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Article

Public Health Expenditures and Health Outcomes: New Evidence from Ghana

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Abstract: The effect of government spending on population's health has received attention over the past decades. This study re-examines the link between government health expenditures and health outcomes to establish whether government intervention in the health sector improves outcomes. The study uses annual data for the period 1980–2014 on Ghana. The ordinary least squares (OLS) and the two-stage least squares (2SLS) estimators are employed for analyses; the regression estimates are then used to conduct cost-effectiveness analysis. The results show that, aside from income, public health expenditure contributed to the improvements in health outcomes in Ghana for the period. We find that, overall, increasing public health expenditure by 10% averts 0.102–4.4 infant and under-five deaths in every 1000 live births while increasing life expectancy at birth by 0.77–47 days in a year. For each health outcome indicator, the effect of income dominates that of public spending. The cost per childhood mortality averted ranged from US\$0.20 to US\$16, whereas the cost per extra life year gained ranged from US\$7 to US\$593.33 (2005 US\$) during the period. Although the health effect of income outweighs that of public health spending, high (and rising) income inequality makes government intervention necessary. In this respect, development policy should consider raising health sector investment inter alia to improve health conditions.

Keywords: public health expenditures; health outcomes; cost-effectiveness; Ghana

JEL Classification: H51; I10; I18; I31

1. Introduction

The benefits of good health have been recognized in the economics literature. It is one of the sources of happiness and wellbeing of people, irrespective of their status in society. It also plays a major role in the economic growth and development of countries (Bloom et al. 2004; Gyimah-Brempong and Wilson 2004; Boachie 2017). Thus, while good health yields utility to the individual and enhances his/her market value, it also increases national output (Weisbrod 1966; Grossman 1972; World Bank 1993). Consequently, improving population's health conditions is considered, among policymakers, an important means of raising human capital; achieve sustainable development; reducing poverty and inequalities; and improving welfare (Grossman 1972; World Bank 1993; Von Schirnding 2005; Sen 2006). This process requires significant investment in the sector.

Investment in the health sector provides an avenue for individuals to improve their health status. Like other investment projects, investing in health requires mobilization of resources, both financial and non-financial. The amount of expenditures incurred in the preparation of and improvements in

population's health are regarded as health expenditures (World Bank 2014, 2016). The implication is that there is a link between healthcare expenditures and health outcomes.

While healthcare can be financed by the private sector, there is a consensus among researchers and many development economists that public health expenditure (public financing of healthcare) is important in addressing equity issues in healthcare consumption and income (re)distribution. It also ensures the provision and optimal consumption of healthcare services whilst reducing catastrophic health expenditures and the burden of diseases (Rad et al. 2013; Yardim et al. 2010). Therefore, increased government health expenditure in developing countries (especially in low- and middle-income countries) and some level of government regulation in the health sector have been advocated (Sachs 2001; Hanson et al. 2008). Indeed, the need for increased government spending on health to improve health conditions and welfare has long been emphasized (see Weisbrod 1966; World Bank 1993). Governments play a vital role in improving the health of their people either directly or indirectly through their policies. As noted by Berger and Messer (2002), changes in public health expenditures alter healthcare delivery systems and utilization patterns.

Hanmer et al. (2003) and Ranis et al. (2000) have argued that aside from economic growth improvements in welfare and other social indicators like health and education can be accelerated by (affirmative) public action. Ranis et al. (2000) maintain that focusing solely on economic growth (income) to achieve such progress could be a recipe for "disaster". This is because countries may achieve neither sustainable growth nor improvement in welfare (i.e., human development indicators). This implies that public action is needed to improve health conditions hence the link between public health expenditures and health outcomes. Improved health and education, or human development in general, would further promote and sustain economic growth (Ranis et al. 2000).

Public health expenditure is one of the policy instruments of government that has come under intense scrutiny over the last three decades. The aim has been to assess and justify government allocations to social sectors such as health, or government interventions in general. Many studies have debunked suggestions that government intervention in the healthcare sector is important for health improvements. These studies usually assess the impact of public health expenditure on health outcomes and find weak or no evidence that public health expenditure improves health (Santerre et al. 1991; Carrin and Politi 1995; Musgrove 1996; Filmer and Pritchett 1999; Berger and Messer 2002; Yaqub et al. 2012; Sede and Ohemeng 2015; Richards and Vining 2016). Many of these studies, if not all, have questioned the efficacy of public health expenditures. The argument is that improvement in income offers a higher command over goods and services, including healthcare. This implies that raising income level or economic growth is the appropriate means to improve welfare measures such as health.

