Does Increasing Health Expenditure Decrease Infant Mortality Rates?

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Abstract

This paper explores whether health expenditure (%GDP) affects infant mortality rates (IMR) at the national level. Our purpose is to determine how governments can invest more efficiently while achieving better health outcomes. We used IMR as a health indicator and data from 2000 to 2015. We considered the best-fitting model to include natural log transformations, country and time fixed effects, and health expenditure lagged by one year. The results showed a positive relationship between IMR and health expenditure, which contradicts our expectations. We conclude that governments should focus on increasing access to skilled birth staff and lowering their poverty levels.

1.Introduction

The main question this paper is seeking to answer is how the percent of GDP devoted to healthcare affects the infant mortality rate (IMR) in a given country. The purpose of this paper is to find insight on where governments should invest money in order to get the best health outcome for their country. Many countries face pressure to cut healthcare costs so it is important to understand how money should be allocated in order to maintain the quality of care at these reduced costs. This paper seeks to identify key determinants in health outcomes at the national level using IMR as the health indicator. Infant mortality rates are a commonly used indicator for worldwide health outcomes that are widely accepted among policy makers and economists (Barenberg, Basu, & Soylu, 2017). The relationship between IMR and health expenditure was expected to be nonlinear and negative where increasing the percent of GDP towards healthcare would decrease IMR at a diminishing rate. We used a natural log transformation on a model using fixed effects as the relationships were expected to be better represented by percent changes.

The results showed that there is actually a positive relationship between IMR and health expenditure, which may indicate the presence of omitted variable bias as this goes against existing literature. However, the results did show that increasing the number of births attended by skilled health staff leads to decreasing IMR and that greater poverty headcount ratios at $1.90/day lead to higher IMR. Our research suggests that health initiatives should focus on these two areas.

Section 2 presents recent literature and background information on health spending and IMR. Section 3 provides a description of our data sources and the variables along with their units of measurement. Section 4 presents our population regression models as equations as the research strategy is discussed. Section 5 includes the results and analyses. Section 6 provides the

summary of our findings and the potential contribution of our research. Section 7 discusses the limitations of our research and how research on this topic can be improved for the future.

2.Literature Review

There exists a lot of literature on how health expenditure affects health outcomes. Some researchers claimed that health expenditure has limited effects on population health and pointed out how there are countries that invest a lot of money into their healthcare system but still achieve less than desirable outcomes (Filmer & Pritchett, 1999). For example, the American population has a relatively lower life-expectancy and worse overall health compared to other developed countries like Switzerland despite the U.S. government spending more money on per person in its healthcare system (The Commonwealth Fund, 2015). Meanwhile, others argued that there is a strong inverse relationship between health expenditure and health outcomes. Researcher Barenberg used IMR in his model in his study of health expenditure and life expectancy in India where he found that there is an obvious positive outcome when developing countries invest largely in their healthcare system (Barenberg, Basu, & Soylu, 2017).

Literature on child mortality is important for exploring the relationship between health expenditure and IMR as well as the impact of health initiatives. It was found that improving access to electricity in low income countries had significant impact with the idea the density of urban areas increases the need for refrigerators, which are important in decreasing the spread of infectious disease (Wang, 2003). Besides access to electricity, it was found at the national level that increasing the share of GDP towards healthcare decreased IMR and that there is a gap between the rich and poor in these rates, making income a significant factor (Wang, 2003).

The impact of sanitation and access to water on health is important for our research as these are key factors when comparing between undeveloped and developed countries. Sanitation

and water are important for maternal health as diarrhea increases the risk for anemia, for which pregnant women are already vulnerable. It was also reported that 15% of maternal deaths caused by infections in the 6 weeks after delivery are mostly from unhygienic procedures during labor and delivery (Cheng, Schuster-Wallace, Watt, Newbold, & Mente, 2012). It was found that IMR decreased when there was an increase in sanitation access (Cheng et al., 2012). It was also found that the rates decreased when there was an increase in access to an improved water source (Cheng et al., 2012).

