Messenger Effects and Spillovers in Early Immunization: A Field Experiment

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Outline

Motivation and Literature

- Early vaccination is **one of the most cost-effective strategies** to improve children health and prevent deaths (WHO, 2018).
- Developing countries have **expanded vaccine supply** (Busso et al., 2015) but **take-up remains low among the poor**.
- **Demand-side limitations**:
  1. lack of information on benefits and costs (Dupas, 2011).
  2. cognitive biases: present bias (Pomares et al. 2020), risk misperceptions (Hoffman, 2020) and scarce mental resources (Mullainathan, 2013); etc.
- Therefore, there is **room for interventions** with information accompanied with behavioral elements (reminders, repetition, affect, social norms, etc.)
- **Messaging through mobile technologies** can be a cost-effective policy.
- Despite the large number of studies, the evidence regarding mobile tech is inconclusive. The medium is one of many elements that matter and, often, these studies have design issues (Oliver-Williams et al., 2017).

Motivation and Literature

- There is evidence of behavioral **spillovers** of "hard" interventions on health outcomes. But there is **much less research on** the existence of spillovers of ***nudging through messaging***.
- Similarly, little is known about the **messenger effects** of interventions that use messages for nudging.
- This paper studies the impact of message nudging on health outcomes considering both **messenger effects and spillovers**.
- In particular, we study the impact of having a **national political leader** as the source of the messages (compared to an anonymous voice) on **child vaccination** (e.g., take-up rates and timely vaccine application).

Summary

- Field experiment in Metropolitan Santo Domingo (DR).
- Over seven thousand low-income households with 0-5 year-old children or pregnant women with 6 months or more.
- Intervention (RCT):
  - **Voice messages** contained information on the **benefits** of timely vaccination, vaccine **schedules**, positive **social norms**, and other affect-related motivations.
  - 23 messages over a span of six months (˜1 per week).
  - RH Treatment: Radio Host voice (female) .
  - VP Treatment: Vice president's voice (female).
- Outcomes: number of vaccine-related visits, number of doses, timely vaccination, immunization delays.
- Results:
  - Positive direct effects
  - Positive spillovers for controls from VP, but none from RH.
  - No spillovers on the treated.

Experiment Setting

The Dominican Republic (2014):

- Population: 10 Million; 78% urban; 40% in Santo Domingo
- **Infant Mortality Rate**: 26.6/1,000 (USA: 5.9)
- Access to ICTs among low-income households: 87.7% (ONE, 2015).
- Access to mobile telephones among low-income households: 66% (ONE, 2015).

Immunization:

- 53.1% of children 18-29 months old received all **basic vaccines** (ENDESA, 2013).
- **Timely vaccination** goes from 44% in 0-1-year-olds, to 11% for 1-2-year-olds, to 2.7% for 2-3-year-olds (our data).

Experiment

- Sample: 7556 low-income households, mostly cash-transfer beneficiaries, metropolitan Santo Domingo with:
  - 0-5 years old children or
  - women with 6 months of pregnancy or more.
- Treatment messages:
  - Information on the benefits of vaccination and timely immunization, norms, affect, appeal to keep the vaccination card in a safe place, etc.
  - Curated and adapted by local professionals and a group of parents of low-income households.
  - Each message lasts 20-30 seconds.
  - 23 weekly messages over a span of six months
- Conditions:
  1. Control: received void messages (**C**).
  2. Radio Host Treatment (**RH**): Standard, female radio host voice.
  3. Vice President Treatment (**VP**): Message recorded by the DR's then VP.

Two Message Examples

1. A continuación, un mensaje de la Vicepresidenta de la República:
"**Hola, te habla Margarita Cedeño. Cuidar a nuestros niños para que crezcan sanos es nuestro deber de padres. Pongamos a nuestros hijos todas sus vacunas a la edad que les toca**." Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto.

2. Te compartimos un mensaje de PROSOLI:
"Hola, **hay un centro de vacunación cerca de ti. Llevar a tus hijos a tiempo para sus vacunas puede salvarles la vida. Vacúnalos a la edad que les toca**. Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto."

Experiment

- Randomized assignment at the household level.
- 2-stage treatment assignment.
- **First stage:** clusters (BL surveyor routes) divided into five groups at random:
  - Complete VP (25%): all households in these clusters received the VP treatment.
  - Complete RH (25%): all households in these clusters received the RH treatment.
  - Complete C (16.6%): all households in these clusters received the C treatment.
  - Half VP (16.6%): half VP treatment, half C.
  - Half RH (16.6%): half RH treatment, half C.
- **Second stage**: we assigned treatment or control conditions to the households within each cluster, at random.
- Design to increase exogenous variability in the spatial density of treated households.

