THE IMPACT OF COMMUNITY HEALTH WORKERS ON CHILDHOOD IMMUNIZATION: EVIDENCE FROM INDIA'S ASHA WORKER PROGRAM

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science

by

Tanvi Rao

August 2013

ABSTRACT

In 2005-06 the Indian government introduced a new band of Community Health Workers known as Accredited Social Health Activists or ASHA workers to improve basic health outcomes through community engagement. The initial rollout of the program, between 2005 and 2009, was heavily focused on 18 “high focus Indian states”, lagging behind on public health indicators. Using multiple rounds of data from the District Level Household & Facility Survey (DLHS), I create cohorts of 12-23 month old infants, spanning a period of ten years, to establish that immunization trends of infants prior to the program were not increasing at a statistically different rate in high focus states relative to non-focus Indian states. I establish that the introduction of the program caused a sharp deviation away from trend in these states relative to their non-focus counterparts. I employ a difference-in-differences framework to identify the effect of the program and use detailed public health data to control for state and time varying factors that could pose potential threats to identification. The model estimates statistically significant increases in the range of 14%-22% in the coverage of specific vaccines and the provision of full immunization in high focus states and a reduction in the percentage of infants with no immunization of up to 16%.

BIOGRAPHICAL SKETCH

Tanvi Rao completed 14 years of schooling at Sardar Patel Vidyalaya, a school in New Delhi, India where she studied from nursery to 12^{th} grade. She completed her undergraduate degree in economics from the Shri Ram College of Commerce (SRCC) at Delhi University in 2010. The same year, Tanvi started the MS program at the department of Applied Economics and Management (AEM) at Cornell University with a concentration in Development Economics. She started PhD coursework alongside her Masters and was formally admitted to the PhD program, in the same department of the university, in the fall of 2012, where she currently studies. Apart from her formal education she considers her several volunteering experiences in NGOs across India to be an important part of her education. Among her other volunteering experiences she was fortunate to be part of a street and slum children's project in Delhi where she taught part-time for two years.

This thesis is dedicated to my parents, two remarkable individuals, who have truly led by example. A “thank you”, in words, would understate recognition for what can only be described as the most defining force in my life.

A huge shout-out, to all my friends and family back home in India who have been at the beck and call of a Facebook message and to all my friends in Ithaca. Thank you, Vidhya, for being family in Ithaca and for talking econometrics while cooking-bathing-eating. And Oleg, with whom I hope to share many more milestones.

Lastly, a silent thank you, to my country India, the complexity of which rattles my conscience, inspires my work and eggs me on to be a better person.

ACKNOWLEDGMENTS

I would like to acknowledge the contribution of my special committee, my chair, Ravi Kanbur, and Jim Berry for their useful insights, comments and guidance throughout the course of this project.

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1. Introduction

The only village-level public health institution in India that has endured the test of time is the Integrated Child Development Services (ICDS) system, popularized as the *anganwadi* system since 1975. Rather than functioning as community health mobilizers or outreach workers, the *anganwadi* workers mostly implement supplementary feeding programs for children under six at the ICDS center and also weigh and monitor the growth of the children who visit the center. India experimented with a band of more general Community Health Workers (CHWs) in 1978 known as the Village Health Guides, but this program was discontinued in most states by 1985 as the central government did not consider the program to be a good return on its investment.

Lack of adequate support, mentoring and supervision were predominant among the factors underlying the failure of the earlier large scale CHW program in India (NHSRC, 2011). However, small scale CHW programs run by NGOs, like the SEARCH program in Gadchiroli, the Comprehensive Rural Health Project in Jamkhed, both in Maharashtra, and the Mitanin program in Chhattisgarh have achieved high regard. With this in view, the Government of India has aimed to implement the ASHA worker program with 'intensive and constant mentoring and support', drawn from frameworks of successful NGO led programs within the country.

Several mid-term evaluations of the ASHA worker program like the 2011 evaluation conducted by the National Health Systems Resource Center (NHSRC), and studies by Bajpai and Dholakia (2011) and by Gopalan, Mohanty et al. (2012) provide qualitative findings on the recruitment, responsibilities, training, incentives and supervision of ASHA workers, in smaller catchment areas, using cross-sectional, mixed-method surveys and focus group discussions. While some quantitative numbers on health outcomes in areas served by ASHA workers have been presented, no previous attempt has been made to rigorously quantify the effect of the program on a public health outcome. The main reasons for cited for this are the fact that no region presents itself as an obvious control for an area "treated" with an ASHA worker and that much of the challenge is in understanding the mechanisms that contribute to the failure or success of an ASHA worker by taking into account the experience of different regions. While this is largely true, a quantification of the impact of the program using multiple years of nationally representative data and econometric methods of control is of relevance in a policy scenario where consensus on the effectiveness of voluntary community health workers is lacking and where previous experiments of a similar nature have failed to achieve scale and sustainability.

The main value of this paper is in the fact that it aims to answer a question largely of interest in the public health literature, employing techniques more popular in the program evaluation branch of econometrics. The program in itself is not amenable to evaluation using techniques more popular among public health practitioners, where statistical focus is concentrated on creating or matching treatment and control groups based on observable levels of different variables. I employ a difference-in-differences methodology that uses panel data techniques to identify a causal parameter of interest even when treatment and control groups differ in observable ways, if the assumptions underlying such models are satisfactorily justified.

The ASHA worker program is a cornerstone strategy of the country's National Rural Health Mission (NRHM) with an implementation time-line ranging from 2005 to 2012. The initial policy statement of the program mandated that an ASHA worker be introduced, in every village with a population of 1000, in 18 high-focus[1] Indian states, which have weak public health indicators and/or weak infrastructure and in tribal areas of non-focus states. Non-focus states were free to implement the program but the central government funded the direct implementation of the program only in high-focus states (NRHM, mission document, 2005-2012). As a result, when the third round of the District Level Household & Facility Survey (DLHS) was conducted in 2007-08, collecting village level information on the availability of an ASHA worker and health sub-center level information on the number of ASHA workers who received the first round of training, on an average, high focus states had introduced and trained ASHA workers by a much larger magnitude in comparison to their non-focus counterparts. In contrast, other provisions of the NRHM such as the provision of an untied grant of 10,000 rupees per annum to each health sub-center or the formation of a Village Health and Sanitation Committee (VHSC) in every village were either similarly or more intensively implemented in non-focus states.

While the data collected by DLHS is detailed and it is possible to track whether an ASHA worker is present or not in an infant's village, the only variation in 'ASHA worker intensity' that I make use of in my analysis is the average of high vis-à-vis non-focus states. This is because this variation in the number ASHA workers is decidedly a result of the articulation of the specific policy in question, as opposed to the endogenous variation within states that could lead some districts or some villages to adopt the ASHA worker program more intensively than others. In other words, program placement bias issues are far more untenable in the latter scenario as opposed to the former.

[1] The18 high focus Indian states are Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Orissa, Uttaranchal, Jharkhand, Chhattisgarh, Assam, Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Tripura, Nagaland, Mizoram, Himachal Pradesh and Jammu and Kashmir. There are a total of 35 states (including union territories) in India.

The NRHM policy prescribes that the ASHA worker be a literate[2] woman resident of the village, preferably in the age group of 25 to 45 years who is to receive training for 23 days in five episodes at the sub-center. The ASHA worker is not a paid worker but a volunteer who receives small sums per task performed.

I choose childhood immunization as the outcome measure to quantify the effect of the ASHA worker program, even though the ASHA worker is envisioned to perform a host of tasks. One reason for this is that immunization is an easily quantifiable outcome and has a time series of available data. Moreover, immunization coverage rates in all of India and in particular rural India are far from universal, despite a long standing commitment by the Indian government towards universal immunization, since the inception of its Universal Immunization Program (UIP) in 1985. Moreover, inter and intra-regional disparities in progress towards full immunization are grave. The government, donor agencies and NGOs target full immunization rates of greater than 80% coverage, but in 2008 this figure was less than 43% in the high focus Indian states.

One of the main tasks assigned to the ASHA worker is to counsel women on the importance of immunization and to mobilize women, children and vulnerable populations for monthly health day activities like immunization camps. Her other tasks include registering pregnant mothers, accompanying pregnant mothers to the health facility for delivery, paying home visits for antenatal care (ANC) for expecting mothers and promoting general awareness about health, sanitation and nutrition.

[2] With education at least up to class 8

The District Level Household and Facility Survey (DLHS) is collected by the Indian Institute of Population Studies (IIPS, Mumbai)[3] and is designed to provide information on family planning, maternal and child health, reproductive health of married women as well as utilization of healthcare services. The survey includes information on individuals and households, a village level questionnaire as well as surveys of health facilities part of the Indian public health set up like Sub-Centers (SCs), Primary Health Centers (PHCs), District Health Centers (DHCs) and Community Health Centers (CHCs). Currently, three rounds of DLHS data are available- DLHS I that collected data in 1998-99, DLHS II (2002-04) and DLHS III (2007-08). All three surveys include detailed questions on immunization which are posed to mothers regarding their last and last but one born child, born within three years prior to the conduct of the interview. The village and sub-center level questionnaires include information on the availability of the ASHA worker and other publicly provided healthcare services.

The rest of the paper is divided as follows. I break down section 1 into three sub-parts; the first part reviews the role of CHWs in healthcare provision, the second sub-part describes in brief the public health set-up in India to place the functioning of the ASHA worker within context, and the third section reviews other NRHM provisions that could have an effect on immunization. In section 2, I provide descriptive statistics and in section 3 I present the empirical model. Sections 4 and 5 are devoted to results and robustness checks and are followed by a detailed discussion of the results in section 6. Section 7 concludes. All tables and figures are in the appendix.

