ESTIMATING THE IMPACT OF INCOME AND PUBLIC SPENDING ON HEALTH IN REDUCING CHILD MORTALITY IN THE DEVELOPING WORLD

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ABSTRACT

This project aims to identify the impact of income and public expenditure on health on mortality rates among children below 5 years of age. In particular, this relationship is examined for the developing world using a sample of 60 countries over a time horizon of 10 years starting 2002. A fixed effects-instrumental variables approach is used to infer a significant causal (not merely associative) impact of income and public health expenditure on child mortality suggesting the need for greater allocation of government expenditure towards health care services as well as enhanced focus on ways to boost income per capita in general, in an effort towards enhancing child health outcomes.

INTRODUCTION

As defined by the United Nations, child mortality (also known as Under five mortality) is "the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates" (United Nations, n.d.). As Mosley and Chen (1984) suggest, death being a measurable and easily aggregated variable, child mortality is an expedient measure of child health. Child mortality constitutes the fourth of the Millennium Development Goals of the United Nations and as 2015, the target year for achieving these goals draws near, it would be useful to analyse the most important factors influencing child mortality so that the last ditch efforts could be channelled in the correct direction. Given that evidence suggests that the highest incidence of child mortality is in the low and middle income nations, it would not be unreasonable to assume that child mortality declines as incomes rise. Moreover, governments around the developing world are spending enormous sums of money to improve child health outcomes through vaccination and awareness programmes, providing subsidised or free treatment for specific diseases etc. Consequently, increased public expenditure on health may be assumed to be correlated with reduced child mortality. However, there is no consensus in the literature as to the precise determinants of child mortality and different studies suggest varying degrees of impact of these factors.

While most of these studies relate to the pre-2000 period, I follow this question up for the new millennium. I use panel data analysis utilising 60 countries from across South Asia, Sub-Saharan Africa and Latin America observed over a 10 year time horizon beginning 2002.

To account for endogeneity arising from measurement error and reverse causality in income and public expenditure on health, I exploit the instrumental variables approach. Results from both the fixed effects as well as the fixed effects-instrumental variables regressions do indeed find a statistically significant effect of income and public expenditure on health in reducing child mortality.

DATA AND METHODOLOGY:

Primarily, the data used in this study has been obtained from the World Development Indicators and World Governance Indicators databases of the World Bank. Using the World Bank classification of countries, the Sub-Saharan African region comprises of 48 countries, South Asia of 8 countries and Latin American of 37 countries. However, since for some countries, data was not available for each year on all of the variables included in the model, not all countries comprising these regions could be considered and only a subset of 60 countries was used for the analysis. Data limitations also forced the time horizon to date back from 2011 although, a 10 year time horizon stretching back from 2013, being more recent, would have yielded better insights. Although over 30 countries were left out from the sample, they were widely heterogeneous in their income levels, so that there should have been no bias arising on this account.

I use data on GDP per capita, public expenditure on health, improved access to water and sanitation, fertility rates and depth of food deficit to assess the impact of income and government provision on child mortality. The precise manner in which the databases define these variables is provided in Table 1. Table 1 also lists the signs of the coefficients for these variables expected apriori and the reasoning behind the expectation. Moreover, it has been assumed that the average data for each country is representative for the entire population. Though this is a strong assumption given that there exists considerable heterogeneity within countries, it facilitates cross-country comparison and is, consequently, relied upon (Smith & Haddad, 2000). Also, studies on child health outcomes (Filmer& Pritchett, 1997; Smith & Haddad, 2000) use female education as one of the determinants of child mortality since this variable can reasonably be assumed to affect child mortality; however, lack of data for most countries on this variable for the study period prevented its inclusion in the present study.

TABLE 1 HERE

To reduce the skewness in the distributions of GDP per capita, public expenditure on health and depth of food deficit and allow these variables to be normally distributed, natural log transformations of each of these variables are used in the model. Intuitively too, mortality would be bound on the lower side even if these measures were increased substantially, making the log specification more appropriate (Pritchett & Summers, 1996). The dependent variable has also been modelled as being in natural logs- both to reduce the skewness in its distribution across countries as well as to enhance the ease of interpretation in terms of elasticities.

