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Impact Evaluation of the Human Resource for Health Deployment Program (HRHDP)

Michael R.M. Abrigo, Gina A. Opiniano, and Zhandra C. Tam

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

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Michael R.M. Abrigo
Gina A. Opiniano
Zhandra C. Tam

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Abstract

We assess the short-term impacts of the Doctors-to-the-Barrios (DTTB), a national physician deployment program in the Philippines that augments the supply of rural healthcare workers in underserved areas, on several health sector outcomes. Using regression discontinuity design, we find that the DTTB program doubles modern contraceptives-use prevalence and reduces child underweight prevalence in poor municipalities, coinciding with increased propensity of having rural health physicians in the community. We estimated a program internal rate of return of 15.9%, which is likely to be severely understated.

Keywords: rural health physician, doctors-to-the-barrios program, maternal and child health

Table of Contents

List of Tables

List of Figures

List of Annexes

Impact Evaluation of the Human Resource for Health Deployment Program (HRHDP)

Michael R.M. Abrigo, Gina Opiniano, and Zhandra C. Tam[1]

1. Introduction

The supply of health care professionals is critical in the delivery of health care services. In the Philippines, while there appears sufficient human resource for health (HRH) at the national level, the HRH supply has become increasingly concentrated geographically over the last 25 years. By 2015, as much as three-quarters of cities and municipalities had not met the threshold HRH density of 45 midwives, nurses and physicians per 10,000 population recommended by the World Health Organization (Abrigo and Ortiz, 2019).

In 1993, the Department of Health (DOH) introduced the Doctors-to-the-Barrios (DTTB) program to augment the supply of rural health physicians in underserved areas. The country's national HRH deployment program has since expanded considerably, augmenting the local supply not only of physicians but practically of all health and allied health professionals. Over the last decade, the DOH-HRH deployment has ballooned from a relatively modest program with budgetary support of PhP182 million that deployed more than 500 HRH in 2010 to a massive endeavor costing government upwards of PhP17 billion that deployed almost 30,000 health care workers in 2020.

Despite the program's importance in the provision of health care services in underserved areas, and the magnitude of its costs to government, there remains scant evidences on the national HRH deployment program's impact on different population health, and health sector outcomes.

This study aims to bridge this gap in the literature by assessing the impact of the DTTB program on the following domains: access to health services, health outcomes, and local health systems including HRH distribution.[2] We exploit the design of the DTTB program that induces as-if random allocation of DTTB physicians among municipalities within a close neighborhood around the municipality income class assignment threshold. This provides a natural experiment to study the potential impacts of the DTTB program.

This study contributes to the thin but growing body of literature documenting the impact of HRH augmentation programs on health sector outcomes. Previous analyses of the DTTB program, for instance, were largely descriptive and focused on implementation issues (c.f. Abrigo, et al., 2021), similar to many studies elsewhere. A few exceptions include those on Brazil's Mais Medicos (More Doctors) program, a similar physician augmentation program, which has been documented to result in more equitable physician distribution (e.g. Maffioli, et

[1] Fellow II, Consultant, and Research Analyst II, respectively, at the Philippine Institute for Development Studies (PIDS). The authors are grateful for insightful comments by Aniceto C. Orbeta, Jr., Roehlano Briones, Lynn Daryl F. Villameter, Hermenegildo M. Caronan, Jr., and other seminar participants at the PIDS research workshop series. All remaining errors are by the authors.

[2] This study is second in a series of studies assessing the DOH-HRH deployment program. See Abrigo et al. (2021) for the first in the series, which provides a process evaluation of the DOH-HRH deployment program and serves as basis for the evaluation design implemented in this current study. Originally, the goal was to conduct an impact evaluation of the whole DOH-HRH deployment program. However, upon review, only the DTTB program provides an evaluable design given the available data.

al., 2019; Russo, 2021), and in reduced hospital admissions (e.g. Fontes, et al., 2018) and mortality rates (e.g. Russo, et al., 2019; Hone, et al., 2020).

Based on our analysis using regression discontinuity design and data from the Philippine National Demographic and Health Survey (NDHS) and the Local Government Unit (LGU) Health Scorecard (HSC), we find that the DTTB program increases modern contraceptives-use prevalence and reduces child underweight prevalence in poor municipalities. These impacts are both clinically and economically significant. We estimate a program internal rate of return of 15.9%, which is likely to be severely understated.

2. Doctors-to-the-barrios program

The Philippine government has been deploying health professionals to augment the supply of health care workers in underserved areas for almost half a century. Starting in 1974, the government required prior community health practice for physicians and nurses for them to acquire professional licenses. This was eventually changed into a voluntary program in 1986. In the early years of health service devolution under the 1991 Local Government Code, the Department of Health (DOH) introduced the Doctors-to-the-Barrios (DTTB) program in response to a 1992 survey that documented 271 municipalities without any physician (Leonardia, et al., 2012). The 1991 LGC mandates local governments to provide primary health care and to hire licensed medical practitioners as local health officers, among others. Since the introduction of the DTTB program, the government's national human resource for health (HRH) deployment program has expanded to include other health and allied health professions (Abrigo, et al., 2021).

Under DTTB program, the DOH recruits physicians and deploys them in low-income class municipalities. Priority is given to fifth- and sixth-class municipalities that had no doctors for at least two years. Municipal local governments may request for DTTB physician augmentation through a formal resolution by the local health board and the sangguniang bayan (municipal council) approved by the municipal mayor. The DOH pays for DTTB physicians' salaries and social security contributions, while the host local governments provide additional benefits, including board, lodging and other allowances. DTTB physicians receives a monthly salary of PhP88,410 (in 2022; salary grade 24), excluding additional benefits, which is significantly above the median salary for similarly experienced physicians (Abrigo, et al., 2021).

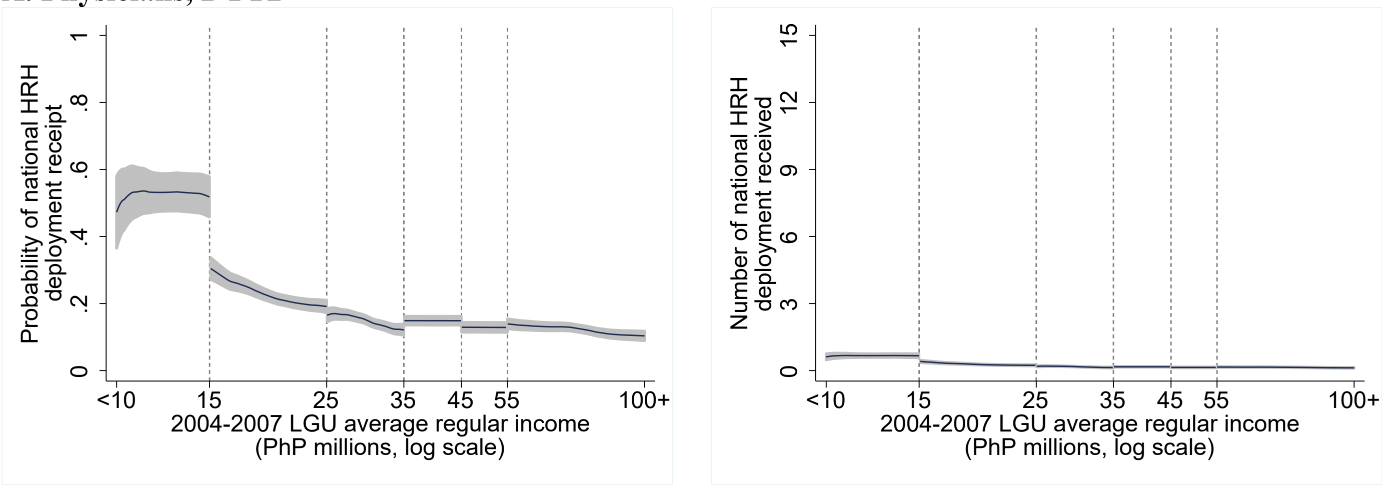
Figure 1 shows the average propensity and number of deployed health care workers by municipality government income and by health care profession between 2016 and 2018. A discontinuity in the propensity of DTTB receipt between fifth- and sixth-class municipalities is evident as a consequence of the program's inclusion preference for low-income local governments. This discontinuity in the propensity of deployment receipt is not evident at other local government income thresholds or in other HRH deployment programs. However, the average number of deployed HRH appears to be increasing in local government incomes with discontinuities at several income class thresholds.

DTTB physicians function as municipal health officers (MHO) or rural health practitioners (RHP) in their host municipalities. As MHOs or RHPs, they are in charge of local health offices, supervise its personnel, and formulate and implement public health programs of local governments. They are also ex-officio vice-chairpersons of local health boards, which propose the annual budgetary allocation for health services in the LGU to the municipal board, as well as serve as advisory committee to the municipal board on health matters.

