# Rural Road Connectivity & Its Effects on Access to Health Care:

## Evidence from India's PMGSY Project

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ABSTRACT

The Pradhan Mantri Gram Sadak Yojana (PMGSY) is a project designed by the Indian government in 2000 to bridge the large infrastructural inequalities that exist between rural and urban regions of India. The project's goals are to construct all-weather roads in rural habitations throughout the majority of India. In 2013, a phase two, PMGSY-II, was initiated to put more emphasis on intra-village road systems and improve access to important village institutions, such as health centers. This paper studies the impact of PMGSY on accessibility to health care facilities in rural India using a difference-in-differences framework. Using data from the Women's Questionnaire in the 2015-2016 Demographic and Health Surveys in India and district level information on roads from the PMGSY public database, I exploit the timing of PMGSY-II roads as a source of exogenous variation in access to health centers. To measure access to health facilities, I examine changes in health care utilization for births occurring from 2010 to 2016. I find that antenatal care and Tetanus vaccinations for mothers improved along with respondents' ability to access vehicle transportation to health facilities in districts treated with PMGSY-II roads. However, while there has been some research conducted on road connectivity and its impacts, more research is needed to continue bolstering the growing body of literature on the effects of rural road development.

## INTRODUCTION

India is one of the fastest growing developing economies in the world. India's growth has led to a great accumulation of wealth, but rural regions across the country remain severely underdeveloped and impoverished. The Human Development Index (HDI), rated India at a .645 in 2020, which places it 131st out of the 189 countries ranked.[1] However, India's *inequality*-adjusted HDI is significantly lower at .475, indicating that health, education, and income are actually worse when accounting for extreme inequalities throughout Indian society.[2,3] The unequal distribution of resources, especially funding for infrastructure between rural and urban areas, contributes greatly to socioeconomic disparities in India. The Pradhan Mantri Gram Sadak Yojana (PMGSY) is a prominent example of a project designed by the Indian government to simultaneously bridge the large infrastructural disparities that exist between rural and urban India and reduce severe poverty in rural regions.

Rural road development is critical because it is a type of economic infrastructure that improves and enables integration of different economic activities.[4] All developing countries, including India, should provide basic infrastructure to everyone in order to stimulate and maintain inclusive economic growth.[5] The alternative, a lack of adequate infrastructure throughout a country, makes economic operations less profitable, which in turn adversely affects the economy.[6] In fact, "in some countries, inadequate and imbalanced infrastructure is the main factor preventing an acceleration of growth, and in such cases, policies focusing on providing infrastructure would boost investment and growth the most." From this evidence, it is clear that rural road development, through projects similar to the PMGSY, are essential to facilitate rural economic development, improve the well-being of rural people, and reduce poverty.

The PMGSY-I project, initially proposed in 2000, sought to provide new connectivity with climate-resistant roads to remote, rural villages, and to upgrade existing roads and localities to habitations of designated population size.. However, the PMGSY-I roads and other rural roads excluded from the PMGSY scheme were receiving poor maintenance and were not facilitating transportation of people, goods, and services. The project manual for the PMGSY-II project stated that PMGSY-I roads were not receiving adequate attention and care.[7] Therefore, a PMGSY-II scheme was introduced in 2012 to consolidate the maintenance, upgradation, and development of existing rural networks to improve the overall efficiency of transportation to rural market centers in an effort to fulfill their primary goal of poverty reduction.[8]

The PMGSY-II scheme, sanctioned in 2013, focused on the upgradation of roads that directly lead to a large market center or connected habitations to other routes that lead directly to a market center.[9] To identify which roads

were most important for upgradation, the project labeled essential routes as either Through Routes (TRs), which directly lead to a large market center, or Link Routes (LRs), that connect a single habitation or multiple habitations to a TR.[10] These important routes were labeled this way because of their ability to provide better access to essential social and economic services.[11] Based on this evidence, it is clear that the PMGSY-II project put more emphasis on developing intra-village road systems and improving access to important village institutions, such as health centers.[12]

The constructed and upgraded roads in the PMGSY-II project were built to connect people to large market centers, providing them a more direct route to fundamental facilities including health centers and hospitals.[13] However, despite project efforts, a severe lack of access to healthcare and health facilities persists in rural India today.[14] Improving overall health within a country is critical for improving both education access and worker productivity, as well as ensuring the overall well-being of the population as a whole.[15] Therefore, the provision of adequate healthcare is necessary to increase a country's growth and development. Consequently, my research contributes to the growing body of literature in development economics on the relationship between road connectivity in rural regions and the amelioration of extreme poverty. Specifically, this study explores the extent to which the PMGSY- II project fulfilled its commitment to improving access to healthcare in order to better understand what needs to be done in the future to address this lingering problem.

Although there have been a number of studies conducted on the socioeconomic impacts of large-scale roads projects, many have emphasized the need to continue to study these projects citing a lack of research on the impacts of increased road connectivity on *rural* societies. In this paper, I seek to fill this gap in the literature by researching how lower transportation costs and travel times, a result of better and more direct roads to necessary health facilities, affect rural habitations' access to different health services. My study seeks to answer the following question: How has improved road connectivity provided by the PMGSY-II project affected access to maternal and child health care throughout rural India?

## DATA

To answer my research question, I analyze data accessed via the Demographic and Health Surveys (DHS) in India and the PMGSY public database. The DHS of India has administered four surveys, one in each of the following year spans: 1992-1993, 1998-1999, 2005-2006, and 2015-2016. These surveys included a women's questionnaire containing information on women and children's health. For my main analysis, I utilize the most recent DHS from

2015-16, where 699,686 women ages 15-49 completed the survey.[16] The survey records all births between 2010-2016; critically, this data includes the interval during which the PMGSY-II roads were constructed.. Thus, the DHS from 2015-2016 contains a data set that is uniquely useful in identifying the effects of the PMGSY-II project.

To measure respondents' ability to access health services, I focus on variables included in the Women's Questionnaire from the 2015-2016 DHS that are related to births. From this survey, I am able to extract district-level information for each birth that was reported between 2010-2016, and specific data on births from before and after the treatment year, 2013, when roads were constructed in the PMGSY-II scheme.