Conversely, Hanmer et al. (2003) and Baldacci et al. (2002) as well as Rajkumar and Swaroop (2008) showed that government intervention is essential to win the fight against poor health and illiteracy, and improve many other social sector outcomes. Recent studies have lent credence to the findings of Hanmer et al. (2003); Baldacci et al. (2002); and Rajkumar and Swaroop (2008). Using various econometric techniques, these studies have shown that government expenditure on health is essential to improving health conditions (Akinkugbe and Mohanoe 2009; Anyanwu and Erhijakpor 2009; Bokhari et al. 2007; Novignon et al. 2012; Heijink et al. 2013; Kim and Lane 2013; Rad et al. 2013; Makuta and O'Hare 2015; Mohapatra 2016; Sirag et al. 2016).

Others argue that unless funds are properly allocated within sectors, or properly targeted to specific groups, spending may be ineffective. For example, Gupta et al. (2002) found public spending on primary healthcare to be weak in reducing mortality among children, and recommended a proper allocation of resources within the health sector to achieve desirable outcomes. They further argue that large improvements in health could be achieved with economic growth that leads to increased private resources for healthcare and that public spending alone is not enough to improve health status despite the fact that public health spending matters more to the poor (Gupta et al. 2003).

These conflicting results and positions on the effectiveness of public healthcare expenditure in improving health outcomes have become one of the central issues in health policy, in terms of the role of government. Many governments in the developing world place less emphasis on government provision of social services as they rely on or expect economic growth to improve social sector outcomes. Further, governments continue to explore new avenues to lower, or at best, contain costs. Thus, while governments aim at improving (equitable) access to healthcare to achieve better health, they also try to control their budgets (Plümper and Neumayer 2013). Government cost containment or tight fiscal policy measures to contain cost may affect sectors of the economy, including the health sector, and will consequently affect the amount of resources devoted to health. Against this background, this study seeks to establish the impact of public health expenditures on health outcomes in Ghana.

We conduct our analysis for Ghana because few studies have explored the relationship between public health expenditures and health outcomes in Ghana. Two earlier studies on Ghana produced conflicting results, perhaps due to their smaller sample sizes, and were unable to address potential endogeneity issues (see Compah-Keye et al. 2013; Boachie and Ramu 2016). Besides, health status remains low due to high malnutrition, morbidity, and mortality (especially maternal and child mortality) compared to the global average. Though significant progress has been made in the sector, available data show that maternal and child mortality (infant and under-five) remain high, and Ghana is among the countries that were unable to achieve most of the Millennium Development Goals (MDGs) targets on health (World Bank 2016). For instance, at the end of 2015, maternal mortality rate was 319 per 100,000 live births as against the target of 50 per 100,000 live births, whereas under-five and infant mortality rates stood at 62 and 43 per 1000 live births, respectively, which were above the targets. That is, despite the progress made, health outcomes remain poor in Ghana. Aside from these issues, budgetary allocation to the sector compared to global average is low and declining gradually. In 2014, for example, only 6.82% of total government expenditure went into health, a fall in previous allocations and below the proposed 15% target under the Abuja Declaration. In this respect, extending the studies by Boachie and Ramu (2016) and Compah-Keye et al. (2013) to re-examine the health effect of public health expenditures in Ghana is important. It would establish the role of government in improving health conditions towards achieving the third goal under the Sustainable Development Goals (SDGs) by 2030.

The study contributes to the literature on Ghana in three areas. First, it is the first study using a relatively larger sample to establish whether higher public spending on health is justified in terms of its output. Secondly, we attempt to address endogeneity issues (e.g., the reverse causation between health outcomes and public health spending). Finally, the study attempts to quantify the monetary cost of averting (one) extra death and extra life year gained to the government. Some of these issues were unaddressed in previous studies on Ghana (see Boachie and Ramu 2016; Compah-Keye et al. 2013) and similar studies on the theme (Novignon et al. 2012; Mohapatra 2016).

Following this background, the rest of the paper progresses as follows. Section 2 details the methodological approach adopted, while Section 3 presents our results. We discuss the results in Section 4 and conclude the study in Section 5 with some policy implications.