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[3] IIPS also conducts the National Family Health Survey (NFHS). DLHS provides estimates that are representative at the district level in India.

1.1 Community Health Workers & Healthcare Provision

The introduction of the ASHA worker program is a core strategy of the Indian government in its efforts to meet the 5th Millennium Development Goal (MDG) of reducing the under-five mortality rate by two-thirds between 1990 and 2015. The revival of CHWs as agents of health-care provision in India complements a global move towards employing CHWs on a national scale.

In January 2013, the United Nations Sustainable Development Solutions Network in collaboration with the Earth Institute at Columbia University launched a campaign to help expand and accelerate CHW programs in sub-Saharan African countries. The "one-million community health worker campaign" aims to equip and deploy one million community health workers, each serving a population of 650 rural inhabitants, by the end of 2015. The campaign has raised funds to scale up existing CHW programs in 10 countries to a national level, deploy quality-controlled protocols to these health workers, and help provide them with broadband and smartphone technology for real-time child and maternal health monitoring.

While the idea of CHWs has been around for at least four-five decades, the renewal of interest in the strategy over the past five-six years has come with the belief that gains in maternal and child health can be made if we use the strategy more effectively and intensively than we have in the past. The new generation of CHW programs, including the ASHA worker program, emphasizes a framework of structured but rapid training of the health care volunteers, a well-defined linkage with the public-health set-up, a standard and well equipped medicinal kit as well as a strategy of leveraging modern communications technology to make the health workers more accessible and easy to monitor.

A well implemented CHW program is powerful because a majority of all health problems of rural populations can be prevented or managed by the people themselves, as long as they are identified and treated on time. The difficulty of bringing highly-qualified doctors and nurses to remote and rural locations makes the idea of “para-health workers” and “bare-foot” doctors all the more attractive.

Patel and Nowalk (2010) highlight the potential of CHW programs in expanding immunization coverage through activities that increase both the supply and demand of immunization services. CHW can increase the supply of immunization services by identifying “hidden” populations living in remote hamlets and migrant populations. Such “targeted outreach” enables the delivery of vaccination services in areas where fixed immunization sites have not been able to deliver. Analogously, CHWs can increase the demand for immunization by eliciting “passive demand” which depends on parents providing consent for immunization, even though they may not actively demand it and also by gaining the trust of and educating communities who do not provide consent for immunization due to misconceptions about vaccine safety and conspiracy theories within communities. Such an example was seen in Ecuador where Amazon River community health workers were engaged to facilitate the identification of hard-to-find households and enhance the delivery of services.

Ryman, Dietz et al. (2008) review evidence from public health and medical journals to document, among others, studies that quantify the effect of CHW interventions on the expansion of immunization in developing countries. The studies that satisfy their inclusion restriction include research designs that are either observational studies based on before-after comparisons or are cross-sectional comparative studies between groups that received a particular CHW intervention and groups that did not (though assignment was not random). For instance Tandon and Gandhi

(1992) present estimates of the effect of the ICDS (*anganwadi* program) on the expansion of immunization by comparing mean immunization outcomes of villages with an ICDS project in existence for 5 years with mean immunization outcomes of villages without an ICDS project and find immunization increases of 30-40% in areas with an ICDS project. However, they present no comparison of their treatment and control groups suggesting that these effects may be significantly biased upwards due to program placement effects. Overall, the authors conclude that given the scale at which CHW programs are looking to be implemented there is a grave dearth of scientific and rigorous research that evaluates their effectiveness.

An issue that has received some interest in the program evaluation literature is the effect of financial and non-financial incentives on the performance of community health providers. Basinga, Gertler et al. (2011) find that when community health providers were given a "payment for performance" or P4P incentive of $4.59 per institutional delivery facilitated by the health provider, in comparison to a control group which had regular input-based funding, there was an increase in 23 percent in the number of births attended to by a professional. This payment amount is comparable to the amount received by an ASHA worker to facilitate an institutional delivery (Rs. 350 per delivery). Ongoing research by Ashraf, Bandiera et al. (2012) as well as the experience of an Indian NGO, the Comprehensive Rural Health Project in Jamkhed, suggest that non-financial incentives also show a lot of promise in motivating CHWs to deliver. For instance, the project in Jamkhed compensates health workers with business training and access to microcredit. Ashraf et. al experimented with a publicly visible thermometer that displayed a star for each female condom sold, and linked the stars to the social impact of preventing HIV. They found that this strategy sold twice as many condoms as the case where providers were offered financial incentives.

Both the provision of financial and non-financial incentives is costly when we consider a program of a scale like the ASHA worker program. The marginal effects of the ASHA worker program would need to be calibrated with the amount spent on each ASHA worker for a cost-benefit analysis that has the potential to throw light on the long term sustainability of the program. This paper aims to do the former by placing careful bounds on the marginal effect of the program in high focus Indian states.

1.2 The Public Health Set-Up in India[4]

Primary health care in rural India is mostly catered to by the public sector, with limited private provision. Indian health policy envisages a three tier structure comprised of Sub-Centers (SC) at the primary level, Primary Health Centers (PHC) at the secondary level, and Community Health Centers (CHC) at the tertiary level. SCs are single-room facilities manned by an Auxiliary Nurse Midwife (ANM), catering to a population of about 4,500 individuals or about four villages. They provide very basic health services like immunizing children, giving family planning advice, providing basic treatment for tuberculosis, leprosy, malaria as well as minor ailments. The ANM worker (sometimes along with another Male Multi-Purpose Worker) also provides advice related to village sanitation, water safety etc. The villages under the care of the ANM workers are usually spread out on an 8-10 km area.

The next level of facility is the PHC which is usually located in a big village within the block. Each block has between 5-10 PHCs and each PHC acts as a referral unit for 5-6 SCs catering to a population of 25000-30000 people. It is manned by a medical officer/doctor, supported by 14 paramedical and other staff and has 4-6 beds for patients but most of the treatment to patients is from the Out Patient Department (OPD). The highest level of facility is a CHC, which is manned by four medical specialists (surgeon, general medicine practitioner, gynecologist and pediatrician), supported by 21 paramedical and other staff and has an operation theater, labor room, x-ray and laboratory facilities. It serves as a referral center for four PHCs. In addition there are also district hospitals that act as an additional secondary tier for rural areas.

[4] This section borrows from Datar A, Mukherji A, Sood N. (2007) and from module 1 of the ASHA worker training module.

The village institution highly relevant for the provision of immunization is the Integrated Child Development Services (ICDS) or '*anganwadi*' center. Each Anganwadi center caters to a population of around 1,000 and there is roughly one center for every village, run by an Anganwadi Worker (AWW). The center is a place where children under six gather every day for 3-4 hours. The main mandate of the AWW is to weigh children, administer supplementary feeds for children and hold monthly health checkups done by the ANM worker to identify and treat sick children. Importantly, the Anganwadi center is the place where the monthly "health day" is organized, usually jointly by the AWW and the ANM worker. Child immunization takes place on "health days"[5] and one of the main tasks of the ASHA worker is to help the AWW and the ANM worker in the organizing these camps.

Other village health personnel include a Village Health Guide (VHG) and a Trained Birth Attendant (TBA), though many states have now discontinued their services. Other physical infrastructure may include private clinics, health centers run by NGOs, pharmacies/medical shops and visits from mobile health units (MHU).

The main rationale behind the introduction of the ASHA worker as a village level CHW is that the existing set of public-health personnel are considered too outstretched to perform outreach and mobilization activities. The ANM worker caters to too large a catchment area to be in close enough contact with all families on a regular basis and the AWW performs a host of other activities and cannot serve the purposes of a more general CHW.

[5] Vaccines are given free to all children on health days. They are also given at the sub- centers and the PHC.

1.3 The National Rural Health Mission

The provisions of the National Rural Health Mission or NRHM are to be understood keeping in mind the above described framework of the Indian public health set-up. The different provisions of the NRHM are important to understand because the introduction of the ASHA worker is only one part of the entire mission, albeit an important one. I delineate, here the along with the introduction of the ASHA worker, some other features of the NRHM. While some of these provisions are highly relevant for the delivery of immunization services, in section 2 I show that these provision were not implemented more intensively in high focus Indian states vis-à-vis non-focus states.

The core strategies of the NRHM include:

a) The introduction of an ASHA worker for every population of 1,000 in 18 high focus Indian states on a priority basis.
b) Strengthening sub-centers (SCs) by giving each SC an untied fund of Rs.10,000 per annum to be used either for hiring additional Multi-Purpose (Male) Workers (MPWs) or ANMs, to sanction new SCs or to upgrade existing ones.
c) Strengthen PHCs by ensuring adequate supply of essential drugs and increasing manpower.
d) Strengthening CHCs, specifically focused on curative care, by increasing manpower (additional anesthetist posting) and creation of new CHCs to meet the population norm as per the 2001 Census.

e) Creation of "health plans" at the village level by a village health committee[6] and a district health plan at the level of the district

Other provisions include measures related to improving sanitation, strengthening disease control programs and mainstreaming "traditional healers" like those from the Ayurveda and Unani streams of medicine for curative care. However, the policy measures specifically relevant in their effect on immunization are the introduction of the ASHA worker and the strengthening of SCs and of PHCs.

The overall work profile of the ASHA worker includes her acting as an interface between the community and the public health system, specifically by acting as a bridge between the ANM and the village, along with the AWW. The ASHA worker must be a literate[7] woman resident of the village (married/widowed/divorced), preferably in the age group of 25 to 45 years. She is to receive training for 23 days in five episodes at the sub-center. The ASHA worker is not a paid worker but a volunteer who receives small sums per task performed. For instance, according to the guidelines issued by the central government, she is to be paid Rs. 150 per immunization session organized. Similarly, she is to be paid per "village health day" or "household toilet promotion" day organized. The estimated maximum amount out-go per ASHA per annum is roughly Rs. 17, 200 or roughly 325 dollars. The total number of ASHA workers hired between 2005 and 2008 was around 602,190 ASHAs across the country.

