Public health spending and infant and child mortality in India: a state-year panel analysis

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Summary

Background: To investigate the association between public health spending and probability of infant and child death in India.

Methods: We used data from the three rounds of National Family Health Survey (NFHS) conducted in India during 1992-93, 1998-99 and 2005-06 to investigate the association between public health spending and probability of infant and child death. We used data from the birth history of three NFHS rounds to create state-year panels of births, infant and child deaths, state-level public finance variables, food grain production, household and individual variables for the period 1980-2005. Two-stage probit regression model is used to investigate the association. State-level per capita gross fiscal deficit is used as an instrument for estimating two-stage probit model.

Findings: Findings suggest association between public health spending and infant and child mortality in India. A 10% increase in per capita public health spending is likely to reduce the probability of infant and child deaths by 0•005 (95% CI: 0•003, 0•007) and 0•003 (95% CI: 0•002, 0•004) respectively. The second and third lags of public health spending were also statistically significant. Other factors affecting infant and child death were sex of the child, birth order, mother's age at birth of the index child, mother's schooling and urban-rural residence.

Interpretation: Public health spending was associated with probability of infant and child death in India. Our findings lend support to the government's initiative to increase public health spending in India.

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Introduction

In the last three decades India has achieved substantial reductions in infant and child mortality – infant mortality rate has declined from as high as 110 infant deaths per 1000 live births in 1981 to 44 infant deaths per 1000 live births in 2011.[1,2] Likewise child mortality rate has declined from 48 in 1981 to 12 in 2011.[1,2] Although the infant mortality rate in India has declined dramatically in the last three decades, it is considerably higher when compared to other neighboring Asian countries like Sri Lanka (11 infant deaths per 1000 live births) and Bangladesh (37 infant deaths per 1000 live births).[3] India is one of the major contributors to global under-5 deaths – about 1.7 million children under age 5 died in 2011 in India (it was approximately 24% of global under -5 deaths).[4]

Public health spending has been identified as one of the important strategies to reduce infant and child mortality in developing countries. Increased public health spending improves the availability, accessibility and affordability of health care services, which reduce the chances of infant and child mortality. Studies have shown that a majority of causes of infant and child deaths can be prevented or treated by low cost interventions such as prenatal care, skilled birth attendance, child immunization, management of diarrhea and malaria, malnutrition, etc.[5-7] In India, approximately 52% and 46% of children under age 5 in rural and urban areas died due to preventable causes of death in 2001-2003.[8] Public health spending can play an important role in making various low cost interventions available and accessible to people in general and poor in particular. It has been estimated that a majority of 1•3 billion poor people around the globe have restricted access to health services due to their inability to pay for the services.[9] Studies have shown that poor are more likely to utilize public health facilities than the rich,[10] and that public health spending matters more to the poor than the rich.[11]

India spends an insignificant proportion of its GDP on health – the public health spending comprised only 1•2% of the India’s GDP in 2011.[3] The budgetary allocation to the health sector has actually declined from 1•3% of the GDP in 1990 to 1•2% in 2011.[3,12] The public-private share in health spending also presents an interesting picture. At the national level, the share of per capita public expenditure on health stood at 28% in 2009-2010. The share of per capita public expenditure on health varies considerably across the states of India. It varied from as low as 17% in Punjab to as high as 65% in Assam in 2009-10.[13,14]

Taking cognizance of the vital role that public health spending can play in improving child survival, a few studies have empirically examined the association between public health spending and infant and child mortality.[15-20] The findings of these studies are mixed.

We could come across only three studies that have examined association between public health spending and infant and child mortality in India. These studies have led to mixed findings. While Makela et al. (2013) found negative association between social sector spending and child mortality,[18] Deolalikar (2005) found a weak relationship.[16] Bhalotra (2007) found the negative association between public health spending and infant mortality only in rural areas.[17] The findings of these studies might have got affected by choice of the analysis and the sample size. For example, Deolalikar could not control for the individual level socio-economic and proximate determinants of child mortality in the statistical models.[16] The study by Bhalotra (2007) might have got affected by the small sample sizes in certain states like Kerala, Assam, Punjab, Tamil Nadu, Haryana and West Bengal.[17] Makela et al. (2013) examined the association between social sector expenditure and child mortality. Social sector expenditure, among others, also included expenditure on education.[18]

Given the lack of systematic and robust evidence, our study investigates the association between public health spending and infant and child mortality in India using the three rounds of National Family Health Survey conducted in India during 1992-93, 1998-99 and 2005-06.

