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Public Health Spending and Child Mortality: New Evidence from Developing Countries in Asia and the Pacific

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Abstract

The effectiveness of public health spending in improving population health is still an ongoing debate, especially for developing countries. This study does not only aim to contribute to this debate, it also attempts to understand whether or not results can be explained by the measurement of public health spending that is utilized. This study participates in the debate by employing three measurements of public health spending, utilizing Lewbel's method to address endogeneity and maintain a large number of observations, and employing a new set of data on countries from Asia and the Pacific. Research findings show that public health spending is an insignificant determinant of child mortality for both infant and under–5 mortality rate. Three possible reasons are discussed to explain these results. Moreover, this study confirms that these results do not rely on the measurement of public health spending that is utilized.

Keyword: Public Health Spending, Child Mortality, Lewbel's Instruments, Developing Countries, Asia and the Pacific

1. Introduction

The World Health Report 1993 is the first global document calling for investing in health spending (World Bank 1993). Health spending comprises both public and private health spending. Public health spending is financed through compulsory social insurance, general taxation, and grants and loans. Private health spending, on the other hand, encompasses private insurance, charity funds, and out-of-pocket payment. Private health spending, especially out-of-pocket payment is a barrier for people to receive healthcare. In countries where out-of-pocket payment is a major source of finance, around 100 million people annually fall into poverty (WHO 2011). Yates and Dhillon (2014) argue that public health spending is the exclusive way for the government to improve population health, especially for the poor. Black, Morris, and Bryce (2003) find that increasing the accessibility of present health care programs could prevent a significant proportion of child death. This implies that increasing public health spending could address important health-related problems. Furthermore, public health

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spending has been sustainably rising over the last decade. Globally, public health spending per capita (PHSPC) was 331 US dollars in 2000 and 676 US dollars in 2012. However, the gap between low and high spending countries is also widening. In 2012, for instance, PHSPC was 430 US dollars per capita in upper middle-income countries and 2,736 US dollars per capita in high-income countries. Just 32 and 86 US dollars per capita were spent in low and lower-middle income countries, respectively (WHO 2015b: 315).

Surprisingly, a seminal study by Filmer and Pritchett (1999) argued that public health spending has an insignificant effect on population health in developing countries. Since the publication of this study, this topic has been an ongoing debate. For instance, a number of studies have argued that public health spending significantly lowers infant and under–5 mortality rates (Bidani and Ravallion 1997; Wang 2003; Novignon, Olakojo, and Nonvignon 2012; Anyanwu and Erhijakpor 2009), but these findings have been challenged in other studies (Babazono and Hillman 1994; Filmer and Pritchett 1999; McGuire 2005). Further complicating the issue, Gani (2008) found that public health spending only lowers infant mortality rate, but not under–5 mortality rate. From these inconclusive findings, this study attempts to contribute to the debate in three important ways: by employing three measurements of public health, Lewbel's method to address endogeneity, and a new set of data and countries.

First, this study employs three measurements of public health spending: public health spending as share of GDP, public health spending per capita, and public health spending as share of government spending (hereafter referred as PHSGDP, PHSPC, and PHSGS, respectively). In the literature, a number of studies have employed PHSGDP (Filmer and Pritchett 1999; Farag et al. 2013; McGuire 2005; Hu and Mendoza 2013; Makuta and O'Hare 2015) whereas other studies have used PHSPC (Babazono and Hillman 1994; Wagstaff 2003; Bokhari, Gai, and Gottret 2007; Gani 2008; Anyanwu and Erhijakpor 2009; Novignon, Olakojo, and Nonvignon 2012). Although both measurements represent a crude measure of macro efficiency (Fleisher et al. 2008), there is a concern that these two measurements produce different results. Wang (2003), for instance, employs both PHSGDP and PHSPC and finds that results are inconsistent. PHSGDP is associated with infant mortality rate, but PHSPC is not. These results seem to rely the measurement of public health spending utilized, and the author still concludes that public health spending significantly affects infant mortality rate. This study also attempts to contribute to this research gap. Furthermore, this study employs PHSGS. Unlike the two above mentioned measurements, PHSGS is a crude sustainability indicator (Fleisher et al. 2008). PHSGS generally represents the government's commitment to healthcare issues as it shows a relative allocation of limited public spending to the health sector. In studies of public finance development, the dichotomy of public budgetary expenditures into economic and social development expenditures has often been used. This resource mobilization varies across countries and across time and development stages of a particular country. Such changes often represent priorities in the governments' policy stances toward various forms of development. However, PHSGS is often missing from existing studies.

