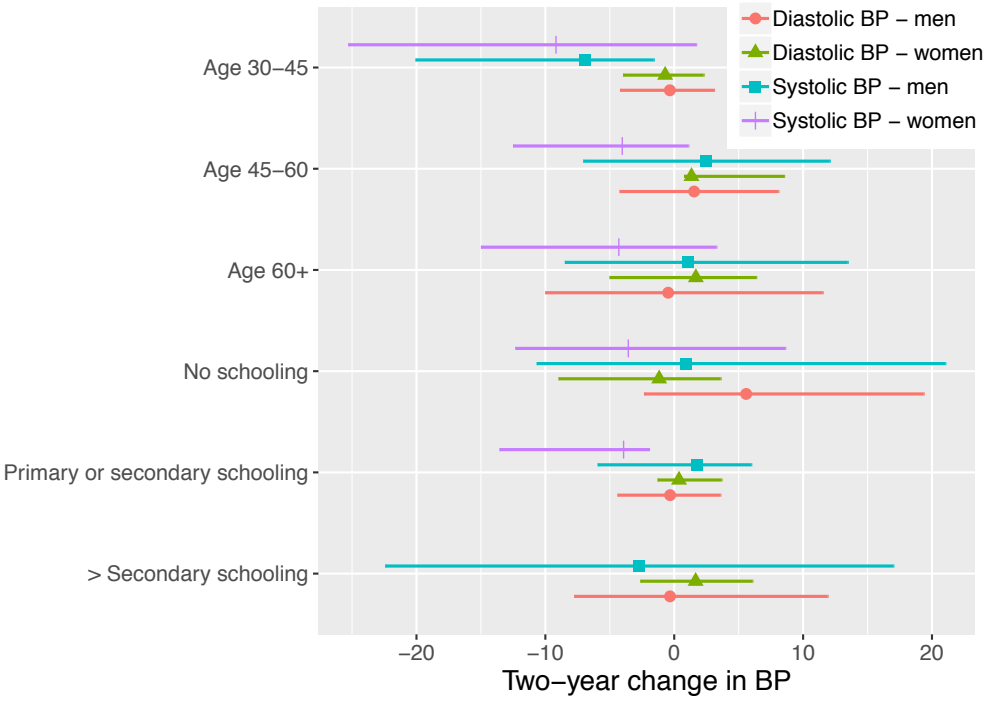

Figure 3: Regression discontinuity estimates of the effect of household-based hypertension screening on two-year change in blood pressure separately by age and schooling groups, South African adults ages 30+, National Income Dynamics Study, 2008-2017. *Notes:* Error bars represent 95% confidence intervals estimated use robust standard errors that are clustered at the individual level; estimate for >secondary schooling for women is omitted due to a small sample size.

Robustness and validity

We tested the assumption that there are not significant discontinuities in other variables that could also influence the outcome at the 140/90 mmHg cutoff for a number of baseline, pre-intervention, variables (**eAppendix VI**). For women in the systolic blood pressure sample, we find no evidence of significant changes at the cutoff point for any of the pre-treatment variables. For men in the systolic blood pressure sample, we find that there is a small increase in age at the 140/90 mmHg cutoff suggesting that the intervention group is slightly older than the control group.

Next, we tested whether field workers may have deliberately underreported respondents' baseline blood pressure measurement to avoid having to administer the intervention. We did this by examining the density of baseline blood pressure to check whether there is a bunching of individuals just below the 140/90 mmHg cutoff and did not find evidence of bunching suggestive of manipulation (**eAppendix V**). The results presented here are also robust to the size of the bandwidth around the 140/90 mmHg cutoffs used to form the treatment and control groups (**eAppendix VII**), potential selection bias introduced by loss to follow-up between waves (**eAppendix IX**). Lastly, our results are consistent when splitting the sample by pairs of waves rather than pooling all five waves of data (**eAppendix X**).

Discussion

We find that home-based hypertension screening results in an important 4.7 mmHg reduction in systolic blood pressure for South African women. While there is no evidence of an effect of hypertension screening for men overall, there are important differences by age. For younger men between the ages of 30 and 45, the intervention did result in a 7 mmHg reduction in systolic blood pressure. We also find some evidence that the impact of the intervention was greater for younger, compared to older, women. Taken together, these results suggest that the screening intervention was particularly important for younger individuals in South Africa. While the age-variation findings are from a non-preregistered subgroup analysis, we find a consistent advantage for younger men when examining each pair of waves separately (**eAppendix X**), providing some evidence of a consistent effect that is not just the result of chance. The advantage for younger women is only present in half of the pairs of data and thus should be interpreted cautiously. In contrast to systolic blood pressure, we find no evidence that the intervention reduced diastolic blood pressure for either men or women. These results are consistent across multiple robustness checks**.**

Our finding that the intervention had a beneficial effect on systolic blood pressure among women overall but not among men overall is consistent with a large literature on chronic diseases in LMICs that generally finds greater levels of health-seeking behavior and treatment adherence among women compared to men. For example, the benefits of antiretroviral treatment scale-up in South Africa – and sub-Saharan Africa more broadly – has disproportionately benefitted women.[25] Researchers that have examined this phenomenon find that among individuals initiated on antiretroviral therapy, women tend to have better medication adherence, care retention, and health outcomes than men.[26] Qualitative studies suggest that this might be because men tend to view healthcare facilities as being designated for women and children,[27,28] gender norms that expect men to endure ill-health rather than to seek help,[29,30] and the restricted opening hours of healthcare facilities,

which may make it more difficult for men to seek care who – in many populations – are more likely to work outside of their communities during the day than women.[31] While HIV services have been studied in more depth in LMICs than those for hypertension, it is likely that many of the same factors also affect men's care-seeking for cardiovascular disease risk factors. The few large-scale studies that exist on care-seeking for hypertension in LMICs have found higher rates of awareness, treatment, and control of hypertension among women than men.[5,11,32,33]