The NRHM mandates that the ASHA worker be promoted all over the country but special emphasis be laid in the 18 high focus states. The way this is carried out is that the Government of India that is the central government provides direct funding for the key components of the

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[6] Comprised of Panchayat Representative/s, ANM/MPW, AWW, teacher, ASHA worker and community health volunteers.

[7] With education at least up to class 8

program like the cost of training, incentives and medical kits for the high focus states but other states are to fund the program, following the activities of the center in high focus states, through an integrated financial envelope. Since, the central government has been a lot more proactive in promoting the ASHA worker in high focus states, the percentage of villages with an ASHA worker vary markedly between the two groups of states.

2 Descriptive Statistics

In this sub-section I describe the data I use and present descriptive statistics to provide background for the empirical estimations that follow.

As mentioned previously, each round of the DLHS survey collects immunization information from mothers regarding their last two surviving children, born in the three years prior to the time at which the interview was conducted. Immunization statistics are typically calculated for infants in the age group 12-23 months, because both international and Government of India guidelines specify that children should be fully vaccinated by the time they complete the first year of their life (NFHS 3, 2005-06). In order to obtain a longer immunization trend from the three survey rounds, I create cohorts of 12-23 month olds, by interview year, within each survey round.

For instance, approximately 99 percent of the interviews in the DLHS 1 survey were conducted in the two years, 1998 (47.38 percent) and 1999 (51.96 percent). Thus, I create two cohorts of 12-23 month olds from the first survey round. Cohort one includes children who were interviewed in any month of 1998 and were born between February 1996 and December 1997. Cohort two includes children who were interviewed in any month of 1999 and were born between February 1997 and December 1998. Similarly, 95 percent of the interviews in the DLHS 2 survey were conducted in 2002 (44.89 percent) and 2004 (50.32 percent). From this survey round I create two more cohorts of children born in February 2000-December 2001 and February 2002-December 2003 respectively. The bulk of the DLHS 3 survey was conducted in 2008 (93 percent of all interviews) and I use this survey round to create my final cohort of children born between February 2006 and December 2007. This fifth cohort of infants was born after the introduction of the ASHA worker and they form the group of infants who are exposed to the program while infants from the other four cohorts form the group that is unexposed for the purpose of my analysis. These details of cohort definitions are summarized in Table 1.

Table 2 presents the percentage of children immunized by cohort, detailing statistics per vaccine and for the cases of full immunization and no immunization in high and non-focus Indian states. From the figures it is evident that immunization rates are substantially higher for infants of all cohorts in non-focus states vis-à-vis high focus states. This is to be expected as high focus states are those Indian states that were found lagging behind on public health indicators and are states with poor delivery of health services on the whole. It is also evident that for high focus states there are huge gains in the percentage of infants immunized across the board for infants in the fifth cohort vis-à-vis the fourth cohort. These gains range from a 13 percent increase in coverage for DPT 3 vaccines to a nearly 20 percent increase for the case of measles vaccine. In contrast, gains in the non-focus states are modest and in some instances like in the case of the DPT3 vaccine, the Polio (OPV3) vaccine and for the case of full immunization, there is a decline in the proportion of infants immunized as we move from cohort 4 to cohort 5.

Table 3 shows the distribution of the percentage of villages with an ASHA worker, by state, for high and non-focus states as measured by the DLHS 3 survey in 2007-08. The ASHA worker program was introduced in 2005 though ASHA workers were continued to be hired in subsequent years. According to data from the website of the Ministry of Health and Family Welfare (MoHFW), Government of India, roughly 0.6 million ASHA workers were hired between 2005 and 2008, out of which roughly 70 percent of these ASHA workers were hired between 2005 and 2007. Matching data from the MoHFW website and the village population data from the DLHS 3 survey, I estimate[8] that during 2005-06 there was roughly one ASHA worker per population of approximately 13,700 people in high focus states and the corresponding figure for non-focus states was roughly one ASHA worker per population of 75,000 people. By 2008, the intensity of ASHA workers increased to one ASHA worker for every 2,900 people in high focus states and one ASHA worker for every 16,000 people in non-focus states.

Table 4 summarizes data on other provisions of the NRHM and how they compare for high and non-focus states. From the table it is evident that in terms of the different provisions, the only NRHM policy that high focus states implemented much more intensively than non-focus states was the number of ASHA workers hired and trained in the sample villages. For all other NRHM policies both the receipt and utilization of funds was much more intensive in non-focus states. For instance, the percentage of villages with an ASHA worker is nearly twice as much in high focus states in comparison with non-focus states and the average number of ASHA workers who have completed the first round of training in high focus states is nearly thrice the number in non-focus states. However, the percentage of sub-centers that have fully utilized untied funds is nearly 21 percent higher in non-focus states and the percentage of primary health centers and community health centers that have fully utilized untied funds are higher by 24 percent and 14 percent respectively in non-focus states. The percentage of villages that formed a Village Health and Sanitation Committee in non-focus states is approximately 85 percent as compared to 64 percent of villages in high focus states. These figures clarify that we are not unfounded in our assertion of the group of high focus states as those states that differ from non-focus states in their implementation of the ASHA worker program. While there may be other state level factors that

[8] These estimations are very rough. I calculate the fraction of ASHA workers who were in place by 2005-06 using the year-wise distribution of ASHA workers hired from the MoHFW website. I then use this fraction to approximate the number of ASHA workers in place by 2005-06 in the DLHS 3 village sample. Using the population of the sample villages, I calculate intensities.

changed at a differential rate between the time-periods represented by cohorts 4 & 5, in terms of NRHM provisions it is unlikely that the group of high focus states, in the aggregate, represent some other public health policy that was implemented in 2005 that would affect immunization in high focus states more than in non-focus states.

3 Empirical Model

The key identifying assumption in a difference-in-differences (DID) framework used to estimate a causal parameter of interest is that outcome trends would be the same in both groups, the treated and control, in the absence of treatment. Treatment induces a deviation from the common trend. In a DID estimation framework, treatment and control groups can differ in terms of factors that are unchanging and this difference is captured by the group fixed effect in the model.

Such a strategy is often used as a second-best approach in the evaluation of programs that were not randomized to begin with. When the treatment is not randomized, a DID model is an improvement over comparisons that either only calculate the mean difference in outcomes between areas with and without the program or those that calculate the difference in the outcome before and after the program in the treated group. In the former, the treatment effect may be biased due to permanent differences in the two groups and in the latter there is no way to control for time-varying factors that may be changing commonly for all groups under consideration.

However, unobservable determinants of immunization that may be changing differentially in treatment and control groups, in the period just before the intervention and the final period at which the outcome is measured are still a potential source of bias and such an argument is often used to refute the validity of DID estimates. In my analysis I present a careful investigation of immunization trends prior to the implementation of the ASHA worker program and sequentially control for state-time varying covariates.

In figures 1.1-1.6 I explore immunization trends for infants between 12-23 months, spanning cohorts 1 to 5. For the cases of BCG (fig. 1.1), measles (fig. 1.4), full immunization (fig. 1.5) and no immunization (fig. 1.6), the idea of common immunization trends prior to the intervention, for successive combinations of cohorts 1-4, are clearly evident. For the cases of the DPT 3 and OPV 3 vaccines (figs. 1.2 and 1.3) there is a steep decline in the rate of immunization growth relative to trend in high-focus states especially when we inspect the segment of the trend line between cohorts 2 and 3. I return to this issue and to an empirical formalization of common trends, in the form of "placebo" DIDs, for pairs of cohorts not exposed to the treatment in the section on robustness following the main results.

The following four equations form the basis for my estimations:

$$DID = \left[\left(\bar{Y}_{cohort\ (t+1)} \middle| high\right) - \left(\bar{Y}_{cohort\ (t)} \middle| high\right)\right] - \left[\left(\bar{Y}_{cohort\ (t+1)} \middle| non\right) - \left(\bar{Y}_{cohort\ (t)} \middle| non\right)\right] \quad (1)$$

$$Y_{it} = \alpha + \beta.1(t=1) + \gamma.1(D_i=1) + \delta.1(t=1).1(D_i=1) + \varepsilon_{it} \quad (2)$$

$$Y_{it} = \alpha + \beta.1(t=1) + \gamma.1(D_i=1) + \delta.1(t=1).1(D_i=1) + \varphi_s + (\varphi_s * t_2) + X_{it} + \varepsilon_{it} \quad (3)$$

$$Y_{it} = \alpha + \beta.1(t=1) + \gamma.1(D_i=1) + \delta.1(t=1).1(D_i=1) + \varphi_s + \vartheta_{st} + X_{it} + \varepsilon_{it} \quad (4)$$

Equation (1) summarizes the intuitive idea behind a DID estimate. The DID estimate, for each vaccine, is obtained by first obtaining the difference in the mean immunization of cohort t ($\bar{Y}_{cohort\ (t)}$) and cohort $t+1$ ($\bar{Y}_{cohort\ (t+1)}$) for the group of high focus states, then by obtaining the same difference for the group of non-focus states and finally calculating a difference of the two.