Data and Methods

Data

We use data from multiple sources to fulfill the objectives of the paper. We derive data on infant and child mortality rates from the annual reports of the Sample Registration System (SRS). The SRS is the most reliable source of data on fertility and mortality in India. The detailed description of SRS can be obtained elsewhere.[21]

For individual level analysis, we use the birth history data from the three rounds of National Family Health Survey (NFHS) conducted in India in 1992-93, 1998-99 and 2005-06. The principle objective of NFHS is to provide state and national level estimates of fertility, mortality, family planning, health and health care. The survey adopted a two-stage sample design in rural areas and a three-stage sample design in urban areas. In rural areas, villages were selected at first stage using a Probability Proportional to Size (PPS) sampling scheme. The required number of households was selected at the second stage using systematic sampling. In urban areas, blocks were selected at the first stage, census enumeration blocks (CEB) containing approximately150-200 households were selected at the second stage, and the required number of households were selected at the third stage using systematic sampling technique (for details regarding sampling, see IIPS and ORC Macro, 2007).[22] The NFHS adopted similar sampling design in each of the survey rounds. The number of ever-married women interviewed in NFHS 1992-93, NFHS 1998-99 and NFHS 2005-06 were 89 777, 91 000 and 124 385 respectively. The response rates were consistently above 90% in each of the survey rounds. There were only slight variations in the response rates across the different states of India in the three survey rounds. By virtue of the similar sampling design, the data from the three rounds of NFHS are comparable, and can be pooled together for analysis.[23]

In the present analysis, we use birth history data from the 15 major states of India, which represents approximately 90% of the India's population.[24] The birth history data in NFHS contains information of all births occurred to women aged 15-49 years interviewed in the survey. The survey also collected information about the survival status of each birth reported in the birth history. In each of the survey round, we used the birth history data to create a new birth file that contained information on every birth occurred since 1980 to women interviewed in that survey round. We then merged the three birth files into one file. This new birth file contained data on each birth occurred during 1980-2005 to women interviewed in the three rounds of NFHS. This new file provided us with a sample of 474 818 births. The numbers of infant and child deaths were 37 041 and 12 747 respectively. This file provided us with a unique opportunity to construct 26 state-year panels of births, infant and child deaths, and individual and household background characteristics.

We further created another state-year panel data file containing information on public health spending, net state domestic product, gross state budgetary deficit, and per capita food grain production. The annual data on public health spending and state level gross fiscal deficit was compiled from the yearly reports entitled "State Finances: A Study of Budgets" published by the Reserve Bank of India.[14] The public health spending includes expenditure on medical and public health services, family planning, water supply and sanitation, and food and nutrition. State governments account for two-thirds of the total public health spending, and the rest is borne by the central government.[25] The net state domestic product (NSDP) at factor cost was obtained from the 'Hand book of Statistics on the Indian Economy' produced annually by the Reserve Bank of India.[26] Data on the yearly food grain production was collected from the 'Annual Agriculture Statistics' published by the Ministry of Agriculture, Government of India.[27] State level public finance variables (i.e. public health spending, net state domestic product and gross state budgetary deficit) were converted into per capita terms at constant price of 2004-05 using NSDP deflator to make those comparable over states and time.

Finally, we merged the two state-year panel data files together to examine the effect of public health spending on infant and child mortality after adjusting for state, household and individual level factors. The individual data are, in this way, nested in a state-year panel.[17]

The dependent variables used in the analysis are infant and child mortality. Infant mortality refers to death of a newborn before completing first year of life. Child mortality refers to death between 1-4 years of age. For analyzing infant mortality, we excluded the births occurred in the 12 months preceding the respective survey dates to account for censoring present in the data. For child mortality analysis, we excluded the births occurred in the 60 months preceding the respective survey dates to account for censoring. The independent variables included in the statistical models are per capita public health spending, per capita state income, sex of child, birth order of child, mother's age at birth of index child, mother's schooling and urban-rural residence. The variables that were controlled in the models are per capita food grain production, caste of household head, religion of household head, father's schooling and state dummies. State dummies were included to control for state-specific heteroscedasticity. These variables are known to be associated with infant and child mortality in India.[17,28]

Methods

We used scatter plots to examine bivariate association between per capita public health spending and infant and child mortality. We also use scatter plots to examine the association in change in per capita public health spending and change in infant and child mortality.