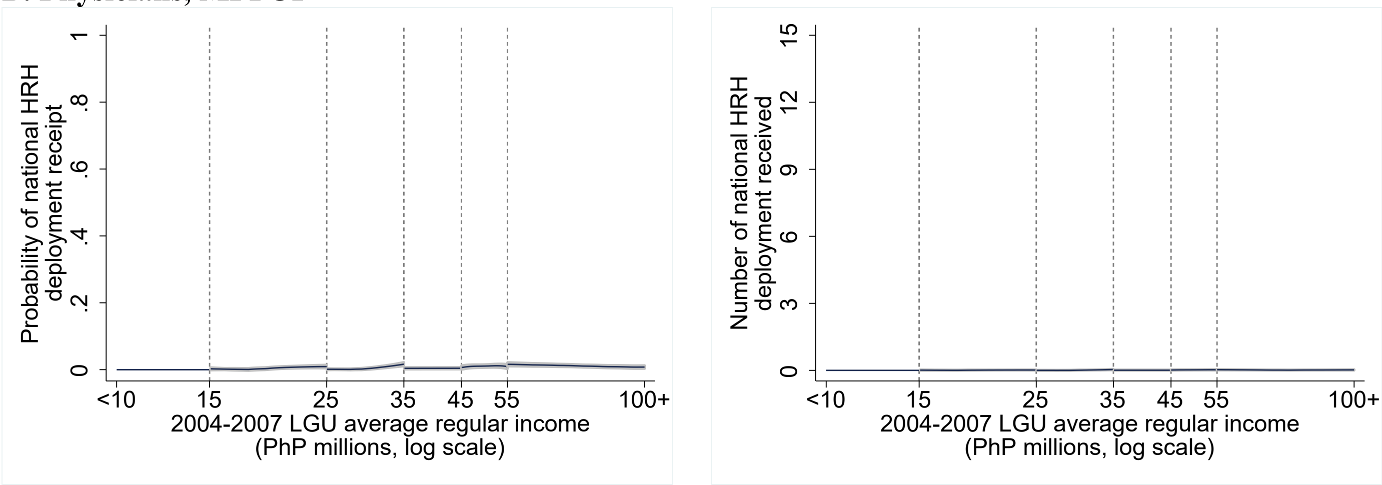
Figure 1. Human resource for health augmentation: Philippines, 2010-2020

Probability of deployment receipt | Average number deployed

A. Physicians, DTTB



B. Physicians, MPPUP



C. Midwives

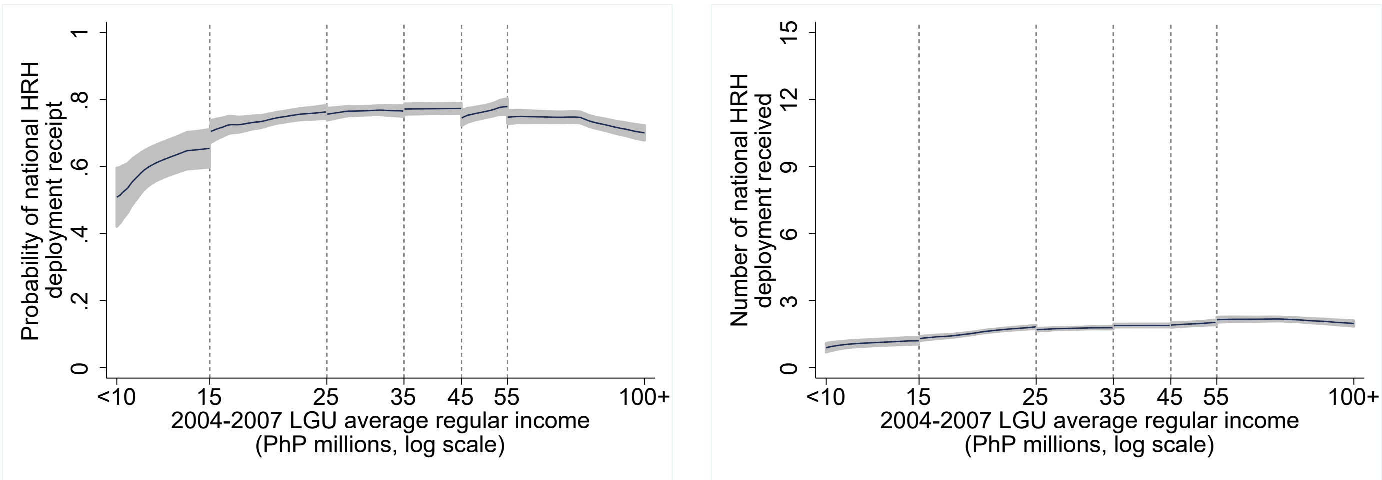
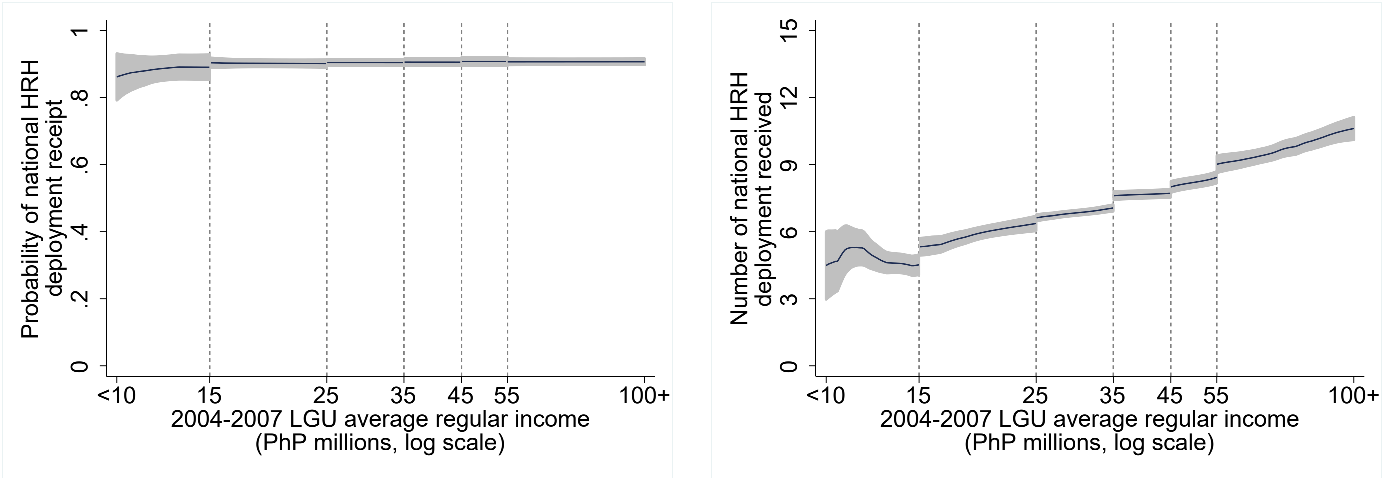


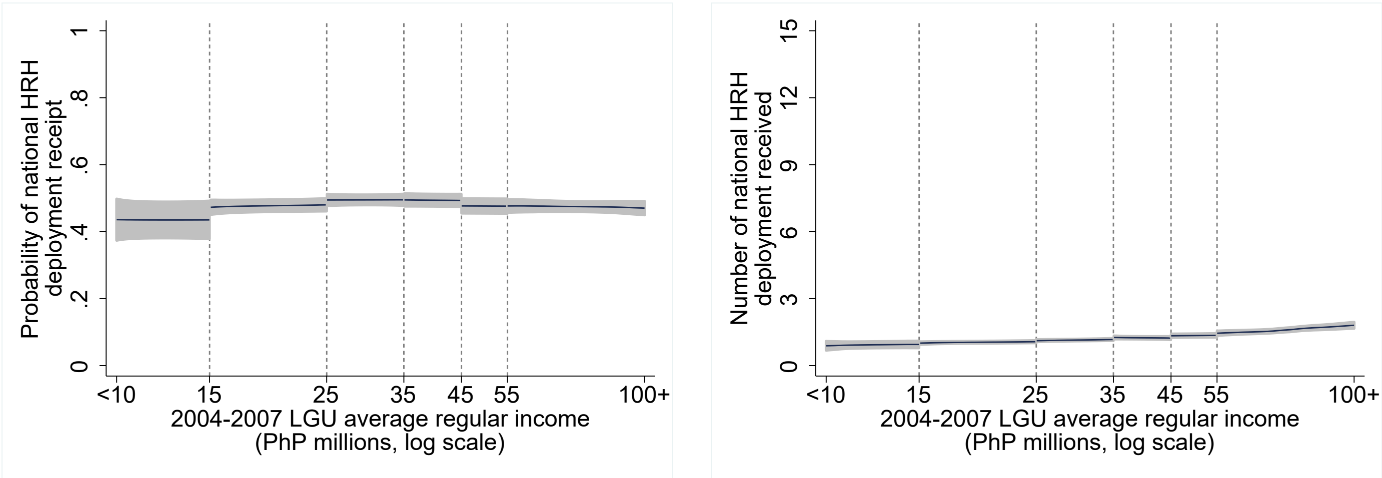
Figure 1. Human resource for health augmentation: Philippines, 2010-2020 (*continued*)

Probability of deployment receipt | Average number deployed

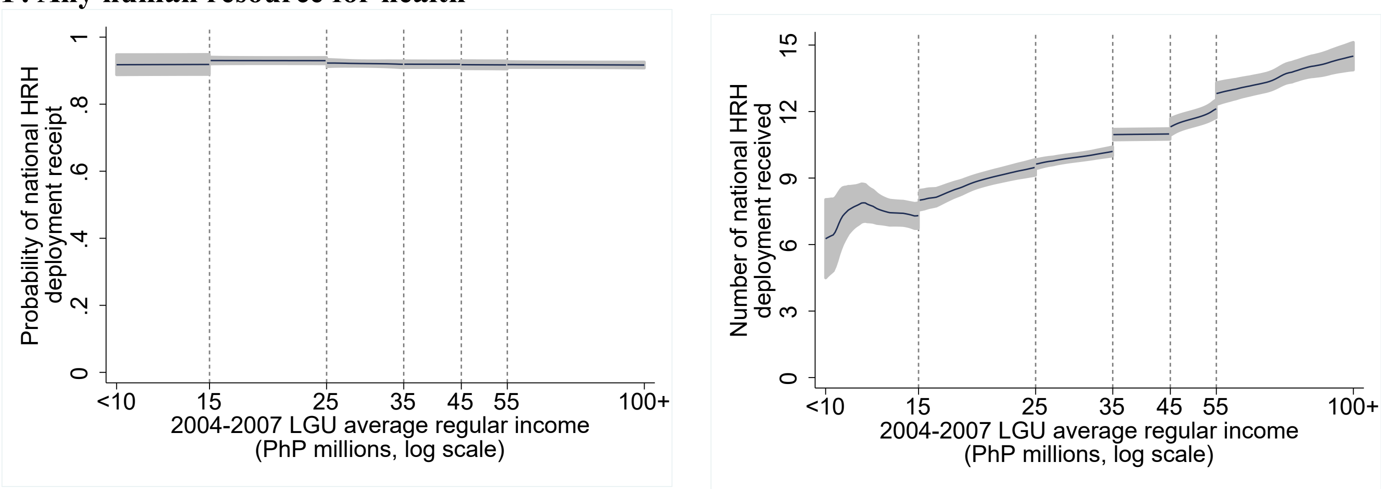
D. Nurses



E. Others not elsewhere classified



F. Any human resource for health



Source: Authors' calculations based on DOH-HRH deployment data.

