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Heterogeneous effects of blood pressure screening

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ABSTRACT

This is the first study that investigates the heterogeneous effects of blood pressure (BP) screening on subsequent changes in BP in a high-income country. We use data from clinical health assessments carried out in 2010 (baseline) and 2014 (follow-up) as part of a nationally-representative longitudinal study on ageing in Ireland. We focus on individuals who at baseline do not report a previous hypertension diagnosis and employ a Regression Discontinuity Design by comparing outcomes at follow-up on either side of the BP cutoff that separates normal to abnormal BP at baseline. We find that the BP screening reduces BP at follow-up, with larger and more precisely estimated effects for males, middle-age individuals (as opposed to older individuals), and individuals without public health insurance coverage.

1. Introduction

Hypertension is the principal risk factor for cardiovascular disease, which in turn is the largest contributor to the global burden of disease (Vos et al., 2020). Hypertension is often undetected, with many individuals suffering from this condition not experiencing noticeable symptoms. In Ireland, around 38% of men and 27% of women aged 30 to 79 suffer from hypertension. Ireland has the lowest hypertension awareness rates of all high-income English speaking countries, with only 48% of men and 54% of women suffering from this condition being aware of their hypertension status (Zhou et al., 2021).

With this background in mind, we investigate whether hypertension screening can be effective at increasing awareness and in turn at lowering BP using data from nurse-led health assessments carried out in 2010 (baseline) and 2014 (follow-up) as part of a nationally representative longitudinal study on ageing in Ireland (TILDA). Respondents' systolic blood pressure (SBP) and diastolic blood pressure (DBP) are measured at baseline and follow-up. Respondents are also given feedback on whether their SBP and DBP are normal (below a BP cutoff) or abnormal (above a BP cutoff) at the end of the assessment. The SBP cutoff is 140 mmHg. The DBP cutoff is 90 mmHg.

We employ a Regression Discontinuity Design (RDD) and compare BP outcomes at follow-up on either side of the BP cutoff that separates normal to abnormal BP at baseline. Following Ciancio et al. (2021) and others, we employ a unidimensional RDD in the first instance and estimate treatment effects which are frontier-specific — systolic or diastolic. We then follow Kämpfen et al. (2023) and adopt a binding-score RDD strategy, which relies on a centering approach that leverages the changes in treatment status at both cutoffs simultaneously.

Given the high rates of hypertension unawareness in Ireland, our analysis focuses on undiagnosed individuals, i.e., individuals who at baseline do not report a previous hypertension diagnosis. We find that BP screening reduces BP at follow-up. Estimates are large and precisely estimated. We also document heterogeneity effects with larger effects for males, middle-aged respondents (as opposed to older respondents), and individuals who are not eligible to public health care.

This paper contributes to various strands of the literature. First, existing evidence on the effects of BP screening is mixed. While studies from High-Income Countries (HICs) such as the United Kingdom (Rodriguez-Lesmes, 2021) find that BP screening does not have any effect on BP at follow-up, studies from Low- and Middle-Income Countries (LMICs) such as Malawi (Ciancio et al., 2021) conclude that BP screening does reduce BP at follow-up. Knowledge and awareness of hypertension status is typically lower in LMICs than in HICs (Mohanty

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Table 1
Descriptive statistics.

	Mean	Std. dev.	Obs
		Baseline characteristics	
SBP	131.331	18.769	2752
DBP	81.178	10.865	2752
Hypertension	0.344	0.475	2752
Above SBP cutoff	0.302	0.459	2752
Above DBP cutoff	0.202	0.402	2752
		Outcomes	
Change in SBP	0.140	16.607	2752
Change in DBP	−1.084	10.153	2752
Hypertension	0.326	0.469	2752
		Controls (at baseline)	
Female	0.550	0.498	2752
Age	60.751	8.003	2749
Age above 80	0.027	0.161	2749

et al., 2022), suggesting that (low) awareness is likely a key determinant of the effectiveness of BP screening. Our study from Ireland shows that among undiagnosed individuals — and thus likely to be unaware of their condition — BP screening leads to improvements in BP characteristics that are consistent with evidence from LMICs.

Our second contribution is that to our knowledge this is the first study that investigates the heterogeneous effects of BP screening by socio-demographic groups in a HIC. Our third contribution is that compared to most previous studies, the information provided to respondents in TILDA is closer to how it would be provided in an actual screening programme. This is because in TILDA BP is measured by qualified nurses who provide oral and written feedback to the respondents at the time of the screening.

2. Data

2.1. Sample

We use data from The Irish Longitudinal Study on Ageing (TILDA), which is a nationally representative sample of community-dwelling individuals aged 50+ in Ireland (Whelan and Savva, 2013). Data are collected via computer-aided personal interviewing and a nurse-led health assessment carried out in a dedicated health centre or in the respondent's own home. We use data from undiagnosed individuals for whom we have valid BP measurements at baseline and follow-up (N = 2,752). Undiagnosed individuals are those who at baseline answer "*No*" to the question "*Has a doctor ever told you that you have high blood pressure or hypertension?*".