We used probit models to estimate the effect of state-level public health spending on probability of infant and child death, adjusted for individual, household and state level confounding factors. Thus probability of death (*D*) of a child from the household (*i*) in state (*s*) at time (*t*) can be modeled as:

$$\boldsymbol{D_{ist} = A_0 + K_{st} + \alpha H_{st} + \beta Y_{st} + \gamma F_{st} + \delta C_{ist} + \theta P_{ist} + \varepsilon_{ist}}$$

where *K* is the state fixed effect, *H* is the log (natural) of per capita public health spending, *Y* is the log of per capita NSDP, *F* is the per capita food grain production, *C* is the vector of individual characteristics such as sex and birth order, *P* is the parental or household level factors such as mother's and father's schooling, caste, religion and urban-rural residence. We estimated robust standard errors clustered by primary sampling units (villages in rural areas and census enumeration blocks in urban areas) to account for the biases that might arise because of the nesting of children in the state-year panel.[29]

A potential problem while estimating the effect of public health spending on infant and child mortality is that of endogeneity. On one hand, high public health spending might reduce infant and child mortality. On the other hand, high infant and child mortality or unobserved variables might push governments to increase budgetary allocation to the health sector. To overcome the problem of endogeneity, we estimated the specified model using two-stage probit model. We used state-level per capita gross fiscal deficit as an instrument. State-level per capita real gross fiscal deficit is correlated with public health spending (an increase in the fiscal deficit and a general resource crunch results in lower budgetary allocation to the health sector), but is independent of infant and child mortality. In the first-stage, ordinary least square was used to predict public health spending as a function of state-level per capita gross fiscal deficit and other explanatory variables. In the second-stage, infant and child mortality were regressed on predicted values of public health spending and other variables using probit model.

Another issue that deserves mention is that public health spending in a particular year may not have immediate effect on the infant and child mortality. The public health spending in terms of health infrastructure and health personal might have lagged effect on infant and child mortality. Another possibility is that public health spending in a particular year is a consequence of high infant and child mortality in a previous year. Hence, we estimate lag models to account for the lagged effect of public health spending on probability of infant and child death. The lagged model also takes care of any contemporaneous correlation between infant and child mortality and public health spending.[17] The lag models were also estimated as instrument variable probit model by incorporating state-level covariates at successive years of lag.

Results

Figure 1 shows the trends in per capita public health spending for major states of India during 1981-2005. In 1981, most of the major states of India were closer in terms of per capita public spending on health. The per capita public health spending ranged between Rs. 95 in Uttar Pradesh to Rs. 210 in Kerala. The gap between the states in per capita public health spending has widened during 1981-2005. In 2005, the per capita public health spending ranged between Rs. 152 in Bihar and Rs. 498 in Rajasthan. Haryana (Rs. 495) and Tamil Nadu (Rs. 474) were not much behind Rajasthan in per capita public health spending.

Figures 2 (a) and 2 (b) shows the scatter plot of per capita public health spending and infant and child mortality in India. A negative association was found between per capita public health spending and infant and child mortality. The R^2 in case of infant and child mortality were of the order of 0•18 and 0•24 respectively. The scatter plot of change in per capita public health spending and change in infant and child mortality is shown in Figure 3. Findings suggest strong negative association between change in per capita public health spending and change in infant and child mortality (R^2 for infant and child mortality were 0•25 and 0•11 respectively).

Table 1 presents the summary statistics of the variables used in the analysis. The average per capita public health spending was Rs. 211. The per capita public health spending was associated with probability of infant deaths (Table 2). Findings suggest that a 10% increase in per capita public health spending (i.e. an increase of Rs. 21) is likely to reduce the probability of infant death by 0•005 (95% CI: 0•003, 0•007). Sex of the newborn, birth order, mother's age at birth of index newborn, mother's schooling and urban-rural residence were associated with probability of infant deaths. The lagged effect of public health spending on probability of infant deaths is shown in Table 3. Results adjusted for state and individual level factors suggest that marginal effects of current year public health spending, second and third lags of public health spending were statistically significant.