One unexpected finding is that the intervention resulted in reductions in systolic, but not, diastolic blood pressure. This pattern may be related to the antihypertensive medications individuals are taking. First, many randomized controlled trials that assess the effect of antihypertensive medicines find greater reductions in systolic compared to diastolic blood pressure, with this difference becoming larger with increasing age.[34] Second, thiazide diuretics, in particular, have been found to more greatly reduce systolic than diastolic blood pressure.[35] Thiazide diuretics are the recommended and most commonly used first-line antihypertensive medications in South Africa.[36] Importantly, lowering systolic blood pressure is the more relevant target for the prevention of cardiovascular events and mortality, especially among older individuals. Several cohort studies and clinical trials found that systolic blood pressure reductions have stronger and more consistent effects on both cardiovascular disease and mortality.[37–40] Reducing systolic blood pressure is especially important in the context of aging populations, like South Africa, since systolic blood pressure continues to rise into older age while diastolic blood pressure tends to level off in midlife.[21]

Our finding of a 4.7 mmHg systolic blood pressure reduction for women and a 7-mmHg systolic blood pressure reduction for younger men is a fairly large improvement at the population level but still short of clinical goals. For reference, most clinical protocols suggest that individuals near the systolic blood pressure cutoff of 140 mmHg should aim for a target blood pressure below 130 mmHg.[41] The improvements we observe relative to clinical goals might reflect losses at any of multiple

steps of the care cascade. First, individuals who are screened and identified as potentially hypertensive may not seek further care. This hypothesis is consistent with descriptive studies from many African countries that generally find very low levels of health-care linkage following a home-based screening.[42–44] Second, individuals who are diagnosed and prescribed treatment may not initiate treatment or may not adhere to treatment after initiation. Studies on the cascade of care for hypertension from African countries do indeed find low levels of treatment and control among individuals diagnosed with hypertension;[5,45] however, the absolute magnitude of these losses is small when compared to the share of hypertensive individuals who make contact with the health systems and are formally diagnosed.[11,32] This pattern suggests that low levels of health-seeking behavior following a positive home-based screening for hypertension may be the most important contributor to the low effect of screening on blood pressure reductions over time found in this study. Indeed, existing results from studies of HIV find very low levels of connection with health systems following a positive test for HIV at the household level.[46,47]

Limitations

We were unable to identify whether field workers administered the intervention or not. Therefore, our results correspond to an intent-to-treat estimate. This issue is not unique to our study, however, and intent-to-treat estimates are commonly used in clinical trials where participant adherence to a treatment or intervention cannot be ensured. Indeed, the intent-to-treat estimate is a better measure of the real-life impact of an intervention than the estimate of effectiveness under conditions of perfect field-worker adherence and intervention fidelity.[23]

Within the NIDS, 31% of households that were selected did not provide a response to the survey. These households were more likely to be white and located in urban areas.[24] Similarly, 26% of individuals in our sample were lost to follow up between waves. In **eAppendix VIII**, we compare

differences in baseline characteristics between those who were and were not lost to follow up and find that individuals lost to follow-up were more likely to report fair or poor self-rated health at baseline, and for women, be more likely to have greater than secondary schooling. However, we find no change to our conclusions after re-estimate our main effects with inverse probability weights to adjust for these observed differences. Inverse probability weighting, however, cannot adjust for loss to follow-up due to unobserved characteristics. A related issue is that 15% of age-eligible individuals were dropped due to missing blood pressure data. Due to these three sample limitations, our results may not represent the effect that would be observed in the overall South African population if the intervention had a different impact on individuals in households that did not respond, that were lost to follow up, or dropped due to missing blood pressure data compared to the individuals included in the analysis.

Lastly, a broader limitation of RDDs is that they estimate local effects (only among individuals near the cutoff of 140/90 mmHg) and may not be generalizable to the entire distribution of blood pressure. This limitation is especially important to consider when interpreting our findings if the goal of screening policies is to identify high-risk individuals who may have blood pressure far above the cutoff. **eAppendix III** presents a full discussion of all the limitations, validity checks, and sensitivity analyses.

Policy Implications

Population aging in South Africa is expected to result in an additional 9-12 million individuals in need of care for hypertension by 2050.[48] South Africa's health system is currently unprepared for providing this level of care and will need to develop new systems to achieve widespread blood pressure control.[13] Controlling blood pressure at the population level is the result of several sequential steps, starting from identifying individuals with hypertension, through treatment initiation and adherence, and

ultimately to controlled blood pressure. Since a substantial share of individuals are lost at each step of this care cascade in both HICs and LMICs,[5,49] intervening at each step has the potential to improve population-wide blood pressure control. An important question for South Africa and other LMICs is which step or steps should be targeted to achieve the most cost-effective improvements in blood pressure control?

Improving detection of hypertension is a potential low-hanging fruit for achieving population-wide blood pressure improvements. This is because hypertension screening is comparatively easier and more affordable than interventions targeted at other steps of the care cascade, such as interventions to improve linkage to care following a positive screening or improving treatment initiation and adherence. The main contribution of our paper is to determine if home-based hypertension screening alone can result in meaningful improvements in blood pressure control without additional resources spent on addressing the more complex steps of the care cascade.

We find that household-based screening has an important effect on blood pressure reductions for South African women and younger men, but there is still a potential for further improvements, especially among men. Our results imply that household screening may need to be combined with interventions that address other cascade steps to result in cost-effective and population-wide improvements in blood pressure control. Decentralizing hypertension care to community-health workers may be a promising strategy for improving treatment initiation and adherence following a positive household hypertension screening. By shifting care to individuals' homes, community health worker-based care might reduce time, cost, access, and behavioral barriers to seeking care at hospitals. These types of programs have already been applied and demonstrated to be effective for other forms of care in similar environments, including HIV care in Tanzania.[50]

At the health facility level, healthcare quality in South Africa and other LMICs tends to be low.[51] Improving the content of care during the patient visit to ensure that individuals understand the

importance blood pressure control, how to control their blood pressure, and how often they should monitor blood pressure may result in a greater share of individuals initiating treatment and ultimately achieving blood pressure control. In systems with an overburdened physician workforce, these activities could also be done by hospital-based care coordinators; indeed, the use of hospital-based care coordinators in India improved multiple cardiovascular disease risk factors including blood pressure.[52]

Achieving blood pressure control for hypertensive patients requires several repeated visits to ensure that medicines are appropriately dosed and then to monitor blood pressure over time. This need for multiple visits is likely an important cause of low blood pressure control because of the strain it places on both patients and providers. Health information systems have the potential to alleviate this burden for both patients and providers. For providers, an information system can track which individuals need to see a provider, when, and for what reasons; for patients, the system can automatically send reminders to patients to prevent missed visits. In addition, some of these visits could even be eliminated if individuals could routinely measure their own blood pressure at home and enter this information into a system that can be remotely monitored by care providers.