Additionally, I use information from the PMGSY public database to establish when and where roads were constructed at the district level throughout India in 2013. This information is gathered through an Online Management, Monitoring & Accounting System (OMMAS) included on the PMGSY project website. This system records information on the construction and timing of each road built under the PMGSY program as well as information on the population size, connectivity status, and the year when roads were constructed for each habitation; the population of villages that received roads was exogenously determined by local project directors. Finally, the PMGSY database is utilized to determine which districts received roads, or were treated, in 2013.

## EMPIRICAL STRATEGY

### *EMPIRICAL SPECIFICATION*

I employ a Difference-in-Differences (DD) technique to measure the causal impact of the placement of the PMGSY roads on the performance of and accessibility to health centers in rural India. The specification is given as follows:

$$(1)\ Y_{idt} = \alpha + \beta_1 PMGSY_i \times Post_t + \beta_2 PMGSY_i + \beta_3 Post_t + X'_{it}\theta + u_{it} \quad (1)$$

where $Y_{idt}$ is the outcome of variables for women and their children in household i, in district d, at time t. *PMGSY* is the dummy variable for whether the district received a road from the PMGSY-II scheme. *Post* is the dummy variable that indicates whether the time period is before or after the PMGSY-II roadwork in 2013. $X'_{it}$ is the vector of individual characteristics that include: age of respondent, the wealth index of the respondent, if the respondent received some level of education, if the child lives with the respondent, if the respondent lives in a rural or urban area, and if the respondent is in a caste or tribe. Lastly,

$u_{it}$ is the error term and I cluster standard errors at the district level.

Another essential aspect of this analysis is that I control for both District Fixed Effects (DFE) and Year Fixed Effects (YFE). DFE control for differences across districts that are constant over time. YFE control for time-trends, or effects that remain the same across districts but change over time.[17] Additionally, I control for a small number of districts that ended up receiving roads in 2014 rather than in 2013.

To estimate any causal effect using the DD technique, some assumptions must be met. The most important assumption is the parallel trends assumption. This assumption states that the control group, or the untreated districts, provide the appropriate counterfactual of the trend that the treatment group, or the treated districts, should follow if they had not received the PMGSY-II roads. Therefore, in the absence of treatment, both control and treatment groups are assumed to trend similarly and to remain constant over time. Although the parallel trends assumption is untestable, the presence of pre-trends in the data across districts lends itself to the conclusion that the impact estimated in the study is a direct result of the treatment.

## *TREATMENT AND CONTROL SPECIFICATION*

The Treatment and Control groups are formed using the criteria of whether or not certain districts received PMGSY-II roads in 2013. However, to identify which roads were most critical to construct and would deliver the highest returns, the National Rural Infrastructure Development Agency selected roads for construction based on the amount of growth centers that fell on each potential route. Growth centers were identified as having "a high population, high level of educational facilities, good health service facilities, good agricultural produce markets (mandis)," and were "well served by buses, railways, [were] already electrified, [had] retail shops selling agricultural inputs and items of daily consumption and postal facilities etc."[18] Due to the use of this specific system to determine what roads would produce the highest returns, there is exogenous variation in road construction of PMGSY-II roads.

The Indian states affected by PMGSY-II roads were Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Telangana and Uttar Pradesh.[19] Therefore, the districts within these states that received PMGSY-II roads in 2013 comprise the Treatment group, while the districts that did not receive PMGSY-II roads in these states comprise the Control group. In total, 286,342 births, 190,898 women, and 640 districts were included in this analysis, and within that, 51 districts and 20,018 people were treated in 2013. My analysis focuses on the implementation of the PMGSY-II roads sanctioned in 2012 and constructed in 2013 in these 51 districts within these six states.

I concentrate my analysis on the PMGSY-II project for multiple reasons.

First, because PMGSY-II roads were approved in these six states, there is a strong source of variation in PMGSY-II road development, as these states had already completed the first phase of the PMGSY project. Additionally, the timing of roads constructed under PMGSY-II is critical because the birth data extracted from the 2015-2016 DHS is available before and after the intervention of PMGSY-II roads built in 2013. Finally, the PMGSY-II project identified a more specific objectiv of phase two project roads, which was to ensure better access to growth centers and "other rural places of importance (growth poles, rural markets, tourist places, education and health centres etc.)."[20]

## OUTCOMES

In this project, I study the effects of building connecting roads on rural Indians' ability to access health care services. The main outcome of interest is whether improved road connectivity increases access to professional health care services. I hypothesize that households in districts that gained access to PMGSY-II roads will have better access to health care services in India than households in districts that did not.

To measure access to health care services, I surveyed and created a variety of outcome variables related to antenatal care, delivery, and postnatal care. I use these specific outcomes to measure access to healthcare because the 2015-2016 DHS only includes data from before and after 2013 related to *births*, whereas most other health information collected is correlated to the time the survey was administered, between 2015 and 2016. In this paper, I separate the different outcome variables as they relate to mothers' care, children's care, and delivery data.

First, there are outcomes to measure whether mothers received improved care surrounding the delivery of their child as a result of improved road connectivity. There are two outcomes related to antenatal care that are divided into two categories; the first antenatal outcome measures if the respondent received antenatal care at a health facility for each birth, labeled ANC, and the second, labeled ANC Visits, measures each respondent's number of antenatal visits to a facility before each birth. The ANC Visits outcome is based off of the World Health Organization's (WHO) recommendation that eight antenatal visits are necessary before the delivery of a child, and therefore women who received eight or more antenatal check-ups are considered to have received adequate antenatal health care.[21] Additionally, there is an outcome for whether the respondent received two doses of the tetanus toxoid, as recommended by the WHO, and this outcome is labeled Tetanus.[22] Finally, there is an outcome to determine whether the respondent received at least one check-up at any point after their delivery, and this indicator is labeled Check After. These outcomes relating to health care for mothers are located in Table 3.

Next, I investigate care surrounding the children born of these respondents from 2010 to 2016. The specific child vaccinations I use as outcomes include the Polio vaccine, BCG vaccine (used against tuberculosis), DPT vaccine (used against diphtheria, pertussis, and tetanus) and the Hepatitis B vaccine.[23] These vaccines are chosen as outcomes based on the information that was provided in the 2015-2016 DHS. Children of respondents are considered to have received the vaccination if their vaccination cards indicated this or if the mother reported they received the specified vaccination. The respective labels for these vaccinations are Polio, BCG, DPT and Hep. Finally, there is an outcome that determines whether a baby received a check-up within two months of delivery or not. This outcome is labeled Postnatal. All of these outcomes related to care for children are found in Table 4.