Table 4 presents the marginal effects of public health spending on child mortality. As in case of infant mortality, public health spending was associated with the probability of child death. Results adjusted for selected variables suggest that a 10% increase in public health spending is likely to reduce the probability of child mortality by 0•003 (95% CI: 0•002, 0•004). Sex of the child, birth order, mother's age at birth of index child, mother's schooling and urban-rural residence were associated with probability of child deaths. The lagged effect of public health spending on child death is shown in Table 5. Results adjusted for state and individual level factors suggest that second and third lags were statistically significant. The marginal effects of the second and third lags of public health spending on child deaths were of the order of -0.024 (95% CI: -0•044, -0•004) and -0•022 (95% CI: -0•038, -0•006).

Discussion

After adjusting for state and individual characteristics, per capita public health spending was associated with probability of infant deaths and child deaths. A 10% increase in per capita public health spending was likely to reduce probability of infant and child deaths by 0•005 (95% CI: 0•003, 0•007) and 0•003 (95% CI: 0•002, 0•004) respectively. Our study, is perhaps the first, to show an association between public health spending and infant and child mortality in India. Notably, Bhalotra (2007) found statistically significant association between public health spending and infant mortality only in rural areas of India.[17] Our findings are consistent with the finding of Gani (2009) who also found statistically significant negative association between public health spending and infant mortality in an analysis based on 127 countries.[20]

Strengths and limitations of our study must also be noted. One of the strengths of our study is the large sample size on which our analysis is based. We merged birth history data from the three rounds of NFHS thus providing us with a very large sample size for the analysis. The large sample size allowed us to conduct robust statistical analysis. Another strength of our study is the use of instrument variable probit model where we used state-level per capita gross fiscal deficit as an instrument. None of the earlier Indian studies have treated public health spending as an endogenous variable.[16-18] The limitations of our study must also be noted. An obvious limitation of our study is that we could not control for household wealth in the regression analysis. Since the analysis is based on state-year panels for 25 years, we controlled for only those variables in the analysis that are time invariant. It is needless to mention that wealth is likely to change with time.

Our findings lend support to a number of government's initiative to improve the health of the people in India. One such initiative is the National Rural Health Mission (NRHM). The NRHM, launched in 2005, aimed at increasing public health spending in the country from less than 1% of the GDP in 2005 to 2-3% in 2012. Indeed, recent data suggest that the share of public spending on health has increased after the launch of NRHM. Another important step under NRHM was to bring architectural corrections in public health care system in rural areas. Under the *Janani Suraksha Yojana* (JSY), the government of India is providing monetary benefits to pregnant women for delivering their babies in public health facilities or government designated private health facilities. Recent evaluations of *JSY* show that the scheme has been successful in increasing institutional births in India.[30] Another important initiative of the Government of India is the National Food Security Bill (NFSB). The NFSB envisages to provide legal entitlement to subsidized food grains to at least 75% of the country's population – 90% in rural areas and 50%

in urban areas.[31] Our findings support and call for such initiatives to reduce infant and child mortality in the country.

Another point that deserves mention is the huge variations in public health spending across the major states of India. Interestingly, the states that have the highest burden of infant and child mortality spend the least on health sector. For example, the per capita public health spending in Uttar Pradesh, Bihar and Madhya Pradesh in 2009 was Rs. 248, Rs. 237 and Rs. 325 respectively. In comparison, the per capita public spending on health was Rs. 786 and Rs. 654 in Haryana and Tamil Nadu respectively.[14] Statistics clearly suggest that states that have lower burden of infant and child mortality spend almost 2 to 3 times more than the states that have higher burden. Our findings call for increasing public health spending in the states that have higher burden of infant and child mortality, and make them at par with the better performing states of India.

Panel: **Research in context**

Systematic review

We used the search terms ("infant mortality"[MeSH Terms] OR ("infant"[All Fields] AND "mortality"[All Fields]) OR ("infant mortality"[All Fields]) AND (“public health spending” [MeSH Terms] OR “public health spending” [All Fields]) AND ("India"[MeSH Terms] OR "India"[All Fields])), ("child mortality"[MeSH Terms] OR ("child"[All Fields] AND "mortality"[All Fields]) OR ("child mortality"[All Fields]) AND (“public health spending” [MeSH Terms] OR “public health spending” [All Fields]) AND ("India"[MeSH Terms] OR "India"[All Fields])) and identified only 3 studies in India. Only two studies have examined the association between public health spending and infant in India.[16,17] The third study[18] has examined the association between social sector spending and child mortality in India. Social sector spending, among others, also included spending on education.