The DTTB program has been shown using a simulation model to be a cost-effective public health intervention (Avancena, et al., 2019), despite the documented low retention of deployed physicians in host municipalities (Politico, 2011; Leonardia, et al., 2012). Politico (2011), for example, documented a low 18% retention rate among DTTB physicians deployed between 1993 and 2009, which may be related to overall job quality at host local governments, as well as deployed physicians having other future professional and personal plans (Politico, 2011; Leonardia, et al., 2012; Abrigo, et al., 2021).

3. Methodology

3.1. Data

We employ health sector outcomes data from two sources, namely, the National Demographic and Health Survey (NDHS), which is a nationally representative survey of women of reproductive age collected by the Philippine Statistics Authority (PSA), and the Local Government Unit (LGU) Health Scorecard (HSC), which provides selected indicators for all LGUs collated by the Department of Health (DOH). The LGU-HSC contains LGU-level aggregated information on health sector outputs and outcomes, while the NDHS has individual-level information on health utilization and outcomes. We only include short-term outcomes that roughly match the annual deployment duration of DTTB physicians, e.g. antenatal care visits, and exclude outcomes that are likely the result of longer processes, e.g. knowledge stock.

The LGU-HSC was designed to guide local government executives and health program managers to track and evaluate local health sector performance. The LGU-HSC is used to benchmark LGU performance against national targets, as well as to trace improvements across reporting periods. Covered indicators in the LGU-HSC varied across the years, although many key outcomes were consistently measured, which we used in our analyses. These indicators have been derived from various government administrative reports, including health surveillance data from the DOH Field Health Services Information System and health sector spending from LGU fiscal data. In our analysis, we use LGU-HSC data from 2012 to 2018.

A key restriction of the LGU-HSC is the limited number of indicators available consistently over several LGU-HSC rounds that may be used for analysis. We thus supplement it with individual-level health utilization, reproductive health, maternal health, and child health information from the 2017 NDHS (PSA, 2018). The NDHS asks household members of recent inpatient and outpatient health facility visits. It also asks about contraceptive use among ever married women respondents. Further, maternal and child health behaviors and outcomes for recent births are also collected.

Unlike the DOH LGU-HSC that is tagged explicitly to LGUs, information on household residence locations in the NDHS are only available at the regional level. Geolocation coordinates were collected for each household, but are masked in the public-use file, with offset of as much as 10km from the centroid of sampled household clusters (Burgert, et al., 2013). In order to assign LGUs to surveyed households, we directly overlaid their geomasked location to LGU polygons, which have been shown to perform better compared with more complex assignment rules in other study settings (e.g. Wilson, et al., 2020).

3.2. Evaluation Design

The DTTB program provides a natural experiment to analyze the impact of the national physician deployment program on health sector outcomes. By design the DTTB program prioritizes the deployment of physicians in lower class municipalities. Between 2016 and 2018, for example, sixth-class municipalities were about twice as likely to have received a DTTB physician compared with fifth-class local governments (Abrigo, et al., 2021). LGU class, on the other hand, is determined by a local government's annual regular income[3] (ARI) with thresholds set by the national government. The most recent reclassification was in 2008 based on 2004 to 2007 average ARI, and are likely not affected by future DTTB assignment.

In this study, we use a regression discontinuity design (RDD) (Thistlewaithe and Campbell, 1960), a quasi-experimental technique,[4] to assess the impact of DTTB receipt on several health sector outputs and outcomes. In an RDD, observational units are sorted based on a running variable, X, in this case local government 2004-2007 average ARI. Treatment assignment, T, in this case DTTB receipt, depends on where an observational unit is situated relative to an assignment threshold, X_c, in this case for LGU income classification.

A key assumption in RDD is that observational units cannot perfectly sort around the assignment threshold. In our RDD implementation, we rely on a local randomization assumption, wherein treatment is assumed to be as-if randomly assigned for observational units that are close enough to the threshold, instead of the more common continuity assumption, wherein outcomes are assumed to be continuous at the threshold absent the treatment. This choice is conditioned by the data generating process. First, households are nested in local governments, which naturally introduces mass points instead of strictly continuous sorting among observational units. Second, there are only 22 sixth-class municipalities, which makes (local) polynomial curve-fitting likely unstable. These limitations make RDD-by-continuity assumption not an ideal approach.

There are other issues that complicates our estimation strategy, which we outline below.

First, while the DTTB program prioritizes low-income LGUs, physician deployment in the lowest class municipalities is not fully saturated. As discussed in the previous section, DTTB is deployed only in LGUs with no government physicians, and requires LGU commitment to provide counterpart benefits to DTTB physicians. Between 2016 and 2018, for example, only 59.3% of sixth-class municipalities were recipients of the DTTB program.

In order to account for this below universal compliance, we employ a fuzzy RDD based on the following Wald estimator:

$$\tau = \frac{E[Y|X < X_c] - E[Y|X > X_c]}{E[T = 1|X < X_c] - E[T = 1|X > X_c]}$$

[3] The LGU regular income is composed of income accruing to the general fund, including internal revenue allotments (IRA), and excluding receipts from special funds, trust funds, transfers, and non-recurring income. IRA, on the other hand, are based on a distribution formula set by the 1991 Local Government Code based on LGU type and number, population, and land area. IRA has historically been a large component of ARI of local governments (Manasan, 2005).

[4] See van der Klaauw (2008), Cook (2008), Imbens and Lemieux (2008), Lee and Lemieux (2010), and Cattaneo and Titunik (forthcoming) for a review of methodology and recent applications.

where Y is our outcome of interest, and $T = 1$ indicates DTTB receipt. With additional assumptions on the data generating process (see Imbens and Angrist, 1994), we may interpret τ as a local average treatment effect, i.e., the average impact of the program on those who have received DTTB as a result of being eligible for the program. We implement the above estimator using instrumental variables (IV) regression with the indicator variable $I[X < X_c]$ as excluded instrument. Further, we also limit our analyses to households and local governments in sixth- and fifth-class municipalities, where the jump in the propensity of DTTB receipt among municipal LGUs is largest (see Figure 1).

From the Wald-estimator above, it is trivial to show that the estimator τ requires that the denominator be bounded away from zero. That is, the IV regression requires that the excluded instrument predicts treatment assignment. In the case where the excluded instrument is only weakly correlated with the treatment assignment, then the IV estimator is generally biased and the related inference has large size distortions (Bound, et al., 1995; Stock and Yogo, 2005). In our RDD analysis, however, estimator bias may be less of an issue as a consequence of our as-if random treatment assignment assumption, although test size distortions may still be an important feature that needs to be addressed.

Second, there are only a few sixth-class municipalities. Limiting observations to those close to the LGU income class assignment threshold further trims the number of potential observations for analysis, which makes inference based on large-sample approximation untenable. With our as-if random treatment assignment assumption, we instead implement a re-randomization approach to construct empirical distributions of the test statistic under our null hypotheses of no treatment effect. In particular, we employed permutation tests where we re-randomize treatment assignment across municipalities in our study sample. For each of our tests, we perform 1,000 permutations, from which we compare the calculated test statistic in our original study sample to derive the implied p-value of the test. Using permutation tests also provides correct statistical coverage rates (Imbens and Rosenbaum, 2005), addressing potential size distortions from the weak instrument problem that we noted above.

Third, we calculated the 2004-2007 average ARI based on LGU income by type from the Bureau of Local Government Finance (BLGF) instead of using the actual on which the 2008 LGU income classifications were based.[5] Relatedly, fourth, it may be possible that households in the NDHS may be assigned into different LGUs instead of the actual as a result of the geolocation masking procedure implemented for the public-use dataset. In addition, fifth, about a third of NDHS sample have no geolocation information available. While those households that are not geotagged tended to be from better endowed households and are less likely to report being sick in the immediate period(s) before the survey, their distribution around the LGU income class threshold are likely to be random. These potential misclassifications are expected to result in attenuation bias. Finally, sixth, while the DTTB program prioritizes low-income class LGUs, deployment of other health professionals is positively associated with LGU income with observable discontinuity at the LGU assignment threshold (Abrigo, et al., 2021). This, on the other hand, is expected to result in downward bias of the RDD estimates.

[5] The actual average ARI used to reclassify LGU income classification in 2008 is no longer available from the BLGF. The actual ARI was based on audited income statements of LGU submitted to the Commission on Audit. In our analyses, we proxy the actual ARI with ARI calculated from unaudited submissions to the BLGF.

When the above issues are taken together, our RDD analysis is stacked against not finding a positive DTTB impact thereby providing as a theoretical bound on the true impact. As such, our results may be interpreted as lower limits of the true impact of the DTTB program.

4. Results

4.1. Window selection

The as-if random assumption that we employ in our RDD is generally not testable. To wit, our strategy assumes that there exists a window around the assignment threshold where treatment assignment is as-if random. The span of this window is typically unknown, like in our study. We instead empirically determine a window where local randomization is likely to hold, which we then employ in our RDD estimation.

For each of the predetermined variables listed on Table 1, we performed statistical tests to assess differences in means and in distribution of the variables between fifth- and sixth-class municipalities following the rerandomization approach by Cattaneo, et al. (2016). We vary the estimation window starting from ±PhP100,000 up to ±PhP5 million in increments of ±PhP100,000 from the income class threshold of PhP15 million. The included variables are the same variables used by the DOH to assess local government need for national health care worker augmentation. We supplement this list with variables that determine LGU allocations of internal revenue allotments, namely, population, land area, and barangay count.

