

Mobile Health Application and Quality of Care at a Hypertension Clinic: Online Supplement *

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1. DID Specification

We checked for the presence of individual and time effects using Gourieroux, Holly, and Monfort (1982) test ($p < 0.001$) and F test ($p < 0.001$) [1]. We also used the Hausman (1978) test to compare between a fixed effects model and a random effects model ($p = 0.01$) [2]. Our model specification is

$$BP_{i,t} = \alpha_i + \beta_t + \beta_1 TREAT_{i,t}, \quad (1.1)$$

where $BP_{i,t}$ is the systolic (or diastolic) BP reading of patient i in year t , $TREAT_{i,t}$ is a dummy variable that takes the value 1 if patient i has adopted the app in period t and 0 if not. The patient fixed effects and the time (year) fixed effects are denoted by α_i and β_t respectively. The regression coefficient β_1 is our DID estimate, that is, it is the additional change in systolic (or diastolic) BP between the treatment group and the control group.

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Table 1: Difference-in-Differences estimates for systolic and diastolic BP from 2014 to 2016.

	<i>Dependent variable:</i>			
	log(Systolic)	Indicator (=1 if Systolic BP $\geq$ 130)	log(Diastolic)	Indicator (=1 if Diastolic BP $\geq$ 80)
	(1)	(2)	(3)	(4)
mHealth adoption estimate	-0.014*** (0.006)	-0.1*** (0.026)	-0.013* (0.005)	-0.032 (0.024)
95% CI	(-0.004, -0.024)	(-0.046, -0.149)	(-0.002, -0.023)	(0.015, -0.08)
Deg. of freedom	1,346	1,346	1,346	1,346
# patients in control	907	907	907	907
# patients in treatment	726	726	726	726

*p<0.1; **p<0.05; ***p<0.01

Note: This table presents regression estimates of specification

$$BP_{i,t} = \alpha_i + \beta_t + \beta_1 TREAT_{i,t},$$

where BP is the systolic or diastolic BP. The main variable of interest is TREAT, and β_1 is the DID estimate. Patient-clustered robust standard errors are in parentheses. Column (1) and (3) gives regression results when the dependent variable is $\log(BP_i)$, and column (2) and (4) gives regression results when the dependent variable is an indicator that takes the value 1 if BP is systolic BP 130 or above and diastolic BP 80 or above respectively.

2. Robustness Tests and Results

We checked the parallel trends assumption by examining the difference in BP from 2012 to 2013 between the adopters and the non-adopters, excluding 412 patients who were not present in either 2012 or 2013. We re-estimated equation 1.1 with BP used as the dependent variable, redefining $TREAT_{i,t}$ to be 1 if the reading was taken in 2013 and patient i had adopted the app and 0 if the reading was taken in 2012. To address false positives from DID models we perform a placebo test: we repeat the estimation but randomly assign treatment to each patient [3, 4]. The probability that each patient is assigned to the treatment group is 44%, to match the overall proportion of adopters. We checked if the DID estimator is significant, and repeat this whole process 1000 times.

The change in BP from 2012 to 2013 between the two groups (checking parallel trends assumption) was insignificant. This suggests that the parallel trends assumption holds between the treatment and control groups before the app was introduced. See Appendix Table 2 for details on this regression. In the placebo test (to check for false positives), the DID estimator with randomly assigned treatment yielded a significant coefficient in 0.03% of the 1000 trials. Thus, we believe it is unlikely that our original DID estimate is the result of a false positive.

Table 2: Difference-in-Differences estimates for systolic and diastolic BP from 2012 to 2013.

	<i>Dependent variable:</i>	
	Systolic	Diastolic
mHealth adoption estimate	−0.882 (1.144)	−0.108 (0.37)
95% CI	(−1.363, 3.127)	(−0.618, 0.834)
Deg. of freedom	1,138	1,138
# patients in control	712	712
# patients in treatment	503	503

*p<0.1; **p<0.05; ***p<0.01

Note: This table presents regression estimates of specification

$$BP_{i,t} = \alpha_i + \beta_t + \beta_1 TREAT_{i,t},$$

where BP is the systolic or diastolic BP reading taken in 2013 and 2012. The main variable of interest is TREAT, and β_1 is the DID estimate. Patient-clustered robust standard errors are in parentheses.