Geographical treatment distribution

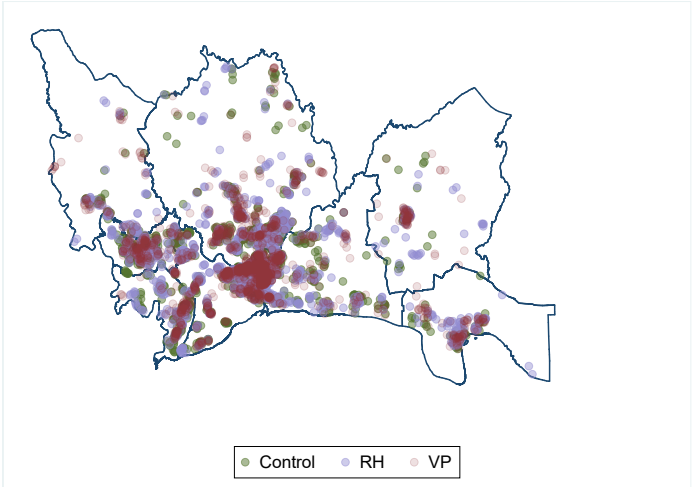


Figure: Geographical treatment distribution

Intervention timeline

- **Baseline**: Information on children's vaccination under 5, households' telephone numbers, socioeconomic conditions, household composition.
- **Endline**: **Image proof of vaccination records**, socioeconomic status, household composition, attitudes towards vaccination, **geo-coordinates**.

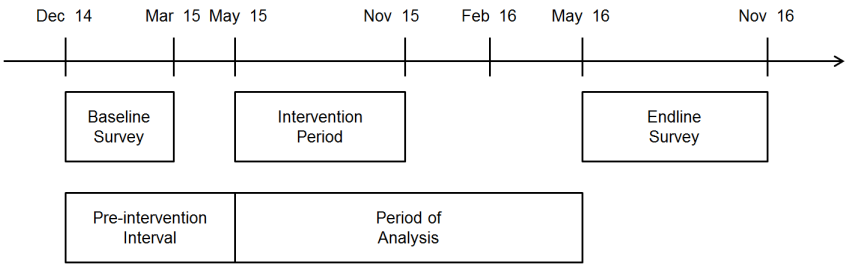


Figure: Intervention timeline

Randomization, Balance

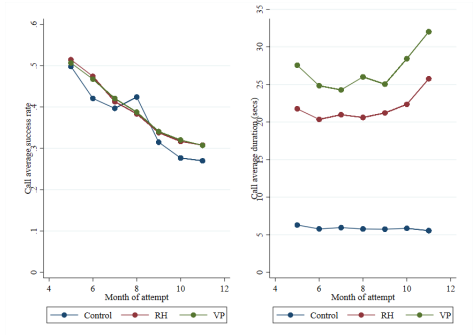
Table: Balance Table

	(1) Control (Average)	(2) RH (Average)	(3) VP (Average)	(4) (1) vs. (2), p-value	(5) (1) vs. (3), p-value	(6) (2) vs. (3), p-value	(7) N
Number of immunization visits	4.173	4.171	4.206	0.980	0.670	0.650	7003
Number of vaccine doses	8.058	8.098	8.117	0.780	0.674	0.890	7003
Percentage of vaccines applied on time	0.441	0.445	0.444	0.657	0.736	0.907	6980
Average delay in vaccination (days)	351.156	340.567	340.172	0.273	0.249	0.966	6985
Immunization card (yes / no)	0.803	0.797	0.808	0.608	0.647	0.324	7003
Number of children under five per household.	1.318	1.318	1.335	0.963	0.329	0.304	7003
Household head's education (years)	7.572	7.614	7.517	0.738	0.661	0.432	6473
Number of unmet basic needs in the household	0.792	0.766	0.787	0.244	0.834	0.331	7003
N	2611	2813	2836				

Compliance

- Compliance with treatment depends on:
  - maintaining phone service
  - picking up the call
  - listening all (or enough) of the message.
- During the intervention period:
  - Phones in service: down from above 90% to approximately 70%.
  - Call attempts that were answered: down from near 60% to approx. 40%.