Finally, I look at two outcomes that examine the modes of transportation used to travel to a health facility for respondents' delivery, and the location of that delivery. For the outcome that indicates whether a respondent received more advanced vehicle transportation to a health facility for their child's delivery, I first determined what modes of transportation would require better, more developed road access. Respondents who acquired transportation to a health facility with a vehicle, specifically an ambulance, government ambulance, car, motorcycle, or bus/train, are considered to have taken transportation that required more developed roads. Respondents who were transported to a health facility for their baby's delivery by a tractor, cart, or on foot are considered to have used less sophisticated modes of transportation that would not have required developed roads. This outcome variable determines whether or not respondents were able to increase their use of advanced transportation which requires better road quality and connectivity to access. This indicator variable is labeled Transport. Additionally, I create an outcome labeled Delivery Location. This outcome determines whether the respondent delivered their child at any type of public or private health facility as opposed to at a home. This indicator variable helps determine whether PMGSY-II roads facilitated access to health facilities that provide more professional care during childbirth. These outcomes regarding the delivery of a child are found in Table 5.

The outcomes for antenatal and postnatal care, for tetanus injections, and for children's vaccinations suggest whether respondents were able to access health services more easily or more directly. First, looking at whether respondents received antenatal and postnatal care reveals the extent to which women had access to health services to ensure the protection of themselves and their children. Moreover, it is logical to assume that respondents' ability to access health services related to the birth of their child is reflected in the overall health of their child post-delivery. Lastly, looking at respondents' ability to access more sophisticated modes of transportation to health facilities for their delivery and respondents' ability to deliver at a health facility can explain how

PMGSY-II roads improved transportation for respondents to health facilities. These different groups of outcomes measure accessibility to health facilities in many ways and work to directly address the research question posed at the onset of this paper.

## RESULT

For Tables 3 through 5, the outcome variables are divided into two columns to compare the DD coefficients when accounting for District Fixed Effects (DFE) and when not accounting for DFE. Values with DFE are more accurate, as they absorb differences in non-time varying characteristics across all districts. This is done to analyze the impact of controlling for the unobservable heterogeneity of districts.

In Table 3, the statistically significant outcomes are the ANC and Tetanus outcomes. The analysis shows that the ANC outcome improved by 2.8 percentage points and is significant at the 5% level. However, when accounting for DFE in the analysis, we see that the ANC outcome actually increases by 3.3 percentage points and is significant at the 1% level. This is important because it indicates that the antenatal outcome with DFE is a more accurate value (as it includes more controls) and also a more statistically significant value. Given this information, we can determine that women in treated districts were actually approximately 5.5% more likely to receive antenatal care at a health facility than in untreated districts. In addition to improvements in antenatal care, we also see improvements in tetanus injections for respondents in treated districts as well. Without DFE, we see the Tetanus outcome improves by 1.9 percentage points in treated districts and this value is significant at the 5% level. When employing DFE, the Tetanus outcome actually increases by about 1.5 percentage points and is significant at the 10% significance level. Given this data, we evaluate that PMGSY-II roads improved the treated respondents' ability to receive the appropriate dosage of tetanus toxoid before delivery by about 2.0%.

In Table 4, the statistically significant results are the DPT, Polio, and BCG outcomes. When not accounting for DFE, we see the DPT outcome increases by 2.4 percentage points, the Polio outcome increases by 2.3 percentage points, and the BCG outcome increases by 2.6 percentage points. All of these values are significant at the 1% level. When taking into account DFE, however, the positive effects of the PMGSY-II roads on all of these outcomes are diminished and no longer significant.

In Table 5, Transport and Delivery Location outcomes are both statistically significant. With no DFE, we see that the Transport outcome improves by 7.14 percentage points and the Delivery Location outcome improves by 2.1 percentage points. Both of these findings are significant at the 1% level.

When applying DFE, we see that the Transport outcome increases by only 3.3 percentage points and is statistically significant at the 5% level, but the Delivery Location results are diminished and no longer statistically significant. Given this information on the Transport outcome though, we deduce that PMGSY-II roads actually improved the treated respondents' access to vehicle transportation to health facilities by about 7.3%.

The data for DPT, Polio, BCG and Delivery Location outcomes were diminished and no longer significant when taking into account DFE. The lack of significance means that the estimators without DFE were biased. The estimators for these outcomes exhibited positive bias before DFE were applied, which means that the effects of the PMGSY-II roads were overestimated. Consequently, we see that when districts' heterogeneity is accounted for through the application of DFE, the DD coefficients for these outcomes are notably reduced and are no longer significant.

Despite the bias in a few of the outcome estimators, we can determine from the data that PMGSY-II roads had a statistically significant effect on improving respondents' ability to access antenatal care, tetanus injections, and more sophisticated transportation to health facilities.

The ability to access modes of vehicle transportation to a health facility for childbirth is important because it is a direct indicator of whether the roads actually improved transportation and connection to critical human services. Women were 7.3% more likely to access transportation by ambulance, government ambulance, car, motorcycle, or bus/train to a health facility if they resided in districts with PMGSY-II roads. This percentage increase reflects that treated respondents had better access to public transportation thereby improving the accessibility to vital health services. These improvements can be directly attributed to the PMGSY-II project. This finding is especially encouraging as it suggests that PMGSY-II roads had a positive effect on respondents' ability to easily access health care services, one of the main objectives of the PMGSY project.