Conclusions

Home-based hypertension screening may be a promising strategy for improving blood pressure outcomes in LMICs. However, further work is needed to ensure that such strategies have maximum reach and impact. Developing and testing interventions to maximize the proportion of individuals who achieve hypertension control following a household-screening is a critical next step for both research and policy.

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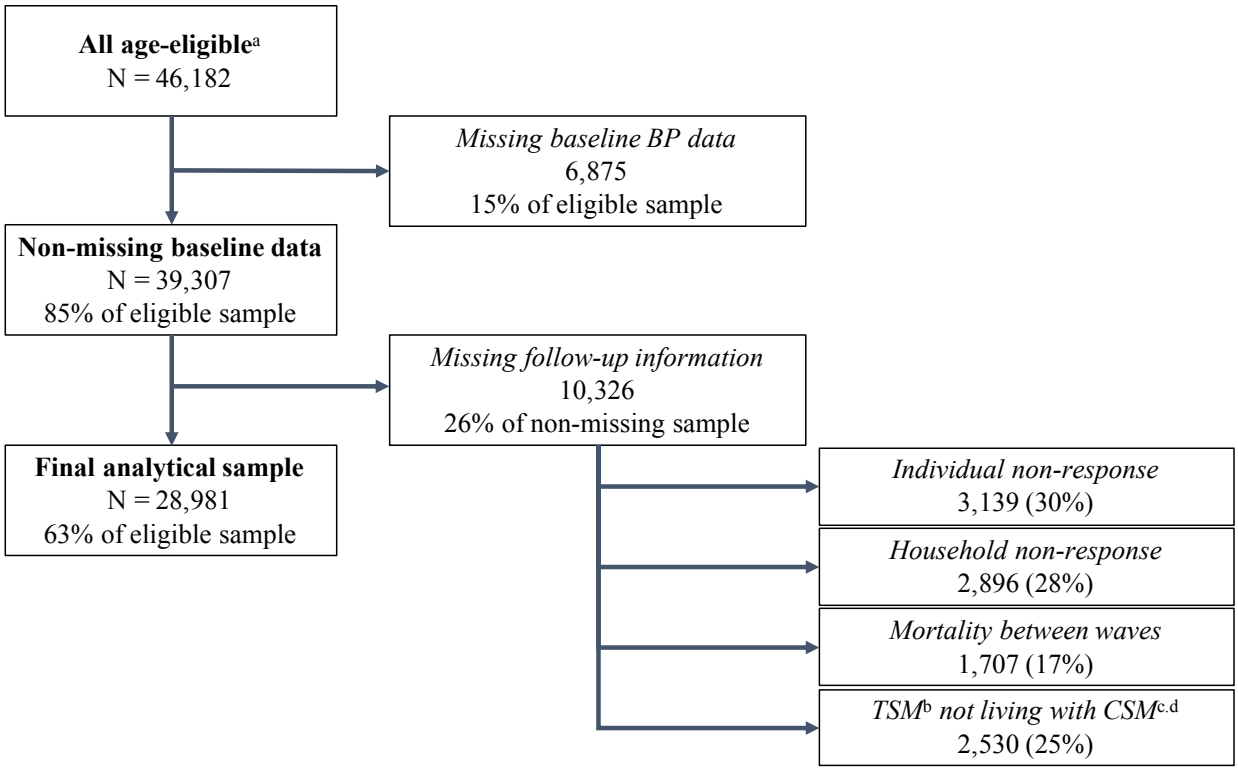
eAppendix I: Missing data and loss to follow-up



S Figure 1: Sample selection flowchart, National Income Dynamics Study, South African adults ages 30+, National Income Dynamics Study, 2008-2017.
[a]Individuals above the age of 30 are considered age eligible
[b]Temporary sample member
[c]Continuing sample member
[d]Follow-up data was only collected on temporary sample members if during the follow-up survey they happened to still reside in the household they were first observed in. If they no longer lived with the CSM, they were not tracked by the NIDS teams in the follow-up waves of data collection.

eAppendix II: Sampling procedures

We copied the following the material directly from the technical manual of the National Income Dynamics Study:

> A stratified, two-stage cluster sample design was employed in sampling the households to be included in the base wave. In the first stage, 400 Primary Sampling Units (PSUs) were selected from Stats SA's 2003 Master Sample of 3000 PSUs. This Master Sample was the sample used by Stats SA for its Labour Force Surveys and General Household Surveys between 2004 and 2007 and for the 2005/06 Income and Expenditure Survey. Each of these surveys was conducted on non-overlapping samples drawn within each PSU.
>
> The target population for NIDS was private households in all nine provinces of South Africa and residents in workers' hostels, convents and monasteries. The frame excludes other collective living quarters such as students' hostels, old age homes, hospitals, prisons and military barracks.
>
> The sample of PSUs for NIDS is a subset of the Master Sample. The explicit strata in the Master Sample are the 53 district councils (DCs). The sample was proportionally allocated to the strata based on the Master Sample DC PSU allocation and 400 PSUs were randomly selected within strata. It should be noted that the sample was not designed to be representative at provincial level, implying that analysis of the results at province level is not recommended.
>
> Fieldworkers were instructed to interview all households living at the selected address/dwelling unit. If they found that the dwelling unit was vacant or the dwelling no longer existed they were not permitted to substitute the dwelling unit but recorded this information on the household control sheet.
>
> The household control sheet is a two page form. This form was completed for every dwelling unit that was selected in the study, regardless of whether or not a successful interview was conducted. Where more than one household resided at the selected dwelling unit, a separate household control sheet was completed for every household and they were treated in the data as separate units. In order to qualify as separate households they should not share resources or food. Lodgers and live-in domestic workers were considered separate households.
>
> All resident household members at selected dwelling units were included in the NIDS panel, providing that at least one person in the household agreed to participate in the study. The household roster in the household questionnaire was used to identify potential participants in the study. Firstly, respondents were asked to list all individuals that have lived under this "roof" or within the same compound/homestead at least 15 days during the last 12 months OR who arrived in the last 15 days and this was now their usual residence. In addition the persons listed should share food from a common 'pot' and share resources from a common resource pool. All those listed on the household roster are considered household members.
>
> All resident household members became NIDS sample members. In addition, non-resident members that were "out of scope" at the time of the survey also became NIDS sample members. Out-of-scope household members were those living in institutions (such as

