

Original research Articles

Estimating the Effect of Maternal and Child Health Outcomes to GDP per Capita

ABSTRACT

Background. Using panel data from 1960 to 2013 of 193 UN countries, this paper explored the effect of maternal and child health outcomes specific to GDP per capita.

Objective. To explore the effect of MDG 4 and 5 to per capita GDP of UN countries.

Method. Data gathered from World Bank were averaged from 1960 to 2013 and was normalized using lagged logarithmic form to fit in the parameters required to run multiple linear regression.

Results. The combination of variables indicating maternal and child health outcomes significantly predicted the effect to GDP per capita at 99% ($p < 0.01$, $F = 199.664$, $df = 4, 171$) with all four variables significantly contributing to the final model. The beta weights suggest that a percentage decrease in infant mortality rate per 1000 live births, maternal mortality rate per 1000 live births and proportion of births attended by skilled personnel contribute a percentage increase in the GDP per capita in US dollars while a percentage increase in the proportion of children immunized with measles contributes a percentage increase in the GDP per capita in US dollars.

Conclusion. Utilizing the empirical model, the maternal and child health outcomes have a minimum effect of 2.32% to 4.81% to GDP per capita.

Keywords: *Millennium Development Goals, Maternal and Child, Effect to GDP, Maternal and Child Health, Health Outcomes, Multiple Linear Regression*

INTRODUCTION

Since 1990, numerous researches have emerged to understand the concept of economic growth. Several variables were considered in the process as determinants of being statistically and economically significant factors that would explain economic growth of countries. Theorist identified that human capital is one of the economic variables. In fact, the presence of human capital as part of several indicators was regarded as one of the most indispensable engine in achieving economic growth.

According to Weil (2013), the improvement in health that has taken place over the last two centuries resulted from three sets of forces: first, improvements in the standard of living, in particular, better nutrition; second, changes in the public health environment, including sanitation and the supply of clean water; and finally, improvements in medical technology, including antibiotics and other medical treatments.

In a study conducted by Bloom, Canning, and Sevilla (2003), health has been found to have a positive and statistically significant effect on economic growth. Results of the study suggest that a year of improvement in a population's life expectancy contributes to an increase of 4% in output. They concluded that this is a relatively large effect, indicating that increased expenditures on improving health might be justified purely on the grounds of their impact on labor

productivity, quite apart from the direct effect of improved health on welfare.

One study conducted which is similar to this paper is the study of Amiri and Gerdtham (2013). The paper explored the impact of maternal and child health on economic growth utilizing a new evidence-based granger causality and data envelopment analysis. The study utilized under-five mortality rate (the number of deaths of children under five years old per 1,000 live births) and maternal mortality ratio (the number of deaths per 1000,000 live births) from 1990 to 2010. On the other hand, GDP per capita was used as indicator for economic growth from 1990 to 2000. Findings of the study suggest that (a) in 105 of 180 (58%) countries, the study find a bi-directional relationships. This indicates that in the majority of countries, changes in under-five mortality have an impact on GDP and vice versa. While in 49 countries (27%) have one-way relationships from under-five mortality to GDP.

In 14 countries (8%) the study find one-way relationships from GDP to under-five mortality. And for the remaining 12 countries (7%), no relationships are found. (b) In 68 of 170 (40%) countries they find bi-directional relationships. One-way relationships from maternal mortality to GDP are found in 50 countries (29%) and one-way relationships from GDP to maternal mortality are found in 19 countries (11%). No relationships are found in 33 countries (19%). The study also find that the magnitude of the effect of reductions in child mortality on GDP in high-income countries (HICs) and upper middle-income countries (UMICs) is larger than lower- middle-income countries (LMICs) and low-income countries (LICs).

However, in contrast, the magnitude of the effect of GDP on maternal and child health outcomes in LMICs and LICs are larger relative to HICs and UMICs. Lastly, the results of the DEA analysis to explore the effects of other growth-related factors in the model, reductions in mortality was found to generally have a large effect on GDP growth, since the average overall efficiency rates for all countries in the data are more than 90% (91.1% in 1990-2000 and 92.2% in 2000-2010). As noted above, the results indicate that a decrease in child mortality would lead to a larger effect on GDP in richer countries compared with poorer countries, although the difference in the average efficiency rate between different groups of countries are not statistically significant.