Equation (2) is a regression-based model of equation (1) and forms the baseline case for all estimations. Equations (3) and (4) include additional covariates in two different specifications. In regression equations (2) to (4), α is the constant, γ is the coefficient on the treatment dummy that takes the value "1" if the infant is in a high-focus state and β is the sum of the coefficients on the included cohort dummies. In the three models, δ is the coefficient of interest or the DID estimator. In models (3) and (4) φ_s denotes state-fixed effects. In (3) $(\varphi_s * t_2)$ accounts for a state-time trend variable. Here t_2 is a trend variable that takes on values 0 to 4 as we move from cohort 1 to cohort 5. In (4), ϑ_{st} denote state-time varying covariates. Finally, in both models, X_{it} is a matrix of individual level covariates and ε_{it} is a random error term.

I estimate the regression equation (3) using all cohorts 1-5. Regression equation (4) is estimated using cohorts 4 & 5 only, that is the cohort of infants who were 12-23 months old in 2004 and those who were 12-23 months old in 2008.

For equations (2) to (4) the dependent variable (Y_{it}) is binary and is coded as “1” if the infant under consideration has received a particular vaccine, the entire set of vaccines or no vaccine. Even though the dependent variable is binary, I use a linear specification for all my estimations. Angrist and Pischke (2008) argue that if there is reason to believe that the Conditional Expectation Function or the CEF (as in equation 1) is a causal parameter of interest then a binary dependent variable does not pose any special challenges. On the other hand calculation of the treatment effect using a limited dependent variable model like a probit or a logit model requires additional distributional assumptions in order to recover the size of the treatment effect. For ease of interpretation of the size of the treatment effect I use a linear probability model.

In all models I cluster standard errors at the state-level. In settings where the treatment varies at a group-level, clustering standard errors ensures that the individual error terms are allowed to be correlated within group. Not clustering standard errors seriously overestimates precision in such settings and imposes the assumption that unobservable shocks to individuals within a group are independent of each other.

4 Results

The first row of table 5 presents DID estimates from estimating regression equation (2) as the baseline case. As mentioned previously, these estimates are obtained using the complete dataset with cohorts 1-5. Here the δ coefficient shows the increase in immunization in high focus states, of infants in cohort 5 relative to the immunization of infants in cohort 4 after differencing out the trend increase in immunization.

These baseline estimates are in the range of 0.14 to 0.16 for individual vaccines and for the case of full immunization and are all highly statistically significant. The baseline case also estimates a statistically significant reduction of 0.16 in the probability of an infant in high focus states not receiving any immunization. It was earlier established that high focus states have a much higher concentration of hired and trained ASHA workers but do not have a higher degree of implementation of other NRHM provisions that could have an effect on immunization. The second row of table 5 adds individual level covariates to the model such as the age and gender of the infant, mother's age, her age at marriage, the caste and religion of the household as well as the type of house the household lives in. These variables are not expected to be a source of omitted variable bias when the treatment varies at an aggregate level but are added to the model because they are strong predictors of immunization and absorb some of the variance in the dependent variable, yielding more precise estimates. As expected the results are slightly stronger both in significance and magnitude with the addition of these covariates. In the third row I add-in state-fixed effects as an additional robustness check.

The last row of table 6 controls for state-time trends. In the absence of specific state-time varying covariates in this specification, the state-time trend variable captures omitted variables at the state-time level that may be causing the group of high focus states to have a higher growth rate of immunization in comparison to non-focus states. The inclusion of this variable reduces the treatment effect of the program for the case of immunization with BCG vaccination and for the case of no immunization, accounting for a part of the upward bias in these estimates.

Nevertheless all results remain statistically significant and suggest that the ASHA worker program increased immunization coverage in the range of 12-17% in high focus Indian states.

In table 6, I present results from estimating the restricted version of the baseline model (2) using cohorts 4 & 5 and sequentially adding covariates to result in the final specification as in regression equation(4). The estimates in the first three rows of table 6 are very similar to the estimates reported previously in table 5. The difference in the two baseline estimations is that table 6 reports a restricted version of the model with only cohorts 4 and 5 and the first row of table 5 reports unrestricted estimates using all cohorts and all pairs of cohort-treatment interactions with cohort 4 being the base case of comparison. I estimate this restricted version of the model in order to be able to control for specific state-time varying covariates for which information in the DLHS 1 survey (corresponding to the first two cohorts) was not available.

The matrix of state-time covariates that I control for are covariates from the village level files of the DLHS 2 and DLHS 3 surveys, aggregated up to the state and cohort (time) level. In particular, I control for “pre” and “post” state averages of a host of variables related to the public health set-up that may be varying differentially for high focus Indian states during the time period elapsed between the time represented by cohorts 4 and 5, i.e. between 2004 and 2008 and that have an effect on immunization.

When assessing the robustness of the baseline estimates to state-time varying covariates, I find that the differential increase in *anganwadi* centers in high focus states vis-à-vis non-focus states accounted for a correction of up to 4-7% in the treatment effect of the ASHA worker program as can be seen for the different cases of immunization in row 3 of table 6. Between 2004 and 2008 the percentage of villages with an *anganwadi* center in high focus states increased from 79% to 90% whereas the corresponding increase in non-focus states was -1%. As was noted earlier, the anganwadi center is a highly relevant institution for immunization delivery as the anganwadi worker is in close touch with mothers of children under 6 and because monthly immunization camps in the village are organization at the anganwadi center. Moreover, prior to the ASHA worker, it was the anganwadi worker's responsibility to maintain immunization records of the village.

In the last row of table 6, in addition to the "percentage of villages with an anganwadi center" covariate I control for a host of other factors that could be additional sources of omitted variable bias. Upon adding these covariates, I find that the treatment effect of the ASHA worker program becomes much stronger as compared to the estimates in row 4 of table 6. Both the point estimates and the significance of estimates upon the addition of the full set of covariates is comparable and in some instances stronger than the baseline case with no covariates. The additional state-averaged covariates that I control for in the final estimation (row 5 table 6) are the percentage of villages that have a government dispensary, the percentage of villages that have a private clinic, the percentage of villages that have a sub-center, the percentage of villages that have a PHC, the percentage of villages that have a CHC, the percentage of villages that have government/district hospital and the percentage of villages that have a private hospital. For villages that do not have a particular health facility, I also have data for the distance to the nearest facility outside of their village. Correspondingly, I control for the average distance of a government dispensary from a village, for the average distance of a private clinic from a village, and corresponding variables that measure the average distance of a sub-center, a PHC, a CHC, and a private hospital from a village. I also control for the percentage of villages with a mobile health clinic visit, the percentage of sub-centers in a state that received and utilized untied NRHM funds and the percentage of sub-center areas in a state that formed Village Health and Sanitation Committees.

Therefore, after controlling for the increase in the percentage of villages with an anganwadi center, the model is robust to differential changes in a host of other public health sector covariates. The final specification suggests that the ASHA worker program increased the coverage of childhood immunization by 14%-22% in high focus Indian states and reduced the percentage of children with no immunization by roughly 16% in high focus states.

5 Robustness Checks

When the regressor of interest varies at a group level, as is the case in a difference-in-differences (DID) research design, identification assumptions are threatened by the possibility that the outcome of interest could vary systematically across the group of regions. This implies that we have reason to suspect that even in the absence of the ASHA worker program increases in immunization coverage in high focus states could be systematically different as compared to increases in immunization in non-focus states. Moreover, if the increase in immunization is correlated with initial levels, this pattern of increase would be observed in the data even if the program had no effect (DUFLO (2001)).

In other words, for credible estimates of the effect of the ASHA worker program on the coverage of basic childhood immunization, it is imperative that immunization trends in high and non-focus Indian states prior to 2005 be investigated. In particular, we need to investigate the claim that our assumed "trend" increase, as proxied by the increase in mean immunization levels among non-focus states, is justified.

Tables 7.1-7.5 present DID estimates for pairs of different cohorts consisting of children who were born and interviewed prior to 2005. Each table has six boxes, one for each vaccine and each box shows mean immunization levels for each cohort-region pair and the difference in the differences estimate as in equation (1) or the δ coefficient in equation (2) . These estimates form "placebo" tests and to the extent that they are not positive and significantly different from zero, they validate our main results.

Tables 7.1-7.3 consists of estimates of δ in equation (2) estimated using cohorts 1 & 2, cohorts 2 & 3 and cohorts 3 & 4. In none of these cases is the estimate of δ, that is the DID estimate, significantly different from zero. At first pass, it may be reasonable to assume that the increase in immunization for high focus states in the absence of the ASHA worker program can be proxied for using the increase in mean immunization among non-focus states for the period under consideration.

However, it may be argued that the estimates in tables 7.1-7.3 are not a good representation of the trend increase in immunization between cohorts 4 & 5 because these cohorts extend over a much longer time period as opposed to other cohort pairs. In particular infants in cohort 4 consist of 12-23 month olds interviewed in 2004 and cohort 5 consists of 12-23 month olds interviewed in 2008. The time elapsed between other cohorts is not more than 2 years. For this reason, in tables 7.4-7.5, I investigate the rate of increase in immunization levels between cohorts 1 & 3 and cohorts 2 & 4. In most cases, estimates of δ are not significantly different from zero. The trends in DPT 3 and OPV 3 vaccines are significantly different from zero and this poses some cause of concern. However, in both cases the DID estimate is significant and *negative*. To the extent to which this biases our results we can expect that our estimates of the effects of the ASHA worker program, for the case of these two vaccines, are an underestimate of the true effect.

6 Discussion of Results

Results in the previous section show large and statistically significant gains in immunization coverage between cohorts 4 and 5 in high focus Indian states. I employ a difference-in-differences estimation framework to argue that these gains in immunization coverage are attributable to India's ASHA worker program, which was implemented with a much higher intensity in high focus Indian states relative to non-focus states. Because these gains in immunization coverage are large, it is imperative that we further explore the mechanisms through which an ASHA worker may be impacting immunization. This is important, both to understand the channels through which community health workers are effective and to provide further credibility to the results at hand.