3.Data Description

Data on health expenditure and infant mortality were obtained from the World Bank. All control variables (births attended by skilled health personnel, headcount poverty ratio at $1.90, females enrolled in primary education, and access to electricity, safe water, and basic sanitation) were obtained from the World Bank as well. We merged separate data sets together to create pooled country-level panel data with the years spanning 2000-2015. This range of years was chosen due to data limitations. There were 455 observations in total where each observation represented a country for a specific year. All of the available countries were used, which resulted in a total of 217 countries. The variables in our data set and their units of measurement are described in Table 1. The means and standard deviations for each variable are shown in Table 2 for the years 2000, 2001, 2014, and 2015 to illustrate trends over time.

Table 1: Variable Descriptions

Health Expenditure	Current health Expenditure expressed as Percentage of GDP
Infant Mortality Rate	Number of infants dying before reaching one year of age, per 1,000 live births in a given year.
Poverty Headcount Ratio	Percentage of the population living on less than $1.90 a day at 2011 international prices.

Birth Rate	Number of live births occurring during the year per 1000 people, for each country.
Access to Safe Water	Percentage of people using drinking water from an improved source that is accessible on premises, available when needed and free from faecal and priority chemical contamination.
Basic sanitation	Percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households.
Electricity	Percentage of population with access to electricity
Births Attended by Skilled Health Staff	Percentage of deliveries attended by personnel trained to give the necessary supervision, care, and advice to women during pregnancy, labor, and the postpartum period
GDP Growth	Annual percentage growth rate of GDP at market prices based on constant local currency.
Female Enrollment, Primary	The ratio of total female enrollment, regardless of age, to the population of the age group that officially corresponds to primary education.

Table 2: Summary Statistics

	2000	2001	2014	2015
Health Expenditure	6.19	6.53	6.67	6.79
	(2.96)	(2.83)	(2.94)	(2.96)
Sanitation	73.18	73.70	75.14	75.52
	(29.66)	(29.44)	(28.86)	(28.74)
Access to Safe Water	78.37	79.01	81.29	81.47
	(25.21)	(24.93)	(24.14)	(24.05)
Headcount ratio at 1.90/day	5.73	7.71	5.55	5.44
	(12.47)	(13.87)	(11.88)	(12.15)
Infant Mortality	29.50	28.46	24.11	23.40
	(26.39)	(25.48)	(21.69)	(21.06)
Female Enrollment PrimaryEd	100.93	101.71	102.53	102.01
	(14.35)	(13.93)	(12.52)	(13.82)

GDP growth(%)	3.98	0.10	3.33	2.82
	(4.63)	(5.28)	(4.29)	(4.80)
Access to Electricity	78.64	79.16	82.42	83.04
	(30.90)	(30.63)	(28.16)	(27.65)
Births Attended by Health Professionals	91.36	93.06	92.02	92.36
	(17.01)	(15.18)	(15.45)	(15.90)
Observations	263	263	263	263

NOTE: Table reports averages with standard deviations in parentheses.

4.Empirical Strategy

Infant mortality and health expenditure were expected to be inversely related where increasing health expenditure would decrease infant mortality rates. Figure 1 shows the negative relationship between health expenditure and IMR in the year 2015. Based on existing research, we expected that education, access to electricity, access to basic sanitation, and percentage of births attended by skilled health personnel would have the greatest effects on infant mortality rates. These factors were included since they greatly affect the spread of disease, which is one of the leading causes of infant death. IMR, health expenditure, and all control variables are continuous. We allowed for heteroskedasticty in the standard errors for each model. First, we ran a simple linear regression to test the effects of health expenditure on infant mortality without using any controls. We then used time and country level fixed effects for our regression model. The model is specified as:

$$InfantMortality_{it} = \beta_0 + \beta_1 HealthExpenditure_{it} + \beta_2 Sanitation_{it} + \beta_3 Electricity_{it} + \beta_4 Births\ Attended_{it} + \beta_5\ Safe\ Water_{it} + \beta_6 Poverty\ Headcount\ Ratio_{it} + \beta_7 Female\ Primary\ Education_{it} + u_{it}$$

where infant mortality is the outcome variable, β's are the parameter coefficients, and u_{it} is the error term.