Interpretation

Ours is perhaps the first study that shows statistically significant association between public health spending and infant mortality in India. Deolalikar (2005) found weak relationship between public health spending and infant mortality in India.[16] Bhalotra (2007) found statistically significant association between public health spending and infant mortality only in rural areas.[17] Moreover, ours is also the first study that shows statistically significant association between public health spending and child mortality in India. Our findings lend support to the government of India's initiatives to increase public health spending in the country.

Conflict of interest

We declare that we have no conflict of interest.

Acknowledgement

None

Contributors

KK and AS conceived the study. KK, AS and FR planned the estimation strategy. KK did the data handling and estimation. KK, AS and SVS analyzed the data. KK, AS, FR and SVS were involved with data interpretation, critical revisions of the paper, and approved the final version. KK is the guarantor.

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Figure 1: Trends in public health spending in major states of India, 1980 - 2005

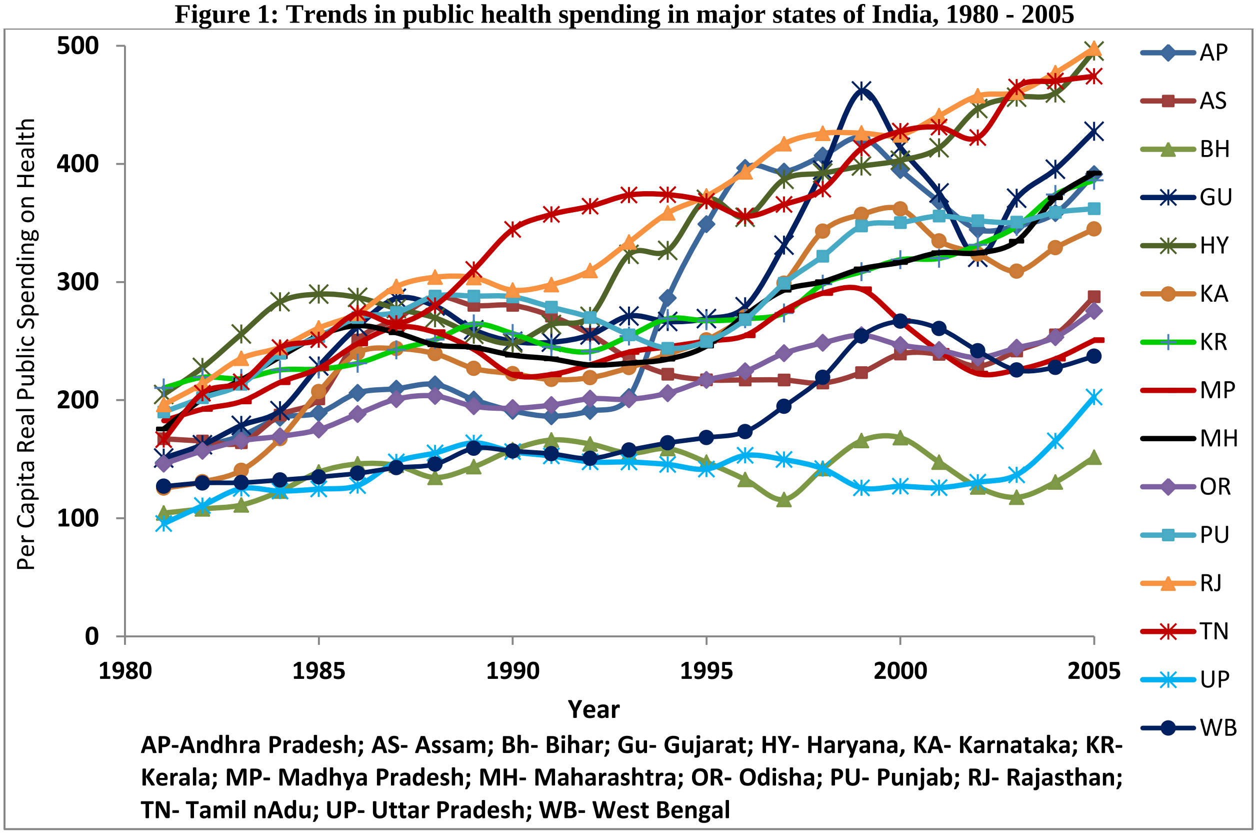


Figure 2 a: Scatter plot showing relationship between per capita public health spending and infant mortality rate, India, 1981-2005