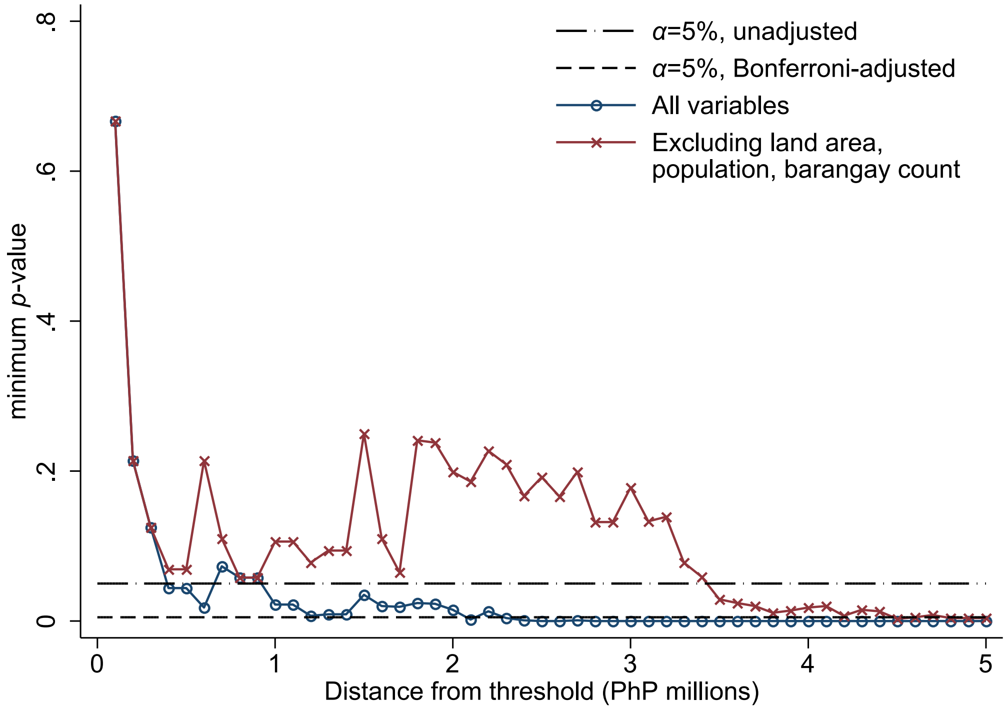
Figure 2 shows the minimum p-values for the tests of distribution we performed for the specified estimation window.[6] We present two sets of results: one where we include all variables, and another where we exclude variables that determine IRA. As may be expected, including all variables results in rejecting the null hypothesis of balanced distribution between fifth- and sixth-class municipalities even for small windows around the assignment threshold since this includes determinants of IRA, which is a substantial portion of the running variable. However, excluding IRA determinants results in wider windows where the hypotheses of having balanced distribution cannot be rejected at conventional α-levels.

We also performed binomial probability tests to assess whether the number of local governments on either side of the income class assignment threshold are distributed as-if random, i.e., having equal chances of being fifth- or sixth-class municipalities, using the same windows above.[7] Figure 3 plots the distribution of municipalities for ARIs between PhP10- and PhP20-million. We cannot reject the null hypothesis that the probabilities are equal for windows less than +/-PhP2.5 million at the 10% α-level.

We prefer an estimation window that is wide enough to include the largest sample possible, but narrow enough for local randomization to be highly plausible. Based on the above results, we use a ±PhP2.25 million estimation window for the rest of our analysis here and in the next subsection. We then assess the robustness of our results based on this window choice using several falsification tests that we present in Section 4.3.

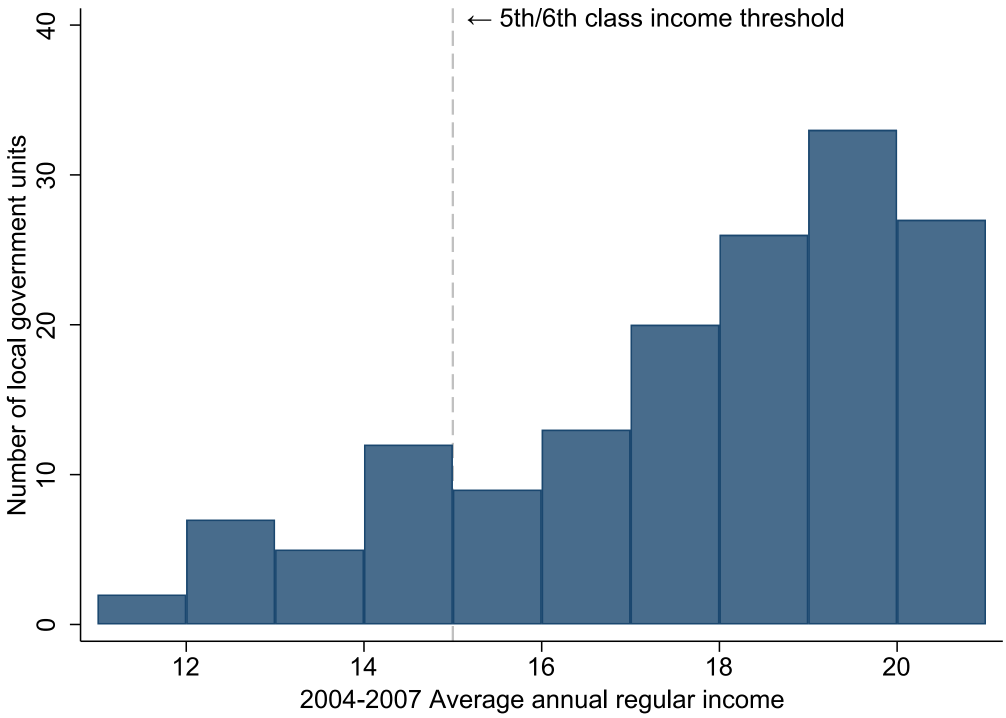
[6] We only show the results of the rank-sum distribution test. The results of the balance tests using differences in means and the rank-sign tests are qualitatively the same, and are omitted for brevity. These excluded results are available upon request from the authors.
[7] The continuity-based RDD analogue is the density test (McCrary, 2008). In an ideal RDD setting, observational units cannot precisely manipulate the running variable. Non-smooth probability densities at the assignment threshold, which suggests selection issues, provides indication of such manipulation.

Figure 2. Balance test on predetermined covariates and specified selection window



Source: Authors' calculations.

Figure 3. Number of local governments around assignment threshold



Source: Authors' calculations.

Table 1. Balance test

	2004-2007 LGU average regular income				Balance test					
	PhP12.75-15.00M		PhP15.00-17.25M		DM		KS		RS	
	Mean	SD	Mean	SD	Stat	p-value	Stat	p-value	Stat	p-value
HRH per 100,000 population (log), 2010	2.62	2.52	3.59	2.24	-0.98	0.16	0.25	0.33	-1.04	0.31
With physician resident (=1), 2010	0.10	0.31	0.04	0.19	0.06	0.57	0.06	0.57	0.86	0.57
LGU per capita PHN expenditure (log), 2001	5.37	0.64	5.23	0.53	0.14	0.49	0.34	0.18	1.20	0.24
LGU per capita PHN expenditure (log), 2010	5.68	0.65	5.59	0.69	0.09	0.70	0.20	0.77	0.35	0.76
Poverty incidence, 2000	0.49	0.13	0.54	0.13	-0.06	0.15	0.21	0.64	-1.03	0.30
Poverty incidence, 2009	0.42	0.14	0.41	0.14	0.01	0.87	0.14	0.94	0.37	0.74
Population density (log), 2000	5.07	1.04	4.84	0.91	0.23	0.44	0.17	0.85	0.80	0.44
Population density (log), 2009	5.22	1.01	4.93	0.94	0.29	0.33	0.28	0.28	1.12	0.28
Focus 44 province (=1)	0.55	0.51	0.63	0.49	-0.08	0.78	0.08	0.78	-0.54	0.78
Focus municipality (=1)	0.15	0.37	0.33	0.48	-0.18	0.21	0.18	0.21	-1.41	0.21
PAMANA municipality, 2019	0.15	0.37	0.19	0.40	-0.04	1.00	0.04	1.00	-0.31	1.00
With 4Ps households (=1) 2019	0.85	0.37	0.93	0.27	-0.08	0.69	0.08	0.69	-0.83	0.69
With IP communities (=1), 2019	0.05	0.22	0.11	0.32	-0.06	0.63	0.06	0.63	-0.73	0.63
GIDA barangay (% of total), 2019	0.24	0.39	0.34	0.41	-0.09	0.45	0.21	0.43	-0.57	0.57
Population (log), 2000	8.51	0.55	8.80	0.55	-0.29	0.08	0.52	0.00	-2.52	0.01
Population (log), 2010	8.66	0.57	8.89	0.59	-0.23	0.19	0.39	0.04	-1.96	0.05
Barangay count (log), 2010	2.04	0.53	2.33	0.45	-0.29	0.04	0.39	0.04	-1.99	0.04
Land area (log), 2010	3.44	0.89	3.96	0.74	-0.52	0.04	0.41	0.03	-2.35	0.02

Source: Authors' calculations. Note: DM – difference in means; KS – Kolmogorov-Smirnov rank-sign test; RS – Rank-sum test; SD – Standard deviation; Stat – test statistic; HRH – Human resource for health; LGU – local government unit; PHN – Population, health and nutrition; PAMANA – Payapa at Masaganang Pamayanan Program; 4Ps – Pantawid Pamilyang Pilipino Program; IP – Indigenous people; GIDA – Geographically isolated and disadvantaged area.

Table 1 summarizes the balance test based on difference in means and in distribution using our elected +/-PhP2.25 million estimation window. The table confirms our earlier assertion that excluding variables that determine IRA results in balanced distribution of predetermined variables between fifth- and sixth-class municipalities in our estimation window. These variables include baseline conditions, such as supply of health care workers, poverty incidence and local government health spending, as well as government programs that may affect access to health care, such as PAMANA and 4Ps.[8] Since differences in IRA-related variables may confound our analyses, we present separate RDD results with and without controls for the predetermined variables listed in Table 1.