Furthermore, Bhargava et al. (2001) conducted a study about modeling the effects of health to economic growth using the Penn World Table and World Development Indicators. The paper modeled the proximate determinants of economic growth at 5 yearly intervals using panel data on GDP series based on purchasing power comparisons in the Penn World Table, and on exchange rate conversions from the World Development Indicators. In the conceptual framework of the analysis, the demographic literature relating life expectancy to income (Preston, 1976) was integrated with models commonly specified for economic growth (Barro and Sala-i-Martin, 1995).

Macroeconomic evidence for an effect on growth is mixed, with evidence of a large effect in some studies. However, there is a possibility that gains from health may be outweighed by the effect of increased survival on population growth, until a fertility transition occurs. The low cost of some health interventions that have large-scale effects on population health makes health investments a promising policy tool for growth in developing countries. In

addition, higher priority could be given to tackling widespread “neglected” diseases—that is, diseases with low mortality burdens that are not priorities from a pure health perspective, but that do have substantial effects on productivity.

Bloom et al. (2003) estimated a production function model of aggregate economic growth including two variables that microeconomists have identified as fundamental components of human capital: work experience and health. The result suggest that good health has a positive, sizable, and statistically significant effect on aggregate output even when we control for experience of the workforce. The study argue that the life expectancy effect in growth regressions appears to be a real labor productivity effect, and is not the result of life expectancy acting as a proxy for worker experience.

In addition, Bloom and Canning (2005) compared the estimated effects of health in a macroeconomic production function model of economic growth with the effects that are found using calibration based on wage regressions. The study suggest that gradual adjustment in income level towards the steady state which means that both the level and growth of inputs can affect economic growth. The study also find that the estimated macroeconomic effects of health are positive, and not significantly different from the microeconomic estimates. The findings were similar for education provided we instrument schooling levels with literacy rates to correct for measurement error.

The simplest channel of causality running from health to economic growth is via the productivity of workers. Individuals who are healthier are able to work more effectively, both physically and mentally. Further, adults who were healthier as children will have acquired more human capital in the form of education. Weil (2007) refers to this as the proximate effect of health on the level of income (Weil, 2013).

To be specific on the issue concerning health (which is a very broad concept) and economic growth, this paper would like to focus on health as an indicator of development and economic growth as GDP per capita. As stipulated in the Millennium Development Goals, the health outcomes pertaining to women, mothers, and children (improving maternal health and achieving universal access to reproductive health) and (reducing child mortality) are one of the key indicators towards development. Identifying the country’s effort to improve maternal and child health will result in greater societal returns especially in the economic dimension. This paper will device a model utilizing maternal and child health outcomes as predictors of GDP per capita to help stakeholders estimate the percentage effect in the GDP per capita with their current maternal and child health.

Significance

This study is focused on exploring the effect of MDG 4 and 5 to per capita GDP of 193 UN countries. The study is relevant in understanding the significant effects of maternal and child health outcomes utilizing the parameters Infant Mortality Rate, Under-five Mortality Rate, Proportion of Children immunized with Measles, Maternal Mortality Ratio and Proportion of Births Attended by Skilled Health Personnel. Particularly, in generating the final model of this study, individuals will gain knowledge on the effects of their current maternal and child health status and will forecast the future effects for them to evaluate. Understanding the effects of the

maternal and child health outcomes to the GDP per capita will help in emphasizing the importance of eradicating contributory factors that will lead to increased mortality and morbidity in maternal and child health. Also, understanding the significant effects of maternal and child health outcomes will help development planners who are interested in public health to formulate strategies to solve maternal and child issues in their respective countries since they already have a baseline information on the contributory effects of these outcomes to their current GDP per capita. Lastly, this study is beneficial because maternal and child health outcomes does not only contribute to the health status of the population but also to the individual economy of countries especially if countries are gearing towards economic growth. Clearly, this dimension should be examined and all issues contributing to the problem of maternal and child health should be resolved.