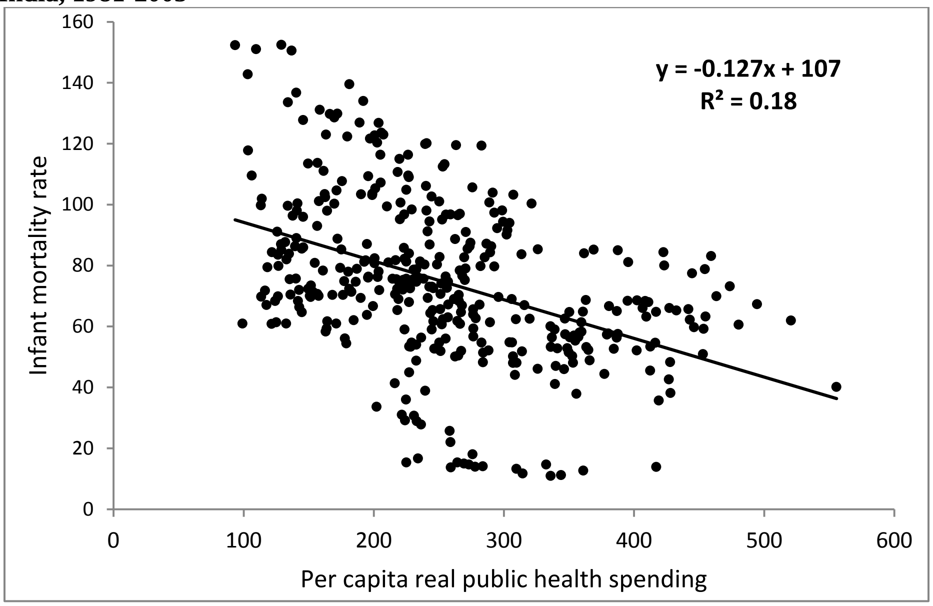


Figure 2 b: Scatter plot showing relationship between per capita public health spending and child mortality rate, India, 1996-2005