4.2. DTTB receipt and health sector outcomes

Table 2 presents means and standard deviations of output and outcome indicators from the 2017 NDHS (Panel A) and 2012-2018 LGU-HSC (Panel B). We can readily use information from this table to estimate the RDD-Wald estimator presented in the previous section. Because the sample in each panel and subpanel may be different, the difference in the propensity of DTTB receipt also varies. In Panel A, including all household members and all women of reproductive age in the analysis result in a difference in DTTB receipt propensity between those living in fifth- and sixth-class municipalities of about 40 percentage points in absolute terms. However, limiting the sample only to women who had recent births and their children leads to a much closer margin of only five percentage points. In Panel B, on the other hand, the difference among municipalities are only about 15 percentage points.

Table 3 summarizes the results of our fuzzy RDD estimates using IV regression. We present both the results of the second-stage regression, as well as a test for weak-identification from the first-stage regression. The latter assesses the strength of our excluded instrument, i.e., whether municipality is below or above income class assignment threshold, in explaining the propensity of DTTB receipt. Following Staiger and Stock's (1997) rule-of-thumb, we use a first-stage F statistic (denoted in Table 3 as CD for Cragg-Donald Wald F) threshold of ten to identify the presence of weak instruments, which limits maximal size distortion and relative bias to no more than 10% (Stock and Yogo, 2005). Also, as noted in the previous section, our local randomization and permutation-based inference provide additional protection against estimator bias and size distortion, respectively.

The results in Table 3 suggests that the deployment of DTTB in low-income class municipalities increases modern contraceptive use prevalence by 54 percentage points (Panel B.B with baseline controls, p-value = 0.05), and decreases underweight prevalence among children below five-years old by 19 percentage points (Panel B.B with baseline controls, p-value = 0.02). It is noteworthy that DTTB receipt increases the probability of having a public health center physician in the municipality by around 33 percentage points, which appears to be stable between specifications, but the estimates are measured imprecisely. For other indicators, we fail to reject the null hypotheses that there is no impact.

[8] The PAMANA (Payapa at Masaganang Pamayanan) program is the government's flagship program for conflict-vulnerable and -affected communities that provides development interventions in these areas. The 4Ps (Pantawid Pamilyang Pilipino Program), on the other hand, is the government's flagship poverty alleviation program that provides conditional cash grants to households for meeting set health and education requirements.

Table 2. Descriptive statistics

A. Demographic and health survey

	Below Threshold		Above Threshold	
	Mean	SD	Mean	SD
A. Health care use				
Visited health facility in past 30 days (=1)	0.07	0.25	0.10	0.30
Travel time to health facility if visited (log)	-0.93	0.88	-0.70	0.96
Confined in hospital in past year (=1)	0.04	0.20	0.03	0.17
DTTB recipient municipality (=1)	0.65	0.48	0.24	0.43
B. Reproductive health				
Contraceptive user (=1)	0.37	0.49	0.27	0.45
Modern contraceptive user (=1)	0.25	0.43	0.20	0.40
With unmet family planning need (=1)	0.10	0.30	0.19	0.40
Visited by health worker in past year (=1)	0.22	0.41	0.32	0.47
Visited health facility in past year (=1)	0.47	0.50	0.43	0.50
DTTB recipient municipality (=1)	0.63	0.49	0.23	0.42
C. Maternal health				
Antenatal care with skilled attendant (=1)	0.92	0.27	0.94	0.24
Timing of first antenatal care visit (month)	3.56	1.46	3.29	1.45
At least four antenatal care visits (=1)	0.69	0.47	0.76	0.43
Delivery assisted by skilled attendant (=1)	0.64	0.48	0.72	0.45
Delivery in health facility (=1)	0.60	0.49	0.72	0.45
Postnatal care visit within two months post-partum	0.74	0.44	0.75	0.43
Postnatal care with skilled attendant (=1)	0.86	0.35	0.92	0.27
DTTB recipient municipality (=1)	0.23	0.42	0.18	0.38
D. Child health				
Immunized in first six months, BCG	0.18	0.39	0.21	0.41
Immunized in first six months, DPT1	0.11	0.31	0.15	0.36
Immunized in first six months, HepB1	0.14	0.36	0.20	0.40
Immunized in first six months, Polio1	0.14	0.36	0.15	0.36
Infant mortality	0.03	0.17	0.04	0.19
DTTB recipient municipality (=1)	0.23	0.42	0.18	0.38

Table 2. Descriptive statistics (continued)

B. LGU health scorecard

	Below Threshold		Above Threshold	
	Mean	SD	Mean	SD
A. Building blocks				
With health center physician (=1)	0.74	0.44	0.70	0.46
LGU per capita PHN expenditure (log)	4.69	2.68	4.90	2.39
With operational DRRM for health plan (=1)	0.56	0.50	0.59	0.50
With public health worker magna carta benefits (=1)	0.33	0.47	0.21	0.41
With PhilHealth PCB accreditation (=1)	0.81	0.39	0.83	0.38
With PhilHealth MCP accreditation (=1)	0.50	0.50	0.66	0.48
With PhilHealth TB-DOTS accreditation (=1)	0.52	0.50	0.67	0.47
DTTB recipient municipality (=1)	0.51	0.50	0.36	0.48
B. Outcomes				
TB detection rate	0.59	0.26	0.61	0.26
TB treatment rate	0.87	0.22	0.80	0.24
Modern contraceptive use prevalence	0.54	0.21	0.41	0.17
Birth delivery by skilled attendant	0.90	0.16	0.87	0.21
Birth delivery in health facility	0.87	0.18	0.82	0.29
Fully immunized children	0.63	0.19	0.61	0.19
Exclusively breastfed, 0-6 months	0.52	0.23	0.54	0.25
Underweight children, 0-59 months	0.08	0.06	0.12	0.07
DTTB recipient municipality (=1)	0.51	0.50	0.36	0.48

Source: Authors' calculations. Notes: Estimates are based on observations in municipalities with 2004-2007 annual regular income within PhP2.5 million from the income class assignment threshold of PhP15 million. SD – Standard deviation.

Table 3. DTTB and health sector outcomes

A. Demographic and health survey

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	CD	N	K
A. Health care use												
Visited health facility in past 30 days (=1)	-0.08	0.09	0.35	349.89	1900	16	-0.61	3.27	0.85	10.63	1553	14
Travel time to health facility if visited (log)	-0.48	0.42	0.33	37.77	167	16	-0.84	0.59	0.85	27.37	155	14
Confined in hospital in past year (=1)	0.03	0.03	0.40	349.89	1900	16	0.13	0.37	0.86	10.63	1553	14
B. Reproductive health												
Contraceptive user (=1)	0.25	0.23	0.44	63.32	362	16	-0.38	1.10	0.76	2.56	279	14
Modern contraceptive user (=1)	0.12	0.16	0.70	63.32	362	16	-0.92	2.94	0.47	2.56	279	14
With unmet family planning need (=1)	-0.27	0.22	0.06	31.81	226	16	-0.73	1.47	0.75	3.02	176	14
Visited by health worker in past year (=1)	-0.27	0.20	0.16	63.32	362	16	-0.07	0.12	0.90	2.56	279	14
Visited health facility in past year (=1)	0.10	0.25	0.78	63.32	362	16	2.31	7.84	0.26	2.56	279	14
C. Maternal health												
Antenatal care with skilled attendant (=1)	-0.23	1.13	0.81	1.12	125	16	3.07	26.53	0.33	0.04	95	14
Timing of first antenatal care visit (month)	2.77	8.27	0.63	1.34	118	16	-25.94	181.47	0.19	0.06	94	14
At least four antenatal care visits (=1)	-0.77	4.05	0.83	1.12	125	16	3.57	33.11	0.78	0.04	95	14
Delivery assisted by skilled attendant (=1)	-0.75	3.72	0.83	2.44	169	16	3.73	16.93	0.43	0.20	120	14
Delivery in health facility (=1)	-1.13	4.23	0.76	2.44	169	16	3.13	14.32	0.52	0.20	120	14
Postnatal care visit within two months post-partum	-0.12	1.80	0.95	1.05	124	16	2.80	27.69	0.76	0.03	94	14
Postnatal care with skilled attendant (=1)	-0.68	2.24	0.67	0.91	93	16	-2.60	30.43	0.12	0.02	79	14
D. Child health												
Immunized in first six months, BCG	-0.34	0.69	0.69	1.28	94	16	-0.74	1.25	0.88	0.13	66	14
Immunized in first six months, DPT1	-0.45	0.93	0.47	1.28	94	16	-0.74	1.25	0.88	0.13	66	14
Immunized in first six months, HepB1	-0.55	0.88	0.34	1.28	94	16	-0.74	1.25	0.88	0.13	66	14
Immunized in first six months, Polio1	-0.09	0.60	0.91	1.28	94	16	-0.74	1.25	0.88	0.13	66	14
Infant mortality	0.27	1.08	0.39	1.09	285	16	-0.32	0.59	0.18	0.79	202	14

Table 3. DTTB and health sector outcomes (continued)