METHODOLOGY

Theoretical Model

$$\text{GDP}_{Log} = \alpha + \beta_1 \text{IMR}_{Log} + \beta_2 \text{UFMR}_{Log} + \beta_3 \text{IM}_{Log} + \beta_4 \text{MMR}_{Log} + \beta_5 \text{HB}_{Log} + \mu$$

- GDP_{Log} is the lagged logarithm of average per capita GDP of 193 countries from 1960 to 2013 measured by the quotient of gross domestic product and midyear population
- IMR_{Log} is the lagged logarithm of average infant mortality rate of 193 countries from 1960 to 2013 expressed in ratio per 1000 live births
- UFMR_{Log} is the lagged logarithm of average underfive mortality rate of 193 countries from 1960 to 2013 expressed in ratio per 1000 live births
- IM_{Log} is the lagged logarithm of proportion of children immunized against measles of 193 countries from 1980 to 2013 expressed in percentage of children from 12-24 months
- MMR_{Log} is the lagged logarithm of average maternal mortality ratio of 193 countries from 1990 to 2013 expressed in ratio per 100,000 live births.
- HB_{Log} is the lagged logarithm of average proportion of births attended by skilled health personnel expressed in percentage from 1984 to 2012

Methodology

A logarithmic functional form was used to achieve the best fit of the variables used in this study. The appropriate lag structure was selected according to the direction of the skewness and kurtosis of the original metadata. Data transformation alone did not correct the problem of normality but since the researcher utilized the entire population in this undertaking, it is assumed that the distribution is normal. The researcher employed all 193 countries to date, excluding one independent and UN recognized country which has no data in all 5 variables namely Nauru and US recognized independent state Vatican. An OLS regression was then conducted to examine the effect of maternal and child health outcome indicators to GDP per capita.

Limitations of Predictor Variable Use

Several indicators of maternal and child health status were available in different sources other than WHO, WB and UNICEF. This study is only limited to the indicators for MDG 4 and 5 set

by the United Nations. The Millennium Development Goals and targets come from the Millennium Declaration signed by 189 countries, including 147 Heads of State, in September 2000. The goals and targets are inter-related and should be seen as a whole. They represent a partnership between the developed countries and the developing countries determined, as the Declaration states, “to create an environment – at the national and global levels alike – which is conducive to development and the elimination of poverty” (United Nations, 2003).

Data

This study opted to estimate the effect of maternal and child health outcomes to country’s GDP per capita. To do such, the researcher made it clear as to which accurate parameters are necessary to be included as indicators of maternal and child health. Based on the handbook released by the United Nations Development Group (2013), the goal number 4 (reduce child mortality) have three indicators namely under-five mortality rate, infant mortality rate, and proportion of children immunized against measles. On the other hand, goal number 5 (improve maternal health) have two indicators namely maternal mortality ratio and proportion of births attended by skilled health personnel. In this study, the researcher utilized four indicators that will serve as variable representation of maternal and child health outcomes that will serve as predictors of GDP per capita. Data came from data repository of World Bank.

RESULTS

Status of Maternal and Child Health

Table 2 presents the case summary of average percentage reduction in infant mortality rate, under-five mortality rate and maternal mortality ratio; and average percentage increase in proportion of children immunized with measles and proportion of births attended with skilled health personnel per continent. Individual country summary is also available upon request.

Based on the findings of this study, the average percentage reduction since the implementation of Millennium Development Goals until 2013 in infant mortality rate in the world is 3.52% ($N=191$). The highest was noted in Europe with an average of 3.50% reduction since 2000 while the lowest was noted in Oceania with average of 0.94% reduction for the past 13 years.

On the other hand, the under-five mortality rate in the world has an average reduction of 3.75% ($N=192$) for since starting 2000 to 2013. The highest reduction was noted in Oceania with 4.58% reduction while the lowest was noted in Australia. Meanwhile, there is an average reduction of 10.65% in the maternal mortality ratio ($N=181$) across continents. Highest reduction was observed in Oceania with 17.14% followed by Asia with 14.44% while the lowest reduction was observed in North America with an average reduction of 5.59%.