Figure: Intervention outcomes



Left: average success rate (more than 5 secs) of answered calls.
Right: average duration of answered calls.

Outcomes

1. Total number of vaccination visits to a health center.
2. Total number of vaccine doses of the Basic Scheme of Immunization.
3. Timely vaccination: percentage of vaccine doses applied according to recommended schedule.
4. Average delay of vaccination: average time between the vaccination date and recommended date.

Detail

Descriptive Stats

- Descriptive statistics show no clear divergence between treatment groups and control group.

Table: Descriptive Stats

	Control Mean (sd)	RH Mean (sd)	VP Mean (sd)	Total Mean (sd)
Outcomes:				
Number of immunization visits	1.086	1.144	1.049	1.093
	(1.006)	(0.995)	(0.940)	(0.980)
Number of vaccine doses	1.787	1.897	1.720	1.801
	(1.713)	(1.681)	(1.529)	(1.641)
Percentage of vaccines applied on time	0.161	0.176	0.171	0.169
	(0.241)	(0.243)	(0.243)	(0.242)
Average delay in vaccination (days)	294.2	286.2	296.1	292.1
	(92.75)	(95.87)	(90.15)	(93.00)
Observations	1568	1715	1695	4978

Treatment Effects Specifications

Intention to treat (ITT) for the child i in the cluster c:

$$Y_{c,i} = \alpha + \beta_{RH} RH_{c,i} + \beta_{VP} VP_{c,i} + \beta_0 Y_{0c,i} + \beta X_{c,i} + \epsilon_{c,i} \quad (1)$$

- Y_0: Dependent variable prior three months to intervention.
- RH and VP: Assignment/Treatment delivered by a radio host voice or by the vice-president's voice, respectively.
- X: Unmet basic needs dummies (exactly one, more than one), HoH's education attainment dummies, HoH's age-range dummies, HoH's gender, child's age, child's ageˆ2.

ITT

- No effect of receiving RH voice messages on any outcome.
- VP treatment slightly increased the proportion of vaccines applied on time. No effect on any other outcome.

Table: Inmunization Outcomes

	(1) Number of immunization visits	(2) Total number of vaccines	(3) % of vaccines applied on time	(4) Average length of delay
VP	0.017	0.031	0.017*	-1.873
	(0.03)	(0.05)	(0.01)	(2.03)
RH	0.026	0.068	0.010	-2.541
	(0.03)	(0.05)	(0.01)	(2.12)
Mean, dept. var in BL	5.886	10.918	0.519	348.703
Observations	4978	4978	3262	4976

Standard errors in parentheses

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

Spatial Spillovers

- Our experiment was going to be subject to spillovers even when keeping only the pure groups.
- We use the following specification:

$$\begin{aligned} Y_{c,i} = \quad & \beta_0 + \beta_1 D(VP)_{c,i} + \beta_2 D(RH)_{c,i} + \beta_3 VP_{c,i} + \beta_4 RH_{c,i} \\ & + \beta_5 D(VP) \times VP_{c,i} + \beta_6 D(RH) \times VP_{c,i} \\ & + \beta_7 D(VP) \times RH_{c,i} + \beta_8 D(RH) \times RH_{c,i} \\ & + \beta X_{c,i} + \epsilon_{c,i} \end{aligned} \tag{2}$$

- $D(T)_{c,i}$ represents the number of households assigned to treatment $T = \{VP, RH\}$ as a proportion of the total number of households in the study within 500 meters from the household of child i.
- β_1 and β_2 capture the effect of spillovers without treatment. β_5, β_6, β_7 and β_8 capture additional spillover effects by treatment.

Spatial Spillovers

	(1) Number of immunization visits	(2) Total number of vaccines	(3) % of vaccines applied on time	(4) Average length of delay
Density VP	0.456***	0.794***	0.072*	-19.688**
	(0.13)	(0.21)	(0.04)	(8.27)
Density RH	0.108	0.287	0.029	-2.686
	(0.12)	(0.20)	(0.04)	(8.81)
VP	0.191*	0.414**	0.094***	-8.164
	(0.10)	(0.17)	(0.03)	(6.97)
RH	0.308***	0.528***	0.048	-19.801***
	(0.10)	(0.17)	(0.03)	(7.35)
VP × Density VP	-0.462***	-0.908***	-0.133***	19.359*
	(0.16)	(0.27)	(0.05)	(10.72)
RH × Density VP	-0.601***	-0.973***	-0.038	36.435***
	(0.17)	(0.30)	(0.06)	(12.02)
VP × Density RH	-0.104	-0.301	-0.106*	1.394
	(0.18)	(0.32)	(0.06)	(12.58)
RH × Density RH	-0.275	-0.476*	-0.066	16.684
	(0.17)	(0.28)	(0.05)	(11.55)
Observations	4978	4978	3262	4976
Mean, dept. var in T1	5.886	10.918	0.519	348.703

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Positive **spillover effects on controls** from the VP treated, but none from the RH treated: **the messenger matters.**
- Positive effects from receiving either type of message on most outcomes.