The descriptive statistics for each of the variables (both in the logged and un-logged form where applicable) are reported in Table 2.

TABLE 2 HERE

Figure 1 presents a scatter plot of each of the explanatory variable (in the preferred functional form) against the dependent variable (U5 mortality in natural logs). These support, and thus strengthen, the signs of the coefficients of each of these variables expected apriori.

FIGURE 1 (APPENDIX) HERE

The estimating equation[1] can, then, be given as follows:[2]

$$logU5mortality_{it} = \alpha_i + \beta_1 logGDP_{it} + \beta_2 logPub\_healthexp_{it} + \beta_3 X_{it} + u_{it} \quad (1)$$

where logU5 mortality represents Under 5 mortality expressed in natural logs, logGDP represents GDP per capita (in natural logs), logPub_healthexp represents Public expenditure on health as a % share of GDP (expressed in natural logs) and X_{it} represents a set of controls including improved access to water and sanitation, fertility rate and depth of food deficit. α_i denotes the time invariant country specific effects and may be thought to include such factors as the cultural and climatic characteristics of each country that may influence child mortality.

I use a Fixed Effects (Within) estimation technique to estimate the above equation. This is because the country fixed effects (α_i) are correlated with the explanatory variables so that a random effects estimator would be inconsistent while the fixed effects estimator would be consistent though inefficient. This is proved by the Hausman test which rejects the null of no systematic difference between the fixed effects and random effects estimation indicating that the fixed effects estimation would be more appropriate. This correlation between α_i and the explanatory variables is intuitively appealing since the specific characteristics of a country could be assumed to determine the income level and other control variables. Alternative estimation techniques such as the pooled OLS estimator would also have been inconsistent given that α_i is correlated with the independent variables.

ESTIMATION RESULTS

Results from estimation of equation (1) using the fixed effects estimation technique are presented in Table 3. Column (1) of Table 3 presents estimates for the baseline specification without any controls using only income and public health expenditure as the regressors. Columns (2) through (5) successively add further controls to this baseline specification.

There exists a strong possibility of variation in child mortality across countries and over time within each country. This would lead to heteroskedasticity in the error term and cause the standard errors of the coefficients to be biased. To correct for the same, I use robust standard errors.

In the baseline specification with no controls, coefficients for both GDP per capita (ln) and public Expenditure on health (ln) are highly statistically significant at the 1% level. Elasticity of Under 5 mortality with respect to GDP per capita and public expenditure on health is -0.85 and -0.14, respectively. In columns (2) to (5), additional controls are added which are statistically

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[1] It has been assumed that the error term follows a white noise process.

[2] It may be argued that GDP per capita and public expenditure may be correlated. However, this may not be specifically so for public expenditure on health since any government may or may not choose to allocate the available resources towards health care provision. In this sample, correlation coefficient was only 0.3467

significant at the 5% level, with the exception of depth of food deficit, and the measure of goodness of fit (R^2) rises across columns. In the full specification column (5), where the full set of controls has been introduced, GDP per capita and public expenditure on health continue to be statistically significant. Nonetheless, the coefficients on these variables fall considerably (in absolute value). Elasticities of child mortality with respect to income and public health expenditure fall to -0.35 and -0.08, respectively. This suggests that, in the baseline specification, these variables would have been capturing some of the effect of other variables that were correlated with these variables as well as with child mortality so that the coefficients on these variables were overestimated.

It must be noted here that there exists the possibility of endogeneity due to reverse causality between child mortality and income as well as public expenditure on health, as many authors (Filmer& Pritchett, 1997; Pritchett & Summers, 1996) have also suggested. Consequently, only an associative relationship can be established between these variables and child mortality and no inferences can be drawn about a causal effect. This is because poorer child health outcomes may lead to higher expenditures by the government on health care provision and to lower incomes. In the next section, I use an instrumental variables technique to show that the relationship is indeed causal instead of being merely associative.