B. LGU health scorecard

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	CD	N	K
A. Building blocks												
With health center physician (=1)	0.32	0.25	0.41	13.21	517	47	0.33	0.13	0.30	14.37	451	41
LGU per capita PHN expenditure (log)	-2.69	4.81	0.54	13.81	507	47	-0.13	0.39	0.77	14.24	445	41
With operational DRRM for health plan (=1)	-0.09	0.42	0.85	15.19	163	45	0.05	0.39	0.93	11.73	157	41
With public health worker magna carta benefits	0.54	0.49	0.23	12.25	212	47	0.57	0.46	0.32	12.58	197	41
With PhilHealth PCB accreditation (=1)	-0.11	0.38	0.76	6.13	305	47	-0.24	0.36	0.43	7.92	268	41
With PhilHealth MCP accreditation (=1)	-1.00	0.99	0.20	6.47	306	47	-1.08	0.95	0.17	8.14	269	41
With PhilHealth TB-DOTS accreditation (=1)	-0.98	0.97	0.15	6.47	306	47	-1.27	1.01	0.09	8.14	269	41
B. Outcomes												
TB detection rate	-0.23	0.30	0.45	5.72	215	47	-0.29	0.29	0.29	6.24	192	41
TB treatment rate	0.42	0.37	0.05	8.82	308	47	0.12	0.18	0.54	9.95	281	41
Modern contraceptive use prevalence	0.76	0.61	0.00	8.91	310	47	0.54	0.38	0.05	9.75	282	41
Birth delivery by skilled attendant	0.16	0.27	0.53	9.42	309	47	-0.07	0.18	0.73	9.57	282	41
Birth delivery in health facility	0.35	0.40	0.31	9.06	312	47	0.05	0.22	0.88	9.59	285	41
Fully immunized children	0.11	0.27	0.63	9.78	302	47	-0.07	0.22	0.78	9.67	277	41
Exclusively breastfed, 0-6 months	-0.12	0.28	0.70	9.00	308	47	-0.30	0.29	0.35	9.82	280	41
Underweight children, 0-59 months	-0.23	0.17	0.01	9.83	292	47	-0.19	0.13	0.02	11.28	263	41

Source: Authors' calculations. Notes: Fuzzy regression-discontinuity design estimates are based on instrumental variable regression using observations in municipalities with 2004-2007 annual regular income within PhP2.25 million from the income class assignment threshold of PhP15 million. Estimated p-values are based on permutation of income class assignment among municipalities in the estimation sample. Est. – estimate; S.E. – Standard error; p – permutation-based p-value; CD – Cragg-Donald F statistic; N – number of observations; K – number of clusters.

The impact of DTTB deployment on contraceptive use and children underweight prevalence are both substantial. For reference, modern contraceptive use prevalence among married women in the poorest household quintile is only at 43.8% (PSA, 2018). Underweight prevalence among children aged below five-years old in the poorest rural household quintile, on the other hand, is at 29.3% (FNRI, 2015). Using these as reference rates, our results suggest that DTTB deployment doubles the odds of using modern contraceptives among poor women, and decreases the odds of being underweight by two-thirds among poor children.

4.3. Falsification and sensitivity analyses

We performed standard falsification tests to assess the validity of our RDD analyses. Earlier in this section, we discussed the results of our binomial probability tests that suggest the distribution of municipalities around the income class assignment threshold are as-if random. We take this as an indication that municipalities cannot precisely self-select into receiving DTTB program around the income class assignment threshold. Results of other falsification tests are presented as Annexes.

Annexes A and B provide the results of additional falsification tests. In Annex A, we show RDD results using the same estimation window in Table 3, but with a placebo threshold, in this case at PhP20 million. Since there is no real cut-off on treatment assignment at this placebo threshold, we expect the RDD results to be not statistically significantly different from zero. In Annex B, we then showed the results of our analysis using our original estimation window and threshold but on placebo outcomes, which we know should not be affected by the treatment but are related with our outcomes of interest. Finding consistent significant impacts based on these falsification tests casts doubt on the validity of our RDD estimates.

We also performed several additional analyses to establish the robustness of our estimates. In Annex C, we show the results of similar RDD analyses in Table 3 but using instead a +/-PhP3.0 million estimation window. The results for modern contraceptive use and child underweight prevalence, and the presence of health center physician are qualitatively the same, although the magnitudes differ for some indicators.

In Annex D, we show impact estimates using alternative estimation strategies (1) difference-in-differences (DID) and (2) DID with inverse propensity score-reweighting. In these strategies, we are limited with repeated-measure outcomes, such as for multi-births among mothers in the 2017 NDHS and for municipality-level LGU-HSC panel data. We limit our sample to first- to sixth-class municipalities that had not received DTTB deployment since 2010 but had been DTTB recipients annually since 2013 or later. By and large, we are able to qualitatively confirm the direction of the impact of DTTB receipt on modern contraceptive use prevalence, and on the propensity of having a public health center physician. In addition, the results suggest that DTTB receipt also increased the propensity of social health insurance accreditation of public health facilities, as well as the propensity of birth delivery by skilled attendants. However, we find the impact on child underweight prevalence to be not statistically different from zero using these alternative strategies.

4.4. Benefit-cost analysis

We compare the implied money-metric population health benefits from the DTTB program with the costs related to its administration. We focus on only one program impact, namely, decline in child underweight prevalence, and link this with changes in expected lifetime income through increased survival probability. It has been well documented that underweight prevalence among children is associated with increased risks of mortality and morbidity (e.g. Olofin, et al., 2013; Wake, et al., 2013).

We first calculate a baseline expected per capita labor income by age where we weight age-specific average labor income profiles in Abrigo, et al. (2020) by the related survival rates derived from the Philippine lifetable in the United Nations (2019) World Population Prospects. We then construct a counterfactual expected per capita labor income age profile by varying age-specific survival propensity based on a 10%-point decline in child underweight prevalence among the poorest household quintile from a baseline of 29.3% (FNRI, 2015), and a 2.6 mortality hazard ratio due to child underweight (Olofin, et al., 2013). Finally, we compare the change in expected per capita labor income with the cost of running the government's human resource for health (HRH) deployment program. In 2019, the government's HRH deployment program had a budget of PhP7.6 billion (in 2015 prices).

Based on the above parameters, life expectancy at birth among averted underweight children in DTTB-recipient municipalities is projected to increase by 3.5 years. When averaged over the whole population, this translates to a PhP717 increase in the net present value of per capita lifetime labor income using a 7% discount rate. This is equivalent to a benefit-cost ratio of 10 when compared with the per capita cost of the HRH deployment program of PhP71. The implied rate of return from the DTTB program through averted mortality is at 15.9%, which is higher than the Philippine government's adopted social discount rate of 10%.

In the above benefit-cost analysis, we have intentionally chosen parameters to provide a low-ball estimate of the social returns to the DTTB program. First, we included the whole program cost of HRH deployment, and not just for the DTTB program. Second, we focused on only one economic pathway, i.e., changes in expected lifetime labor income through averted mortality from decreased child underweight prevalence. Third, we used the lowest among the set of RDD impact estimates that we have calculated for child underweight prevalence. The benefits from the DTTB program are likely greater than the estimates that we present here.

5. Conclusion

We document significant clinical and economic impacts of the Doctors-to-the-Barrios (DTTB) program. Using a regression discontinuity design (RDD), we find that the DTTB program doubles modern contraceptives-use propensity and decreases child underweight prevalence by two-thirds in poor municipalities. Considering only the increase in expected lifetime labor income as a result of averted deaths from reduced child underweight prevalence, we estimate the program's internal rate of return at 15.9%, which is likely to be severely understated. These results underscore the importance of health care workers in underserved areas.

The results we found are in line with recent studies on the several positive impacts of physician augmentation on health outcomes (Fontes, et al., 2018; Hone, et al., 2020; Russo, et al., 2019; Russo, 2021). Unlike these existing studies, however, our analysis barely scratched the surface on the Philippine experience. While the use of RDD allowed us to leverage on a natural experiment induced by the DTTB program's design, it limited the number of samples that we may employ in our analysis. Future evaluations may consider using other research designs.

References

Abrigo, M.R.M., and D.A.P. Ortiz (2019). Who are the health workers and where are they? Revealed preferences in location choice decision among health care professionals in the Philippines. PIDS Discussion Paper Series No. 2019-32. Quezon City, Philippines: PIDS.

Abrigo, M.R.M., G.A. Opiniano, and Z.C. Tam (2021). Process evaluation of the Department of Health human resources for health deployment program. PIDS Discussion Paper Series No. 2021-07. Quezon City, Philippines: PIDS.

Bound, J., D.A. Jaeger, and R.M. Baker (1995). Problems with instrumental variables estimation when the correlation between the instrument and the endogenous explanatory variable is weak. *Journal of the American Statistical Association*, 90(430), 443-450.

Burgert, R., J. Colston, T. Roy, and B. Zachary (2013). Geographic displacement procedure in georeferenced data release policy for the Demographic and Health Surveys. DHS Spatial Analysis Report No. 7. ICF International: Maryland, USA.

Cattaneo, M.D., and R. Titunik (Forthcoming). Regression discontinuity designs. *Annual Review of Economics*, forthcoming.

Cattaneo, M.D., R. Titiunik, and G. Vazquez-Bare (2016). Inference in regression discontinuity designs under local randomization. *Stata Journal*, 16(2), 331-367.

Cook, T.D. (2008). "Waiting for life to arrive": A history of the regression-discontinuity design in Psychology, Statistics and Economics. *Journal of Econometrics*, 142(2), 636-654.

Fontes, L.F.C., O.C. Conceicao, and P.d.A. Jacinto (2018). Evaluating the impact of physician's provision on primary healthcare: Evidence from Brazil's More Doctors Program. *Health Economics*, 27(8), 1284-1299.

Food and Nutrition Research Institute [Philippines] (2015). *Philippine Nutrition Facts and Figures: 8th National Nutrition Survey: Anthropometric Survey*. Taguig City, Philippines: DOST-FNRI.

Hone, T., T. Powell-Jackson, L.M.P. Santos, R.d.S. Soares, F.P. de Oliviera, M.N. Sanchez, M. Harris, F.d.O.d.S. Santos, and C. Millett (2020). Impact of the Programa Mais Medicos (more doctors Programme) on primary doctor supply and amenable mortality: quasi-experimental study of 5565 Brazilian municipalities. *BMC Health Services Research*, 20, 873.

Imbens, G.W., and J. Angrist (1994). Identification and estimation of local average treatment effects. *Econometrica*, 62(2), 467-495.

Imbens, G.W., and P.R. Rosenbaum (2005). Robust, accurate confidence intervals with a weak instrument: Quarter of birth and education. *Journal of the Royal Statistical Society Series A (Statistics in Society)*, 168(1), 109-126.

Imbens, G.W., and T. Lemieux (2008). Regression discontinuity designs: a guide to practice. *Journal of Econometrics*, 142(2), 615-635.