In Table 8, I compare the percentage of mothers who received advice/consultation by a doctor or a health worker in 2004 and 2008 in high and non-focus states. In particular, I look at the coverage of outreach services related to immunization, institutional deliveries, family planning and awareness of RTI/STIs[9] and AIDS. With regards to immunization services, large gains in outreach coverage are evident in high focus states. The percentage of mothers of infants in cohort 4 (interviewed in 2004) who were advised by a doctor or health worker to get their child immunized was roughly 38 percent and this figure increased to 71 percent for mothers of infants in cohort 5 (interviewed in 2008). In contrast, virtually no change was seen in non-focus states. There is a close to 4 percent gain in the percentage of women motivated by a doctor/health worker to institutionally deliver, in high focus states, between 2004 and 2008 but a decline of nearly 11 percent for the same in non-focus states. There is a larger gain in the coverage of family planning related outreach in high focus states, when compared to their non-focus

[9] Reproductive Tract Infections and Sexually Transmitted Infections are acronymized as RTI/STI.

counterparts, between the two years, but a larger gain in the spread of RTI/STI and AIDS awareness for the latter group of states. Keeping in view the large gains in immunization, institutional deliveries and family planning outreach in high focus states relative to non-focus states, it is interesting to note that the payment related tasks of the ASHA worker involve payment per immunization session and "pulse polio day" organized, per institutional delivery facilitated and for motivating couples towards tubectomies and vasectomies[10].

In Table 9, I look at the break down of different sources from which mothers of infants in cohort 5 were motivated to get their children immunized, in high and non-focus states. The most ideal comparison would have been to see the change in the composition of these sources among mothers of infants in cohorts 4 and 5 but, unfortunately, this detailed break-down of sources was not collected for mothers in previous surveys. While it is not surprising to see that both public health networks of information provision as well as the flow of "positive health-related advice" among private networks are stronger in the non-focus states, it is informative to notice that in a short period and despite not realizing the full scope of its intensity by 2008, the ASHA worker is a significant source of information for mothers in high focus states. 10.23 percent of mothers in high focus states claimed to have been motivated by an ASHA worker as opposed to 2.13 percent in non-focus states. However, in terms of the raw increase in the number of mothers who claim to have been motivated by a doctor/health worker to get their child immunized in high focus states, direct motivation by an ASHA worker accounts for only 30% of the increase[11].

[10] Other payment related tasks are for organizing a Village Health Day, for motivating the adoption of tuberculosis treatment, a household toilet promotion fee and to detect and refer leprosy cases.

[11] This figure was obtained by dividing the number of mothers who reportedly were motivated by the ASHA worker to get their child/children vaccinated by the increase in the number of mothers who were motivated by a doctor/health worker in favor of immunization.

Undoubtedly, a good part of the increase can be attributed to the increased number of *anganwadi* centers in high focus states. As was discussed before, there was a sharp increase in the number of *anganwadi* centers in high-focus states, as compared to non-focus states, over the time period under consideration. While, this increase in anganwadi centers was controlled for in previous regressions, the extent to which the two effects can be cleanly separated is not immediately clear. Moreover, the ASHA worker is envisioned not to work in isolation but as an integral part of the public health system, working together with other health personnel to both ease their work-pressures and assist them in performing their duties more efficiently. For instance, the ASHA worker works with the ANM and the *anganwadi* worker to organize monthly village health days. Therefore, the extent to which the increase in information provision via other health workers is attributable to the ASHA worker is again not quantifiable in this context.

To further buttress the idea that the large increase in immunization in high focus states was because of an increase in outreach as opposed to a general increase in the quality of other public health infrastructure, I look at the breakdown of the reasons cited by mothers for not getting their child immunized, among the sample of infants in who received no immunization. These results are tabulated in Table 10 for cohorts 4 and 5 in high and non-focus states. While these figures are to be treated with some caution owing the difference in the way the reason were elicited from respondents in the two survey rounds, some stylized facts can be gleaned. First of all, there is a reduction in the percentage of mothers who cite that they were unaware of the need for immunization in high focus states but an increase in the percent unaware in non-focus states. There is also a steep decline in the percentage of mothers who claim that the place of immunization was unknown to them in both high and non-focus states. In contrast, when we look at variables more indicative of the physical supply of infrastructure, there was a close to 56 percent decline in the percentage of mothers who stated that the place of immunization was too far to go to in non-focus states but a one percent increase in the percentage of mothers who cited this reason in high focus states. Other factors like the inconvenience in the time of immunization provision and the availability of ANMs and vaccines were more or less unchanged in the two groups of states.

While direct motivation by an ASHA worker towards immunization is the most obvious channel for outreach, there are undoubtedly indirect ways in which an ASHA worker can exert a positive influence on mothers. In Tables 11 and 12, I explore two indirect channels, via motivation for institutional deliveries and antenatal care. In Table 11, which pertains to the group of high focus states, I compare the predicted probabilities of immunization for infants in cohort 5 whose mothers were motivated by an ASHA worker for institutional delivery or to avail of antenatal care with those infants whose mothers did not receive motivation by an ASHA worker for the same. The predicted probabilities are reported for the sample of infants whose mothers received motivation for delivering institutionally/antenatal care only from an ASHA worker and no other health worker or family member and whose mothers received no direct motivation from any doctor or health worker for immunization. Table 12 reports the same figures but for the group of non-focus states.

While a causal investigation of the aforementioned mechanism is beyond the scope of this paper, table 11 suggests that the predicted probability for immunization of infants whose mothers were motivated for institutional deliveries/antenatal care is higher when compared to the group of infants whose mothers were not, in high focus states. While effects are evident for both cases, they are stronger for when the mother was motivated for antenatal care. In contrast, eyeballing table 12 makes it clear that predicted immunization probabilities are much higher for the group of infants whose mothers were not motivated for antenatal care or institutional deliveries by an ASHA worker. The numbers make it clear that for the group of non-focus states, ASHA workers were operational only in those areas of the state that performing exceptionally poorly and this is line with the policy rule of the program which placed ASHA workers only in areas with majority tribal population in non-focus states.

Table 13 summarizes OLS results that backdrop tables 11 and 12. While nothing definitive can be implied, statistically significant differences between the two groups of infants are evident. The direction of "causation" is clear for non-focus states, but for the case of high-focus states, the question of spill-over effects between different tasks of the ASHA worker remains open and encouraging.

Overall, the broad picture that emerges is one of increased outreach in high focus states relative to non-focus states and a reduction in unawareness pertaining to immunization. Apart from increased number of ASHA workers and *anganwadi* centers there does not seem to be any perceptible increase in the supply of other public health infrastructure. While direct motivation by an ASHA worker for immunization accounts for roughly 30 percent of the increase in outreach in high focus states, suggestive evidence for indirect/spillover effects via motivation for institutional delivery and antenatal check-ups is presented.

7 Conclusion

Several developing countries in sub-Saharan Africa and South Asia are in the process of scaling up CHW interventions in efforts to meet the Millennium Development Goals in the run up to 2015. India implemented a national CHW program, the ASHA worker program in 2005, with the aim of providing one ASHA worker per population of 1,000 in 18 high focus Indian states and in tribal areas of non-focus states. Currently, the program is being scaled up further to most states in India.

This paper uses three rounds of data representative at the district level to assess the effect of the program on a central task of the public health machinery in India- the provision of universal childhood immunization. Much of the evaluation of the program till date has been qualitative in nature and this paper attempts to quantify the effect of the program using evaluation techniques less common in the public health domain. It is hoped that the marginal effects estimated by the study can be used to shed light on the sustainability of the program, in a scenario where previous experiments of a similar nature have not borne fruition.

Between 2005 and 2009 the ASHA worker program was implemented twice as intensively in high focus Indian states in comparison to non-focus states. This assignment was not random because states that were lagging behind on specific public health indicators, i.e. the high focus states, were chosen for the initial implementation of the program. In such a scenario, a difference-in-differences framework is employed to study the effect of the ASHA worker program, in high focus Indian states, on the provision of different vaccinations, the outcomes on full immunization and the reduction in no immunization. This estimation strategy does not require treatment and control states to balance on baseline characteristics, but for an identifying assumption of common immunization trends to be satisfied in the two groups of states. This identifying assumption is presented in great detail in the paper.

Additionally, the paper controls for a host of state-time varying covariates relevant to the public health set-up and which may have an effect on immunization delivery as these are likely to be sources of omitted variable bias. Here, it is found that controlling for the differential increase in the number of *anganwadi* centers in high focus states, an institution highly relevant for immunization provision, revises the treatment effect of the ASHA worker program downwards by a significant amount but after controlling for this covariate the model is highly robust to a host of other state-time varying covariates and state-time trends.

The model estimates statistically significant increases in the range of 14%-22% in the coverage of specific vaccines and the provision of full immunization in high focus states and a reduction in the percentage of infants with no immunization of up to 16%.

An explanation of the results is attempted by exploring other available data on the functioning of the ASHA worker. In particular, I look at the change in the coverage of outreach activities by health personnel between 2004 & 2008, the major channels through which mothers are motivated to get their child immunized and the change in the composition of reasons that mothers cite to not get their child immunized. Finally, I present a preliminary take on the indirect effects of the ASHA worker on immunization via spill-overs through other tasks.