Coefficients on water, sanitation and fertility rates are also statistically significant. Since a causal relationship going from child mortality to these variables can safely be dispensed with, it can be inferred that a one percentage point increase in the population with access to improved water source and sanitation facilities lowers child mortality by approximately 1.4 and 1.6 percentage points respectively. Also, an additional birth per woman raises child mortality by 13 percentage points. It may be pointed out that the effect of each of these variables is in the direction expected apriori as indicated by the signs of their coefficients. Strangely though, the coefficient on depth of food deficit (ln) is statistically insignificant suggesting that access to food is not an important factor in explaining child mortality.

TABLE 3 HERE

ROBUSTNESS CHECKS & INSTRUMENTAL VARIABLES ESTIMATION

As stated earlier, there exists a strong case for endogeneity arising from reverse causation and also due to measurement error in income and public expenditure on health. There also exists the possibility of omitted variable bias as factors such as culture may be associated with both good health as well as high incomes (Pritchett & Summers, 1996). This possibility is supported by the David McKinnon[3] test which rejects the null hypothesis of exogeneity. Accordingly, I use

[3] David McKinnon test for endogeneity was preferred over the Hausman test since the latter cannot be applied when standard errors are estimated using the robust option.

instrumental variables to establish a causal relationship of income and public health expenditure with child mortality.

I use Gross Capital Formation as a share of GDP (expressed in natural logs), external balance on goods and services (% of GDP) and a measure of government effectiveness to instrument for GDP per capita and public expenditure on health; the insight being that higher domestic investment and a positive external balance on trade in goods and services would raise GDP[4] but would have no direct effect on child mortality. Also, higher government effectiveness would only affect child mortality via an increased provision of health care services by the government without there being any independent effect. Thus these instruments would be uncorrelated with the general error term in equation (1), fulfilling the exclusion restriction. Moreover, given that there were two endogenous regressors, the criteria of an F statistic of above 10 in the first stage regression could not be used to determine the strength of the relevance condition. Consequently the Cragg-Donald F statistic was used to determine the extent to which the instruments were correlated with the endogenous regressors. Stock and Yogo (2005) critical values were used and the null of weak identification was rejected at the 15% maximal IV size. Based on the fulfilment of both the relevance condition and the exclusion restriction, it may be inferred that the above instruments are valid and FE-IV estimation may be applied. I use a 2SLS estimation technique and the results from this 2SLS FE-IV estimation are presented in the third column of Table 5.

TABLE 5 HERE

As the estimates in Table 5 suggest, the coefficients for GDP per capita and public expenditure on health are considerably higher in the instrumental variable estimation than in the standard Fixed Effects estimation. Although the coefficients of water, sanitation and depth of food deficit are almost the same in the two procedures, fertility rate loses its statistical significance in the FE-IV approach.

Given the difference in the magnitude of coefficients between the fixed effects and the FE-IV estimation procedures, the instrumental variables estimates are relied upon.

CONCLUDING DISCUSSION

Results indicate a statistically significant impact of income and public spending on health in reducing child mortality. More precisely, a 1 percentage point increase in GDP per capita would reduce child mortality by a substantial 0.43%. Similarly, a 1 percentage point increase in government expenditure on health could reduce child mortality by 0.22%. Intuitively, higher incomes may be associated with better educational attainments of the parents leading to better knowledge of child care. Higher incomes may also influence child health via better affordability of health care services and improved living standards in general. Higher government spending on health could affect child health outcomes, possibly through increased