boarding school hostels, halls of residence, prisons or hospitals) which were not part of the sampling frame. These individuals had a zero probability of selection at their usual place of residence and were thus included in the NIDS sample as part of the household that had listed them as non-resident members. These two groups constitute the permanent sample members (PSMs) and should have had an individual questionnaire (adult, child or proxy) completed for them. These individuals are PSMs even if they refused to be interviewed in the base wave.

An initial sample of 9600 dwelling units was drawn with the expectation of realizing 8000 successful interviews. However, during the initial round of fieldwork for Wave 1 we did not achieve the target number of households. Therefore we went back to the field to attempt to overturn refusals in 48 PSUs and to visit 24 new dwelling units in 32 of these areas. Stats SA drew an additional 24 dwelling units from their Master Sample in predominantly White and Asian PSUs in order to improve representation of these population groups in the data.

In addition to information from the Technical Manual, we copied the following additional information on the sampling procedure from Leibbrandt et al. (2010):

Within each PSU, Stats SA provided two clusters with a total of 24 dwelling units. Stats SA provided maps for all PSUs and detailed listings with these 24 dwelling units marked. These listings had been updated several times since originally compiled in 2003 in order to increase the ease with which fieldworkers could find the specific dwelling units. (The sample of dwelling units itself had not, of course, been changed.). In spite of this, it was sometimes necessary to re-list a PSU if dramatic changes had occurred since the listing had last been updated. For example, if an informal settlement had been cleared to make way for formal houses, the listing was unusable. In these cases, the PSU was re-listed and a new systematic sample of dwelling units was selected. The drawback of re-listing a PSU is that the chance of sample overlap with dwelling units that had already been selected for other surveys is substantially increased. The extent of this overlap cannot be quantified as the lists are no longer comparable.

In summary, the first stage of the sampling resulted in a sample of 400 PSUs. Within each of these PSUs there were two unused clusters (drawn by means of systematic sampling at the time that the Master Sample was created in 2003). This gave us a sample of 24 dwelling units in each of 400 PSUs, making a total of 9600

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eAppendix III: Detailed description of methods

We use a regression discontinuity design to evaluate the causal effect of household-based hypertension screening on BP change over time. The RDD design can be used to estimate causal effects in the absence of randomization when assignment to an intervention is based on an arbitrary discrete cutoff of a continuous running variable.[16] For our study, the continuous running variable is maximum baseline BP and the discrete cutoff is a systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg. This cutoff determines assignment to the screening intervention because survey enumerators were instructed to only provide the intervention if individuals had a maximum BP above this cutoff. The cutoff is arbitrary because it is not based on an underlying pathophysiological phenomenon that occurs at this precise level of BP.[19] We estimate an intent-to-treat (ITT) causal effect since all enumerators may not have complied with the intervention. Under the assumption that enumerators did not perfectly adhere to the instructions given by the survey team, the causal effect we estimate is the effect of having a higher probability of receiving the intervention. Unfortunately, we cannot quantify this probability because the enumerators did not record to whom they administered the intervention.

Intuitively, the RDD estimates causal effects by assuming that participants just above and just below the arbitrary cutoff are exchangeable with each other. This assumption is particularly plausible in this study because BP monitors measure BP with a degree of random measurement error and BP varies randomly over time within individuals.[20] Thus, within a narrow bandwidth around the BP cutoff, participants were effectively randomized to the intervention.

More formally, the main assumption needed to estimate causal effects under the RDD is that the potential outcome in the absence of treatment is a continuous function of the underlying running variable. Therefore, any discontinuities in the function at the cutoff point are solely due to the intervention. This assumption can be violated under two conditions. The first is manipulation of the running variable. Enumerators may have manipulated the BP values (i.e., noted down a BP value below the cutoff for those who had a measurement above the cutoff and/or vice-versa). We believe this is unlikely because there was no clear incentive for enumerators to note down a different BP from the one that was observed. Nonetheless, we examined whether manipulation of the running variable occurred by testing whether the density of the baseline running variable is clustered just above or just below the cutoff. Second, the RDD assumption can also be violated is if there is a discontinuity in other important characteristics at the cutoff point, such that discontinuities may not just reflect the effect of the intervention. This could be the case if the BP cutoff was also used to assign interventions other than the one being studied here. Since this was not the case in the NIDS, violation of this assumption is unlikely. Nonetheless, this second assumption can also be partially verified by estimating the effect of the intervention on pre-intervention variables that should not be discontinuous at the cutoff (so-called "negative controls").

Implementation of the RDD

We first restrict our sample to only individuals ages 30+ since population-based screening efforts in LMICs tend to focus on adults in middle and older age. Following the recommendation for RDDs with multiple assignment variables, we employ the so-called univariate approach to analyze our data.[21] Specifically, when using diastolic BP as the running variable, we exclude all participants with systolic BP ≥140 mmHg. Similarly, when using systolic BP as the running variable, we exclude those with diastolic BP ≥90 mmHg. This restriction ensures that none of the participants below the cutoff in diastolic BP received the intervention based on systolic BP and vice-versa. We did not exclude participants from our analysis who should have received the intervention in a preceding wave because this study aims to estimate the impact of a household-based hypertension screening campaign on BP and, in our view, it most likely that such a hypertension screening campaign would measure BP in the

entire population above a certain age threshold regardless of whether individuals have been previously told that their BP is high.