## ROBUSTNESS

### *PRE-TRENDS*

To ensure the validity of my findings, it is necessary to determine whether Treatment and Control groups trend similarly before the treatment occurred in 2013 and before the PMGSY project started in 2000. Consequently, it is necessary to look at pre-trends in the DHS data from before 2013 and before the PMGSY project commenced in 2000. The presence of similar pre-trends in the Treatment and Control groups ensures that the parallel-trends assumption is met and is a sign of endogeneity.[24]

A study titled "The Effect of Rural Road Development on Hospital Births: Evidence from India" that conducted an analysis on PMGSY-II roads and that formed the same Treatment and Control groups as used in my study, found that both groups exhibited parallel trends between 1996 and 1999. Moreover, when separating districts by their PMGSY-II treatment status, the study found that the two groups were "almost identical in magnitude" as well, based on survey data from the 1998-1999 DHS.[25]

Additionally, I analyze pre-trends from 2010 to 2012 for the outcomes that yielded the most significant results in Figures 1 through 3. First, Figure 1 depicts the means for the Transport outcome, and it is evident from this graph that the Treatment and Control groups exhibit relatively parallel trends before PMGSY-II roads were constructed. This trend can also be noticed numerically in Tables 2, 6, and 7, and in Table 10 we see that the value of the Transport outcome in the Treatment group actually surpasses that of the Control group.

In Figure 2, the Antenatal outcome is trending similarly in both Treatment and Control groups between 2010 and 2012, before PMGSY-II construction. This trend can also be noticed numerically in Tables 2, 6, and 7. We can also observe in Table 11 that the mean for the Antenatal outcome in the Control group is only about .039 higher than the mean for the Treatment group in 2016, whereas in 2010 that difference was about .094, as shown in Table 2.

Finally, in Figure 3 we can see that the Tetanus outcome is also trending similarly for both Treatment and Control groups before treatment. This trend can also be observed numerically in Tables 2, 6, and 7. Additionally, we can see in Table 11 that by 2016 the mean for the Tetanus outcome for the Treatment group is essentially the same, whereas in 2010, shown in Table 2, the mean for the Control group was significantly higher.

From the Figures, we see that the means for the Transport, Antenatal, and Tetanus outcomes trend similarly for both Treatment and Control groups in the years leading up to the construction of PMGSY-II roads in 2013. In summary, these Figures convincingly depict parallel trends between Treatment and Control groups, and therefore further validate the findings.

## *LIMITATIONS*

Although this study has statistical significance and includes rigorous robustness checks, there are some limitations to the research methods that warrant discussion.

First, there are some limitations in the study due to the way responses were recorded in the 2015-2016 DHS. For both the Postnatal outcome and for outcomes related to Mother Care, responses were only recorded for the most recent birth, so there are fewer responses under these categories. Furthermore, the number of observations, N, is much smaller for births occurring in years

2010 and 2016. This is because in 2010 it was less likely that respondents had their most recent birth in that year, as they were questioned about five years later in 2015 to 2016. Additionally, because respondents were questioned in 2015 and part of 2016, women would be less likely to report having a baby in the year 2016 based on the time they were surveyed. Finally, responses are lower for the Transport outcome because responses could only be recorded if the respondent chose to deliver at a health facility as opposed to choosing to deliver at a home.

Additionally, there could be some limitations to the findings related to the Transport outcome. The limitations arise from the possible presence of additional and unobservable confounding factors that influenced respondents' decisions to take their different forms of transportation. For example, a respondents' lack of ability to access advanced transportation could have been related to insufficient funds for public transportation, unavailability of ambulances, or inability to own a car or motorcycle, and not due to the lack of developed roads to access these modes of transportation.

Finally, there are possible social and financial limitations to accessing health care in India that could not be accounted for in this study. Further research is needed to explore how India's caste system, cultural practices, financial barriers, and gender discrimination effect different individuals' ability to access health care.

## CONCLUSION

Despite the possible limitations to the study, the findings from this research are significant and signal improvements in antenatal care, tetanus vaccinations, and transportation to health facilities. These improvements are important considering that antenatal care and tetanus injections are both essential in ensuring the health of the fetus *and* mother throughout pregnancy and delivery.[26] A majority of problems at birth can be avoided or identified ahead of time when a mother receives antenatal care.[27] Additionally, receiving the recommended two doses of tetanus injections is necessary to avoid tetanus infections in the pregnant mother, convulsions after birth, and neonatal tetanus infections in newborns. Tetanus infections in newborns are especially concerning since they can often occur due to "exposure of the unhealed umbilical cord stump to tetanus spores, which are universally present in soil."[28] Moreover, because tetanus spores will always be present in our environment, eradication of this infection is only possible through widespread immunization. Finally, the results of the study show that roads enhanced transportation capabilities to health facilities. This ultimately reveals that roads directly provided better and easier access to health services in rural India, a main objective of the PMGSY-II project. Overall, improvement of women's and household's ability to access

health care in general can only benefit the communities and societies of India and increases the likelihood of a healthy and growing population.[29]

These findings are reassuring, but there is more that India can do to ensure that its citizens are getting the best health care possible. We can see from the means for the ANC Visits outcome in Tables 2 and 6 through 11 that there are still very low levels of mothers receiving the optimal level of antenatal care as recommended by the WHO. So, although the number of women receiving antenatal checks improved as a result of PMGSY-II roads, there is more that should be done to ensure that women obtain adequate health care before the delivery of their child. Additionally, we see from the means of the Postnatal outcome in Tables 2 and 6 through 11 that there are still very low numbers of babies receiving a postnatal check-up within two months after their birth. Receiving a check-up within two months after delivery is essential to the survival of the child, as "most infant deaths occur in the first six weeks after delivery."[30] The lower means for the ANC Visits and Postnatal outcomes suggests to me that there are still barriers to accessing routine check-ups at health facilities. In summary, although PMGSY-II roads enriched the districts they were constructed in, there is still room for improvement in India's healthcare provision .

Based on these findings, I recommend that policies be enacted to encourage families to obtain adequate antenatal care and necessary postnatal care for their children. According to a study by Esopo et al., behavioral interventions and policies that educate, organize, and monitor women's antenatal care will be most effective in helping women attain the level of antenatal care that they need.[31] Therefore, I urge India to implement policies to provide better education services to women concerning the importance and recommended elements of antenatal care.