Lee, D.S., and T. Lemieux (2010). Regression discontinuity designs in Economics. *Journal of Economic Literature*, 48(2), 281-355.

Maffioli, E.M., T.A.H. Rocha, G. Vivas, C. Rosales, C. Staton and J.R.N. Vissoci (2019). Addressing inequalities in medical workforce distribution: Evidence from a quasi-experimental study in Brazil. *BMJ Global Health*, 4, e001827.

Manasan, R.G. (2005). Local public finance in the Philippines: Lessons in autonomy and accountability. *Philippine Journal of Development*, 32(2), 31-102.

Philippine Statistics Authority (2018). *Philippines National Demographic and Health Survey 2017*. Philippine Statistics Authority, and The DHS Program, ICF: Quezon City, Philippines, and Maryland, USA.

Russo, L.X. (2021). Effect of More Doctors (Mais Medicos) Program on geographic distribution of primary care physicians. *Scielo Public Health*, 26(4), 1585-1594.

Russo, L.X., A. Scott, P. Sivey, and J. Dias (2019). Primary care physicians and infant mortality: Evidence from Brazil. *PLoS One*, 14(5), e0217614.

Staiger, D., and J.H. Stock (1997). Instrumental variables regression with weak instruments. *Econometrica*, 65(3), 557-586.

Stock, J.H., and M. Yogo (2005). Testing for weak instruments in linear IV regression. In D.W.L. Andrews and J.H. Stock, editors, *Identification and inference for econometric models: Essays in honor of Thomas Rothenberg*. Cambridge: Cambridge University Press.

Thistlewaithe, D.L., and D.T. Campbell (1960). Regression-discontinuity analysis: An alternative to the ex-post facto experiment. *Journal of Educational Psychology*, 51(6), 309-317.

van der Klaauw, D. (2008). Regression-discontinuity analysis: a survey of recent developments in Economics. *Labour*, 22(2), 219-245.

Wilson, E., E. Hazel, L. Park, E. Carter, L.H. Moulton, R. Heidkamp, and J. Perin (2020). Obtaining district-level health estimates using geographically masked location from Demographic and Health Survey data. *International Journal of Health Geographics*, 19, 2. DOI:10.1186/s12942-020-0198-4

Annex A. Falsification test: Placebo threshold

A. Demographic and health survey

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	CD	N	K
A. Health care use												
Visited health facility in past 30 days (=1)	-0.49	2.50	0.38	6.4	3836	26	-0.03	0.06	0.81	671.16	2261	18
Travel time to health facility if visited (log)	-13.64	79.83	0.02	0.4	309	26	0.63	1.04	0.75	9.37	210	18
Confined in hospital in past year (=1)	-0.18	0.98	0.48	6.4	3836	26	0.09	0.06	0.36	671.16	2261	18
B. Reproductive health												
Contraceptive user (=1)	-0.10	0.61	0.89	7.16	739	26	-0.16	0.14	0.63	115.75	419	18
Modern contraceptive user (=1)	-0.01	0.51	1.00	7.16	739	26	-0.11	0.12	0.68	115.75	419	18
With unmet family planning need (=1)	0.57	1.87	0.17	2.61	518	26	0.16	0.07	0.03	65.45	285	18
Visited by health worker in past year	-0.87	1.94	0.26	7.16	739	26	-0.08	0.07	0.67	115.75	419	18
Visited health facility in past year	-0.74	1.51	0.32	7.16	739	26	-0.39	0.21	0.29	115.75	419	18
C. Maternal health												
Antenatal care with skilled attendant (=1)	-0.29	0.42	0.60	5.56	253	26	-0.32	0.52	0.28	2.44	136	18
Timing of first antenatal care visit (month)	3.89	7.02	0.44	4.09	246	26	-1.39	2.31	0.64	2.31	134	18
At least four antenatal care visits (=1)	-1.41	1.86	0.25	6.21	252	26	0.02	0.46	0.98	2.44	136	18
Delivery assisted by skilled attendant (=1)	-2.39	3.01	0.39	6.56	334	26	-0.89	1.61	0.41	2.61	183	18
Delivery in health facility (=1)	-2.26	3.04	0.43	6.56	334	26	-0.89	1.62	0.40	2.61	183	18
Postnatal care visit within two months post-partum	-0.10	0.53	0.83	5.56	253	26	3.86	4.63	0.00	2.41	135	18
Postnatal care with skilled attendant (=1)	0.63	0.74	0.51	5.05	211	26	-0.03	0.14	0.91	6.63	108	17
D. Child health												
Immunized in first six months, BCG	0.07	0.46	0.94	10.04	170	26	-0.22	0.30	0.70	9.13	90	17
Immunized in first six months, DPT1	-0.03	0.45	0.97	10.53	169	26	-0.22	0.30	0.70	9.13	90	17
Immunized in first six months, HepB1	0.07	0.46	0.94	10.04	170	26	-0.22	0.30	0.70	9.13	90	17
Immunized in first six months, Polio1	-0.03	0.45	0.97	10.53	169	26	-0.22	0.30	0.70	9.13	90	17
Infant mortality	0.17	0.31	0.62	7.75	545	26	-3.35	36.42	0.18	0.06	327	18

Annex A. Falsification test: Placebo threshold (continued)

B. LGU health scorecard

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	CD	N	K
A. Building blocks												
With health center physician (=1)	0.57	2.07	0.78	0.29	1397	127	0.61	0.35	0.14	6.95	880	80
LGU per capita PHN expenditure (log)	42.36	193.97	0.14	0.24	1375	127	0.59	0.91	0.41	5.93	877	80
With operational DRRM for health plan (=1)	0.80	1.46	0.46	2.26	485	121	0.18	2.05	0.92	0.62	322	80
With public health worker magna carta benefits (=1)	-0.03	1.19	0.99	2.14	584	127	4.80	15.36	0.13	0.31	389	80
With PhilHealth PCB accreditation (=1)	0.28	0.73	0.61	1.62	850	127	-0.92	1.27	0.06	2.32	530	80
With PhilHealth MCP accreditation (=1)	-1.69	3.17	0.34	1.51	850	127	1.60	2.23	0.12	2.33	531	80
With PhilHealth TB-DOTS accreditation (=1)	-0.65	1.64	0.68	1.51	850	127	-0.30	0.86	0.72	2.33	531	80
B. Outcomes												
TB detection rate	0.30	0.60	0.59	3.22	671	127	0.57	0.84	0.15	2.15	417	80
TB treatment rate	-0.64	0.76	0.10	2.52	843	127	-0.69	1.05	0.14	1.50	551	80
Modern contraceptive use prevalence	0.48	0.85	0.40	2.32	851	127	-1.52	2.72	0.03	1.30	552	80
Birth delivery by skilled attendant	1.28	1.97	0.07	2.21	842	127	0.23	0.84	0.78	1.43	552	80
Birth delivery in health facility	1.26	2.03	0.20	2.34	852	127	0.72	1.55	0.48	1.47	556	80
Fully immunized children	-0.60	0.86	0.30	2.13	839	127	-0.66	1.05	0.29	1.56	551	80
Exclusively breastfed, 0-6 months	-0.99	1.35	0.10	2.13	838	127	-0.56	1.15	0.53	1.33	549	80
Underweight children, 0-59 months	-0.09	0.25	0.66	2.37	795	127	0.45	0.73	0.06	1.34	533	80

Source: Authors' calculations. Notes: Fuzzy regression-discontinuity design estimates are based on instrumental variable regression using observations in municipalities with 2004-2007 annual regular income within PhP2.25 million from a placebo income class assignment threshold of PhP20 million. Estimated p-values are based on permutation of income class assignment among municipalities in the estimation sample. Est. – estimate; S.E. – Standard error; p – permutation-based p-value; CD – Cragg-Donald F statistic; N – number of observations; K – number of clusters.

Annex B. Falsification test: Placebo outcomes

	Est.	SE	p	CD	N	K
A. Without baseline controls						
Household wealth index	0.09	0.52	0.89	73.73	414	16
Years of education among adults 15 years or older	-1.27	1.93	0.52	217.27	1139	16
4Ps beneficiary household (=1)	0.01	0.24	0.98	73.73	414	16
B. With baseline controls						
Household wealth index	1.19	3.27	0.83	11.30	352	14
Years of education among adults 15 years or older	1.92	11.04	0.92	10.23	980	14
4Ps beneficiary household (=1)	0.26	0.08	0.86	11.30	352	14

Source: Authors' calculations. Notes: Fuzzy regression-discontinuity design estimates are based on instrumental variable regression using observations in municipalities with 2004-2007 annual regular income within PhP2.5 million from the income class assignment threshold of PhP15 million. Estimated p-values are based on permutation of income class assignment among municipalities in the estimation sample. Est. – estimate; S.E. – Standard error; p – permutation-based p-value; CD – Cragg-Donald F statistic; N – number of observations; K – number of clusters.