[4] From the macroeconomic equilibrium condition: GDP = C+I+G+(X-M)

provision of maternal and child care, vaccination coverage and access to superior quality treatment. These results are in line with earlier studies. For example, Pritchett & Summers (1996) examined 88 countries during 1960-80 and estimated an income elasticity between 0.43 and 0.75 according to the instrument used, which was statistically significant. Filmer & Pritchett (1997) and Wang (2002) also find a statistically significant impact of income. The extent of impact of public spending on health on child mortality is more disputed in the literature. Wang (2002) uses an instrumental variables estimation technique for 60 low income countries observed between 1990-1999 to find a statistically significant effect of public health expenditure. Other researchers (Anand & Ravallion, 1993 cited in Filmer & Pritchett, 1997; Bidani & Ravallion, 1997 cited in Filmer & Pritchett, 1997) have also reached similar conclusions. On the other hand, Filmer & Pritchett (1997) claim the contrary. However, they conduct a cross-sectional analysis ignoring the time dimension of the impact which may account for the differences in their results.

The analysis conducted in this project also points to a significant impact of improved access to water and sanitation in improving child health outcomes although the magnitude of the coefficients is not very large. This possibly supports the fact that a large proportion of deaths of under-5 children in developing nations are due to diarrheal and respiratory illnesses as well as other infectious diseases rather than due to under nutrition. While Charmarbagwala et al (2004) claim that access to clean drinking water and sanitation facilities lower child mortality, Filmer & Pritchett (1997) hold the opposite view as far as access to safe water is concerned. However, as above, the robustness of this deduction may be questioned. Contradictorily, Wang (2002) argues for a statistically significant impact of access to sanitation facilities.

Surprisingly, fertility rates lose their statistical significance in explaining child mortality in the FE-IV analysis. This may, however, be explained by the fact that it may be conditional on the level of income, so that higher incomes may be associated with lower fertility rates.[5] Depth of food deficit (ln) continues to be statistically insignificant in the instrumental variables estimation.

As pointed towards above, data limitations precluded the inclusion of a measure of educational attainment among the population as an explanatory variable. Studies (Filmer & Pritchett, 1997; Pritchett & Summers, 1996) that consider this variable, do find a statistically significant effect. Moreover, definitions of what constitutes safe drinking water or improved sanitation facilities may vary across countries although effort was made to utilise a single database for all countries so that variation arising out of differences in definitions across databases could at least be minimised.

POLICY IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

In light of the fact that governments in developing nations as well as international agencies are struggling to somehow meet the target of the fourth Millennium Development Goal of the

[5] Correlation between GDP per capita (ln) and Fertility Rate was -0.74 for the sample considered.

United Nations by 2015, the forgoing analysis suggests the pathways in which if effort is directed, shall at least take them part of the way towards achieving their goal. It emphasizes the need for governments to increase spending on health care provision for children. Since the measure used above also included the external borrowings and grants from international agencies and non-governmental organisations, the analysis also implies that greater amounts in aid may also have desirable impacts. Improving the quality of water and sanitation facilities may also work to improve child health outcomes. However, as indicated by most other studies, the greatest feats can be achieved by providing a boost to incomes as a whole owing to the fact that higher incomes have the potential to lower mortality among children through a number of channels.

This analysis utilised average data for each country over the 10 year time span. To better account for heterogeneity across the population within each country, a possible area for further research would be to use data collected at the individual or household level to estimate this model to assess the impact of income and public spending on health in explaining under-5 mortality. This would also help to ascertain the differences in influence of these factors across rural and urban regions of each country and across different socio-economic and ethnic groups.

Table 1: Definitions of variables used

Variable Name	Definition	Sign Expected Apriori	Mechanism of influence
Water (% of population with access to improved source)	Access to an improved water source refers to the percentage of the population using an improved drinking water source. The improved drinking water source includes piped water on premises and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, etc)	Negative	Access to improved water source would reduce child mortality from diarrheal illnesses.
Sanitation (% of population with access to improved source)	Access to improved sanitation facilities refers to the percentage of the population using improved sanitation facilities. The improved sanitation facilities include flush/pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet.	Negative	Improved Sanitation would reduce the prevalence of diseases and improve child health outcomes
GDP per capita (in constant 2005 US$)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars.	Negative	Higher income would allow access to better standard of living (including access to food, health facilities)