Consequently, there is an average 0.62% ($N=191$) increase in the proportion of children immunized with measles since 2000. The highest in 13 years was documented in Oceania with 2.31% increase. Consequently, an average increase of 79.25% ($N=176$) in the proportion of births attended with skilled health personnel since 2000 until 2013. The highest was documented in Europe with an average of 95.61% increase while the lowest was recorded in Oceania with only 19.40% increase in the past 13 years.

Findings shows that there is a remaining big percentage in the infant mortality rate, under-five mortality rate reduction and proportion of children immunized with measles increase that countries should work out enable to improve child mortality status. Still, the result implies that even though the percentage presented were not that big, we can appreciate that there is an improvement of child mortality in the world which is less than 4% in both infant mortality and under-five mortality rate, and less than 1% increase in the proportion of children immunized with measles.

On the other hand, a significant percentage was noted in the maternal mortality ratio with almost 11% reduction and proportion of births attended with skilled health personnel with 79% increase since 2000. This implies that over the past decade, there is an improvement in the maternal health as evidenced by the percentage reduction and increase in the maternal health indicators. Still, there is a big opportunity to further improve the maternal health in the world.

Effect of Maternal and Child Health Outcomes to GDP per capita

Table 3 shows the model summary and coefficient values table of the model of this study. Among the three proposed models, the researcher utilized model three since among the three, model three has the most significant lesser errors. Model 3 has an F statistics of 199.664 which suggest that it is statistically significant at 99% (p-value <0.01) and the data fits the model. Therefore we reject the null hypothesis and decide to use the model since it accounts for significantly more variance in the criterion variable that would be expected by chance (diagnostic procedures carried out are available in the separate attachment).

Findings of this study shows an $R=0.908$, $R\text{ Square}=0.824$, $\text{Adjusted } R\text{ Square}= 0.820$ and standard error of the estimate= 0.26401 . Findings suggest that the predictor variables $\text{IMR}_{\text{Log10}}$, IM_{Log10} , $\text{MMR}_{\text{Log10}}$ and HB_{Log10} accounts for about 82% of the model which implies a very high degree of correlation. The remaining 18% is attributed to other factors other than the indicators specified in the model. On the average, our estimates of GDP per capita with this model will be wrong by 26.4%.

Table 4 also shows the coefficients table of the model. Looking at the p-value of the t-test for each predictor variables, and the standard errors, we can see that each maternal and child indicators contributes to the model. After running a regression of $\text{GDP}_{\text{Log10}}$ on infant mortality rate, proportion of children immunized with measles, maternal mortality ratio and proportion of births attended with skilled health personnel, the estimated intercept is 4.809 while the estimated slopes of the variables are: $\text{IMR}_{\text{Log10}} = -0.407$ (0.136 error), $\text{IM}_{\text{Log10}} = 0.238$ (0.082 error), $\text{MMR}_{\text{Log10}} = -0.489$ (0.078 error) and $\text{HB}_{\text{Log10}} = -0.205$ (0.084 error). Using the values presented in the unstandardized coefficient values, the empirical model would be:

$$\text{GDP}_{\text{log10}} = 4.809 - 0.407 (\text{IMR}_{\text{log10}}) + 0.238 (\text{IM}_{\text{log10}}) - 0.489 (\text{MMR}_{\text{log10}}) - 0.205 (\text{HB}_{\text{log10}}).$$

A t-value of -2.98 for $\text{IMR}_{\text{log10}}$ is significant at 99% ($p<0.01$). This implies that a percent decrease in infant mortality rate per 1000 live births will increase GDP per capita by 0.41% in US dollars. Next, a t-value of 2.90 for IM_{log10} is significant at 99% ($p<0.01$). This means that a percent increase in proportion of children immunized with measles will increase GDP per capita by 0.24% in US dollars. Furthermore, a t-value of -6.250 for $\text{MMR}_{\text{log10}}$ is significant at 99% ($p<0.01$). Thus, a percent decrease in maternal mortality ratio per 1000 live births will increase

GDP per capita by 0.49% in US dollars. Finally, a t-value of -2.456 for $HB_{\log 10}$ is significant at 95% ($p < 0.05$). This means that a percent decrease in proportion of births attended by skilled health personnel will increase GDP per capita by 0.21% in US dollars.