BP is measured twice according to a standard protocol (Murphy et al., 2016). The mean systolic and diastolic readings are obtained from these two measurements. At the end of the assessment, the nurse provides feedback to the respondent pointing out if their BP is "normal" —less than 140/90 mmHg—, or "abnormal".

2.2. Outcome variables

We consider three outcome variables. The first two capture changes in mean SBP and mean DBP, respectively, between baseline and follow-up. The third is an indicator of hypertension derived from those measurements, $\mathbb{1}(\text{mean SBP} \geqslant 140 \vee \text{mean DBP} \geqslant 90)$.

2.3. Descriptives

Fig. 1 is a scatter plot of the mean DBP measurements against the mean SBP measurements at baseline. Descriptive statistics are presented in Table 1. A total of 34.4% of respondents are classified as hypertensive at baseline. Around 55% of respondents are females and the average age is 60.8 years.[1]

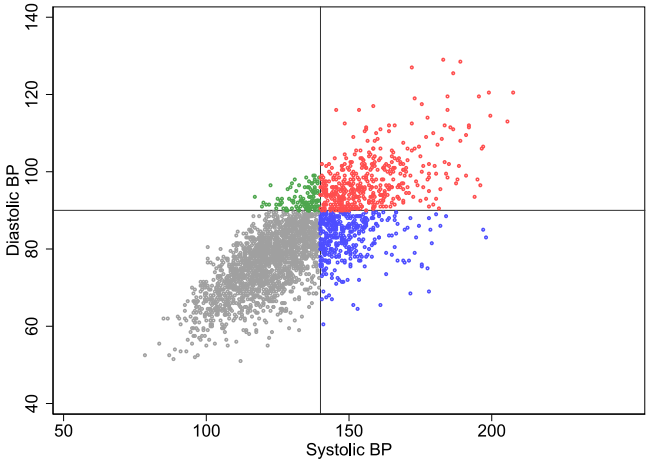


Fig. 1. Scatter plot of the systolic and diastolic BP at baseline.

3. Econometric specifications

3.1. Unidimensional RDD

The unidimensional RDD strategy estimates treatment effects that are frontier-specific. To ensure that treatment status (but nothing else) differs on each side of the respective cutoff, respondents who cross the other threshold are excluded from the sample used for unidimensional RDD. For example, the effect of crossing the 140 mmHg systolic cutoff is estimated along the frontier defined by that cutoff and below the DBP cutoff.

We use local linear regression along with triangular weights generated by kernel functions centered at the threshold to estimate treatment effects. To determine the bandwidths of observations on either side of the cutoff, we use the Mean Square Error (MSE) optimal bandwidth selector to set the bandwidths that can differ on each side of the threshold (Calonico et al., 2017). To calculate standard errors, we employ the heteroskedasticity-robust plug-in residuals variance estimator (Calonico et al., 2017).

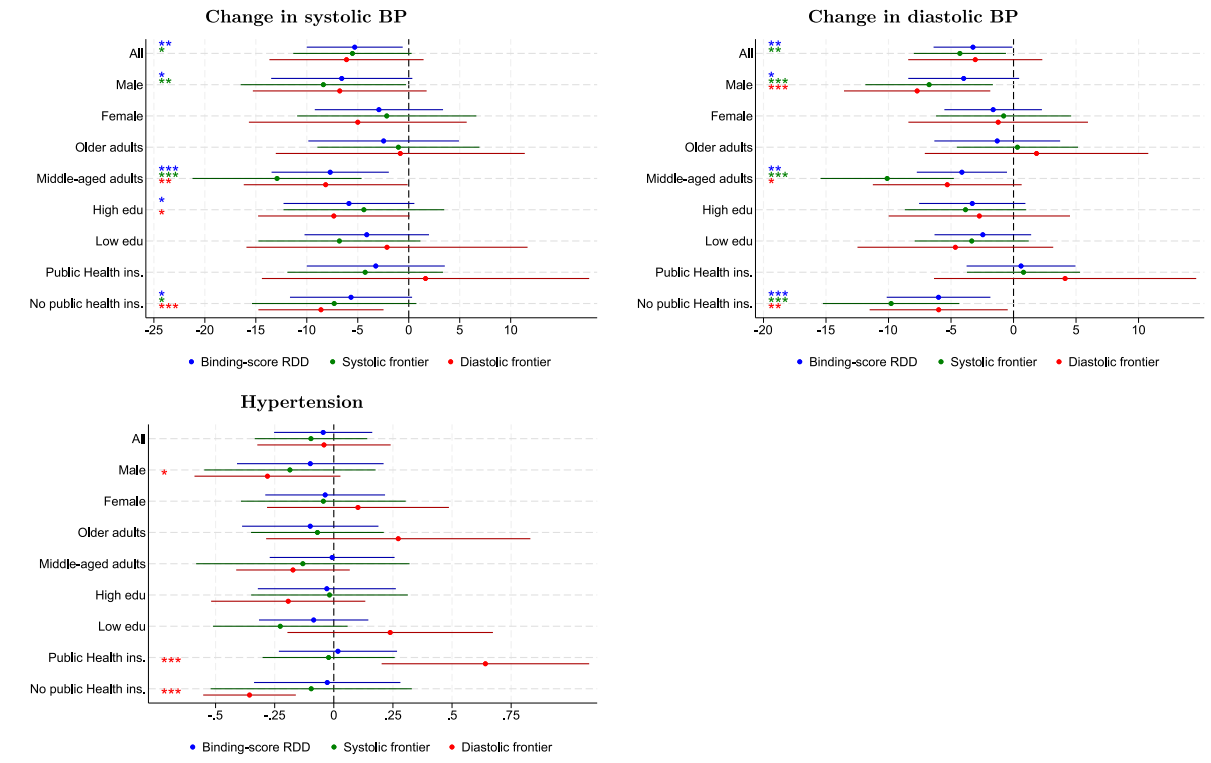
The main drawback of the unidimensional RDD approach is a substantial reduction in both information and statistical power due to the exclusion of a large number of observations in each unidimensional RDD. Additionally, the effects identified are frontier-specific.