2. Methodology

2.1. Data

We source our data from the World Bank's World Development Indicators (WDI) database and other publications of the World Bank as well as various publications of the departments of the Government of Ghana (GoG). Except private health expenditure (PvHE), the data cover the period 1980–2014. Data on private health expenditure cover 1987–2014. For the study period, we employ the method of interpolation to fill in missing data, whenever necessary. This gives us a larger sample size relative to earlier studies on Ghana.

2.2. The Health Outcomes Model

In exploring the relationship between public health expenditure and health outcomes, an aggregate Health Production Function (HPF) is specified, with public health expenditure as an input. The output of the HPF is defined as the result of using healthcare and health related services provided or financed by the government and/or that financed through private expenditures. Guided by Grossman (1972), Wagstaff (1986), and other empirical literature on the subject matter, we present our health outcomes model as given below.

$$Y_t = f(HE_t, X_t), \quad t = 1, 2, 3 \dots T \quad (1)$$

where Y_t is a vector of the three dependent variables, i.e., health status or outcome measure, at time t . The health outcome/status measures are life expectancy at birth (LEB), infant mortality rate (IMR) and under-five mortality rate (UMR). HE_t is total health expenditure and X_t is a vector of other factors influencing health status or outcomes at time t . Equation (1) can be respecified as:

$$Y_t = \alpha HE_t + \beta X_t + \varepsilon_t \quad (2)$$

α and β , respectively, are the coefficients of healthcare spending and other independent variables, while ε_t is the error term and is to capture unobservable factors affecting health. The error term is assumed be normally distributed with zero mean and constant variance. Since our objective is to assess the impact of public health spending on health, we disaggregate total health expenditure into private health expenditure (PvHE) and public health expenditure (PuHE); these are measured as percentage of GDP. Therefore, Equation (2) is respecified as:

$$Y_t = \alpha_1 PuHE_t + \alpha_2 PvHE_t + \beta X_t + \varepsilon_t \quad (3)$$

To capture the elasticities while correcting any skewness in the data and address nonlinearity issues, the empirical version of Equation (3) uses logarithmic form of the series. That is, aside from obtaining elasticities directly, the logarithmic transformation also helps to account for the nonlinear relationship between the regressand and the regressors. Further, it ensures results comparability with previous studies (Filmer and Pritchett 1999).

As noted earlier, this study uses three main indicators as measures of health outcomes: life expectancy at birth (LEB), infant mortality rate (IMR), and under-five mortality rate (UMR). While there are several measures of health outcomes, these three indicators have been widely accepted to measure the health status of populations. Despite criticisms, these indicators and other mortality measures usually have complete data over a long period and for several countries; this makes data accessibility easier (Herzer and Nunnenkamp 2015). Further, indicators such as mortality among infants and under-fives help in analyzing how policy measures affect the vulnerable and/or different age groups in society. We acknowledge that life expectancy at birth and mortality measures have no means of revealing the actual health conditions of various segments of the population within the country, and fail to account for the quality of life years. However, the general assumption is that countries with healthy populations will have low mortality and higher life expectancy.

The other independent variables are real per capita income (RGDPC) measured in constant 2005 US\$ 2005; immunization uptake levels (IMS) measured by proportion of children aged between 12 and 23 months immunized against measles; education (both sexes (EDU) and females (FED)) measured by primary school enrolment rate; and access to improved water (STN) measured by population with access to safe drinking water. The density of physicians ((PHY), physicians per 1000 people) is also included in the models to capture the availability of healthcare personnel in the country and its effect on health.

2.3. Estimation Methods and Identification

The instrumental variables (IV) estimation technique using the two-stage least squares (2SLS) is used to estimate the three models of health outcomes to find the effect of public health spending on health. The choice of this estimator is based on two reasons. First, the instrumental variable approach is a useful tool in addressing possible simultaneity issues (Green 2003; Gujarati 2004). Health outcomes, public spending, and income are considered endogenous based on the extant literature on the theme. Secondly, it addresses the problem of measurement errors in the variables (Filmer and Pritchett 1999; Green 2003; Gujarati 2004). A major pre-condition in the IV estimation is that the instruments should be able to explain the variations in the regressors (instrumented variables). However, the error term and the instruments should be uncorrelated (Green 2003; Gujarati 2004).