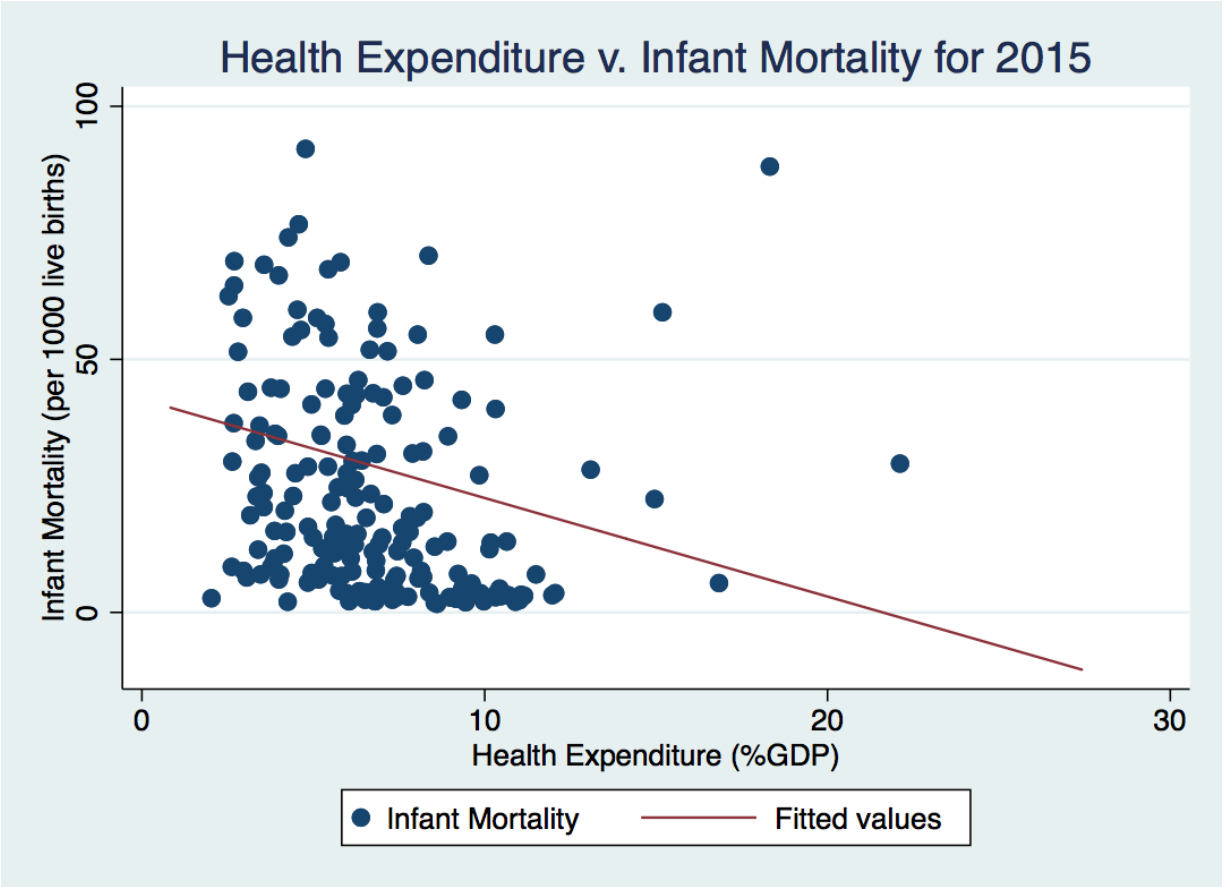

Figure 1: Infant Mortality by Health Expenditure for 2015

Using country fixed effects, we were able to control for all time invariant factors that make the countries different from each other, which helps prevent omitted variable bias. The time fixed effects allowed us to control for the effects of time. This was important since global economic events like the 2008 recession or even technological growth would cause bias otherwise. We also added the following variables as controls: access to sanitation, access to safe water, access to electricity, female enrollment in primary school, births attended by skilled health personnel, and headcount poverty ratio at $1.90/day.

We also used the natural log transformation with fixed effects to get a log-log form specified as:

$$lnInfantMortality_{it} = \beta_0 + \beta_1 lnHealthExpenditure_{it} + \beta_2 Sanitation_{it} + \beta_3 Electricity_{it} + \beta_4 Births\ Attended_{it} + \beta_5\ Safe\ Water_{it} + \beta_6 Poverty\ Headcount\ Ratio_{it} + \beta_7 Female\ Primary\ Education_{it} + u_{it}$$

This model was used since the relationship between IMR and the variable of interest, health expenditure, was expected to be nonlinear as it is more reasonable to analyze the effect in terms of elasticities. It was expected that the coefficient describing average percent change in IMR resulting from a 1% increase in health expenditure would be negative.