Appendix- Tables and Figures

Table 1- Summary of cohorts of infants aged 12-23 months

Cohort	Interviewed In	Born between	Number of Infants
1	1998	Feb 1996-Dec 1997	31511
2	1999	Feb 1997-Dec 1998	35192
3	2002	Feb 2000-Dec 2001	28670
4	2004	Feb 2002-Dec 2003	30502
5	2008	Feb 2006-Dec 2007	60775

Source: DLHS 1, DLHS 2, DLHS 3

Table 2- Percentage of 12-23 month olds immunized in high & non focus states

	BCG		DPT 3		OPV 3		Measles		Full		None	
	High	Non	High	Non	High	Non	High	Non	High	Non	High	Non
cohort 1	61.49	87.46	50.53	80.82	53.93	81.77	41.59	73.52	35.56	67.59	32.07	8.41
cohort 2	61.90	87.91	50.42	80.87	52.52	81.83	44.96	77.23	37.23	69.80	32.97	8.20
cohort 3	61.97	90.34	40.45	79.41	41.76	78.11	38.88	76.01	27.02	65.85	33.14	7.34
cohort 4	63.16	91.69	40.63	82.21	41.17	82.77	40.33	76.78	29.60	71.00	33.45	6.39
cohort 5	82.21	94.03	53.54	78.24	55.88	81.72	60.42	82.55	43.35	69.64	15.70	4.63

Note: Children are fully immunized if they receive 1 dose of BCG vaccine, 3 doses of DPT vaccine, 3 doses of Polio vaccine (excluding Polio 0) and 1 dose of measles vaccine as recommended by MoHFW guidelines. 'None' refers to children who do not receive any of the 4 groups of vaccines. All figures are calculated for the sample of rural infants in the age group.

Source: DLHS 1, DLHS 2, DLHS 3

Table 3- Percentage of Villages with ASHA Worker in each State

High-Focus States		Other States	
State	**Percentage**	**State**	**Percentage**
Jammu & Kashmir	72.70	Punjab	69.05
Himachal Pradesh	24.42	Chandigarh	79.66
Uttarakhand	75.74	Haryana	80.46
Rajasthan	73.86	Delhi	31.08
Uttar Pradesh	86.39	West Bengal	13.40
Bihar	80.30	Gujarat	38.57
Sikkim	80.77	Daman & Diu	10.91
Arunachal Pradesh	72.88	Dadra & Nagar Haveli	38.79
Manipur	71.95	Maharashtra	10.20
Mizoram	68.39	Andhra Pradesh	69.13
Tripura	89.06	Karnataka	15.55
Meghalaya	75.87	Goa	0.00
Assam	85.76	Lakshadweep	100.00
Jharkhand	53.93	Kerala	29.04
Orissa	57.52	Tamil Nadu	1.20
Chhattisgarh	91.05	Pondicherry	4.77
Madhya Pradesh	74.06	Andaman & Nicobar	42.59

Source: DLHS 3

Table 4- Descriptive Statistics on different NRHM provisions in high & non focus states

	High Focus	Non Focus
% of villages with an ASHA worker	74.02	33.04
Average number of ASHA workers who have completed first round of training in Sub-Center area	4.60	1.66
% of Sub-Centers that have received untied funds	76.26	89.14
% of Sub-Centers that have fully utilized untied funds	28.92	50.13
% of Sub-Center areas that have a Village Health & Sanitation Committee	63.96	84.64
% of Primary Health Centers that have received untied funds	65.34	87.20
% of Primary Health Centers that have fully utilized untied funds	24.26	48.02
% of Community Health Centers that have received untied funds	81.82	90.09
% of Community Health Centers that have fully utilized untied funds	32.62	46.06
% of District Hospitals with a Rogi Kalyan Samiti (RKS)	86.61	93.43

Source: DLHS 3

Table 5- Regression results from equation (3) estimated using cohorts 1-5
(DID estimates (δ) of the effect of the ASHA worker program on the probability of immunization)

	BCG	DPT3	OPV3	Measles	Full	None
Baseline	0.167***	0.169**	0.158**	0.143**	0.151**	-0.160***
With Individual Level Covariates	0.173***	0.175***	0.164**	0.151**	0.159**	-0.166***
With state-fixed effects	0.168***	0.167**	0.159**	0.145**	0.148**	-0.165***
With state-time trends	0.122***	0.153***	0.169***	0.130**	0.174**	-0.111***

Notes:

1) + $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

2) The individual level covariates are the infant's age, infant's gender, mother's age, mother's age at marriage, total number of children born to the mother, religion and caste of the household and type of house (kuccha or pucca).

3) The R-squared of the final set of regressions ranges between 0.17 and 0.20 and the number of observations is 144,598.

Table 6- Regression results from the model estimated using cohorts 4 & 5
(DID estimates of the effect of the ASHA worker program on the probability of immunization)

	BCG	DPT3	OPV3	Measles	Full	None
Baseline	0.167***	0.169**	0.158**	0.143**	0.151**	-0.160***
With Individual Level Covariates	0.176***	0.182***	0.169***	0.158**	0.165**	-0.168***
With state-fixed effects	0.174***	0.172***	0.162**	0.148**	0.150**	-0.169***
With "% of villages with an anganwadi center" covariate	0.105*	0.145*	0.162*	0.0997	0.127+	-0.0936*
With all other state-time varying covariates (Including the anganwadi center covariate)	0.169***	0.187**	0.224***	0.166***	0.149***	-0.162***

Notes:
1) + p<0.10, * p<0.05, ** p<0.01, *** p<0.001

2) The state-time varying covariates are % of villages (in a state) that have a government dispensary, % of villages that have a private clinic, % of villages that have a sub-center, % of villages with a PHC, % of villages with a CHC, % of villages with a government hospital, % of village with a private hospital, average distance of a government dispensary from a village, average distance of a private clinic from a village, average distance of a SC from a village, average distance of a PHC from a village, average distance of a CHC from a village, average distance of a private hospital from a village, % of villages with an anganwadi center, % of villages with a mobile health clinic visit, % of sub-centers who received untied funds as part of NRHM, % of sub-centers that utilized untied funds and % of sub-center areas that formed a Village Health and Sanitation Committee.

3) The R-squared of the final set of regressions varies between 0.15-0.19. The number of observations is 68,672 and the individual level covariates are the same as in Table 5.

Robustness Check Tables (7.1-7.5)

Table 7.1- Difference-in-Differences (DID) estimates for different cohorts born prior to the intervention

	BCG			DPT 3			OPV 3		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 1	0.615	0.873		0.505	0.807		0.54	0.817	
Cohort 2	0.619	0.878		0.504	0.808		0.526	0.819	
Difference	0.004	0.005	-0.001	-0.001	0.001	-0.002	-0.014	0.002	-0.016
	Measles			Full			None		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 1	0.416	0.734		0.355	0.674		0.319	0.084	
Cohort 2	0.45	0.771		0.3717	0.6977		0.328	0.081	
Difference	0.034	0.037	-0.003	0.0167	0.0237	-0.007	0.009	-0.003	0.012

Table 7.2- Difference-in-Differences (DID) estimates for different cohorts born prior to the intervention

	BCG			DPT 3			OPV 3		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 2	0.619	0.879		0.505	0.809		0.525	0.819	
Cohort 3	0.619	0.902		0.406	0.794		0.418	0.781	
Difference	0	0.023	-0.023	-0.099	-0.015	-0.084	-0.107	-0.038	-0.069
	Measles			Full			None		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 2	0.45	0.772		0.372	0.698		0.329	0.081	
Cohort 3	0.391	0.761		0.271	0.658		0.331	0.074	
Difference	-0.059	-0.011	-0.048	-0.101	-0.04	-0.061	0.002	-0.007	0.009

Table 7.3- Difference-in-Differences (DID) estimates for different cohorts born prior to the intervention

	BCG			DPT 3			OPV 3		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 3	0.62	0.903		0.405	0.794		0.418	0.781	
Cohort 4	0.632	0.916		0.406	0.821		0.4115	0.827	
Difference	0.012	0.013	-0.001	0.001	0.027	-0.026	-0.0065	0.046	-0.052
	Measles			Full			None		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 3	0.389	0.760		0.27	0.658		0.33	0.073	
Cohort 4	0.402	0.767		0.296	0.709		0.333	0.064	
Difference	0.013	0.007	0.006	0.026	0.051	-0.0257	0.003	-0.009	0.012

Table 7.4- Difference-in-Differences (DID) estimates for different cohorts born prior to the intervention

	BCG			DPT 3			OPV 3		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 1	0.615	0.873		0.505	0.807		0.54	0.817	
Cohort 3	0.62	0.902		0.405	0.794		0.419	0.781	
Difference	0.005	0.029	-0.024	-0.1	-0.013	-0.087*	-0.121	-0.036	-0.085*
	Measles			Full			None		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 1	0.416	0.734		0.355	0.674		0.319	0.084	
Cohort 3	0.389	0.759		0.271	0.658		0.329	0.073	
Difference	-0.027	0.025	-0.052	-0.084	-0.016	-0.068	0.01	-0.011	0.021

Table 7.5- Difference-in-Differences (DID) estimates for different cohorts born prior to the intervention

	BCG			DPT 3			OPV 3		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 2	0.619	0.879		0.505	0.809		0.525	0.819	
Cohort 4	0.632	0.916		0.407	0.821		0.412	0.827	
Difference	0.013	0.037	-0.024	-0.098	0.012	-0.11**	-0.113	0.008	-0.121**
	Measles			Full			None		
	High	Non	Difference	High	Non	Difference	High	Non	Difference
Cohort 2	0.45	0.772		0.372	0.698		0.329	0.081	
Cohort 4	0.405	0.768		0.296	0.709		0.334	0.064	
Difference	-0.045	-0.004	-0.041	-0.076	0.011	-0.087*	0.005	-0.017	0.022

Table 8: Percentage of mothers who have received advise/consultation by a doctor or a health worker

	High Focus		Non Focus	
	2004	2008	2004	2008
Immunization	38.11	71.56	78.62	78.90
Institutional Delivery	18.99	23.32	50.83	39.01
Family Planning	7.87	16.63	18.98	24.64
RTI/STI	7.7	16.79	10.33	22.17
AIDS	14.85	18.46	11.98	21.43

Notes:

1) For immunization, institutional delivery and family planning, DLHS 3 questioned respondents about each source (including family members, NGOs) separately. Responses are re-coded into a dummy that takes value 1 if responded was motivated by a doctor, ANM, other health worker, anganwadi worker or ASHA worker to avail of a particular service. DLHS 2 simply asks if the respondent was motivated by a doctor/health worker.