3. Baseline values before and after matching

We observe that both the means and the distribution of each of these covariates are nearly identical between the two groups. Appendix Table 3 gives the mean summary statistics for baseline measurements belonging to the treatment and control group. The distribution of all covariates between the two groups both before and after matching is presented in Appendix Figure 2.

Table 3: Mean baseline values for treatment and control groups, for matched datasets.

	Treatment Group (n=726)	Control Group (n=726)
Avg. Age	61.23	65.6
% Female	0.5386	0.5689
% Male	0.4614	0.4311
Avg. BMI	31.67	30.88
% nonsmoker	0.6405	0.5978
% former smoker	0.2961	0.3017
% light smoker (<10 per day)	0.0110	0.0110
% heavy smoker (>10 per day)	0.0496	0.0868
% smoking status unknown	0.0028	0.0028
% nondrinker	0.4931	0.5069
% former drinker	0.0041	0.0041
% light drinker (<2 per day)	0.4008	0.3788
% heavy drinker (>2 per day)	0.0096	0.1179
% unknown drinker	0.0923	0.0923
% White	0.9559	0.9559
% Black	0.0165	0.0165
% Asian	0.0055	0.0055
% Other Race	0.022	0.011
Avg. 2014 Office Systolic	132.42	130.21

Table 4: Genetic matching estimate of the app treatment estimate

	<i>Dependent variable: Systolic BP (mmHg)</i>		
	All	BP<130	BP≥140
mHealth adoption estimate	-1.65** (0.689)	-0.82 (0.86)	-3.68** (1.54)
95% CI	(-0.3, -3.00)	(-0.87, 2.5)	(-0.66, -6.7)
Deg. of freedom	1,359	602	354
# patients in control	726	323	194
# patients in treatment	726	323	194

*p<0.1; **p<0.05; ***p<0.01

Note: This table presents DID regression estimates with matching. Patient-clustered robust standard errors are in parentheses.

Blood Pressure(Last Month)

Systolic	Diastolic	Pulse	Date & Time
126	86	56	2015-03-18 01:53:49 pm
125	75	67	2015-03-18 11:12:25 am
126	83	62	2015-04-08 02:18:56 pm

Blood Pressure Averages

Week	Systolic	Diastolic	Pulse	MAP	Readings
2015-04-05	126	83	62	97	1
2015-03-15	126	77	71	93	7
2015-03-08	129	81	77	97	9
2015-03-01	128	89	110	102	12
2015-02-22	150	87	62	108	3
2015-02-08	142	97	61	112	3
2015-02-01	133	88	79	103	4
2015-01-25	139	96	73	110	3
2015-01-18	152	93	71	113	2
2015-01-11	151	97	80	115	5

Month-Year	Systolic	Diastolic	Pulse	MAP	Readings
4-2015	126	83	62	97	1
3-2015	128	84	89	98	28
2-2015	141	91	68	107	10
1-2015	149	96	76	114	11
12-2014	147	92	65	110	27
11-2014	144	88	69	107	64
10-2014	148	92	72	110	41
9-2014	141	85	75	104	54

Month-Year	Before breakfast	2 hours after breakfast	Before lunch	2 hours after lunch	Before dinner	2 hours after dinner	Bedtime
2-2015	79(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
11-2014	81(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
10-2014	70(2)	0(0)	97(1)	0(0)	0(0)	0(0)	0(0)
9-2014	81(3)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
8-2014	77(7)	115(1)	0(0)	0(0)	0(0)	0(0)	0(0)
7-2014	73(14)	0(0)	64(2)	0(0)	0(0)	0(0)	0(0)
6-2014	79(13)	92(4)	0(0)	0(0)	0(0)	81(3)	0(0)
5-2014	95(19)	95(3)	0(0)	0(0)	0(0)	0(0)	0(0)
4-2014	80(19)	101(11)	81(7)	87(9)	79(7)	90(6)	90(12)
3-2014	95(22)	119(19)	93(9)	115(10)	97(16)	117(16)	105(18)

Medication List

Date	Name	Dosage	Description
2015-03-12	Xarelto	20mg a day	
2015-03-11	Metoprolol	50mg 2x a day	
2015-03-11	Diltiazem	300mg a day	
2014-11-20	Doxazosin	1mg a day	
2014-10-25	Diovan	160mg 2 at night	
2014-07-28	Torsemide	10mg 2 a day	
2014-04-02	Invokana	300mg a day	
2014-03-18	Epleranone	50mg 2x a day	
2014-03-07	Crestor	10mg a day	