We also thought that there may be a lagged effect on health spending since the amount spent may be a response to the IMR. There may also be a lagged effect due to the 2008 recession causing healthcare spending to be cut the year after. To test the lagged effect, we used the model specified as:

$$lnInfantMortality_{it} = \beta_0 + \beta_1 lnlagHealthExpenditure_{it} + \beta_2 Sanitation_{it} + \beta_3 Electricity_{it} + \beta_4 Births\ Attended_{it} + \beta_5\ Safe\ Water_{it} + \beta_6 Poverty\ Headcount\ Ratio_{it} + \beta_7 Female\ Primary\ Education_{it} + u_{it}$$

It was also expected that more data on income would have an important impact but could not be included in the model due to a lack of data available at the national level. This may cause some omitted variable bias.

5.Empirical Analysis

Table 3: Results of Effects on Infant Mortality Rates from 2000-2015

VARIABLES	(1) Infant Mortality	(2) Infant Mortality	(3) Infant Mortality	(4) lnInfant Mortality	(5) lnInfant Mortality	(6) lnInfant Mortality
Health Expenditure	-1.947***	-0.317**	0.085			
	(0.195)	(0.139)	(0.128)			
Sanitation		0.149	0.227***	0.018***	0.018***	0.017***
		(0.129)	(0.084)	(0.003)	(0.004)	(0.004)
Births		-0.336***	-0.315***	-0.008***	-0.007***	-0.007***

Attended by Health Professionals						
		(0.079)	(0.070)	(0.002)	(0.002)	(0.002)
Female Enrollment PrimaryEd		-0.044*	-0.051***	0.002**	0.002*	0.002
		(0.026)	(0.019)	(0.001)	(0.001)	(0.001)
Access to Electricity		-0.114**	-0.048	0.002	0.002	0.002
		(0.050)	(0.054)	(0.002)	(0.002)	(0.002)
Access to Safe Water		-0.096***	0.010	0.001	0.000	0.001
		(0.022)	(0.022)	(0.002)	(0.002)	(0.002)
Headcount ratio at 1.90/day		0.394***	0.335***	0.004***	0.004***	0.005***
		(0.044)	(0.042)	(0.001)	(0.001)	(0.001)
lnGDPHealth Exp				0.091*		
				(0.053)		
lnlagGDPHealthExp					0.116***	0.132***
					(0.040)	(0.044)
lnGDPgrowth						0.023***
						(0.007)
Observations	2,976	455	455	455	454	386
Controls	NO	YES	YES	YES	YES	YES
Country FE	NO	YES	YES	YES	YES	YES
year FE	NO	NO	YES	YES	YES	YES
Adjusted R-squared	0.0409	0.986	0.991	0.991	0.992	0.991

NOTE--Data are at the national level. The years are 2000-15. *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the results from each regression. First, we ran a simple linear regression using model 1 to test the effects of health expenditure on infant mortality without using any controls. The results showed that increasing health expenditure led to decreased IMR (at the 1% level).

The regression was then run using country fixed effects to test the effects of health expenditure on infant mortality. We also included the control variables in this model. This is represented in table 3 as model 2. The coefficient on health expenditure was still negative but at

the 5% level. It was also found that increasing the percent of births attended and access to safe water is associated with decreased IMR (at the 1% level).

Once time fixed effects were added, the relationship between health expenditure and IMR became statistically insignificant while sanitation became significant. This is shown under model 3. At this point we ran the nonlinear regression using a natural log transformation, fixed effects, and the same controls where the relationship between health expenditure and IMR became significant at the 10% level, but it also became positive. Since it was expected to have a negative relationship, this may indicate that model 4 has upward bias. It could also indicate that there is a lagged effect on health expenditure since the positive relationship in the previous model may have resulted from high spending being a response to a higher IMR. To correct for this, we used the same nonlinear model again except we had health expenditure lagged by one year. This was model 5. The results, however, still showed a positive relationship but at a higher significance of 1%. The adjusted R-squared for this model was 0.9916 which is 0.0002 higher than that of the previous model's R-squared of 0.9914. This model showed that increasing the headcount poverty ratio by 0.01 was associated with 0.4 percent increase in IMR (at the 1% level). This model also showed that a one percent increase in births attended by skilled health staff is associated with a 0.7 percent decrease in IMR. Sanitation had a significant and unexpectedly positive relationship with IMR while access to safe water was insignificant. We ran an F-test with these two variables where they were determined to have high multicollinearity. Even though access to safe water was individually insignificant, it has joint significance with access to basic sanitation. This would have caused the higher standard errors and p-values for these coefficients.