Spatial Spillovers

	(1) Number of immunization visits	(2) Total number of vaccines	(3) % of vaccines applied on time	(4) Average length of delay
Effect of D(VP) on VP	-0.006	-0.114	-0.061*	-0.329
	(0.101)	(0.172)	(0.035)	(6.954)
Effect of D(VP) on RH	-0.145	-0.179	0.035	16.747*
	(0.123)	(0.22)	(0.046)	(9.03)
Effect of D(RH) on VP	0.005	-0.014	-0.077*	-1.292
	(0.136)	(0.241)	(0.044)	(8.668)
Effect of D(RH) on RH	-0.167	-0.190	-0.036	13.998*
	(0.119)	(0.193)	(0.036)	(7.676)
Observations	4978	4978	3262	4976
Mean, dept. var in T1	5.886	10.918	0.519	348.703

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

- Generally no spillover effects among the treated.
- We run a series of robustness checks, and find qualitatively similar results.
  Detail
- There is no evidence of heterogeneity in treatment effects (HoH's education level, toddler's age, and HH's UBNs).

Mechanisms

- What is the mechanism behind the spillover effects?
- We have to explain (1) existence of spillovers from VP, and (2) absence of spillovers from RH. **We rule out**:
  1. Imitation: we would expect to see spillovers from the RH treatment too, as effects on the treated are similar.
  2. Hearing about the messages from treated households: neither treatment density has an effect on control households' probability of being aware of the messages.
- However, it is possible that VP treated households are more likely to share the information, even if they do not explicitly talk about their messages.

Policy Simulation

Conclusion

- We deploy an RCT where the treatments consisted of voice messages containing information and behavioral / affective encouragement for toddler's vaccination.
- We study how the **spillover effects** of messaging nudges **vary according to the messenger**.
- After taking spillovers into account, we find that:
  1. Both treatments have positive effects on the treated households. The RH effects seem to be slightly stronger.
  2. Only the VP treatment has spillover effects on the non treated households.
  3. There are generally no spillover effects among treated households
- Our results can be used to inform future policy on nudging interventions to improve health outcomes.

Thanks

Robustness Checks

- We evaluate robustness by changing how we define treatment density. We distinguish between households that are
  - **relatively closer** (within 300 meters)
  - **relatively further away** (from 300 to 500 meters away)

  from the subject.
- Our results are robust:
  1. VP retains spillover effects on controls for 3 of 4 outcomes (originally 4).
  2. RH still has no spillover effect on controls.
  3. Almost no evidence of spillovers on the treated.
  4. Direct effects of similar magnitude.
- Results suggest the spillovers from the VP treatment are caused by the nearest neighbors (within 300 meters): the coefficients for treatment density at a distance from 300 to 500 meters are never significant.

General Info on Densities

Table: Municipality-level Info

Province	Municipality	Poverty by Quality of life Index (2010)	# health centers of primary care	Projected population 2016	Projected population 2016/1000	# health centers for every 1000 people	Area (km2)	# people in sample
Santo Domingo	**Santo Domingo Este**	26.4	69	1,079,873.00	1,079.87	15.65	169.20	4,877 [t]
	Santo Domingo Oeste	25.8	32	413,464.00	413.46	12.92	54.00	2,021
	Santo Domingo Norte	40.8	51	602,423.00	602.42	11.81	387.90	6,974
	Boca Chica	42.6	7	161,615.00	161.62	23.09	140.90	1,634
	San Antonio de Guerra	46.9	9	50,028.00	50.03	5.56	283.70	868
	Los Alcarrizos	42.6	6	310,399.00	310.40	51.73	45.20	3,406
	Pedro Brand	55.5	9	84,226.00	84.23	9.36	45.20	993
National District	**Santo Domingo de Guzman**	26.7	160	1,015,150.00	1,015.15	6.34	91.60	15,724