To illustrate further, Table 4 shows the effect of maternal and child health outcomes to the GDP per capita in percentage of the countries grouped according to their continents. (A complete per country maternal and child health outcomes effect to GDP per capita is also available).

Based on the findings, the mean effect of maternal and child health outcomes is 3.38% of the country's GDP per capita. This implies that supported by statistical evidences and utilizing the model generated in this study, there is a minimum of 2.32% and a maximum of 4.81% of a country's GDP per capita is being affected by the maternal and child health outcomes while the remaining more than 97.68% of the GDP per capita is affected by other factors other than maternal and child health outcomes.

CONCLUSION

This paper examined the maternal and child health status of countries across the globe and formulated a regression model to estimate the effect of the maternal and child health outcome status to the country's per capita GDP. Since 2000, there is a 3.52% average reduction of infant mortality rate, 3.75% average reduction of under-five mortality, 0.62% average increase in the proportion of children immunized with measles, 10.65% average reduction of maternal and 79.25% average increase in the proportion of births attended by skilled health personnel.

Lastly, the mean effect of maternal and child health outcomes to GDP per capita is 3.39%. This implies that based on the empirical findings of this study, there is a minimum of 2.32% to a maximum of 4.81% of the country's GDP per capita that is being affected by the maternal and child health outcomes while the remaining more than 95% of the country's GDP per capita is affected by other factors. This implies that 2.32% of the country's GDP are at risk if maternal and child health status is not acceptable and significantly poor.

In the realizations of this study, it was found that health is indeed a very important form of human capital. Since human capital contributes to economic growth, this findings quantify the effects of these health outcomes in relation to its effects to the GDP per capita of countries across nations. Several studies supports the findings of this study that health contributes an effect to the economic growth (Weil, 2013; Bloom, canning and Sevilla, 2001; Bloom, canning and Sevilla, 2003; Bloom and Canning, 2005; Bhargava et al., 2001) Health was believed to enhance the workers' productivity by increasing their physical capacities, such as strength and endurance, as well as their mental capacities, such as cognitive functioning and reasoning ability. It was expected that there should be a positive relationship between health and productivity. Evidence of this link is increasing at the microeconomic level.

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Appendix A

Table 1. Summary of Descriptive Statistics. Summary of data gathered from World Bank per indicator of MDG 4 (Infant Mortality Rate, Under-five Mortality Rate and Proportion of Children Immunized with Measles) and MDG5 (Maternal Mortality Ratio and Proportion of Births Attended by Skilled Health Personnel).

Variables	N	%	Minimum	Maximum	Mean	Std. Deviation
GDP per Capita	190	98	149.50	81749.18	6338.07	10584.15
Infant Mortality Rate	191	98	4.0	163.2	54.61	39.75
Under-five Mortality Rate	191	98	.00	291.43	81.27	69.30
Proportion of Children Immunized with Measles	191	98	28.37	99.00	76.82	15.77
Maternal Mortality Ratio	181	93	4.33	1800.00	248.59	327.57
Proportion of Births Attended by Skilled Health Personnel	184	95	7.10	100.00	78.43	25.96

Source: Author's Calculation

Table 2. Status of Maternal and Child Health. Percentage Case Summaries per Continent. The author averaged the reduction and increase of cases since 2000 (where the MDG started) to explore the average reduction of regions per indicator if MDG after 13 years. Reduction was calculated by subtracting the year from the previous year starting 2000 and was averaged until 2013. Per country result is available upon request.