Second, many existing cross-country studies have employed cross-sectional data (Babazono and Hillman 1994; Gupta, Verhoeven, and Tiongson 2003, 2002; Bokhari, Gai, and Gottret 2007); however, these studies could not address heterogeneity issues or time-consistent unobservable effects. Some other studies have employed unbalanced panel data (McGuire 2005; Anyanwu and Erhijakpor 2009; Novignon, Olakojo, and Nonvignon 2012) because it can address time-consistent unobservable effects (Wooldridge 2010: 281–285); however, precise explanations are necessary to justify why panel data is unbalanced (Wooldridge 2010: 282). One of reasons for unbalanced panel is the employment of conventional instruments. Gupta, Verhoeven, and Tiongson (2002), for instance, employ conventional instruments; nevertheless, the number of observations decreases, and instruments are weak. The present study also tries conventional instrument such as military spending of neighbor countries, but many observations are missing, and this instrument is weak. Hence this study employs Lewbel's method (Lewbel 2012) because this method was developed to generate instruments when conventional instruments are weak and unavailable. This method also helps to maintain a large number of observations in this present study. Hence, unlike existing studies, this study can employ balanced panel data.

Third, Sub-Saharan Africa and the Southern Asia regions are identified as the first and second regions with the highest child mortality, respectively. Unlike the Sub-Saharan Africa region, the acceleration of child mortality reduction is low in the Southern Asia region (Liu et al. 2016). Existing studies seem to focus on the highest child mortality region, and very few pay attention to the second highest region. For instance, there are several studies in sub-Saharan African countries (Anyanwu and Erhijakpor 2009; Novignon, Olakojo, and Nonvignon 2012; Makuta and O'Hare 2015), developed countries (Babazono and Hillman 1994; Brown 2014), developing countries (Gupta, Verhoeven, and Tiongson 2002, 2003), and both developed and developing countries (Farag et al. 2013; Bokhari, Gai, and Gottret 2007; McGuire 2005; Filmer and Pritchett 1999; Hu and Mendoza 2013; Wagstaff 2003). Unlike many existing studies, however, this study focuses on developing countries specifically in the Asia and the Pacific region.

To contribute to the debate on the effectiveness of public health spending in improving population health, child mortality is employed as a proxy for health outcomes in this study. In this study, child mortality refers to both under–5 and infant mortality rates. Infant and under–5 mortality rates are the probability of dying before the child turns to one and five years old, respectively, and they are measured per 1,000 live births. Reidpath and Allotey (2003) confirm that child mortality remains a vital proxy of health outcomes because it is the first and foremost factor to be affected before other health outcomes, especially in resource-constrained countries. McGuire (2005) provides three additional reasons. First, child mortality can be prevented from specific causes through policy more than mature mortality. Second, child death leads to more forgone years than adult death. Third, child health is susceptible to socio-economic and social service change. Infant or/and under–5 mortality rates have been nearly exclusively used as the proxy of health outcomes to measure the effectiveness of public health spending in the existing literature (Anyanwu and Erhijakpor 2009; Bhalotra 2007; Gupta, Verhoeven, and Tiongson 2002; Farag et al. 2013; Rajkumar and Swaroop 2008). Furthermore, child mortality reduction is on many global development agendas. For instance, the 4th Minimum Development Goal (MDG4) targeted to lower two-thirds of 1990's under–5 mortality rate by 2015. However, the MDG4 was not achieved. Child mortality reduction was then included in the 3rd Sustainable Development Goals (SDG3). Two targets of SDG3 are to reduce infant and under–5 mortality rates to 12 and 25 per 1,000 live births, respectively, by 2030 (WHO 2015a: 8).

2. Research Method

2.1. Econometrics Model

The effectiveness of public health spending in improving child mortality has been an ongoing this debate. Equation 1 estimates the effect of public health spending on child mortality.

$$CM_{ct} = \alpha + \beta G_{ct} + \theta_i x_{ict} + u_{ct} \tag{1}$$

where CM_{ct} is child mortality (infant or under–5 mortality rate) in country c at time t; CM_{ct} depends on public health spending G_{ct} (PHSGDP, PHSGS, or PHSPC), and other explanatory variables x_{ict} (GDP per capita, improved water source, improved sanitation, urban population, age under 15, and age 15 to 64). The definition of these selected variables is shown in Appendix 1. Note that age above 64 is not included to avoid a multicollinearity issue because the three age-related demographic variables add up to 100 percent. As this study employs a cross-country analysis, heterogeneity is an issue in equation 1. To address this issue, equation 2 includes a country fixed-effect.