The RDD requires choosing three inputs for estimation: the bandwidth around the cutoff, the polynomial degree used to approximate the potential outcome function, and a weighting function for observations within the bandwidth. We follow current best practices and use local linear specifications with triangular weights.[22] Local linear specifications prevent potentially overfitting the raw data while triangular weights give more influence to observations closer to the cutoff. For the bandwidth, narrower bandwidths tend to reduce bias but increase variance. To balance this bias-variance tradeoff while preventing analyst manipulation of the bandwidth size to maximize treatment effects, we use a data-driven mean squared error (MSE) optimal bandwidth that is empirically determined and not set by the analyst.[23] Based on these choices, we estimate the following regression within the MSE-optimal bandwidth separately for systolic and diastolic BP:

$$E(Y|T,X) = \beta_0 + \beta_1 X + \beta_2 T + \beta_3 (T * X) + \sum_i \gamma_i Z_i$$

Here Y is the change in BP between waves, T is an indicator variable for receiving the intervention (being above the cutoff), X is baseline BP, and the interaction between X and T captures the change in the slope of the relationship between X and Y above the cutoff. Additionally, since our data are from four between-wave periods (2008 to 2010-2011, 2010-2011 to 2012, 2012 to 2014-2015, and 2014-2015 to 2017) we include indicator variables for period of observation ($\sum_i \gamma_i Z_i$) and cluster observations at the individual level. The effect of the intervention on Y is estimated by β_2.

After estimating the main treatment effects, we assess heterogeneity in the treatment effect by estimating the above regressions stratified by age groups (ages 30-45, ages 45-60, ages 60+) and schooling groups (no schooling, primary or secondary schooling, greater than secondary schooling).

Robustness and validity checks

We conduct a number of validity and robustness checks. As mentioned previously, we examine the density of the baseline running variable to check for potential enumerator manipulation and also estimate the effect of the treatment on a number of pre-treatment negative controls to ensure that the cutoff was not used to assign any other interventions. Next, we assess the sensitivity of our results to the choice of bandwidth by re-estimating the main effects for bandwidth sizes of 50%, 75%, 125%, and 150% of the MSE-optimal bandwidth. We also evaluate the sensitivity of our results to possible selection bias introduced through loss-to-follow up between waves by re-estimating our main results with inverse-probability (IP) weights to adjust for the differential distribution of observed baseline characteristics between those that were and were not lost to follow-up.[24] Lastly, we assess the generalizability of our locally estimated effects by comparing pre-treatment characteristics of the overall and within-bandwidth samples.

eAppendix IV: Expanded version of Table 1

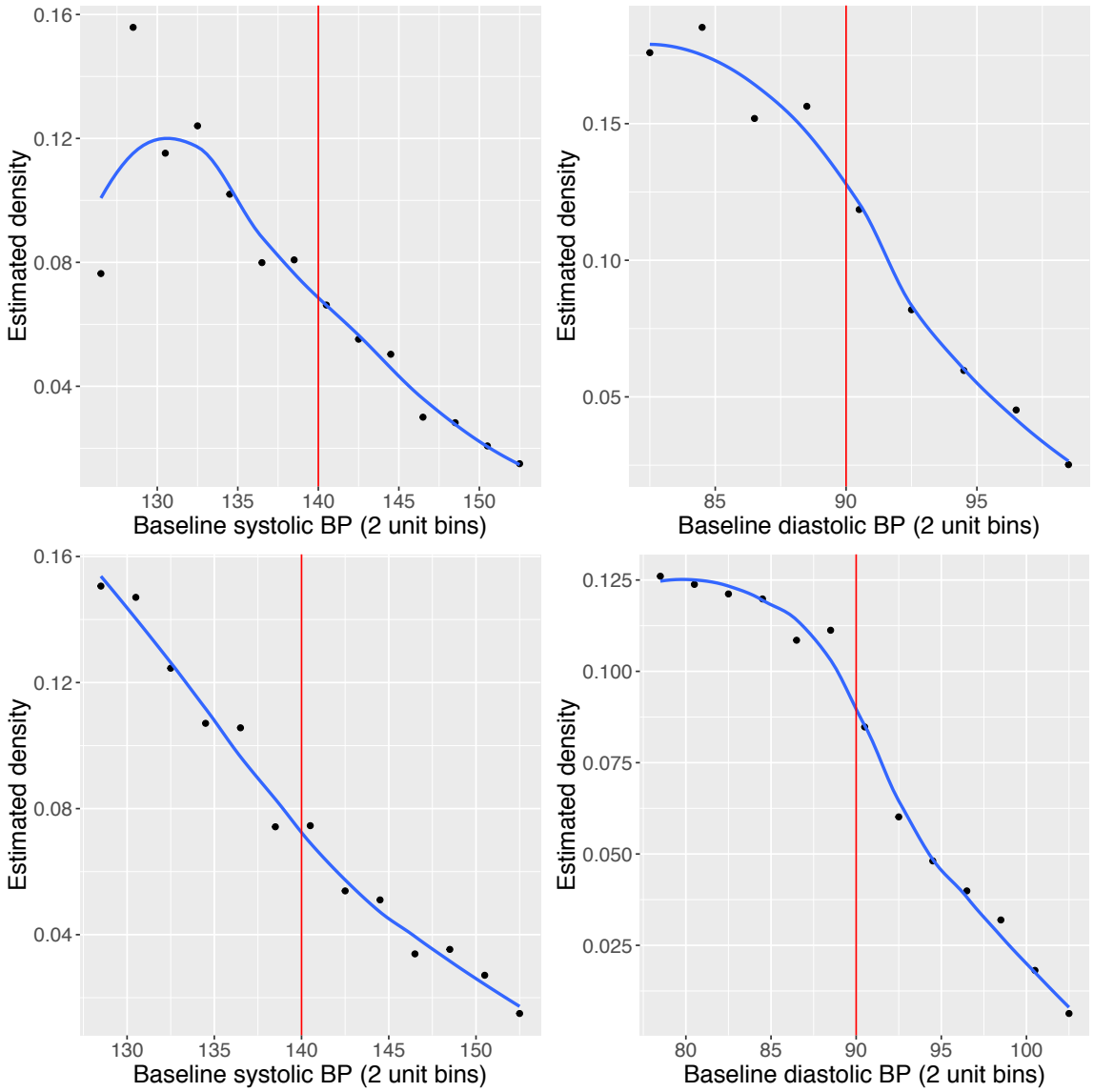
S Table 1 Overall and within-bandwidth descriptive characteristics for the systolic and diastolic blood pressure samples.