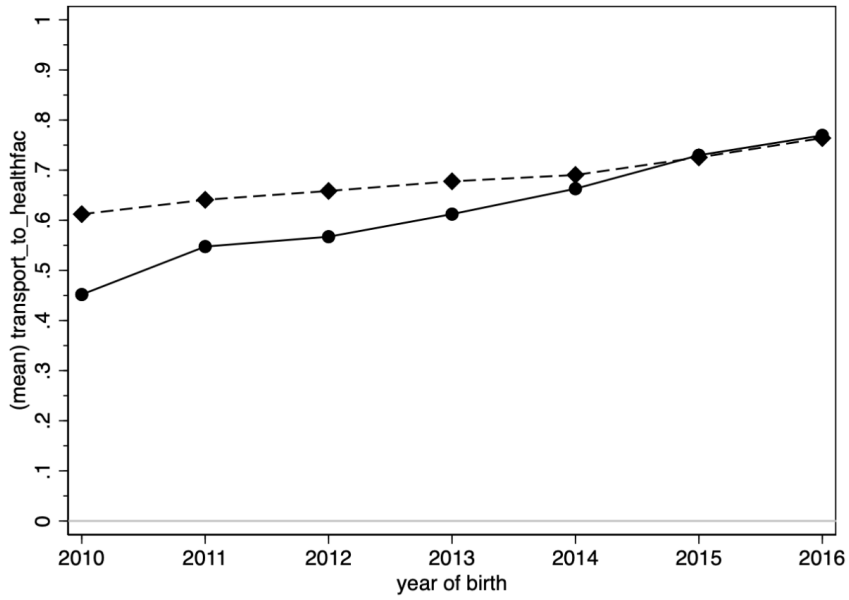
Secondly, India should focus on subsidizing the public healthcare system in-country. India's yearly investment in public healthcare is extremely low at approximately 1.28% of GDP as of 2018.[32] Recently, India has pledged to increase that amount to 3% by 2022; however, India's healthcare investment rate should be increased to 6-9%, as India's spending on infrastructure totaled to about 9% of its GDP in 2017. Specifically, funding should focus on government-sponsored health care, since India already boasts a robust private healthcare system that remains inaccessible to poorer, rural areas. Therefore, India must allocate greater funds towards ensuring that India's public primary health centers and subcenters are well-equipped and meet the standards set by the Ministry of Health and Family Welfare. Together these policies will ensure that more Indians are gaining access to necessary healthcare services, helping to establish a healthier society and saving more Indians from extreme poverty.

Based on the above results and analysis , it is clear that more research is needed to contribute to the growing body of literature on the possible effects

of rural road development and the barriers to accessing health care in India. Therefore, it is important to continue research in this specific area to continue to identify efficient and cost-effective ways for developing countries to improve the well-being of their people, as the PMGSY-II project has done, so that they can continue to promote a healthy economy, society and population.

## TABLES AND CHARTS

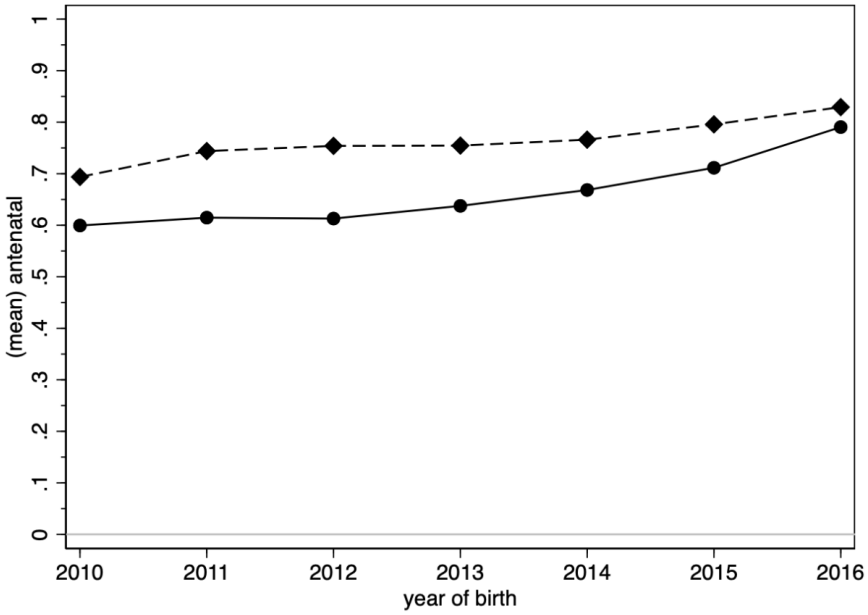
***FIGURE 1: TRANSPORT MEANS (2010–2016)***




*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Figure shows pre-trends for the Transport outcome in the years 2010 to 2016. The solid line is the Treatment group, while the dotted line is the Control group.*

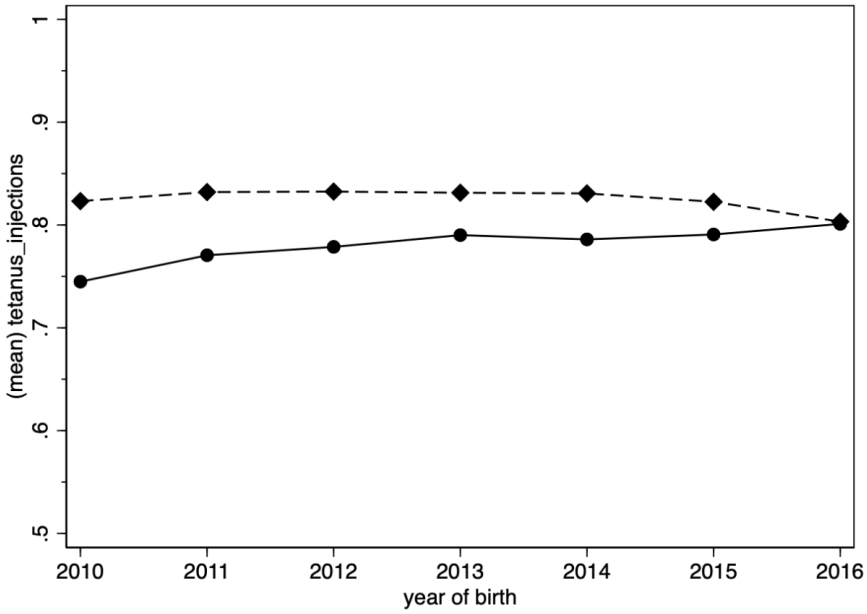
***FIGURE 2: ANC MEANS (2010–2016)***




*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Figure shows pre-trends for the ANC outcome in the years 2010 to 2016. The solid line is the Treatment group, while the dotted line is the Control group.*