$$CM_{ct} = \alpha + \beta G_{ct} + \theta_i x_{ict} + \delta c_c + v_{ct} \tag{2}$$

where $u_{ct} = \delta c_c + v_{ct}$, c_c is the fixed-effect of country c, v_{ct} is the residual of country c at time t. Instead of estimating equation 2 by level-level regression, this study employs log-log regression. Filmer and Pritchett (1999) suggest two advantages of using log-log regression. First, an interpretation is easy as an estimate (β) is an elasticity, and it is convenient to compare results with existing studies. Secondly, log-log regression could also observe a nonlinear relationship. Gupta, Verhoeven, and Tiongson (2002) support that log-log regression is an appropriate model. Log-log regression is dominantly applied in the existing literature. Equation 3 is formulated using log-log regression.

$$lnCM_{ct} = \alpha + \beta lnG_{ct} + \theta_i x_{ict} + \delta c_c + v_{ct} \tag{3}$$

It is noted that dependent variables and an independent variable of interest (public health spending) and a control variable such as GDP per capita are logged, and remaining variables are not logged. Though the country fixed-effect corrects time-invariant unobservable effects, equation 3 still produces a biased estimate as public health spending is endogenous due to an omitted variables bias. A lagged child mortality, for instance, is correlated with both current public health spending and child mortality (Bokhari, Gai, and Gottret 2007). This study does not include lagged child mortality as an explanatory variable because it could suppress the significance level of other independent variables, especially public health spending (Achen 2000).

2.2. Addressing the Endogeneity

Instrumental variables are inevitably needed to address the endogeneity of public health spending. However, finding good conventional instruments is practically challenging for two reasons. First, instruments are not widely available, and second instruments are often too weak. Furthermore, employing conventional instruments could reduce the number of observations, especially with cross-country studies. For instance, Gupta, Verhoeven, and Tiongson (2002) state their research findings must be cautious due to a small sample size and weak instruments. The present study also tries conventional instrument such as military spending of neighbor countries, but many observations are missing, and this instrument is weak. Hence this study employs Lewbel's method to generate heteroscedasticity-based instruments to address the endogeneity (Lewbel 2012) because this method was developed to generate instruments when conventional instruments are weak or unavailable. This method also helps to maintain a large number of observations in this present study. Mishra and Smyth (2015) confirm that estimates using heteroscedasticity-based instruments fall between ordinary least square (OLS) estimates and estimates using conventional instruments.

Lewbel (2012) developed a method to exploit heteroscedasticity to generate instruments. This method employs Z— a subset of control variables (x_i)—to create instruments. The Z has to be exogenous, and this is a standard assumption in the econometrics. The principal requirement of this method is the existence of heteroscedasticity in a first-stage regression before instrumentation. In other words, the regression of public health spending on control variables without instruments must produce heteroscedastic variance. According to Lewbel (2012), the Breush-Pagan test (Breusch and Pagan 1979) can be employed to examine the existence of heteroscedasticity. Table 2, 3, and 4 show that the x^2 of Breush-Pagan test is high and the p-value is lower than 0.10. These results indicate that the first-stage regression before instrumentation produces heteroscedastic variance. Hence the Lewbel's method is appropriate. As this requirement is met, instruments are generated by $[Z-E(Z)]\,\varepsilon_2$. Z is a subset of control variables (x_i) except for the endogenous variable. There are six variables in this study: $E(Z)$ is a subset of the means of control variables (Z), and ε_2 is the estimated residual from the first-stage regression before instrumentation.

There is no standard approach to regarding choice of Z, whether Z is equal to or less than x_i. Mishra and Smyth (2015) confirm that the choice of Z—equal or lower than x_i—does not matter. This study employs all control variables—with Z equal to x_i—to generate instruments. Usually, generated instruments comprise both weak and strong instruments. Here, strong instruments are selected. Consistent with Brown (2014), this study employs weak instrument tests developed by Stock and Yogo (2005) to evaluate the strength of generated instruments. Moreover, Lewbel (2012) also suggests that the orthogonality condition of generated instruments can be checked by using the overidentification test developed by Hansen (1982). Therefore, generated instruments which satisfy these tests are selected. In most cases, instruments generated from urban population and age 15 to 64 are strong and valid, which satisfies weak instrument, underidentification, and overidentification tests. Finally, Two-Stage Least Square regression (2SLS) is employed. As the Lewbel's method is applied, it is necessary to correct the heteroscedasticity. Also, panel data may be serially correlated; hence, heteroscedastic and autocorrelation consistent (HAC) standard errors are employed. The present study employed Stata version 14 using the written command "ivreg2" developed by Baum, Schaffer, and Stillman (2007).

2.3. Data and Variables

Control variables were carefully selected. Any variable which is reflected in public health spending was not selected. For instance, immunization rate is not included because it results from public health spending. In other words, public health spending is the total amount, and immunization rate is a proportion of public health spending allocated to vaccines. If immunization rate was included, the significant level of public health spending may be absorbed in immunization; hence, it may result in an insignificant impact on child mortality. To avoid this potential collinearity issue, this study selected six control variables including GDP per capita, improved water source, improved sanitation, urban population, age under 15, and age 15 to 64.