	Men				Women			
	Overall		Within bandwidth		Overall		Within bandwidth	
Systolic BP	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age	46.8	13.1	49.5	14.0	47.6	13.5	54.2	13.5
	%	*n*	*%*	*n*	*%*	*n*	*%*	*n*
Urban	0.52	3205	0.50	1143	0.47	5299	0.44	1229
> Secondary schooling	0.16	961	0.14	314	0.14	1615	0.10	284
Fair/poor SRH	0.16	973	0.17	385	0.20	2263	0.25	698
Prior stroke	0.01	78	0.01	32	0.02	176	0.02	57
Prior diabetes	0.05	302	0.06	143	0.07	740	0.10	288
Prior heart attack	0.02	143	0.02	49	0.04	451	0.05	131
Smoker	0.42	2611	0.41	938	0.08	919	0.09	263
Has health insurance	0.13	795	0.13	296	0.10	1155	0.08	235
N		6163		2265		11396		2802
Diastolic BP	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age	45.3	12.3	44.8	11.7	46.1	12.5	46.6	12.2
	%	*n*	*%*	*n*	*%*	*n*	*%*	*n*
Urban	0.53	3378	0.55	1481	0.48	6060	0.48	3879
> Secondary schooling	0.17	1065	0.17	456	0.14	1844	0.14	1111
Fair/poor SRH	0.15	936	0.13	358	0.19	2384	0.19	1517
Prior stroke	0.01	65	0.01	22	0.02	196	0.02	125
Prior diabetes	0.04	255	0.04	113	0.06	753	0.07	534
Prior heart attack	0.02	129	0.02	48	0.04	485	0.04	305
Smoker	0.42	2688	0.40	1075	0.08	1047	0.09	733
Has health insurance	0.13	849	0.15	400	0.10	1322	0.10	842
N		6405		2699		12753		8045

Source: Author's analysis of the 2008, 2010-2011, 2012, 2014-2015, and 2017 waves of the National Income Dynamics Study.
Notes: Bandwidths are for the regressions estimating the effect of the intervention on two-year change in blood pressure.

eAppendix V: Assessing manipulation of the running variable

S Figure 2 presents the estimated density of baseline BP separately by sex and BP groups. For both the systolic and diastolic BP samples, we find no visual evidence of bunching around the discontinuity suggestive of manipulation among either sex.



S Figure 2 Estimated density of baseline maximum systolic and diastolic BP, South African adults ages 30+, National Income Dynamics Study, 2008-2017.
[1]The density is estimated using a LOWESS line over two-unit (in mmHg) blood pressure bins
[2]The density is estimated within the optimal bandwidths for each BP-sex group
[3]The red vertical line represents the cutoff above which survey enumerators were instructed to provide the intervention

eAppendix VI: Analysis of pre-treatment negative controls

S Table 3 presents estimates of the "effect" of the intervention on several pre-treatment negative controls that should not be affected by the intervention. In general, we find little evidence of an "effect" on pre-treatment negative controls suggestive of a lack of continuity in the potential outcome function. There are three exceptions: we find a discontinuous increase of 2.266 years of age at the cutoff for men in the systolic BP sample, a 5.2 percentage point increase in the probability of reporting fair or poor self-rated health for men in the diastolic BP sample, and a 1.5 percentage point decrease in the probability of reporting prior stroke for women in the diastolic BP sample. Given the large number of estimates presented in S Table 1, there is a high probability that these results are driven by chance. Nonetheless, the impact of these violations of the negative controls on BP outcomes should be considered in the interpretation of the results. Importantly, however, we find no evidence of discontinuity in any negative controls for women in the systolic BP sample.

S Table 3 Regression discontinuity estimates of the "effect" of household-based blood pressure screening on pre-treatment negative controls, South African adults ages 30+, National Income Dynamics Study, 2008-2017.

	Men			Women		
Systolic BP	Effect	Lower CB	Upper CB	Effect	Lower CB	Upper CB
Age	2.266	1.464	8.694	1.092	-2.589	4.180
Urban	-0.037	-0.194	0.079	-0.059	-0.219	0.033
> Secondary schooling	-0.013	-0.124	0.077	-0.034	-0.120	0.023
Fair/poor SRH	-0.034	-0.123	0.084	0.106	-0.014	0.210
Prior stroke	-0.012	-0.057	0.013	0.005	-0.010	0.050
Prior diabetes	-0.001	-0.086	0.047	-0.030	-0.115	0.051
Prior heart disease	-0.003	-0.060	0.019	-0.026	-0.074	0.047
Smoker	-0.060	-0.206	0.065	-0.003	-0.075	0.072
Has health insurance	0.003	-0.097	0.092	-0.035	-0.133	0.015
Diastolic BP	Effect	Lower CB	Upper CB	Effect	Lower CB	Upper CB
Age	-0.156	-2.103	3.001	0.955	-0.154	2.998
Urban	0.027	-0.144	0.087	-0.029	-0.114	0.020
> Secondary schooling	-0.004	-0.127	0.046	-0.017	-0.071	0.021
Fair/poor SRH	0.052	0.003	0.147	0.013	-0.034	0.066
Prior stroke	-0.003	-0.036	0.011	-0.015	-0.043	-0.005
Prior diabetes	0.011	-0.025	0.073	-0.007	-0.040	0.026
Prior heart disease	0.010	-0.035	0.036	0.014	-0.013	0.042
Smoker	-0.084	-0.255	-0.029	0.000	-0.048	0.032
Has health insurance	-0.013	-0.147	0.019	-0.007	-0.083	0.002