Public expenditure on health (in ln % of GDP)	Public health expenditure consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds	Negative	Higher Public Health Expenditure on health care facilities would improve the quality and quantity of these services available
Fertility Rate	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.	Positive	More children per woman would lower the resources available for each child (including care)
Depth of Food Deficit	The depth of the food deficit indicates how many calories would be needed to lift the undernourished from their status, everything else being constant. The average intensity of food deprivation of the undernourished, estimated as the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population (food-deprived), is multiplied by the number of undernourished to provide an estimate of the total food deficit in the country, which is then normalized by the total population.	Positive	Food deprivation would increase the probability of mortality through malnutrition causing lower immunity to diseases among children

Source: World Development Indicators, World Bank (2013)

Table 2: Descriptive Statistics

Variable		No. of observations	Mean	Std Dev	Min	Max
Basic variables used						
U5mortality (in ln)	overall	N=600	4.03838	.9061032	1.740466	5.42539
	Between	n= 60		.9022345	1.884514	5.337927
	Within	T= 10		.1386609	3.559789	4.656611
GDP per capita (in ln)	overall	N= 600	7.091199	1.178459	4.892407	9.600842
	Between	n= 60		1.182233	5.001316	9.416978
	Within	T= 10		.109954	6.709985	7.382557
Public Health Expenditure (ln % share of GDP)	overall	N=600	.9869431	.5016177	-.388652	2.420162
	between	n= 60		.4624282	-.2517055	2.070083
	within	T=10		.2024683	.1157177	1.895235
Water	overall	N=600	76.01333	16.63765	32.6	99.8
	Between	n= 60		16.58132	40.82	99.55
	Within	T= 10		2.449968	67.6933	84.39333
Sanitation	overall	N= 600	47.50883	27.91172	7.6	98.9
	Between	n= 60		28.0573	8.81	98
	Within	T= 10		1.918327	40.68883	54.18883
Fertility Rate	overall	N= 600	4.120607	1.607712	1.45	7.681
	Between	n= 60		1.608876	1.5362	7.6125
	Within	T= 10		.1874854	3.428907	4.877907
Depth of food deficit (ln)	overall	N= 600	4.734826	.9562647	0	6.484635
	Between	n= 60		.9425477	1.262236	6.364067
	Within	T= 10		.1984795	3.47259	6.037539
Un-logged form						
U5 mortality	overall	N=600	78.6665	53.56599	5.7	227.1
	Between	n= 60		52.49262	6.61	208.47
	Within	T=10		12.45957	37.8665	156.7565
GDP per capita	overall	N=600	2290.085	2550.462	133.274	14777.22
	Between	n= 60		2544.829	148.6331	12374.73
	Within	T= 10		354.9769	466.6377	4692.57
Public Health Expenditure (% of GDP)	overall	N=600	3.02386	1.505405	.6779702	11.24768
	Between	n= 60		1.36873	.7804342	8.194618
	Within	T= 10		.6488225	.2974275	6.90217
Depth of food deficit	overall	N=600	158.5433	115.3517	1	655
	Between	n= 60		113.6051	5.1	583.2
	Within	T=10		24.36829	73.94333	268.9433

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Table 3: Fixed effects estimates

Dependent variable U5 mortality (in ln)	(1)	(2)	(3)	(4)	(5)
GDP per capita (ln)	-.8490394*** (.1021999)	-.828708*** (.1104082)	-.5615498*** (.1230445)	-.4054049*** (.1115582)	-.3527937*** (.1211421)
Public Health Expenditure (ln share of GDP)	-.1425972*** (.0383034)	-.1413863*** (.0378484)	-.106411*** (.0359311)	-.094788*** (.0315471)	-.0823851** (.0308658)
Depth of food deficit(ln)		.0334299 (.041948)	-.007061 (.0339519)	-.0208923 (.0314839)	-.010586 (.0315393)
Water			-.0235467*** (.0038057)	-.016835*** (.0044869)	-.0137316*** (.00447)
Sanitation				-.0215711*** (.0061538)	-.0162565** (.0067692)
Fertility Rate					.1317415** (.0655933)
R^2 (overall)	0.5888	0.5931	0.6782	0.7605	0.7881
Number of observations	600	600	600	600	600