Source: SISDOM MSP. Own calculation

Outcomes

1. **Total number of vaccination visits to a health center:** The number of different dates on a child's vaccination card, considering only the days within the period of analysis.
2. **Total number of vaccine doses of the Basic Scheme of Immunization:** The number of vaccine doses applied according to the vaccination card, considering only the days within the period of analysis.
3. **Timely vaccination:** The ratio of vaccine doses applied on schedule (with one month of tolerance) over all the vaccine doses that should have been applied during the period of analysis based on the child's age and the recommended schedule.
4. **Average delay of vaccination**: The difference in days between the date the dose was applied and the date it should have been applied based on the child's age and the recommended schedule (with one month of tolerance). We then take the average across vaccines. We only consider vaccines that should have been applied during the period of analysis. If a vaccine that should have been applied does not appear on the vaccination card, we assign it the maximum possible delay: the difference between the last day of the period of analysis and the theoretical date of application. back to Outcomes

Compliance Detail

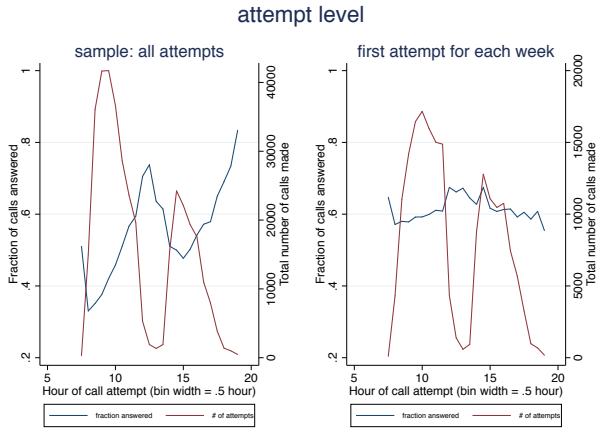
Table: Compliance Detail

Indicator	Month of intervention						
	May	**June**	**July**	**August**	**September**	**October**	**November**
In-service call rate	0.924	0.844	0.797	0.807	0.770	0.730	0.695
group C	0.941	0.842	0.855	0.865	0.776	0.749	0.676
group L	0.915	0.839	0.776	0.790	0.761	0.730	0.703
group VP	0.919	0.851	0.795	0.807	0.777	0.720	0.705
Answered call rate	0.574	0.528	0.485	0.490	0.438	0.408	0.390
group C	0.589	0.519	0.536	0.559	0.449	0.417	0.373
group L	0.570	0.527	0.467	0.471	0.427	0.399	0.394
group VP	0.566	0.535	0.482	0.489	0.443	0.411	0.401
Average duration of calls (seconds)	19.232	17.969	19.537	20.545	19.807	21.890	21.335
group C	6.287	5.773	5.982	5.767	5.749	5.875	5.564
group L	21.787	20.343	20.918	20.566	21.201	22.277	25.629
group VP	27.508	24.754	24.227	26.057	25.080	28.424	32.106
Success rate of calls (more than 5 seconds)	0.507	0.456	0.413	0.390	0.335	0.310	0.296
group C	0.498	0.421	0.397	0.424	0.315	0.277	0.270
group L	0.514	0.474	0.413	0.383	0.338	0.317	0.308
group VP	0.507	0.467	0.421	0.387	0.341	0.320	0.307

Attempts and Answer Rates Per Hour

- The time with more call forwarding was the time with less answered rate.

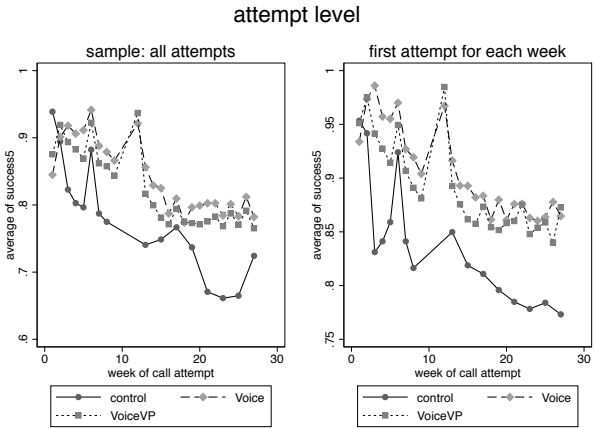
Figure: Answered calls per hour



Success Rate (Duration >5 Seconds)

- More than 20% of households didn't success the first 5 secs of the calling.