3.2. Binding-score RDD

Binding-score RDD (Reardon and Robinson, 2012) creates a single running variable from the two assignment variables, i.e., mean SBP ($\bar{s}_i$) and DBP ($\bar{d}_i$).

We center $\bar{s}_i$ and $\bar{d}_i$ relative to their respective thresholds $\bar{x}_{i,c} = \bar{x}_i - c_x$ with $x = \{s, d\}$. and standardize each centered variable on its standard deviation $\bar{x}^{std}_{i,c} = \bar{x}_{i,c}/sd_x$. We then calculate the maximum distance of these two standardized and centered assignment variables away from their respective cutoff (0), $r_i = max(\bar{s}^{std}_{i,c}, \bar{d}^{std}_{i,c})$. r_i corresponds to the new running variable. Any individuals with $r_i \geqslant 0$ has BP characteristics, either SBP or DBP, outside the normal range. The discontinuity at the cutoff 0 is estimated in the same fashion as the in unidimensional RDD.

[1] Age of the respondents in TILDA is capped at 80.



Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Fig. 2. Heterogeneous effects of BP screening.

Table 2
Effects of BP screening.

	Binding-score RDD		Unidimensional RDD			
		N	Sys front.	N	Dia front.	N
	(1)	(2)	(3)	(4)	(5)	(6)
Change in SBP	−5.299**	1067	−5.523*	761	−6.105	470
	(0.027)		(0.062)		(0.113)	
Change in DBP	−3.245**	994	−4.291**	711	−3.061	736
	(0.044)		(0.022)		(0.263)	
Hypertension[a]	−0.045	990	−0.097	724	−0.041	596
	(0.671)		(0.426)		(0.773)	

Notes: P-values reported in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. N is the effective number of observations used in estimation. Corresponding results from specifications without controls, and/or using local quadratic regression are presented in Appendix Table A.1. Discontinuity plots are presented in Fig. A.1.

Although still a local average effect, the estimated effect using binding-score RDD is not as local as in the unidimensional case because it corresponds to overall average treatment effect at the frontier running along the *two* thresholds. By incorporating data from all four quadrants in Fig. 1 —including individuals above both cutoffs (red dots) — there is a gain in power, as well as external validity, compared to the unidimensional approach.

In all our estimations, we control for a vector of exogenous and predetermined covariates that includes age (including a dichotomous variable for age 80+) and sex. We provide evidence in Appendix B that the identification assumptions required for RDD hold in our setting.

4. Results

Table 2 shows estimates of the discontinuities in the outcome variables at the BP cutoffs. The results of the binding-score approach indicate that individuals at the cutoff experience a large drop in SBP of 5.3 mmHg (p-value = 0.027) relative to individuals right below the cutoff. A similar effect is estimated from the discontinuity at the systolic frontier (−5.5 mmHg, p-value = 0.062) and at the diastolic frontier (−6.1 mmHg, p-value = 0.113). Similar effects are found for changes in DBP. However, these effects do not translate into a statistically significant drop in the probability of being hypertensive at follow-up.

4.1. Heterogeneous effects

We document important heterogeneity in the estimated effects across key socio-demographic characteristics, more specifically sex, age, educational attainment, and public health insurance coverage.[2] The heterogeneous effects displayed in Fig. 2 indicate that BP screening appears to be effective among males; younger individuals (which is individuals aged < 59 years old where 59 is the median age in the sample); and for individuals without public health insurance.[3]

5. Conclusion

Using a nationally representative sample of Irish older adults, we find that BP screening improves the BP characteristics of screened

[2] Public health insurance coverage is equivalent to possessing a Full Medical Card or a GP Visit Card.

[3] Appendix Tables A.2–A.9 show the corresponding estimates.

individuals who at baseline do not report a previous hypertension diagnosis, with larger effects for males, younger respondents, and individuals without public health insurance. Our results suggest that the health information provided through the screening might trigger a health response if that information is new to the respondent.

Data availability

TILDA data is available from the Irish Social Science Data Archive at University College Dublin (http://www.ucd.ie/issda/data/tilda/) and at the Interuniversity Consortium for Political and Social Research (ICPSR) at the University of Michigan (http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/34315). The code will be shared by the authors on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2024.111845.

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