***FIGURE 3: TETANUS MEANS (2010–2016)***




*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Figure shows pre-trends for the Tetanus outcome in the years 2010 to 2016. The solid line is the Treatment group, while the dotted line is the Control group.*

***TABLE 1: SUMMARY STATISTICS – CONTROLS***

| Variable | N | Mean | Standard Deviation | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Education Level | 190898 | .7110237 | 0.4532881 | 0 | 1 | 0.6334877 | 0.7154767 |
| Respondent Age | 190898 | 27.32755 | 5.36459 | 15 | 49 | 27.49556 | 27.3179 |
| Wealth Index | 190898 | 2.891722 | 1.409717 | 1 | 5 | 2.595583 | 2.90873 |
| Child with Respondent | 183435 | 0.9919645 | 0.0892806 | 0 | 1 | 0.9931027 | 0.9918998 |
| Rural/Urban | 190898 | .7494316 | 0.4333415 | 0 | 1 | 0.7963927 | 0.7467346 |
| Caste/Tribe | 189540 | .9583676 | .1997482 | 0 | 1 | 0.9885091 | 0.9566256 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the controls used in my empirical analysis. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 2: SUMMARY STATISTICS – OUTCOMES 2010***

| Variable | N | Mean | Standard Deviation | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 7283 | 0.8190306 | 0.3850192 | 0 | 1 | 0.744898 | 0.8232477 |
| ANC Visits | 7196 | 0.1299333 | 0.3362534 | 0 | 1 | 0.1179487 | 0.13062 |
| ANC | 7291 | 0.6886572 | 0.4630744 | 0 | 1 | 0.5994898 | 0.6937237 |
| Check After | 7283 | 0.6388851 | 0.4803568 | 0 | 1 | 0.5663265 | 0.6430126 |
| Hep | 15030 | 0.732668 | 0.4425818 | 0 | 1 | 0.6260658 | 0.7388275 |
| DPT | 15030 | 0.8399202 | 0.3666923 | 0 | 1 | 0.7235079 | 0.8466465 |
| Polio | 15030 | 0.8768463 | 0.3286245 | 0 | 1 | 0.7697929 | 0.8830319 |
| BCG | 15030 | 0.8702595 | 0.3360289 | 0 | 1 | 0.7612667 | 0.8765571 |
| Postnatal | 7283 | 0.3130578 | 0.4637695 | 0 | 1 | 0.2933673 | 0.3141779 |
| Transport | 5479 | 0.6043074 | 0.4890436 | 0 | 1 | 0.4518519 | 0.6122096 |
| Delivery Location | 15750 | 0.7098413 | 0.4538499 | 0 | 1 | 0.6141367 | 0.7153893 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2010. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 3: MOTHER CARE DATA***

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Tetanus | Tetanus | ANC Visits | ANC Visits | ANC | ANC | Check After | Check After |
| Treated | 0.019** | 0.015* | 0.003 | -0.003 | 0.028** | 0.033*** | 0.016 | 0.009 |
| Standard Error | (0.009) | (0.009) | (0.007) | (0.007) | (0.011) | (0.010) | (0.011) | (0.010) |
| District Fixed Effects | No | Yes | No | Yes | No | Yes | No | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 183,771 | 183,771 | 181,970 | 181,970 | 183,771 | 183,771 | 183,771 | 183,771 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: This table displays the difference-in-differences coefficients from the regression of treatment of PMGSY-II roads on respondents tetanus injections before delivery, if the respondent received more than eight antenatal visits before delivery, if respondents received at least one antenatal visit before delivery, and if the respondent received a check-up any time after their delivery. Controls include data on age of respondent, education level, the wealth index of the respondent, if the child lives with the respondent, if the respondent is typically allowed to go to a health facility, and if the respondent is in a caste or tribe. The estimation compares the DD coefficients with District Fixed Effects and without District Fixed Effects. Standard errors are clustered at the district level. P<.01 ***; P< .05 **; P< .1 **

***TABLE 4: CHILD CARE DATA***

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hep | Hep | DPT | DPT | Polio | Polio | BCG | BCG | Postnatal | Postnatal |
| Treated | 0.002 | -0.009 | 0.024*** | 0.011 | 0.023*** | 0.004 | 0.026*** | 0.006 | 0.004 | 0.008 |
| Standard Error | (0.008) | (0.008) | (0.008) | (0.007) | (0.006) | (0.006) | (0.007) | (0.006) | (0.011) | (0.010) |
| District Fixed Effects | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 246,043 | 246,043 | 246,043 | 246,043 | 246,043 | 246,043 | 246,043 | 246,043 | 183,771 | 183,771 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: This table displays the difference-in-differences coefficients from the regression of treatment of PMGSY-II roads on respondents tetanus injections before delivery, if the respondent received more than eight antenatal visits*

*before delivery, if respondents received at least one antenatal visit before delivery, and if the respondent received a check-up any time after their delivery. Controls include data on age of respondent, education level, the wealth index of the respondent, if the child lives with the respondent, if the respondent is typically allowed to go to a health facility, and if the respondent is in a caste or tribe. The estimation compares the DD coefficients with District Fixed Effects and without District Fixed Effects. Standard errors are clustered at the district level.*

*P<.01 ***; P< .05 **; P< .1 **

***TABLE 5: DELIVERY DATA***

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **Transport** | **Transport** | **Delivery Location** | **Delivery Location** |
| Treated | 0.071*** | 0.033** | 0.021*** | -0.001 |
| Standard Error | (0.014) | (0.013) | (0.008) | (0.007) |
| District Fixed Effects | No | Yes | No | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 143,173 | 143,173 | 246,043 | 246,043 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: This table displays the difference-in-differences coefficients from the regression of treatment of PMGSY-II roads on respondents tetanus injections before delivery, if the respondent received more than eight antenatal visits before delivery, if respondents received at least one antenatal visit before delivery, and if the respondent received a check-up any time after their delivery. Controls include data on age of respondent, education level, the wealth index of the respondent, if the child lives with the respondent, if the respondent is typically allowed to go to a health facility, and if the respondent is in a caste or tribe. The estimation compares the DD coefficients with District Fixed Effects and without District Fixed Effects. Standard errors are clustered at the district level.*

*P<.01 ***; P< .05 **; P< .1 **

## ENDNOTES

1 UNDP, "Human Development Reports," http://hdr.undp.org/en/countries/profiles/IND

2 The country that ranked the highest in the 2020 Human Development Report was Norway with an HDI of .957 and an inequality-adjusted HDI of .899. Niger ranked the lowest with an HDI of .394 and an inequality-adjusted HDI of .284.