2) Sample includes respondents interviewed in 2004 and 2008 only, to maintain consistency with cohorts 4 and 5

Table 9: Sources of motivation to get child immunized in 2008

	High Focus	Non Focus
Doctor	9.93	17.61
ANM	33.2	42.93
Health Worker (other)	6.93	7.84
Anganwadi Worker	32.32	40.54
ASHA	10.32	2.13
NGO/CBO	0.84	0.30
Husband	19.57	26.28
Mother-in-law	9.69	16.35
Mother	5.44	12.37
Relatives/Friends	23.83	21.38
Self	34.74	40.87
Other	1.21	0.82

Note: This table tabulates the percentage of mothers, of infants in cohort 5, who responded 'yes' when asked if each source listed above motivated the respondent to get their child immunized.

Table 10: Reasons for not getting child immunized in high & non-focus states

	High Focus		Non Focus	
	Cohort 4	Cohort 5	Cohort 4	Cohort 5
Child too young for immunization	1.85	5.76	1.39	12.34
Unaware of need for immunization	40.84	37.2	27.42	31.17
Place of immunization unknown	10.24	3.75	6.93	1.95
Time of immunization unknown	5.13	4.30	10.8	3.9
Fear of side-effects	6.09	9.51	10.8	11.69
No faith in immunization	2.81	3.66	3.32	4.55
Place of immunization too far to go	8.16	9.32	7.48	3.25
Time of immunization inconvenient	1.61	2.56	1.94	1.3
ANM absent	8.74	8.68	4.43	4.55
Vaccine not available	1.39	0.91	0.55	0.65
Mother too busy	4.81	4.2	5.82	9.09
Family problem, including illness of mother	2.46	0.82	2.22	4.55
Child ill, not brought	1.07	3.2	2.22	5.84
Child ill, brought, but not given	0.28	1.19	0.00	0.65
Long waiting time	0.28	0.09	0.55	0.65
Financial Problem	-	1.55	-	0.00
Child is girl	-	1.37	-	0.00
Other	3.74	1.92	14.13	3.9
Number of Observations	4598	1094	361	154

Notes:

1) Each row contains the percentage of mothers of infants in cohorts 4 & 5 who listed the given reason as the reason for not getting their child immunized.

2) The tabulations are to be treated with some caution. In DLHS 2 (cohort 4) respondents were asked to state a single reason but in DLHS 3 (cohort 5) they stated multiple reasons. For comparability in the latter case, I limit the sample to those individuals who only stated a single reason.

3) The sample is limited to individuals whose infants received no vaccination.

Table 11- Predicted probability of immunization for infants whose mothers were motivated for antenatal care and institutional delivery by an ASHA worker in high focus states

	Institutional Delivery	
	Motivated for Delivery	Not Motivated for Delivery
BCG	0.712	0.706
DPT3	0.477	0.411
OPV3	0.499	0.439
Measles	0.517	0.472
Full	0.376	0.314
None	0.255	0.266
	Antenatal Care (ANC)	
	Motivated for ANC	Not Motivated for ANC
BCG	0.720	0.672
DPT3	0.444	0.371
OPV3	0.480	0.402
Measles	0.523	0.437
Full	0.367	0.278
None	0.258	0.299

Notes:

1) Predicted probabilities are for immunization of infants whose mothers received motivation for institutional delivery/ANC *only* from an ASHA worker and received no motivation for immunization by *any* doctor/health worker.

2) Predicted probabilities are obtained from a linear regression model.

Table 12- Predicted probability of immunization for infants whose mothers were motivated for antenatal care and institutional delivery by ASHA worker in non-focus states

	Institutional Delivery	
	Motivated for Delivery	Not Motivated for Delivery
BCG	0.793	0.902
DPT3	0.464	0.698
OPV3	0.524	0.750
Measles	0.568	0.757
Full	0.359	0.613
None	0.174	0.076
	Antenatal Care (ANC)	
	Motivated for ANC	Not Motivated for ANC
BCG	0.896	0.905
DPT3	0.654	0.704
OPV3	0.720	0.750
Measles	0.841	0.761
Full	0.589	0.619
None	0.071	0.085

Notes:

1) Predicted probabilities are for immunization of infants whose mothers received motivation for institutional delivery/ANC *only* from an ASHA worker and received no motivation for immunization by *any* doctor/health worker.

2) Predicted probabilities are obtained from a linear regression model.

Table 13: OLS results for indirect effects on immunization via mothers who were motivated by ASHA for ANC and institutional delivery

	Institutional Delivery		ANC	
	High Focus	Non-Focus	High Focus	Non-Focus
BCG	0.00605	-0.109*	0.0484***	0.00933
DPT3	0.0667***	-0.234***	0.0735***	-0.0498
OPV3	0.0599***	-0.226***	0.0775***	-0.0305
Measles	0.0451**	-0.189*	0.0861***	0.0802*
Full	0.0622***	-0.254***	0.0898***	-0.0297
None	-0.0108	0.0984*	-0.0408***	-0.0146
No. of observations	35,215	12,637	33,935	12,037
R-squared	0.065	0.027	0.078	0.031

Notes:
1) Reported coefficients are for dummies of whether the infants' mother was motivated by an ASHA worker for institutional delivery/ANC.

2) Variables controlled for are receipt of motivation for institutional delivery/ANC by doctor, ANM, other health worker, *anganwadi* worker, ASHA, NGO/CBO, husband, mother-in-law, mother, relatives/friends, self and others and whether or not responded was motivated for immunization by doctor, ANM, other health worker and *anganwadi* worker.

3) R-squared is of the final regression with dependent variable "none".