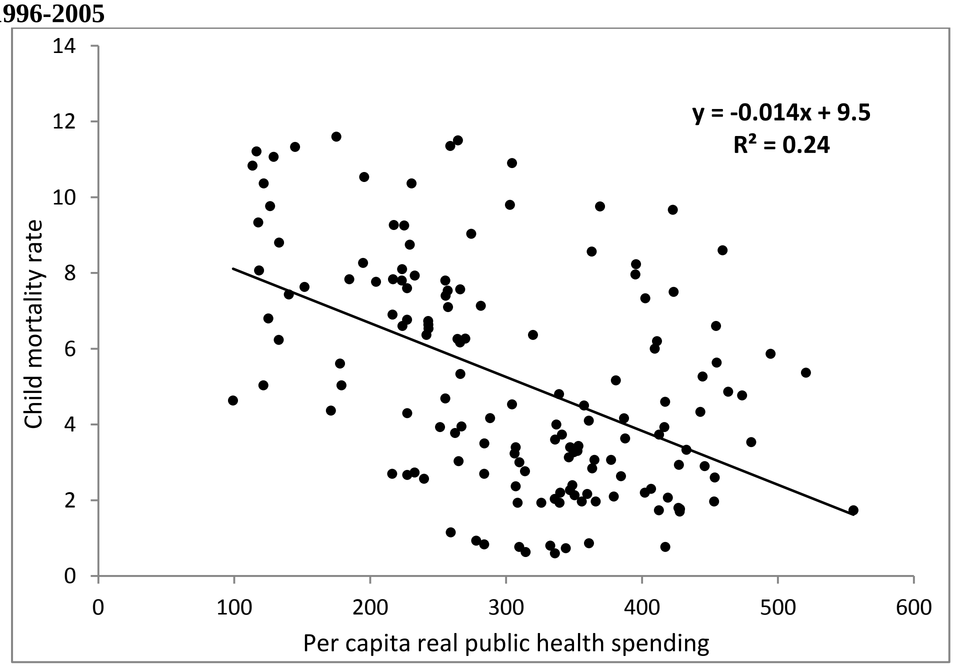
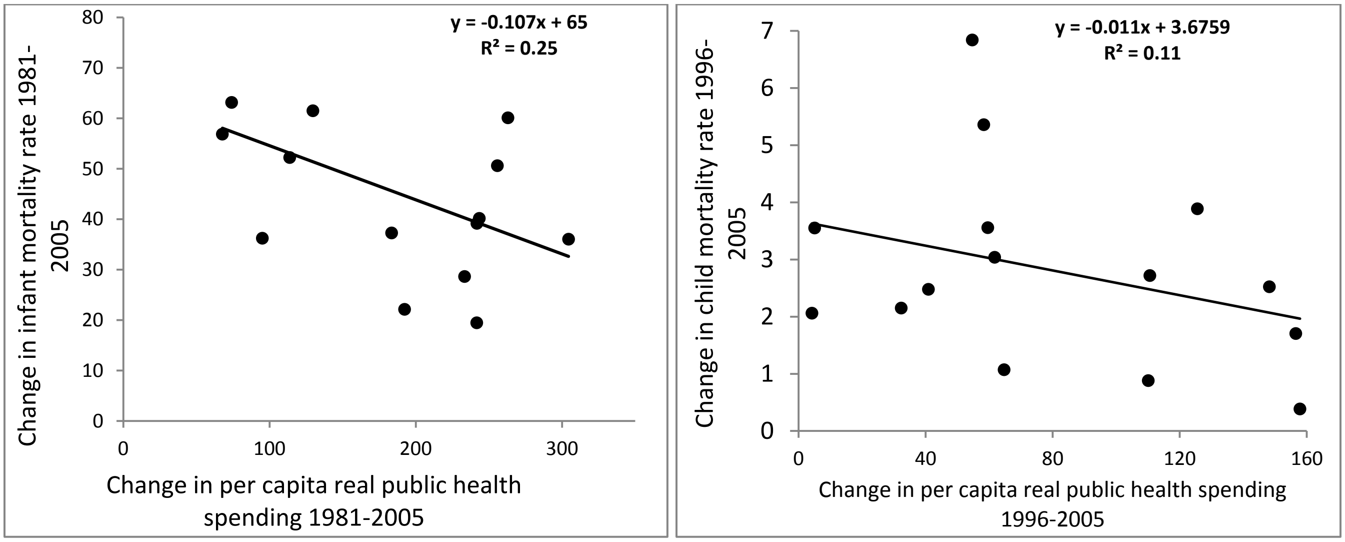


Figure 3: Scatter plot showing change on change in infant and child mortality, India



	Mean value
Per capita public health spending	211 (82)
Per capita net state domestic product	12 333 (5 491)
Per capita food grain gain production	223 (140)
Male	0•52
Female	0•48
Birth order	2•86 (1.90)
Mother's age at birth of index child	23•53 (5.29)
Mother's years of schooling	2•66 (4.08)
Father's years of schooling	5•34 (4.97)
Scheduled Caste	18•43
Scheduled Tribe	8•50
Other Caste	73•06
Hindu	80•33
Muslim	15•24
Christian	1•56
Other Religion	2•87
Rural	24•27
Urban	75•73

Table 1: Summary Statistics

Note:-Values in the parenthesis are standard deviations.

	Model 1		Model 2	
	Marg. Eff.	**95% CI**	**Marg. Eff.**	**95% CI**
Per capita public health spending	-0•054*	(-0•074, -0•034)	-0•051*	(-0•071, -0•032)
Per capita Income	-0•009	(-0•023, 0•004)	0•001	(-0•012, 0•015)
Sex				
Female®				
Male			0•005*	(0•003, 0•007)
Birth order			0•007*	(0•006, 0•008)
Mother's age at birth of index child				
15-19 years®				
20-24 years			-0•035*	(-0•038, -0•033)
25-29 years			-0•053*	(-0•057, -0•049)
30-34 years			-0•058*	(-0•064, -0•053)
35 years and above			-0•061*	(-0•068, -0•055)
Mother's years of schooling				
No education®				
1 to 5 years			-0•011*	(-0•014, -0•008)
6 to 9 years			-0•016*	(-0•020, -0•012)
10 to 12 years			-0•025*	(-0•030, -0•019)
13 and more years			-0•033*	(-0•042, -0•024)
Place of residence				
Urban®				
Rural			0•012*	(0•009, 0•015)

Table 2: Marginal effect of public health spending on infant deaths in India, 1980-2005