GDP per capita is a major control variable. Developed countries tend to have lower child mortality than developing countries because they have a better capability in addressing health care issues. Pritchett and Summers (1996: 865), for instance, find that a percentage change in the GDP per capita is resulted in −0.2 and −0.4 percentage change in infant and under–5 mortality rate, respectively. Moreover, GDP per capita correlates with both public health spending and child mortality. Excluding GDP per capita would bring an omitted variables bias. Improved sanitation and water source are also two crucial control variables. Improved sanitation is the proportion of the population accessing improved sanitation, and improved water source is the proportion of the population accessing an improved drinking water source. These two variables could reduce child mortality through the prevention of infectious diseases such as diarrhea, and mild or severe stunting (Esrey et al. 1991; Fink, Günther, and Hill 2011).

Urban population is also an essential control variable, and it is measured in proportion to the population. The urban population has access to better public services such as healthcare and transportation than the rural population. Urban areas generally have lower child mortality than rural areas (Wang 2003). Moreover, demographic variables such as age under 15 and age 15 to 64 are included in this study, and they are measured in proportion to the population. These variables control for demographic structures of different countries. A country with an ageing population has less concern about child mortality than a country with a young population. These variables could also reflect the structure of public health spending. A country with an ageing population tends to allocate less public health spending on child health issues than a country with a young population (Novignon, Olakojo, and Nonvignon 2012).

Multicollinearity happens when two independents variables are perfectly correlated. The highest correlation is between GDP per capita and PHSPC, which is 0.705 (see Appendix 2). Wang (2003) includes variables that its correlation score is around 0.8. This indicates that multicollinearity is not a concern in this study. The World Development Indicator is the source of data (World Bank 2017). 36 low and middle-income countries were selected including eight countries of South Asia, 23 countries of East Asia and the Pacific, and five countries of Central Asia. However, six countries were excluded due to incomplete data or data unavailability. As a result, 30 countries remains selected, and a list of these selected countries is in Appendix 3. Data covers 13 years from 2002 to 2012.

3. Research Results

3.1. Descriptive Statistics

Table 1 shows descriptive statistics of all chosen variables in 2012. There are 30 countries or observations. The average under–5 mortality rate is 37.13 per 1,000 live births, and the standard deviation is 23.01 per 1,000 live births. The average infant mortality is 30.05 per 1,000 live births

Table 1 Descriptive Statistics of Variables in 2012

Variable	Mean	Std. Dev
Under–5 mortality rate (per 1000 live births)	37.17	23.01
Infant mortality rate (per 1000 live births)	30.05	17.20
PHSGDP (%)	3.18	2.37
PHSGS (%)	9.89	4.62
PHSPC (PPP US dollars)	191.17	183.74
GDP per capita (PPP US dollars)	6513.01	5539.46
Improved sanitation (%)	66.43	25.14
Improved water source (%)	84.41	14.86
Urban population (%)	35.62	14.96
Age under 15 (%)	31.85	6.65
Age 15 to 64 (%)	63.20	5.48

with a standard deviation of 17.20 per 1,000 live births. These figures indicate a wide variation in child mortality among these countries. There are three measurements of public health spending: PHSGDP, PHSGS, and PHSPC. The average PHSGDP is 3.18%, and the standard deviation is 2.37%. The average PHSGS is 9.89% with a standard deviation of 4.62%. The average PHSPC is 191.17 US dollars per capita, and its standard deviation is 183.74 US dollars per capita. The average GDP per capita is 6513.01 US dollars per capita, and the standard deviation is 5539.46 US dollars. Improved sanitation and water source are 64.43% and 84.41%, respectively. It seems that the populations in these countries had more access to improved water sources than sanitation. There is a low proportion of urban population in these countries, just 35.62%. There are 31.85%, and 63.20% of the population age under 15 and age 15 to 64, respectively. These demographic figures suggest that there is a low proportion of ageing population in the sample.

3.2. Empirical Results

Note that there are two variables of child mortality including under–5 and infant mortality rates. Each dependent variable regresses on current measurements of public health spending (330 observations). Two robustness analyses were conducted. First, Similar to Brown (2014) and Hu and Mendoza (2013), additional regressions used lagged public health spending (300 observations). Second, sample was restricted to 24 low and lower-middle income countries (LLMIC) which 264 observations were available. Table 2, 3, and 4 show the empirical results using PHSGDP, PHSPC, and PHSGS, respectively. There are two columns in the first row-under–5 and infant mortality rates. In the second row, there are three columns including current PHS, lagged PHS, and a LLMIC sample. The current PHS column shows empirical results using current public health spending, and a lagged PHS column employs lagged public health spending. The last column restricts observations to a LLMIC sample. The third row shows that each column of the second row has two regression results including OLS and 2SLS.