As an attempt to deal with the unexpected positive relationships, we ran the same regression again as our 6^{th} model, but added the variable GDP growth which we transformed

with the natural log. However, the relationships did not change, but the R-squared did decrease by 0.0007, indicating that the previous model without GDP growth fits the model better.

Using model 5 as our final model, the results are inconsistent with our expectation that increasing health expenditure leads to lower infant mortality rates. However, some of our findings still provide valuable economic insight. Based off of our model, governments should focus on increasing the number of births attended by skilled health staff and reducing the level of extreme poverty. This finding is illustrated in figure 2.

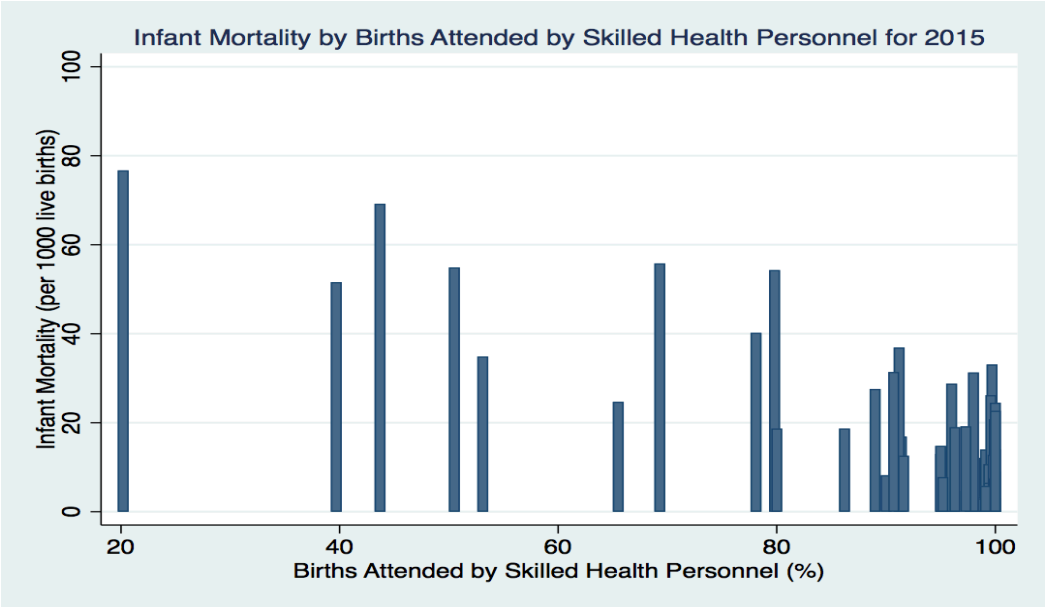

Figure 2: Infant Mortality by Births Attended by Skilled Health Personnel for 2015

6.Limitations and Future Research

It appears that our model suffers from upward bias, which could most likely be corrected by adding more data in future research. A major limitation stems from the fact that many developing countries do not have the vital registration systems that serve as the main source of mortality estimates. This results in having to apply indirect estimation techniques to derive the data which is less accurate. More accurate data might be needed for the future studies in order to get a clearer result. Lack of global data on income also limited our research as it would have

provided insight into how individual income affects access to vital healthcare resources during pregnancy and delivery.

7.Summary

The results showed a positive relationship between IMR and health expenditure at the 1% level, which does not support our original expectation. However, there were still some important findings from our research. We found that an average increase in the headcount poverty ratio by 0.01 is associated with an expected increase in IMR by 0.4 percent. We also found that a 1% increase on average in births attended by skilled health personnel is associated with an expected decrease in IMR by 0.7 percent. We conclude that countries should focus on allocating money more efficiently in order to achieve better health outcomes as opposed to simply increasing GDP devoted to their healthcare system. We think reducing the level of extreme poverty in countries will lead to better health outcomes. The main takeaway from our research is that health initiatives and government policies should focus on increasing the number of skilled health personnel that can attend deliveries as well as increasing access to them.