[1]Each effect and confidence interval pair corresponds to a single regression
[2]All regressions were estimated using the optimal bandwidth for the blood pressure outcomes
[2]Effects were estimated using a local linear specification with triangular weights

[3]The regression function included dummy variables for year of baseline survey
[4]95% CI are based off of robust standard errors that were clustered at the individual level

eAppendix VII: Robustness of main findings to bandwidth size

S Table 4 presents the main estimates of the effect of the screening intervention on BP change for the optimal bandwidth (OBW) and four additional bandwidths. We find that the point estimates are very robust to the choice of bandwidth with only minor variations in effect size across the various bandwidth choices. It is important to note that the confidence intervals surrounding the estimate change based on the bandwidth size, although this variation ultimately does not change our main study conclusions.

S Table 4 Regression discontinuity estimates of the effect of household-based blood pressure screening on blood pressure with variable bandwidths, South African adults ages 30+, National Income Dynamics Study, 2008-2017.

	50% OBW	75% OBW	OBW	125% OBW	150% OBW
Systolic BP					
Male effect	0.0	0.9	0.9	0.9	1.3
95% CI	(-7.2,10)	(-6.9,5.9)	(-5,5.8)	(-4.2,5.4)	(-4.1,4.8)
p-value	0.75	0.88	0.88	0.88	0.88
Female effect	-5.8	-6.1	-4.7	-4.1	-3.8
95% CI	(-13.4,4.6)	(-12.8,-0.1)	(-12.6,-2.1)	(-10.6,-1.5)	(-9.5,-1.3)
p-value	0.34	0.05	0.01	0.01	<0.01
Diastolic BP					
Male effect	0.3	0.2	0.4	0.6	0.7
95% CI	(-5.9,3.6)	(-2.8,3.8)	(-2.5,2.9)	(-2.3,2.4)	(-2,2.3)
p-value	0.63	0.76	0.89	0.99	0.9
Female effect	0.5	0.3	0.1	0.1	0.1
95% CI	(-1.2,3.8)	(-1.3,2.4)	(-1,2.1)	(-1.1,1.7)	(-1,1.6)
p-value	0.32	0.54	0.49	0.68	0.66

[1]OBW: optimal bandwidth
[2]Effects were estimated using a local linear specification with triangular weights
[3]The regression function included dummy variables for year of baseline survey
[4]95% CI are based off of robust standard errors that were clustered at the individual level

eAppendix VIII: Difference in baseline characteristics between individuals lost and not lost to follow-up.

S Table 5 compares differences in the mean of baseline characteristics between those in the sample those dropped due to loss to follow-up. For men, the only large difference is that individuals lost to follow up were more likely to report fair or poor self-rated health at baseline. This pattern was the same for women with the addition that those lost to follow-up were also more likely to be college educated.

S Table 5 Mean differences in baseline variables between individuals lost and not lost to follow-up, South African adults ages 30+, National Income Dynamics Study, 2008-2017.

	Men		Women	
	In sample	Lost to follow-up	In sample	Lost to follow-up
Baseline systolic BP	134.93	134.47	133.15	134.79
Baseline diastolic BP	86.59	86.20	87.67	88.20
Age	48.07	48.05	49.58	50.77
Urban	0.15	0.16	0.12	0.14
> Secondary schooling	0.53	0.55	0.47	0.52
Fair/poor SRH	0.17	0.21	0.22	0.27
Prior stroke	0.01	0.02	0.02	0.02
Prior diabetes	0.06	0.06	0.08	0.09
Prior heart disease	0.02	0.03	0.05	0.05
Smoker	0.41	0.43	0.09	0.12
Has health insurance	0.13	0.14	0.09	0.12

eAppendix IX: Robustness of main findings to missing follow-up corrections

S Table 6 presents the main study results estimated using IP weights to correct for the differential distribution of baseline characteristics between those who were in the sample and those lost to follow-up between waves. Our main results are robust to this correction and we observe almost no change in the point estimates or confidence intervals.

S Table 6 Regression discontinuity estimates of the effect of household-based hypertension screening on two-year change in blood pressure with inverse probability weights to correct for loss-to-follow up, South African adults ages 30+, National Income Dynamics Study, 2008-2017.

	Men	Women
Systolic BP		
Estimated effect	0.1	-4.8
95% CI	(-7.3,5.6)	(-12.7,-2.1)
p-value	0.79	<0.01
Diastolic BP		
Estimated effect	0.1	0.2
95% CI	(-2.8,3.4)	(-0.9,2.3)
p-value	0.84	0.40

[1]Effects were estimated using a local linear specification with triangular weights
[2]The regression function included dummy variables for year of baseline survey
[3]95% CI and p-values are based off of robust standard errors that were clustered at the individual level
[4]We used a mean-squared error optimal bandwidth size that was empirically determined
[5]IP weights were estimated using the following covariates as predictors of loss to follow up: age, female, urban residence, schooling, self-rated health, smoker, has health insurance, prior diagnosis of diabetes, prior diagnosis of heart problems, prior diagnosis of stroke, baseline mean BP

eAppendix X: Consistency of the point estimates across waves of data

S Tables 7 and **8** present the results of the main paper separated by pairs of data waves. For men, we find that the main result of a systolic BP reduction for those between ages 30-45 is consistent across waves—although the size of the effect varies slightly, there is an important negative effect for each pair of waves. For women, we find that our main effect of a reduction among all individuals is mostly consistent across waves; the main exception is that we do not observe a meaningful effect for the wave 3 to 4 transition. However, given that there is a meaningful effect for 3 of the 4 waves, we believe it is unlikely that the waves 3 to 4 null finding signals an overall spurious result.