Before interpreting 2SLS regression results, it is necessary to check the quality of employed instruments. Table 2, 3, and 4 also include heteroscedasticity tests and instrumental variable tests. Though three measurements of public health spending may have the same or different instruments depending on the quality of instruments, three tests—underidentification, weak identification, and overidentification tests—in Table 2, 3, and 4 indicate that the instruments are strong and valid. For instance, the underidentification test produces a high Kleibergen-paap rk LM statistic, which is statistically significant. This test shows that the employed instruments are not under-identified. The weak identification test shows that the Kleibergen-Paap rk Walkd F statistic are more than 10, and it also higher than critical value of 10% maximal size. Based on the rule of thumb, the hypothesis of weak instruments is rejected. Lastly, the overidentification test produces a very low Hansen J statistic, and the p-value is more than 0.10. These results indicate that the instruments meet the orthogonality condition. Furthermore, it is noted that the country fixed-effect is included in each regression analysis, and it is written as “yes” in the row of country-fixed effects. Similarly, the written “yes” in the row of age control (two categories) indicates that regression analyses include age under 15 and age 15 to 64.

Table 2 shows empirical results using PHSGDP. The results show that PHSGDP is associated with neither under–5 nor infant mortality rate. GDP per capita is an important predictor of child mortality. Under the current PHSGDP column, the coefficient of log GDP per capita for under–5 mortality rate is −0.665 and −0.660 in the OLS and 2SLS, respectively. The coefficient of GDP in respect to infant mortality rate is −0.596 and −0.594 in the OLS and 2SLS, respectively. These figures indicate that one percentage change in GDP per capita is associated with −0.665 and −0.660 percentage change in under–5 mortality rate in the OLS and 2SLS, respectively, and −0.581 and −0.602 percentage change in infant mortality rate in the OLS and 2SLS, respectively. Furthermore, the percentage of urban population is significantly associated with infant mortality rate in the 2SLS, and its coefficient is −0.011. One unit change in the urban population is associated with a −1.1 percentage change in infant mortality rate. Other control variables are statistically insignificant. Results are consistent when a lagged PHSGDP is employed. PHSGDP is an insignificant predictor of child mortality. The GDP per capita is the only variable that significantly associates with the under–5 mortality rate whereas both GDP per capita and urban population significantly predict infant mortality rate. Results are robust when observations are restricted to the LLMIC sample. PHSGDP is not a significant variable, and GDP per capita remains the significant variable of child mortality in the LLMIC sample, but the coefficient is smaller than the full sample. The urban population is no longer a significant predictor of infant mortality rate. Hence, PHSGDP is a statistically insignificant predictor of child mortality.

Table 3 shows empirical results using PHSPC. Results show that the current PHSPC is an insignificant predictor of child mortality. The GDP per capita is the only significant predictor of under–5 mortality rate while both GDP per capita and urban population have significant effects on infant mortality rate. The coefficient of log GDP per capita is slightly smaller than in Table 4. Similar to the above result, PHSPC is found to be insignificant when a lagged PHSPC is employed. Results using the LLMIC sample is consistent with the current and lagged PHSPC columns. PHSPC is an insignificant predictor, but GDP per capita is a significant predictor of child mortality in the LLMIC sample. The coefficient of GDP per capita in the LLMIC sample is smaller than the full sample. In summary, PHSPC is not statistically associated with child mortality.

In addition to PHSGDP and PHSPC, Table 4 presents the relationship between PHSGS and child mortality. While PHSGDP and PHSPC are logged, PHSGS are not logged because logged PHSGS does not produce heteroscedastic variance in the first-stage regression before instrumentation. Findings are consistent with both Tables 2 and 3 that PHSGS is also not a significant predictor of child mortality. GDP per capita remains the only significant predictor of under–5 mortality rate. In addition to GDP per capita, urban population is also significantly associated with infant mortality rate. By contrast, a