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5 Ibid, 194

6 Ibid, 427.

7 "Pradhan Mantri Gram Sadak Yojana Programme Guidelines (PMGSY-II)," August 2013, 3, https://pmgsy.nic.in/sites/default/files/pdf/PMGSY_Guidelines_Final.pdf

8 Ibid, 4.

9 National Rural Infrastructure Development Agency, "PMGSY," March 2021, http://omms.nic.in

10 Ibid.

11 Ibid.

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14 Aravind Kasthuri "Challenges to Healthcare in India- the Five As," Indian Journal of Community Medicine, (July 2018), Vol. 43 No. 3, pp. 141–143, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6166510/

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17 District Fixed Effects capture the impacts of unobservable aggregate trends across districts in the data, while Year Fixed Effects capture the impacts of unobservable aggregate trends across time in the data.

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26 Allen Templeton, "The Public Health Importance of Antenatal Care," Facts, Views & Vision in ObGyn 7[1] (2015): 5–6, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4402443/

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31 Kristina Esopo, Lilly Derby and Johannes Haushofer, "Interventions to improve adherence to antenatal and postnatal care regimens among pregnant women in sub-Saharan Africa: a systematic review," BMC Pregnancy and Childbirth 20[316] (My 2020): https://doi.org/10.1186/s12884-020-02992-y

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***TABLE 6: SUMMARY STATISTICS - OUTCOMES 2011***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 21131 | 0.8286877 | 0.3767905 | 0 | 1 | 0.7705779 | 0.8320076 |
| ANC Visits | 20909 | 0.1185136 | 0.323223 | 0 | 1 | 0.1057269 | 0.1192475 |
| ANC | 21144 | 0.7369467 | 0.4403015 | 0 | 1 | 0.614711 | 0.7439256 |
| Check After | 21131 | 0.6736075 | 0.4689039 | 0 | 1 | 0.6252189 | 0.676372 |
| Hep | 40213 | 0.7630866 | 0.425194 | 0 | 1 | 0.6857654 | 0.7676347 |
| DPT | 40213 | 0.8472633 | 0.359738 | 0 | 1 | 0.7627574 | 0.8522341 |
| Polio | 40213 | 0.8851615 | 0.3188309 | 0 | 1 | 0.8285586 | 0.888491 |
| BCG | 40213 | 0.8732997 | 0.3326411 | 0 | 1 | 0.8097583 | 0.8770373 |
| Postnatal | 21131 | 0.3383181 | 0.4731486 | 0 | 1 | 0.3073555 | 0.340087 |
| Transport | 16050 | 0.6361371 | 0.4811248 | 0 | 1 | 0.5475896 | 0.6408372 |
| Delivery Location | 42070 | 0.7223437 | 0.4478482 | 0 | 1 | 0.6799154 | 0.7248709 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2011. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 7: SUMMARY STATISTICS - OUTCOMES 2012***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 31220 | 0.8296925 | 0.3759087 | 0 | 1 | 0.7787286 | 0.8325108 |
| ANC Visits | 31245 | 0.12572 | 0.4349562 | 0 | 1 | 0.1167793 | 0.1262169 |
| ANC | 31245 | 0.7466155 | 0.4349562 | 0 | 1 | 0.6129426 | 0.7540109 |
| Check After | 31220 | 0.6714926 | 0.4696779 | 0 | 1 | 0.6033007 | 0.6752637 |
| Hep | 50909 | 0.8036104 | 0.3972705 | 0 | 1 | 0.7037957 | 0.8094614 |
| DPT | 50909 | 0.8539944 | 0.3531153 | 0 | 1 | 0.7829017 | 0.8581618 |
| Polio | 50909 | 0.8920034 | 0.3103792 | 0 | 1 | 0.8435615 | 0.894843 |
| BCG | 50909 | 0.876623 | 0.3288727 | 0 | 1 | 0.820149 | 0.8799335 |
| Postnatal | 31220 | 0.3430493 | 0.4747354 | 0 | 1 | 0.2933985 | 0.345795 |
| Transport | 23962 | 0.6540773 | 0.4756781 | 0 | 1 | 0.5672414 | 0.6584949 |
| Delivery Location | 53444 | 0.7327109 | 0.4425487 | 0 | 1 | 0.6891801 | 0.7352778 |

Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2012. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 8: SUMMARY STATISTICS - OUTCOMES (2013)***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 31220 | 0.8296925 | 0.3759087 | 0 | 1 | 0.7787286 | 0.8325108 |
| ANC Visits | 31245 | 0.12572 | 0.4349562 | 0 | 1 | 0.1167793 | 0.1262169 |
| ANC | 31245 | 0.7466155 | 0.4349562 | 0 | 1 | 0.6129426 | 0.7540109 |
| Check After | 31220 | 0.6714926 | 0.4696779 | 0 | 1 | 0.6033007 | 0.6752637 |
| Hep | 50909 | 0.8036104 | 0.3972705 | 0 | 1 | 0.7037957 | 0.8094614 |
| DPT | 50909 | 0.8539944 | 0.3531153 | 0 | 1 | 0.7829017 | 0.8581618 |
| Polio | 50909 | 0.8920034 | 0.3103792 | 0 | 1 | 0.8435615 | 0.894843 |
| BCG | 50909 | 0.876623 | 0.3288727 | 0 | 1 | 0.820149 | 0.8799335 |
| Postnatal | 31220 | 0.3430493 | 0.4747354 | 0 | 1 | 0.2933985 | 0.345795 |
| Transport | 23962 | 0.6540773 | 0.4756781 | 0 | 1 | 0.5672414 | 0.6584949 |
| Delivery Location | 53444 | 0.7327109 | 0.4425487 | 0 | 1 | 0.6891801 | 0.7352778 |

Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2013. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 9: SUMMARY STATISTICS - OUTCOMES (2014)***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 48946 | 0.8282597 | 0.3771584 | 0 | 1 | 0.7860052 | 0.8307276 |
| ANC Visits | 48536 | 0.1150898 | 0.3191336 | 0 | 1 | 0.1047938 | 0.1156942 |
| ANC | 48964 | 0.7606609 | 0.4266844 | 0 | 1 | 0.6683938 | 0.7660499 |
| Check After | 48946 | 0.6751113 | 0.468338 | 0 | 1 | 0.6308775 | 0.6776949 |
| Hep | 50492 | 0.8259724 | 0.3791369 | 0 | 1 | 0.7424023 | 0.8308121 |
| DPT | 50492 | 0.8681969 | 0.3382799 | 0 | 1 | 0.8031838 | 0.871962 |
| Polio | 50492 | 0.9154718 | 0.2781811 | 0 | 1 | 0.8701158 | 0.9180984 |
| BCG | 50492 | 0.900103 | 0.2998656 | 0 | 1 | 0.8422576 | 0.9034529 |
| Postnatal | 48946 | 0.3528378 | 0.4778577 | 0 | 1 | 0.3198815 | 0.3547627 |
| Transport | 38409 | 0.6890573 | 0.4628854 | 0 | 1 | 0.6629945 | 0.6904867 |
| Delivery Location | 52791 | 0.7794889 | 0.4145952 | 0 | 1 | 0.7403485 | 0.7817865 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2013. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 10: SUMMARY STATISTICS - OUTCOMES (2014)***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 34134 | 0.8207066 | 0.3836034 | 0 | 1 | 0.7907801 | 0.8225435 |
| ANC Visits | 33855 | 0.1128046 | 0.3163585 | 0 | 1 | 0.1091837 | 0.1130271 |
| ANC | 34150 | 0.7908931 | 0.4066768 | 0 | 1 | 0.7115385 | 0.7957668 |
| Check After | 34134 | 0.6913049 | 0.4619618 | 0 | 1 | 0.6560284 | 0.6934701 |
| Hep | 33133 | 0.7191923 | 0.4494005 | 0 | 1 | 0.6530069 | 0.7231714 |
| DPT | 33133 | 0.7570096 | 0.4288958 | 0 | 1 | 0.7360298 | 0.7582709 |
| Polio | 33133 | 0.8774032 | 0.3279788 | 0 | 1 | 0.8610963 | 0.8783836 |
| BCG | 33133 | 0.8674132 | 0.3391328 | 0 | 1 | 0.8488558 | 0.8685288 |
| Postnatal | 34134 | 0.3670534 | 0.4820083 | 0 | 1 | 0.3186424 | 0.3700249 |
| Transport | 26809 | 0.725801 | 0.4461181 | 0 | 1 | 0.7298177 | 0.7255569 |
| Delivery Location | 34658 | 0.7851001 | 0.4107588 | 0 | 1 | 0.7788318 | 0.7854846 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2015. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

***TABLE 11: SUMMARY STATISTICS - OUTCOMES (2014)***

| Variable | N | Mean | SD | Min | Max | Treated | Not Treated |
|---|---|---|---|---|---|---|---|
| Tetanus | 8609 | 0.803113 | 0.3976693 | 0 | 1 | 0.801061 | 0.803207 |
| ANC Visits | 8544 | 0.0980805 | 0.2974409 | 0 | 1 | 0.0909091 | 0.0984088 |
| ANC | 8610 | 0.8275261 | 0.3778137 | 0 | 1 | 0.7904509 | 0.8292239 |
| Check After | 8609 | 0.6824254 | 0.4655601 | 0 | 1 | 0.6923077 | 0.6819728 |
| Hep | 8394 | 0.5712414 | 0.4949281 | 0 | 1 | 0.4258242 | 0.5778331 |
| DPT | 8394 | 0.4780796 | 0.499549 | 0 | 1 | 0.3406593 | 0.4843088 |
| Polio | 8394 | 0.7861568 | 0.4100419 | 0 | 1 | 0.7115385 | 0.7895392 |
| BCG | 8394 | 0.801644 | 0.3987854 | 0 | 1 | 0.7554945 | 0.803736 |
| Postnatal | 8609 | 0.3970264 | 0.48931 | 0 | 1 | 0.403183 | 0.3967444 |
| Transport | 6588 | 0.7642684 | 0.4244874 | 0 | 1 | 0.7694915 | 0.7640235 |
| Delivery Location | 8694 | 0.7659305 | 0.4234402 | 0 | 1 | 0.7810026 | 0.7652435 |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: The Table shows summary statistics for the all outcomes in the year 2016. The Treated column shows the means for responses in the Treatment group, while the Not Treated column shows the means for responses in the Control group.*

**This table was included in original regression analysis but was not included in the analysis in this study:*

***TABLE 12: WEIGHT-FOR-HEIGHT AND HEIGHT-FOR-AGE DATA***

| | **Weight-Height Standard Deviation** | | **Weight-Height Percentile** | | **Height-Age Percentile** | | **Height-Age Standard Deviation** | |
|---|---|---|---|---|---|---|---|---|
| Treated | -0.156*** | -0.113** | -3.359*** | -2.429** | 0.723 | 0.988 | 0.051 | 0.063 |
| Standard Error | (0.046) | (0.047) | (1.025) | (1.036) | (1.065) | (1.100) | (0.064) | (0.065) |
| District Fixed Effects | No | Yes | No | Yes | No | Yes | No | Yes |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

*Data Source: DHS Survey 2015-2016 India and PMGSY Road Data from OMMS*

*Note: This table displays the difference-in-differences coefficients from the regression of treatment of PMGSY-II roads on children's weight-for-height percentile and standard deviation and children's height-for-age percentile and standard deviation. Controls include data on age of respondent, education level, the wealth index of the respondent, if the child lives with the respondent, if the respondent is typically allowed to go to a health facility, and if the respondent is in a caste or tribe. The estimation compares the DD coefficients with District Fixed Effects and without District Fixed Effects. Standard errors are clustered at the district level.*

*P<.01 ***; P< .05 **; P< .1 **