Continent		Average reduction in Infant Mortality since 2000 in %	Average reduction in Under-five Mortality since 2000 in %	Average increase in Proportion of Immunization since 2000 in %	Average reduction of Maternal Mortality Ratio since 2000 in %	Average increase in proportion of skilled Health personnel since 2000 in %
Asia	N	47.00	47.00	47.00	46.00	45.00
	Mean	4.10	4.19	0.50	14.44	81.30
	Minimum	-0.69	-0.33	-1.77	-11.87	19.06
	Maximum	10.43	10.80	3.69	50.46	100.00
	Std. Deviation	1.92	2.18	0.99	12.16	26.48
Africa	N	54.00	54.00	54.00	53.00	53.00
	Mean	3.21	3.92	1.08	11.65	62.01
	Minimum	0.00	1.12	-0.85	-14.07	7.10
	Maximum	7.87	9.16	3.85	30.91	99.88
	Std. Deviation	1.59	1.66	1.10	7.84	23.33
North America	N	23.00	23.00	23.00	20.00	22.00
	Mean	2.56	2.68	0.12	5.59	87.90
	Minimum	0.87	-2.22	-0.69	-20.48	24.95
	Maximum	5.13	5.42	1.69	22.51	99.90
	Std. Deviation	1.20	1.58	0.56	11.16	19.98
South America	N	12.00	12.00	12.00	12.00	12.00
	Mean	3.50	3.67	0.16	6.05	90.28
	Minimum	1.94	2.15	-0.92	-21.40	67.95
	Maximum	6.38	6.52	1.00	19.28	99.80
	Std. Deviation	1.49	1.51	0.56	12.40	10.46
Europe	N	41.00	42.00	41.00	39.00	30.00
	Mean	4.31	4.05	0.50	8.55	95.61
	Minimum	1.73	0.00	-1.54	-64.67	28.90
	Maximum	8.68	8.63	6.77	39.18	100.00
	Std. Deviation	1.63	1.88	1.24	16.52	14.75
Australia	N	13.00	13.00	13.00	10.00	13.00

Table 3. Model Summary and Coefficient Values

	Model 1	Model 2	Model 3
(Constant)	4.817	4.734	4.809
	0.161	0.160	0.162
IMR_Log	-1.383**	-	-0.407***
	0.559	-	0.136
UFMR_log	0.957*	-0.319**	-
	0.531	0.131	-
IM_log	0.226***	0.246***	0.238***
	0.082	0.082	0.082
MMR_log	-0.522***	-0.501***	-0.489***
	0.080	0.081	0.078
HB_log	-0.232***	-0.217**	-0.205**
	0.084	0.085	0.084
F Statistics	162.477	195.697	199.664
R	0.909	0.906	0.908
R Square	0.827	0.821	0.824
Adjusted R	0.822	0.817	0.820
Standard Error of Estimate	0.26230	0.26620	0.26401
P-value	Significant at 10%	Significant at 10%	Significant at 10%

Source: Author's Calculation

	Mean	2.10	2.39	0.73	11.09	84.42
	Minimum	0.22	0.25	-1.85	-10.47	23.80
	Maximum	4.48	5.01	5.38	26.13	100.00
	Std. Deviation	1.17	1.26	1.62	9.99	24.10
	N	1.00	1.00	1.00	1.00	1.00
Oceana	Mean	0.94	4.58	2.31	17.14	19.40
	Minimum	0.94	4.58	2.31	17.14	19.40
	Maximum	0.94	4.58	2.31	17.14	19.40
	Std. Deviation					
Total	N	191.00	192.00	191.00	181.00	176.00
	Mean	3.52	3.75	0.62	10.65	79.25
	Minimum	-0.69	-2.22	-1.85	-64.67	7.10
	Maximum	10.43	10.80	6.77	50.46	100.00

Table 4. Effects of maternal and child health outcomes to GDP per capita in percentage. Results were forecasted from the model generated from this research utilizing the averaged GDP per capita data of countries from World Bank. Individual country results is available upon request.

Source: Author's Calculation

Continent	N	Minimum	Maximum	Std. Deviation	Mean	% of Total N
Asia	47	2.54	4.24	.45449	3.3624	24.5%
Africa	54	2.32	4.43	.34371	2.7627	28.1%
North America	23	2.67	4.54	.47510	3.5576	12.0%
South America	12	2.81	3.72	.25274	3.2695	6.3%
Europe	42	3.45	4.81	.30614	4.0954	21.9%
Australia	13	2.61	4.49	.62468	3.6024	6.8%
Oceania	1	3.09	3.09	.	3.0890	0.5%
Total	192	2.32	4.81	.62090	3.3865	100.0%