Figure: Success of answered calls



Messages Examples

1. A continuación, un mensaje de la Vicepresidenta de la República:
"Hola, te habla Margarita Cedeño. **Cuidar a nuestros niños para que crezcan sanos es nuestro deber de padres. Pongamos a nuestros hijos todas sus vacunas a la edad que les toca**." Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto.
2. Te compartimos un mensaje de la Vicepresidenta de la República: "Hola, te habla Margarita Cedeño. **Hay un centro de vacunación cerca de ti. Llevar a tus hijos a tiempo para sus vacunas puede salvarles la vida. Vacúnalos a la edad que les toca**." Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto.

back to Experiment

Messages Examples

1. A continuación, un mensaje de PROSOLI:
"Hola, **Cuidar a nuestros niños para que crezcan sanos es nuestro deber de padres. Pongamos a nuestros hijos todas sus vacunas a la edad que les toca**. Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto."
2. Te compartimos un mensaje de PROSOLI: "Hola, **Hay un centro de vacunación cerca de ti. Llevar a tus hijos a tiempo para sus vacunas puede salvarles la vida. Vacúnalos a la edad que les toca**. Para más información, llamar a *462, opción 1. Muchas gracias por tu tiempo. Hasta pronto."

back to Experiment

Messages Examples (English translation)

1. Up next, a message from the Vicepresident:
"Hello, this is Margarita Cedeno speaking. **Taking care of our children so that they grow up healthy is our duty as parents. Let's give our children all their vaccinations at the adequate age**." For more information, call *462, option 1. Thank you very much for your time. See you soon.
2. We share with you a message from PROSOLI:
"Hello, **there is a vaccination center near you. Taking your children on time for their vaccinations can save their lives Vaccinate them at the adequate age**. For more information, call *462, option 1. Thank you very much for your time. See you soon."

Heterogeneity

	(1) Number of immunization visits	(2) Total number of vaccines	(3) % of vaccines applied on time	(4) Average length of delay
Interactions:				
Treatment × High school	-0.000	-0.023	0.004	-1.304
	(0.05)	(0.07)	(0.00)	(1.40)
Treatment × Higher education or above	0.074	0.143	0.006	1.093
	(0.11)	(0.16)	(0.01)	(2.89)
Treatment × Infant/toddler's age	0.000	-0.002	0.000	-0.010
	(0.00)	(0.00)	(0.00)	(0.05)
Treatment × 1 UBN	0.033	0.045	-0.003	-1.003
	(0.05)	(0.07)	(0.00)	(1.23)
Treatment × 2 or more UBNs	-0.048	-0.077	0.009	-4.006
	(0.10)	(0.13)	(0.01)	(3.53)
Constant	4.131***	5.884***	0.336***	-244.219***
	(0.14)	(0.20)	(0.02)	(4.88)
Observations	5413	5413	5413	5413

Standard errors in parentheses

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

Table: Heterogeneity Effects (just interactions): There are no significant effects within heterogeneous groups. Both treatments RH and VP represents the treated group.

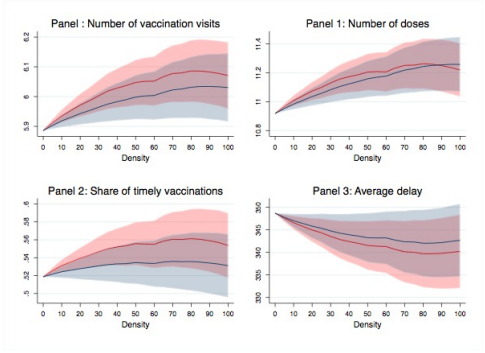
Policy Simulation (preliminary)

RH has slightly stronger direct effects but does not exhibit spillover effects. Therefore, it is not clear which would be more effective policy.

- We simulate the overall impact of a VP-only and RH-only interventions.
  - Based on our regression results.
  - For densities between 0% and 100% with a step of 5.
  - 20 simulations at every chosen density.
- We allow for uncertainty in two ways:
  - Randomize treatment assignment every time.
  - Randomly generate the coefficients for each individual every time, based on our point estimates and their covariances.

Policy Simulation (preliminary)

- On average, the **VP-only intervention outperforms** the RH-only intervention.
- There is much overlap in the results.
- Inverted "u" pattern: trade-off between increasing treatment density and reducing the number of people affected by spillovers.
- Preliminary because ...



The lines indicate the average across the 20 simulations. The shaded areas are bounded by the 90th and 10th percentile.

back to Mechanisms