Annex C. Robustness check: Alternative estimation window

A. Demographic and health survey

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	KP	N	K
A. Health care use												
Visited health facility in past 30 days (=1)	-0.03	0.05	0.54	1053.4	2827	24	-0.02	0.07	0.83	2.50	2367	21
Travel time to health facility if visited (log)	-0.02	0.37	0.97	105.51	238	24	-0.54	0.31	0.35	2.33	224	21
Confined in hospital in past year (=1)	0.00	0.02	0.95	1053.4	2827	24	0.01	0.03	0.92	2.50	2367	21
B. Reproductive health												
Contraceptive user (=1)	-0.01	0.12	0.98	229.76	545	24	0.01	0.06	0.95	2.58	445	21
Modern contraceptive user (=1)	0.00	0.09	0.96	229.76	545	24	-0.06	0.07	0.55	2.58	445	21
With unmet family planning need (=1)	-0.10	0.10	0.27	126.19	349	24	-0.26	0.07	0.02	2.56	284	21
Visited by health worker in past year	-0.06	0.10	0.57	229.76	545	24	0.02	0.05	0.80	2.58	445	21
Visited health facility in past year	-0.11	0.14	0.53	229.76	545	24	0.25	0.07	0.09	2.58	445	21
C. Maternal health												
Antenatal care with skilled attendant (=1)	0.16	0.19	0.57	29.45	184	24	0.24	0.18	0.26	3.87	142	21
Timing of first antenatal care visit (month)	-0.11	1.11	0.92	29.79	173	24	1.32	1.23	0.53	3.62	141	21
At least four antenatal care visits (=1)	-0.02	0.54	0.98	29.45	184	24	-0.05	0.16	0.88	3.87	142	21
Delivery assisted by skilled attendant (=1)	0.12	0.62	0.80	44.74	255	24	-0.06	0.18	0.88	3.37	186	21
Delivery in health facility (=1)	0.03	0.66	0.94	44.74	255	24	-0.19	0.16	0.39	3.37	186	21
Postnatal care visit within two months post-partum	0.05	0.32	0.88	29.05	183	24	0.71	0.36	0.07	3.87	141	21
Postnatal care with skilled attendant (=1)	0.10	0.28	0.65	20.73	136	23	0.87	0.61	0.09	1.48	114	20
D. Child health												
Immunized in first six months, BCG	0.04	0.21	0.88	16.89	133	23	-0.67	0.96	0.54	0.58	94	20
Immunized in first six months, DPT1	0.00	0.15	1.00	16.89	133	23	-0.67	0.96	0.54	0.58	94	20
Immunized in first six months, HepB1	-0.01	0.15	0.93	16.89	133	23	-0.67	0.96	0.54	0.58	94	20
Immunized in first six months, Polio1	0.09	0.17	0.65	16.89	133	23	-0.67	0.96	0.54	0.58	94	20
Infant mortality	0.03	0.06	0.64	40.31	428	24	-0.03	0.05	0.70	4.07	316	21

Annex C. Robustness check: Alternative estimation window (continued)

B. LGU health scorecard

	Without baseline controls						With baseline controls					
	Est.	SE	p	CD	N	K	Est.	SE	p	CD	N	K
A. Building blocks												
With health center physician (=1)	0.31	0.16	0.19	37.77	726	66	0.35	0.09	0.08	26.71	616	56
LGU per capita PHN expenditure (log)	-2.17	2.99	0.44	33.59	699	66	0.08	0.30	0.82	26.48	610	56
With operational DRRM for health plan (=1)	-0.14	0.34	0.67	22.21	233	64	0.11	0.47	0.84	11.46	215	56
With public health worker magna carta benefits	0.36	0.36	0.27	19.36	297	66	0.57	0.45	0.26	14.59	270	56
With PhilHealth PCB accreditation (=1)	0.02	0.18	0.91	21.00	423	66	-0.14	0.20	0.48	14.90	368	56
With PhilHealth MCP accreditation (=1)	-0.55	0.46	0.17	21.60	424	66	-0.64	0.57	0.22	15.39	369	56
With PhilHealth TB-DOTS accreditation (=1)	-0.72	0.44	0.04	21.60	424	66	-1.05	0.61	0.02	15.39	369	56
B. Outcomes												
TB detection rate	-0.34	0.21	0.06	13.63	308	66	-0.36	0.29	0.12	7.10	271	56
TB treatment rate	0.12	0.15	0.43	23.43	430	66	0.02	0.13	0.87	15.95	384	56
Modern contraceptive use prevalence	0.38	0.24	0.04	24.01	432	66	0.49	0.29	0.04	15.56	386	56
Birth delivery by skilled attendant	0.17	0.17	0.35	24.94	431	66	-0.08	0.13	0.60	15.92	386	56
Birth delivery in health facility	0.27	0.23	0.24	23.92	436	66	0.01	0.17	0.96	15.60	390	56
Fully immunized children	0.02	0.15	0.88	25.79	424	66	0.06	0.18	0.77	15.48	382	56
Exclusively breastfed, 0-6 months	0.01	0.18	0.96	24.94	431	66	0.04	0.23	0.90	16.75	384	56
Underweight children, 0-59 months	-0.13	0.07	0.03	25.31	410	66	-0.10	0.08	0.14	16.58	365	56

Source: Authors' calculations. Notes: Fuzzy regression-discontinuity design estimates are based on instrumental variable regression using observations in municipalities with 2004-2007 annual regular income within PhP3.0 million from the income class assignment threshold of PhP15 million. Estimated p-values are based on permutation of income class assignment among municipalities in the estimation sample. Est. – estimate; S.E. – Standard error; p – permutation-based p-value; CD – Cragg-Donald F statistic; N – number of observations; K – number of clusters

Annex D. Robustness check: Difference-in-differences estimation

A. Demographic and health survey

	Unweighted							With inverse-propensity weights						
	Est.	SE	P	N	K	F	p(F)	Est.	SE	P	N	K	F	p(F)
A. Maternal health														
Antenatal care with skilled attendant (=1)	0.00	0.03	0.94	1919	204	1.40	0.24	-0.02	0.06	0.73	622	68	2.06	0.16
Timing of first antenatal care visit (month)	0.19	0.13	0.14	1842	204	0.01	0.91	-0.23	0.25	0.35	610	68	3.79	0.06
At least four antenatal care visits (=1)	-0.07	0.03	0.01	1916	204	0.32	0.57	-0.07	0.05	0.15	621	68	4.45	0.04
Delivery assisted by skilled attendant (=1)	0.02	0.03	0.47	2607	204	0.05	0.82	0.01	0.03	0.77	821	68	1.25	0.27
Delivery in health facility (=1)	0.01	0.03	0.82	2607	204	0.00	0.98	0.09	0.08	0.28	821	68	1.87	0.18
Postnatal care visit within two months post-partum	0.02	0.03	0.61	1916	204	1.87	0.17	-0.07	0.10	0.52	621	68	0.79	0.38
Postnatal care with skilled attendant (=1)	0.01	0.03	0.73	1402	200	0.30	0.58	-0.12	0.14	0.40	456	67	1.79	0.19
B. Child health														
Immunized in first six months, BCG	-0.01	0.06	0.85	1319	202	…	…	-0.16	0.12	0.16	403	67	…	…
Immunized in first six months, DPT1	-0.01	0.06	0.83	1309	202	…	…	-0.16	0.12	0.17	402	67	…	…
Immunized in first six months, HepB1	-0.02	0.06	0.80	1316	202	…	…	-0.16	0.12	0.17	402	67	…	…
Immunized in first six months, Polio1	-0.01	0.06	0.84	1309	202	…	…	-0.16	0.12	0.17	402	67	…	…
Infant mortality	-0.01	0.01	0.27	2965	204	2.50	0.12	-0.04	0.03	0.20	929	68	1.08	0.30

Annex D. Robustness check: Difference-in-differences estimation (continued)

B. LGU health scorecard

	Unweighted							With inverse-propensity weights						
	Est.	SE	p	N	K	F	p(F)	Est.	SE	p	N	K	F	p(F)
A. Building blocks														
With health center physician (=1)	0.15	0.04	0.00	3416	488	3.45	0.06	0.10	0.03	0.00	2989	427	2.56	0.11
LGU per capita PHN expenditure (log)	-0.12	0.05	0.01	3377	487	2.10	0.15	-0.05	0.03	0.12	2981	427	3.95	0.05
With operational DRRM for health plan (=1)	-0.07	0.07	0.35	1899	458	0.66	0.42	-0.09	0.08	0.28	1768	413	0.03	0.86
With public health worker magna carta benefits (=1)	0.01	0.05	0.86	2168	474	0.02	0.89	0.00	0.06	0.96	1992	417	0.26	0.61
With PhilHealth PCB accreditation (=1)	0.07	0.03	0.03	3201	477	3.72	0.05	0.08	0.03	0.02	2832	417	3.59	0.06
With PhilHealth MCP accreditation (=1)	0.07	0.04	0.14	3202	477	1.01	0.32	0.10	0.05	0.04	2833	417	1.90	0.17
With PhilHealth TB-DOTS accreditation (=1)	0.03	0.04	0.49	3202	477	2.43	0.12	0.02	0.05	0.69	2833	417	7.01	0.01
B. Outcomes														
TB detection rate	0.00	0.02	0.89	2511	477	0.16	0.69	-0.02	0.03	0.55	2258	417	0.18	0.67
TB treatment rate	0.00	0.02	0.86	3147	477	0.66	0.42	-0.01	0.03	0.62	2843	417	0.03	0.86
Modern contraceptive use prevalence	0.04	0.02	0.01	3157	477	0.08	0.78	0.04	0.02	0.02	2849	417	0.41	0.52
Birth delivery by skilled attendant	0.05	0.02	0.02	3142	477	1.18	0.28	0.04	0.02	0.07	2845	417	1.90	0.17
Birth delivery in health facility	0.01	0.03	0.58	3170	477	0.40	0.53	0.02	0.03	0.59	2866	417	1.00	0.32
Fully immunized children	-0.01	0.01	0.37	3086	477	0.02	0.89	-0.01	0.02	0.46	2794	417	0.26	0.61
Exclusively breastfed, 0-6 months	-0.01	0.02	0.61	3140	477	0.94	0.33	0.01	0.03	0.73	2833	417	4.07	0.04
Underweight children, 0-59 months	0.00	0.01	0.52	3068	477	1.05	0.31	0.00	0.01	0.58	2774	417	1.07	0.30

Source: Authors' calculations. Notes: Estimates are based on simple difference-in-differences using interacted regression model with or without weighting. In inverse-propensity score-weighted models, the propensity of ever receiving DTTB physician between 2010 to 2018 is modelled using baseline characteristics listed in Table 1. The estimation sample includes first to sixth class municipalities that had not received DTTB deployment from 2010, but have continuously received annual deployment starting 2013 or later until 2018. Standard errors are clustered at the household level. Est. – estimate; S.E. – Standard error; p –p-value; N – number of observations; K – number of clusters; F – F statistic on test for pre-trend; p(F) – p-value of F-statistic on test for pre-trend.