References Cited

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Filmer, D., & Pritchett, L. H. (1999). The impact of public spending on health: Does money matter? *Social science medicine,*1309-1323. Retrieved December 1, 2018, from https://www.ncbi.nlm.nih.gov/pubmed/10509822.

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rename BirthsAttended Births_Attended
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rename Access Electricity
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by year: eststo: estpost sum GDPHealthExp School Sanitation Safe_Water Prenatal Poverty
Maternal_Mortality Literacy InfantMorta Freshwater Electricity Births_Attended Birth_rate
Anemia if year==2008 | year == 2009 | year == 2014 | year == 2015
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Primary_Female Electricity Safe_Water Poverty, r



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outreg2 using Outreg2.doc, word append label keep(GDPHealthExp Sanitation Births_Attended
Primary_Female Electricity Safe_Water Poverty) nor2   nocons  dec(3)  nonotes title(Table 3:
Results of Effects on Infant Mortality Rates from 2000-2015) addtext(Controls, YES, Country
FE, YES, year FE, NO) addnote("NOTE--Data are at the national level. The years are 2000-15.
*** p<0.01, ** p<0.05, * p<0.1") addstat(Adjusted R-squared, e(r2_a))
eststo clear


reg InfantMorta i.countrynum i.year GDPHealthExp Sanitation Births_Attended
Primary_Female Electricity Safe_Water Poverty, r
outreg2 using Outreg2.doc, word append label keep(GDPHealthExp Sanitation Births_Attended
Primary_Female Electricity Safe_Water Poverty) nor2   nocons  dec(3)  nonotes title(Table 3:
Results of Effects on Infant Mortality Rates from 2000-2015) addtext(Controls, YES, Country
FE, YES, year FE, YES) addnote("NOTE--Data are at the national level. The years are 2000-15.
*** p<0.01, ** p<0.05, * p<0.1") addstat(Adjusted R-squared, e(r2_a))
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eststo clear


reg lnInfantMorta i.countrynum i.year lnGDPHealthExp Sanitation Births_Attended
Primary_Female Electricity Poverty Safe_Water, r
outreg2 using Outreg2.doc, word append label keep(lnGDPHealthExp Sanitation
Births_Attended Primary_Female Electricity Safe_Water Poverty) nor2   nocons  dec(3)  nonotes
title(Table 3: Results of Effects on Infant Mortality Rates from 2000-2015) addtext(Controls,
YES, Country FE, YES, year FE, YES) addnote("NOTE--Data are at the national level. The
years are 2000-15. *** p<0.01, ** p<0.05, * p<0.1") addstat(Adjusted R-squared, e(r2_a))
eststo clear

reg lnInfantMorta i.countrynum i.year lnlagGDPHealthExp Sanitation Births_Attended
Primary_Female Electricity Safe_Water Poverty, r
outreg2 using Outreg2.doc, word append label keep(lnlagGDPHealthExp Sanitation
Births_Attended Primary_Female Electricity Safe_Water Poverty) nor2   nocons  dec(3)  nonotes
title(Table 3: Results of Effects on Infant Mortality Rates from 2000-2015) addtext(Controls,
YES, Country FE, YES, year FE, YES) addnote("NOTE--Data are at the national level. The
years are 2000-15. *** p<0.01, ** p<0.05, * p<0.1") addstat(Adjusted R-squared, e(r2_a))
eststo clear


reg lnInfantMorta i.country i.year lnlagGDPHealthExp Electricity Sanitation Births_Attended
Safe_Water Poverty Primary_Female lnGDPgrowth, r
outreg2 using Outreg2.doc, word append label keep(lnlagGDPHealthExp Sanitation
Births_Attended Primary_Female Electricity Safe_Water Poverty lnGDPgrowth) nor2   nocons
dec(3)  nonotes title(Table 3: Results of Effects on Infant Mortality Rates from 2000-2015)
addtext(Controls, YES, Country FE, YES, year FE, YES) addnote("NOTE--Data are at the
national level. The years are 2000-15. *** p<0.01, ** p<0.05, * p<0.1") addstat(Adjusted R-
squared, e(r2_a))


twoway (bar InfantMorta Births_Attended if year == 2015)
graph save Graph "/Users/Mndiharce/Documents/EC204 Project/Infant mortality vs births
attended.gph"


total InfantMorta GDPHealthExp Electricity Sanitation Births_Attended Safe_Water Poverty
Primary_Female

log close
```