Table 2　Empirical Results Using PHSGDP

Variables	Under–5 mortality rate						Infant mortality rate					
	Current PHSGDP		Lagged PHSGDP		LLMIC sample		Current PHSGDP		Lagged PHSGDP		LLMIC sample	
	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]
PHSGDP (log)	0.030	0.016	0.017	0.013	0.053	0.007	0.016	0.013	0.011	0.008	0.039	0.002
	(0.036)	(0.031)	(0.033)	(0.033)	(0.033)	(0.029)	(0.031)	(0.028)	(0.030)	(0.028)	(0.027)	(0.025)
GDP per capita (log)	*−0.665*[a]	*−0.660*[a]	*−0.680*[a]	*−0.678*[a]	*−0.564*[a]	*−0.539*[a]	*−0.596*[a]	*−0.594*[a]	*−0.595*[a]	*−0.594*[a]	*−0.469*[a]	*−0.449*[a]
	(0.188)	(0.111)	(0.209)	(0.134)	(0.153)	(0.103)	(0.175)	(0.099)	(0.189)	(0.112)	(0.128)	(0.073)
Improved sanitation	−0.002	−0.002	−0.004	−0.004	−0.002	−0.002	−0.001	−0.001	−0.002	−0.002	−0.001	−0.001
	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.002)	(0.004)	(0.003)	(0.005)	(0.003)
Improved water source	0.003	0.0027	0.003	0.003	−0.006	−0.006	0.004	0.004	0.004	0.004	−0.006	−0.005
	(0.009)	(0.005)	(0.009)	(0.005)	(0.007)	(0.004)	(0.008)	(0.005)	(0.009)	(0.005)	(0.006)	(0.004)
Urban population	−0.009	−0.009	−0.010	−0.010	−0.001	−0.002	−0.011	*−0.011*[c]	−0.012	*−0.012*[c]	−0.001	−0.002
	(0.011)	(0.006)	(0.012)	(0.007)	(0.011)	(0.007)	(0.010)	(0.006)	(0.011)	(0.006)	(0.010)	(0.006)
Age control (two categories)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	330	330	300	300	264	264	330	330	300	300	264	264
R-squared	0.766	0.765	0.739	0.739	0.771	0.766	0.799	0.799	0.781	0.781	0.833	0.829
Underidentification test (LM statistic)	—	*13.361*[a]	—	*12.626*[a]	—	*14.186*[a]	—	13.362[a]	—	*12.626*[a]	—	*14.168*[a]
Weak identification test (F-statistic)	—	47.25	—	48.11	—	28.48	—	47.25	—	48.11	—	28.48
Overidentification test (J statistic)	—	0.227	—	0.016	—	0.054	—	0.029	—	0.029	—	0.130
Breush-Pagan test (x^2)	—	*29.95*[a]	—	*34.77*[a]	—	*24.14*[a]	—	*29.95*[a]	—	*37.77*[a]	—	*24.14*[a]

Note: HAC standard errors are in parentheses.

[1]Generated instruments from urban population and age 15 to 64 are employed.

[a] $p < 0.01$, [b] $p < 0.05$, [c] $p < 0.1$

Table 3 Empirical Results Using PHSPC

Variables	Under–5 mortality rate						Infant mortality rate					
	Current PHSPC		Lagged PHSPC		LLMIC sample		Current PHSPC		Lagged PHSPC		LLMIC sample	
	OLS	2SLS[2]	OLS	2SLS[3]	OLS	2SLS[1]	OLS	2SLS[2]	OLS	2SLS[3]	OLS	2SLS[1]
PHSPC (log)	0.004	0.005	−0.013	−0.049	0.035	−0.008	−0.007	0.011	−0.016	0.045	0.023	−0.010
	(0.040)	(0.037)	(0.042)	(0.033)	(0.035)	(0.037)	(0.036)	(0.031)	(0.038)	(0.030)	(0.030)	(0.032)
GDP per capita (log)	-0.658^a	-0.659^a	-0.658^a	-0.729^a	-0.573^a	-0.526^a	-0.581^a	-0.602^a	-0.573^a	-0.642^a	-0.474^a	-0.437^a
	(0.191)	(0.116)	(0.203)	(0.146)	(0.162)	(0.105)	(0.172)	(0.108)	(0.181)	(0.125)	(0.133)	(0.076)
Improved sanitation	−0.002	−0.002	−0.004	−0.004	−0.001	−0.001	−0.00	−0.001	−0.002	−0.002	−0.0002	−0.001
	(0.005)	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.004)	(0.002)	(0.004)	(0.003)	(0.005)	(0.002)
Improved water source	0.003	0.003	0.004	0.002	−0.007	−0.005	0.004	0.003	0.004	0.003	−0.006	−0.005
	(0.009)	(0.005)	(0.010)	(0.005)	(0.007)	(0.004)	(0.009)	(0.005)	(0.009)	(0.005)	(0.007)	(0.004)
Urban population	−0.009	−0.009	−0.009	−0.010	−0.002	−0.002	−0.011	-0.011^c	−0.011	-0.012^c	−0.002	−0.002
	(0.011)	(0.006)	(0.012)	(0.007)	(0.012)	(0.007)	(0.010)	(0.006)	(0.011)	(0.006)	(0.010)	(0.006)
Age control (two categories)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	330	330	300	300	264	264	330	330	300	300	264	264
R-squared	0.764	0.764	0.738	0.732	0.767	0.762	0.798	0.797	0.782	0.773	0.830	0.826
Underidentification test (LM statistic)	—	11.225^a	—	10.67^a	—	11.090^a	—	11.225^a	—	10.667^a	—	11.090^a
Weak identification test (F-statistic)	—	46.96	—	38.43	—	17.96	—	46.94	—	38.43	—	17.96
Overidentification test (J statistic)	—	1.204	—	0.937	—	0.840	—	2.111	—	2.344	—	0.224
Breush-Pagan test (x^2)	—	47.09^a	—	41.42^a	—	27.23^a	—	47.09^a	—	41.42^a	—	27.32^a