S Table 7 Point estimates of the effect of the intervention on blood pressure separated by pairs of data waves, South African **men** ages 30+, National Income Dynamics Study, 2008-2017.

	All waves	W1 to W2	W2 to W3	W3 to W4	W4 to W5
Systolic BP					
Overall effect	0.94	-2.75	7.21	0.13	2.61
Age 30-45	-6.95	-12.66	-2.94	-14.49	-3.68
Age 45-60	2.47	8.07	2.58	-17.84	11.73
Age 60+	1.07	-9.17	5.60	6.61	-3.59
No schooling	0.92	1.07	16.52	-2.68	-8.11
Primary/Secondary schooling	1.77	0.77	1.52	-0.70	5.56
> Secondary schooling	-2.77	-54.48	17.63	0.99	-4.09
Diastolic BP					
Overall effect	0.38	-2.70	1.39	0.97	0.45
Age 30-45	-0.34	1.02	-1.50	0.33	-0.54
Age 45-60	1.54	-6.70	3.06	1.04	8.08
Age 60+	-0.47	-8.53	12.00	-0.10	-15.87
No schooling	5.58	-12.23	9.76	10.76	-2.15
Primary/Secondary schooling	-0.32	-2.39	1.81	-0.71	0.85
> Secondary schooling	-0.33	17.64	-11.49	2.11	-2.12

[1]Each effect estimate corresponds to a single regression
[2]Effects were estimated using a local linear specification with triangular weights
[3]The all waves column contains the results shown in the main paper

S Table 8 Point estimates of the effect of the intervention on blood pressure separated by pairs of data waves, South African **women** ages 30+, National Income Dynamics Study, 2008-2017.

	All waves	W1 to W2	W2 to W3	W3 to W4	W4 to W5
Systolic BP					
Overall effect	-4.73	-2.02	-6.78	-0.30	-7.94
Age 30-45	-9.17	-1.88	-4.55	-11.39	-35.48
Age 45-60	-4.03	2.02	-19.80	-0.55	-1.22

Age 60+	-4.30	-7.45	-5.98	3.78	-4.74
No schooling	-3.56	2.43	-10.27	0.66	-0.94
Primary/Secondary schooling	-3.93	-4.79	-5.90	0.47	-5.93
> Secondary schooling	-14.18	9.63	2.83	-12.18	-49.87
Diastolic BP					
Overall effect	0.10	2.14	-0.78	-0.08	1.53
Age 30-45	-0.70	2.35	-4.86	-1.21	2.88
Age 45-60	1.34	-0.48	1.79	1.49	0.94
Age 60+	1.68	3.55	0.11	2.74	-1.53
No schooling	-1.17	3.25	-5.33	0.61	-3.76
Primary/Secondary schooling	0.37	1.05	0.37	0.13	1.64
> Secondary schooling	1.66	5.16	0.28	-2.19	3.10

[1]Each effect estimate corresponds to a single regression
[2]Effects were estimated using a local linear specification with triangular weights
[3]The all waves column contains the results shown in the main paper

eAppendix XI: Description of pre-intervention baseline variables

Variable	Survey questions	Classification
Age	Calculated based on date of interview and the respondent's self-reported date of birth	Continuous variable for years of completed age
Urban	Location for each household was classified by survey enumerators into traditional, urban, and farms based on the 2011 census	Binary variable equal to 1 if the household was listed as being located in an urban area
>Secondary schooling	Based on the response to the question "What is the highest level of education you have successfully completed?"	Binary variable equal to 1 if the individual reported any of the following levels of schooling: National Technical Certificate 1-3, certificate, diploma, bachelor's degree, honours degree, higher degree (masters, doctorate)
Fair/poor SRH	Based on the response to the question "How would you describe your health at present? Would you say it is excellent, very good, good, fair, or poor?"	Binary variable equal to 1 if the individual reported fair or poor
Prior stroke	Based on the response to the question "Have you ever been told by a doctor, nurse or health care professional that you have had a stroke?"	Binary variable equal to 1 if the individual reported yes
Prior diabetes	Based on the response to the question "Have you ever been told by a doctor, nurse or health care professional that you have diabetes or high blood sugar?"	Binary variable equal to 1 if the individual reported yes
Prior heart disease	Based on the response to the question "Have you ever been told by a doctor, nurse or health care professional that you have heart problems?"	Binary variable equal to 1 if the individual reported yes
Smoker	Based on the response to the question "Do you smoke cigarettes?"	Binary variable equal to 1 if the individual reported yes
Has health insurance	Based on the response to the question "Are you covered by medical aid?"	Binary variable equal to 1 if the individual reported yes

eAppendix XII: Health Information Sheet

National Income Dynamics Study

Wave 1 (2008)

Information Sheet

YOUR PHYSICAL MEASUREMENTS

Respondent's Height	_____ _____ _____ centimetres
Respondent's Weight	_____ _____ _____ kilograms
Respondent's Waist	_____ _____ _____ centimetres

Blood Pressure reading 1	**Blood Pressure reading 2**
SYSTOLIC _____ _____ _____	SYSTOLIC _____ _____ _____
DIASTOLIC _____ _____ _____	DIASTOLIC _____ _____ _____
PULSE _____ _____ _____	PULSE _____ _____ _____

☐		Our readings of your blood pressure are within the normal range (Systolic less than 140 and Diastolic less than 90)
☐		Your blood pressure readings are higher than normal. High blood pressure is dangerous because it makes the heart work too hard. High blood pressure increases the risk of heart disease and stroke. High blood pressure can also cause other problems, such as heart failure, kidney disease, and blindness. You can control high blood pressure by taking action.
	☐	It is recommended that you should seek medical care within 2 months. (Systolic 140 to 159 or Diastolic 90 to 99)
	☐	It is recommended that you should seek medical care within 1 month. (Systolic 160 to 179 or Diastolic 100 to 109)
	☐	It is recommended that you should seek **medical care immediately**. (Systolic more than 179 or Diastolic more than 109)