Figure 1- Immunization Trends in High & Non Focus Indian States

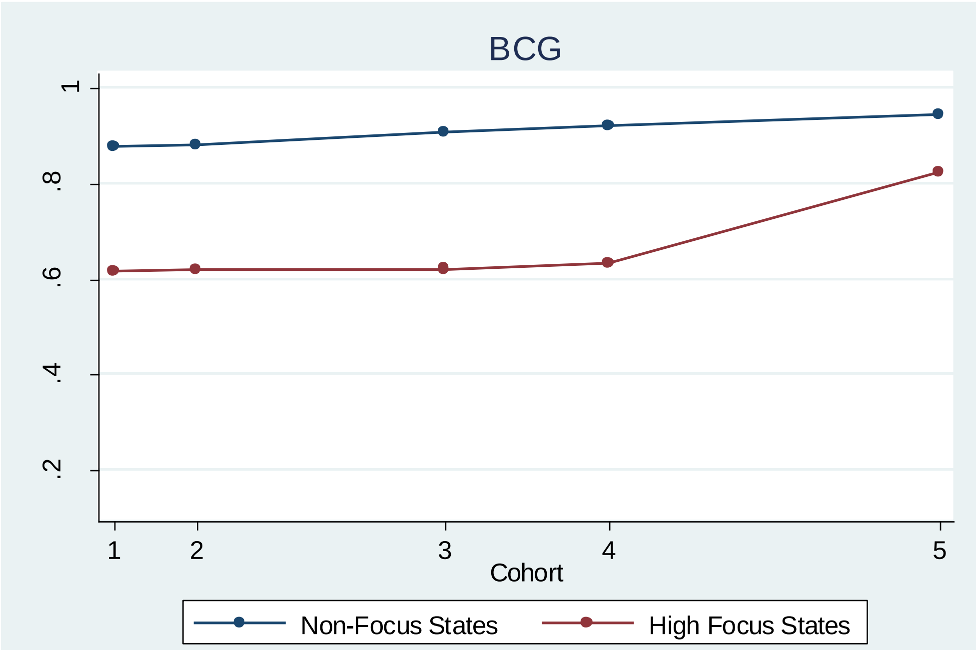

Figure 1.1

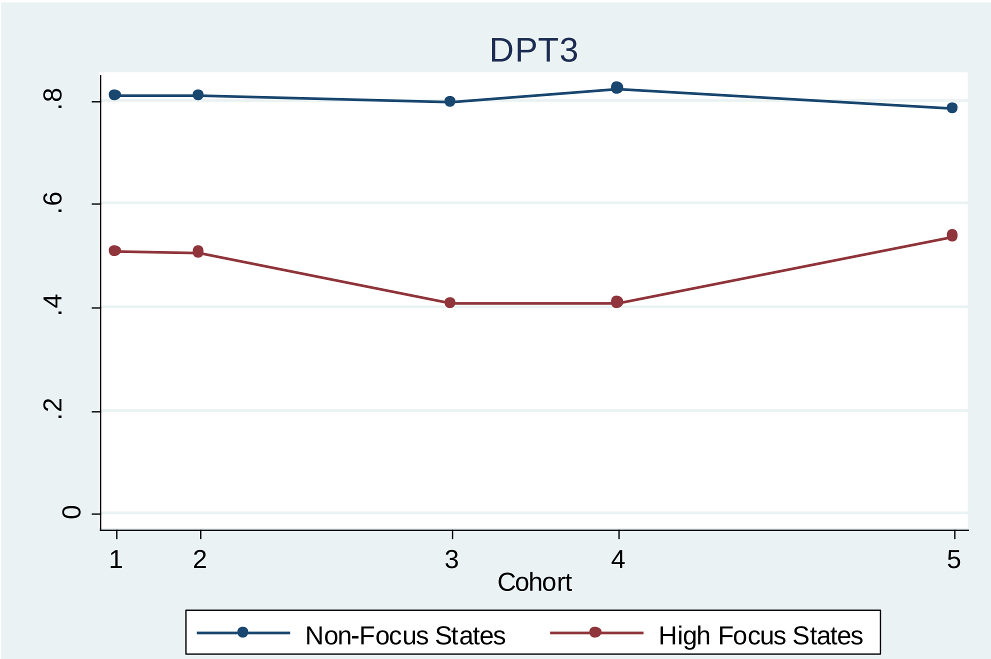

Figure 1.2

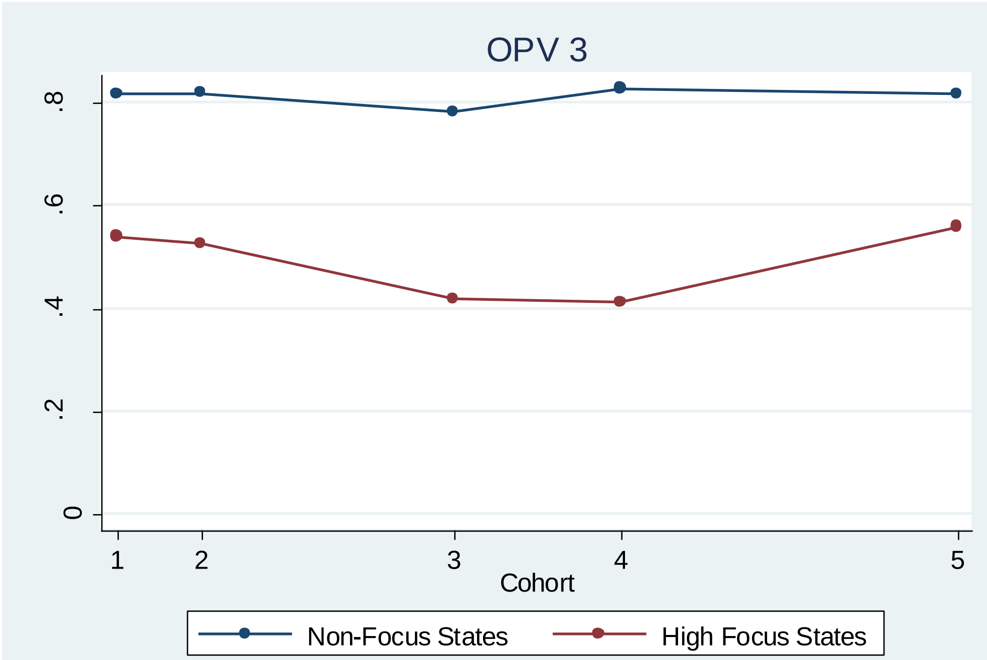

Figure 1.3

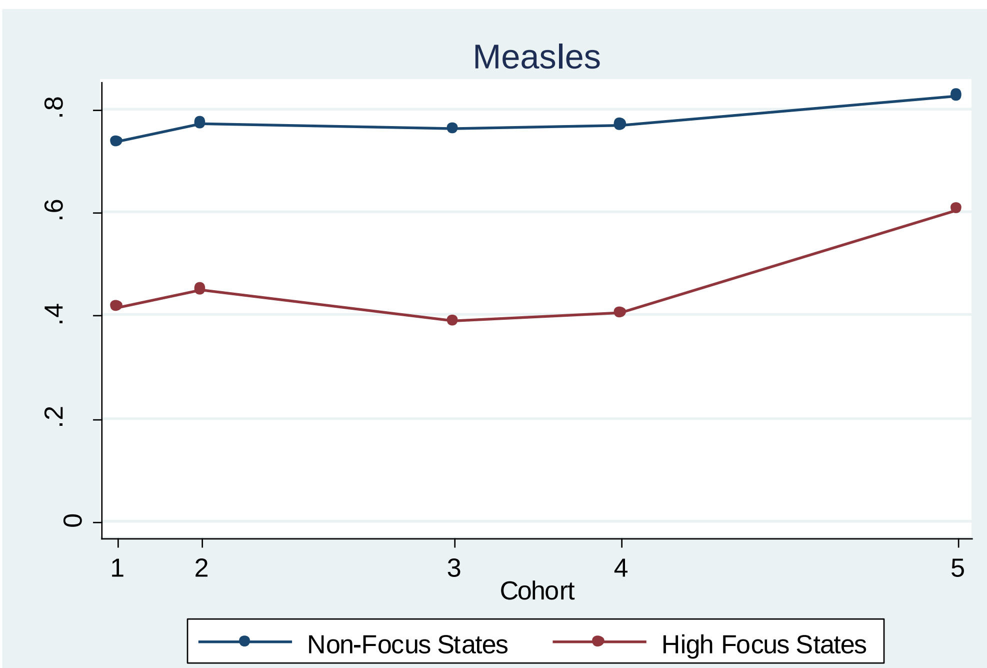

Figure 1.4

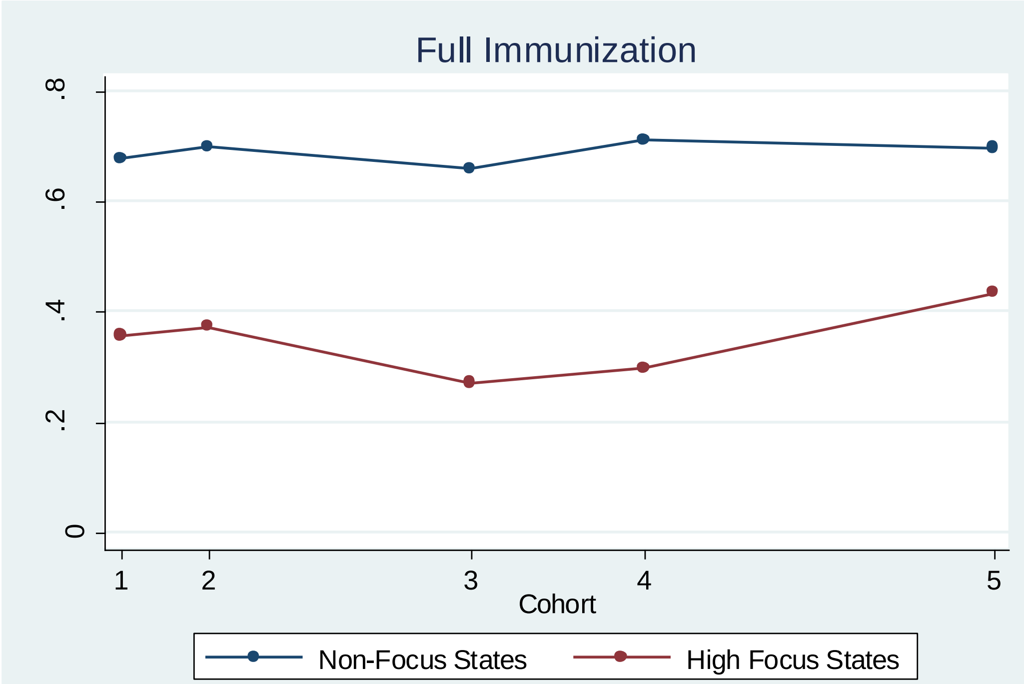

Figure 1.5

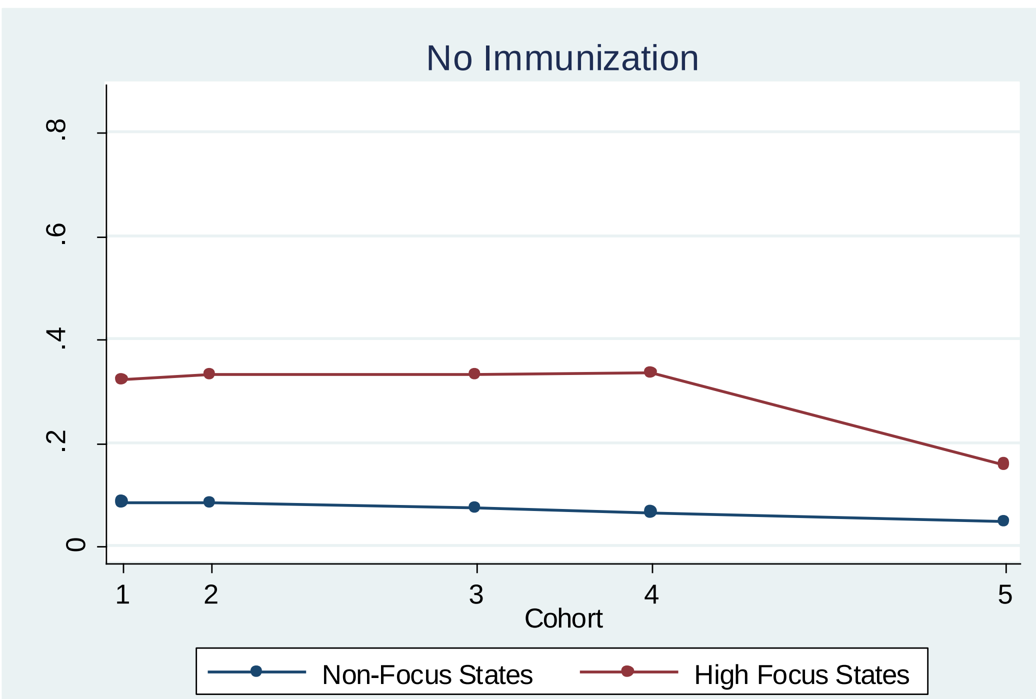

Figure 1.6

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