Note: HAC standard errors are in parentheses.
[1]Generated instruments from urban population and age 15 to 64 are employed.
[2]Generated instruments from age under 15 and age 15 to 64 are employed.
[3]Generated instruments from urban population and age under 15 are employed.
^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$

Table 4 Empirical Results Using PHSGS

Variables	Under–5 mortality rate						Infant mortality rate					
	Current PHSGS		Lagged PHSGS		LLMIC sample		Current PHSGS		Lagged PHSGS		LLMIC sample	
	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]	OLS	2SLS[1]
PHSGS	0.0003	−0.0020	0.0003	−0.0016	0.0020	−0.0020	−0.0006	−0.0022	0.00002	−0.0014	0.0012	−0.0023
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
GDP per capita (log)	-0.654^{a}	-0.652^{a}	-0.673^{a}	-0.672^{a}	-0.537^{a}	-0.534^{a}	-0.589^{a}	-0.587^{a}	-0.591^{a}	-0.590^{a}	-0.449^{a}	-0.446^{a}
	(0.187)	(0.111)	(0.208)	(0.130)	(0.160)	(0.106)	(0.173)	(0.098)	(0.188)	(0.109)	(0.132)	(0.077)
Improved sanitation	−0.002	−0.002	−0.004	−0.004	−0.002	−0.001	−0.001	−0.001	−0.002	−0.002	−0.001	0.0002
	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.002)	(0.004)	(0.003)	(0.005)	(0.003)
Improved water source	0.003	0.002	0.004	0.003	−0.005	−0.006	0.003	0.003	0.004	0.004	−0.005	−0.006
	(0.009)	(0.005)	(0.009)	(0.005)	(0.007)	(0.004)	(0.008)	(0.005)	(0.009)	(0.005)	(0.007)	(0.004)
Urban population	−0.009	−0.009	−0.009	−0.009	−0.001	−0.002	−0.010	-0.010^{c}	−0.012	-0.011^{c}	−0.002	−0.003
	(0.011)	(0.006)	(0.012)	(0.008)	(0.012)	(0.007)	(0.010)	(0.006)	(0.011)	(0.006)	(0.011)	(0.006)
Age control (two categories)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	330	330	300	300	264	264	330	330	300	300	264	264
R-squared	0.764	0.763	0.738	0.737	0.765	0.762	0.798	0.798	0.781	0.781	0.829	0.825
Underidentification test (LM statistic)	—	12.206^{a}	—	11.558^{a}	—	11.856^{a}	—	12.206^{a}	—	11.558^{a}	—	11.856^{a}
Weak identification test (F-statistic)	—	35.89	—	56.84	—	50.95	—	35.89	—	56.84	—	50.95
Overidentification test (J statistic)	—	0.136	—	0.046	—	1.618	—	0.007	—	0.002	—	0.842
Breush-Pagan test (x^2)	—	97.74^{a}	—	90.61^{a}	—	72.14^{a}	—	97.74^{a}	—	90.61^{a}	—	72.14^{a}

Note: HAC standard errors are in parentheses

[1]Generated instruments from urban population and age 15 to 64 are employed.

^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.1$.

lagged PHSGS is a statistically insignificant predictor of child mortality. This insignificant relationship is also found in the LLMIC sample. GDP per capita is the only significant predictor of child mortality in the LLMIC sample. Therefore, PHSGS is not statistically associated with child mortality.

According to Tables 2, 3, and 4, results are robust that public health spending is insignificantly associated with child mortality. No measurement of public health spending is significantly associated with infant or under–5 mortality rate in either the full sample or the LLMIC sample. This study concludes that public health spending is not significantly associated with child mortality-neither with infant nor under–5 mortality rate. This study also confirms that this relationship does not rely on the measurement of public health spending that is utilized.