Notes: Robust standard errors in parantheses
***p<0.01 **p<0.05 *p<0.1
Column 1 gives the estimates for the coefficients in the baseline specification. Columns 2-5 gives the estimates with the successive inclusion of additional controls. Column 5 represents the specification with the full set of variables. Goodness of fit (overall R^2)increases in successive columns. While GDP per capita (ln) remains statistically significant at 1% level throughout, Public Expenditure on health loses statistical significance between columns (3) and (4). However, in the full specification, all variables have a statistically significant effect at the 5% level, except for Depth of food deficit.

Table 4: Diagnostic Tests

TEST	VALUE OF TEST STATISTIC	INFERENCE DRAWN
Fixed vs Random (Hausman test)	$\chi^2_{(6)}$= 72.60 (p=0.0000)	Fixed effects estimation to be used instead of random effects
Exogeneity test (David McKinnon test)	F= 3.154122 (p= 0.0435)	Instrumental Variable estimaton to be preferred
Underidentification test (Anderson canon. corr. -N*ln(1-CCEV) LR stat.)	χ^2 = 31.28 (p=0.0000)	Model not underidentified
(Cragg-Donald N*CDEV statistic)	χ^2= 32.21 (p=0.0000)	
Weak Instruments (Cragg Donald F statistic)	F= 10.596	Model not weakly identified at the 15% maximal IV size
Overidentification (Sargan test)	χ^2 = 2.760 (p=0. .0967)	Model not overidentified at the 10% significance level

Notes: 1) Hausman test: Ho: Difference between fixed effects(consistent) and random effects(consistent only if x_{it} is uncorrelated with α_i) estimation not systematic. Ho is rejected at the 5% significance level indicating that there is correlation between regressors and country fixed effects and fixed effects estimation must be used
2) David McKinnon test : Ho: Fixed effects estimates are consistent. Rejection of Ho at 5% significance level indicates that there exists endogeneity and IV estimation must be used.
3) Anderson canon. corr. -N*ln(1-CCEV) LR stat and Cragg-Donald N*CDEV statistic : Ho: Model is underidentified. Rejection at 1% significance indicates no problem of underidentification
4) Cragg Donald F statistic: Ho: Equation is weakly identified. Stock-Yogo(2005) critical values are used and Ho is rejected at 15% maximal IV size (critical value = 8.18)
5) Sargan test: Ho: Model is over identified. Ho is rejected at 10% significance level.

Table 5: Fixed Vs IV estimates

Dependent Variable U5 mortality (ln)	Fixed Effects estimation	Instrumental Variable Estimation
GDP per capita (ln)	-.3527937*** (.1211421)	-.4368879** (.1707443)
Public health expenditure (ln share of GDP)	-.0823851** (.0308658)	-.2259554*** (.0643827)
Water	-.0137316*** (.00447)	-.0131589*** (.0021985)
Sanitation	-.0162565** (.0067692)	-.015029*** (.0041892)
Fertility Rate	.1317415** (.0655933)	.0649986 (.0587113)
Depth of food deficit (ln)	-.010586 (.0315393)	-.0205101 (.0223232)
Overall R^2	0.7881	0.6733
No. Of observations	600	600

Notes: ***p<0.01 **p<0.05 *p<0.1

Standard errors in parantheses- Robust se in case of Fixed Effects estimates

In IV estimation, Gross Capital Formation(in ln) and External Balance on goods and services are used as instruments for GDP per capita (ln) and Government Effectiveness is used as an instrument for Public health expenditure (ln share of GDP)

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APPENDIX

Figure 1: Scatter plots of each explanatory variable against child mortality