Note: -Results in model 1 are adjusted for per capita food grain production
-Results in model 2 are adjusted for per capita food grain production, caste, religion, and father's years of schooling.
-State dummy was included in both the models to control for the state specific heteroscedasticity.
-* p < 0.05

	Model 1		Model 2		Model 3	
	Marg. Eff.	**95% CI**	**Marg. Eff.**	**95% CI**	**Marg. Eff.**	**95% CI**
Adjusted for state level factors only						
Current year	-0•052*	(-0•076, -0•027)	-0•049*	(-0•075, -0•023)	-0•054*	(-0•083, -0•026)
One year lag	-0•037*	(-0•058, -0•017)	-0•018	(-0•045, 0•008)	0•011	(-0•018, 0•0410)
Two years lag			-0•051*	(-0•071, -0•031)	-0•069*	(-0•098, -0•040)
Three years lag					-0•038*	(-0•059, -0•016)
Adjusted for state and individual level factors						
Current year	-0•053*	(-0•077, -0•029)	-0•051*	(-0•077, -0•025)	-0•055*	(-0•083, -0•027)
One year lag	-0•032*	(-0•053, -0•012)	-0•016	(-0•042, 0•011)	0•013	(-0•017, 0•042)
Two years lag			-0. •046*	(-0•066, -0•026)	-0•067*	(-0•096, -0•039)
Three years lag					-0•034*	(-0•055, -0•012)

Table 3: Marginal effect of the lag of public health spending on infant deaths in India, 1980-2005

Note: - State dummy was included in both the models to control for the state specific heteroscedasticity.
-* p < 0.05

	Model 1		Model 2	
	Marg. Eff.	**95% CI**	**Marg. Eff.**	**95% CI**
Per capita public health spending	-0•030*	(-0•043, -0•017)	-0•029*	(-0•042, -0•016)
Per capita Income	-0•011*	(-0•022, 0•000)	-0•007	(-0•018, 0•003)
Sex				
Female®				
Male			-0•011*	(-0•012, -0•010)
Birth order			0•004*	(0•004, 0•005)
Mother's age at birth of index child				
15-19 years®				
20-24 years			-0.006*	(-0•008, -0•004)
25-29 years			-0•013*	(-0•016, -0•011)
30-34 years			-0•021*	(-0•025, -0•017)
35 years and above			-0•026*	(-0•032, -0•021)
Mother's years of schooling				
No education®				
1 to 5 years			-0•007*	(-0•009, -0•004)
6 to 9 years			-0•017*	(-0•020, -0•014)
10 to 12 years			-0•023*	(-0•028, -0•018)
13 and more years			-0.•030*	(-0•041, -0•019)
Place of residence				
Urban®				
Rural			0•007*	(0•005, 0•009)

Table 4: Marginal effect of public health spending on child deaths in India, 1980-2005

Note: -Results in model 1 are adjusted for per capita food grain production
- Results in model 2 are adjusted for per capita food grain production, caste, religion, and father's years of schooling.
-State dummy was included in both the models to control for the state specific heteroscedasticity.
-* $p < 0.05$

	Model 1		Model 2		Model 3	
	Marg. Eff.	**95% CI**	**Marg. Eff.**	**95% CI**	**Marg. Eff.**	**95% CI**
Adjusted for state level factors only						
Current year	-0•032*	(-0•050, -0•014)	-0•026*	(-0•047, -0•005)	-0•022	(-0•046, 0•001)
One year lag	-0•018*	(-0•032, -0•005)	-0•016	(-0•036, 0•003)	-0•011	(-0•034, 0•012)
Two years lag			-0•033	(-0•046, -0•02)	-0•023*	(-0•044, -0•003)
Three years lag					-0•022*	(-0•038, -0•006)
Adjusted for state and individual level factors						
Current year	-0•033*	(-0•051, -0•015)	-0•027*	(-0•048, -0•007)	-0•023*	(-0•046, -0•001)
One year lag	-0•017*	(-0•030, -0•003)	-0•016	(-0•035, 0•004)	-0•010	(-0•033, 0•012)
Two years lag			-0•031*	(-0•044, -0•018)	-0•024*	(-0•044, -0•004)
Three years lag					-0•022*	(-0•038, -0•006)

Table 5: Marginal effect of the lag of public health spending on child deaths in India, 1980-2005

Note: - State dummy was included in both the models to control for the state specific heteroscedasticity.
-* $p < 0.05$