4. Discussion

This study finds that PHSGDP is an insignificant predictor of child mortality-both infant and under–5 mortality rate. Similarly, PHSPC is insignificantly associated with child mortality. Unlike Wang (2003), these two commonly-used measurements of public health spending produce the same results. In addition to these two measurements, PHSGS was also found to have an insignificant association with child mortality. Similar to Anyanwu and Erhijakpor (2009), both current and lagged public health spending produce the same results in this study. Unlike Gani (2008), this study finds that public health spending is insignificantly associated either infant or under–5 mortality rate. Because none of three measurements of public health spending－PHSGDP, PHSPC, and PHSGS－is associated with child mortality, this study argues that public health spending is ineffective in improving child mortality. Furthermore, this study confirms that the results do not rely on the measurements of public health spending that is utilized. This study produced results consistent with some empirical studies (Babazono and Hillman 1994, Filmer and Pritchett 1999, McGuire 2005).

There are at least three possible reasons to explain the present findings. Firstly, there is a high percentage of private health spending in the analyzed countries. For instance, in the South-East Asia region, private health spending accounted for 62.1% of health spending in 2012 (WHO 2015b). This implies that people rely more on out-of-pocket payment to receive health care than public health spending. Secondly, given the amount of public health spending in these countries, leakage is another possible reason. Cambodia is an example. It was estimated that Cambodia leaked public health spending of around 50 million US dollars in 2010 due to improper procurement management. Specifically, the purchasing prices of pharmaceuticals and medical supplies in Cambodia were about six times higher than the international reference prices (World Bank 2011). Lastly, reaching poor households is another possible explanation. Developing countries have higher rate of child mortality, especially among poor households. It is very critical to ensure that public health spending proportionately benefit more to poor households than rich households. Surprisingly, poor households receive only a limited proportion of public health spending. For instance, households in the poorest income quantile receive 16.78%, 12.49%, 13.46%, 6.64%, and 14.76% of public health spending in Bangladesh, India, Indonesia, Nepal, and Vietnam, respectively (O'Donnell et al. 2007). Given the current amount of public health spending, outcomes could be maximized or child mortality could be greatly reduced if resources are fairly distributed to the poor households. In summary, the countries analyzed in the present study should take into account the three abovementioned issues to improve public health spending.

5. Conclusion

This study finds that none of three measurements of public health spending-measured as a share of GDP, per capita, and share of government spending-is associated with either infant or under–5 mortality rates. Findings are statistically robust among three analyses including employing current public health spending, utilizing lagged public health spending, and excluding upper middle-income countries from the full sample (LLIMC sample). GDP per capita is a significant predictor of both under–5 and infant mortality rates while urban population is only associated with infant mortality rate in the full sample. Hence, this study concludes that there is an insignificant relationship between public health spending and child mortality. Three possible reasons are highlighted to explain this insignificant relationship including a high proportion of private spending, the leakage of public health spending, and unfair distribution of public health spending. This study also confirms that this relationship is not altered by the measurement of public health spending that is utilized.

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Appendix 1　Definition of the Variables

Variable	Definition
Infant and under-5 mortality rate	The probability per 1,000 live births that a newborn baby will die before reaching age one and five years old, respectively.
Public health spending (PHS)	Recurrent and capital health spending from government budgets, loans and grants, and compulsory social insurance. It can be measured per capita (PHSPC), as a share of GDP (PHGDP), or as a share of government spending (PHSGS).
GDP per capita	GDP is gross domestic product converted to US dollars using the purchasing power parity (PPP) rate based on the year 2011.
Urban population	The proportion of the population that lives in urban areas
Improved sanitation	The proportion of population with access to improved sanitation including flush/pour flush (to a piped sewer system, septic tank, or pit latrine), ventilated improved pit (VIP) latrines, pit latrines with slabs, and composting toilets.
Improved water source	The proportion of the population with access to improved drinking water source such as piped water on premises or other improved water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection).
Age under 15	The proportion of the population under age 15 years old.
Age 15 to 64	The proportion of the population ages 15 to 64 years old.

Appendix 2　Correlation among Independent Variables

No	Independent variables	1	2	3	4	5	6	7
1	PHSGDP	1.000						
2	PHSGS	0.680	1.000					
3	PHSPC	0.499	0.410	1.000				
4	GDP per capita	−0.067	−0.025	0.705	1.000			
5	Improved sanitation	−0.074	0.018	0.469	0.584	1.000		
6	Improved water source	0.086	0.158	0.478	0.496	0.631	1.000	
7	Urban population	−0.105	−0.283	0.411	0.691	0.404	0.276	1.000

Appendix 3　List of Selected Countries

Region	Countries
South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka
East Asia and Pacific	Cambodia, China, Fiji, Indonesia, Kiribati, Lao PDR, Malaysia, Micronesia Fed. Sts, Mongolia, Papua New Guinea, Philippines, Samoa, Solomon Islands, Thailand, Timor-Leste, Tonga, Vanuatu, and Vietnam
Central Asia	Kazakhstan, Kyrgyz Republic, Tajikistan, and Uzbekistan

Note: the LLMIC sample excludes underlined countries.