Figure 1: Patient view of health summary through the mHealth app

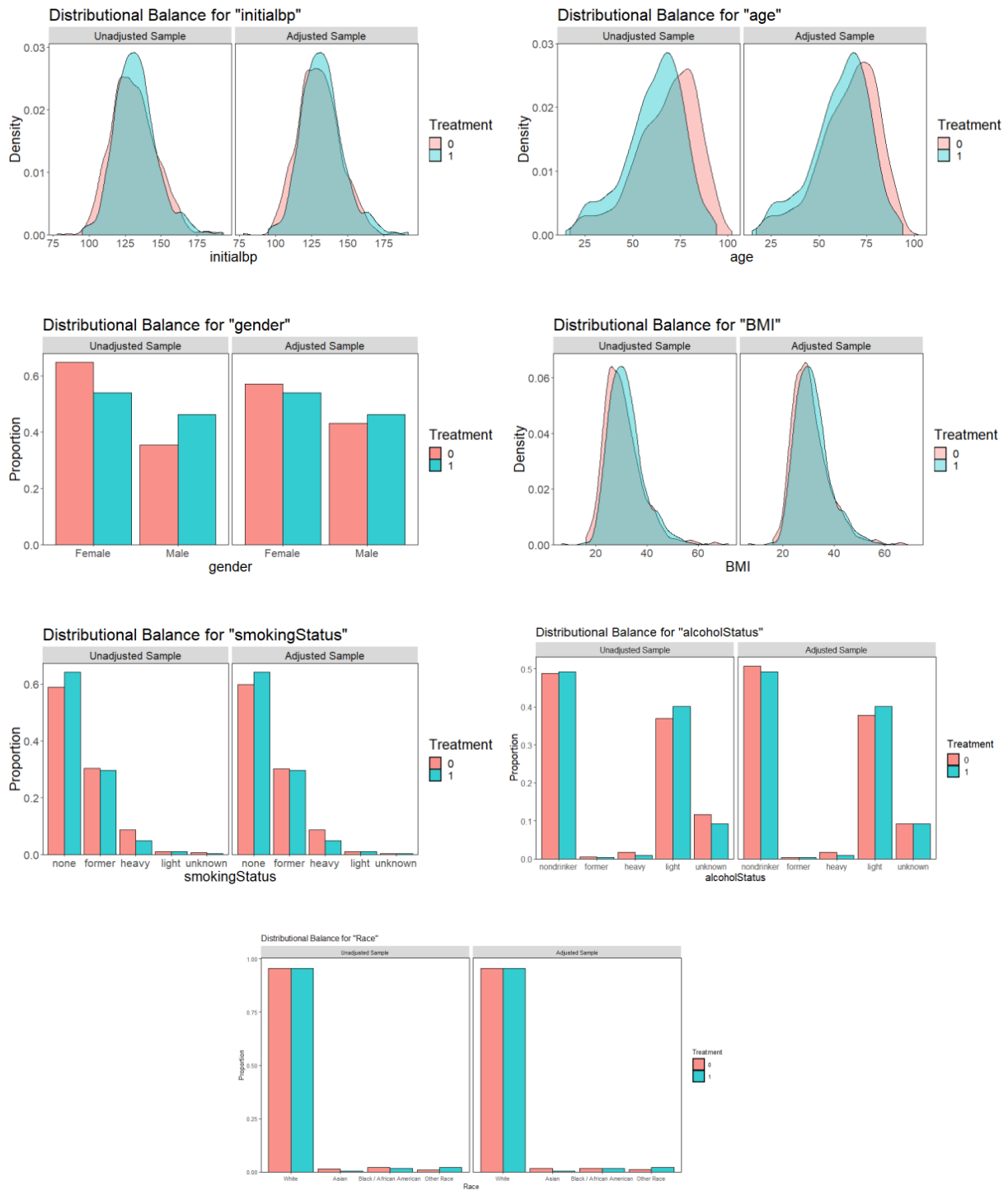


Figure 2: Distribution of baseline covariates between the treatment and control groups, before and after matching.

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