Even though the instrumental variable procedure provides consistent estimates and serves as a good avenue to solve simultaneity issues, measurement errors, and omitted variable bias, its efficiency and reliability depend on the validity and the appropriateness of the instruments used (Green 2003; Gujarati 2004). One of the practical difficulties in implementing IV estimations in general is associated with obtaining good instruments that explain the variations in the instrumented regressors but uncorrelated with the error term. Invalid or bad instruments may produce unreliable estimates than the conventional OLS (Makuta and O'Hare 2015). Therefore, identification test using the Hansen J statistic is used to test how well our chosen instruments perform. The Hansen J statistic tests the null hypothesis that the instruments used in the model are valid so that rejecting the null hypothesis is an indication of invalid instruments.

Regarding instrumentation, lags of public health expenditure and per capita income, and demography (population aged 65 years or higher) are used as instruments for public health expenditure and income. We assume that health outcomes, public health expenditure, and income are simultaneously determined. Here, public health expenditure and income could explain variations in health outcomes. At the same, health outcomes may also explain the changes that occur in income and government expenditure on health, and empirical evidence supports this view. Therefore, one-year lag of public health expenditure and real per capita income, and demography (i.e., share of population aged 65 years or higher) are used as instruments. The reason being that the previous year's spending and income could explain current health outcomes (mortality and life expectancy). On the contrary, currently observed health outcomes would not explain past levels of income and government spending on health. Arguably, this study also posits that ageing influences healthcare expenditure and per capita income but does not explain currently observed health outcomes. These assumptions form the basis for the instruments selected. We estimate all models using OLS after which the 2SLS estimator is employed. As a robustness check, the models are also estimated using the Autoregressive Distributed Lag (ARDL) and the Fully Modified OLS (FM-OLS) estimators in a cointegration context.

2.4. Cost Effectiveness Analysis (CEA)

One important question that arises relates to the cost per life saved from government resources and the amount of income required to save a life if government spending on health is assumed to be zero. What is the associated cost for every life saved or life year gained? To answer to this question, the regression estimates are used to produce average cost-effectiveness ratios for public health expenditure. We also apply the CEA methodology to obtain income-effectiveness ratios for increases in real per capita income. Cost comprises of the extra expenditure incurred in reducing mortality and raising life expectancy. Effectiveness means the extra improved health gained (i.e., additional mortality decline and extra gain in life expectancy) caused by increasing government health spending, or income by 10%. The study adopts the methodology applied in Joyce et al. (1988) to produce the ratios. We conduct our analyses for three scenarios.

3. Results

3.1. Descriptive Analysis

Between 1980 and 2014, life expectancy at birth averaged at about 57 years with a standard deviation of 2.54 years. Thus, a newborn in Ghana was expected to live for about 57 years on average. Depending on conditions at the time of birth, such a child has the potential to live a minimum of 52.27 years and maximum 61.31 years. While this is higher than the Sub-Saharan Africa (SSA) regional average for the period, it is 10 years lower than the global average of 67.07 years. Within the same period, the mean number of deaths among infants and children below age five were 70.90 and 111.70 per 1000 live births respectively. Over the years, infant and under-five mortality rates have fallen. However, the (annual) rate of decline has been slow.

Public health expenditure also fluctuated during the study period. Government spent an average of 1.92% of GDP on healthcare with a standard deviation of 0.97% of GDP. The minimum expenditure was 0.35% of GDP which occurred in 1983, a period of major economic hardships. In 2010, public health expenditure represented 3.83% of GDP, the maximum that government spent during the period. Though there is data paucity on privately financed health expenditures, available data suggest that between 1987 and 2014, the mean private health expenditure in Ghana was 1.56% of GDP (standard deviation (SD) = 0.12%). The minimum and maximum privately financed health expenditure for the period stood at 1.2% and 1.8% respectively. Thus, public and private sectors have almost financed healthcare on slightly equal terms.

Income has been one of the most important factors that affect government's ability to finance health expenditure. It also has an indirect effect on health. Between 1980 and 2014, Ghana's real per capita income averaged US\$462 (SD = US\$119.55). Since 1984, real per capita income consistently rose. The minimum real per capita income was recorded in 1983 and the maximum in 2014. Prior to 1984, per capita GDP grew at an average rate of −6.5%. Rising income makes available more resources to the government so that public and merit goods such as healthcare and other public services could be provided. Table 1 provides a summary statistics of the variables in this study.

Table 1. Summary Statistics of the variables.

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
LEB	35	57.238	2.540	52.272	61.312
UMR	35	111.703	31.716	64.000	166.200
IMR	35	70.903	17.662	44.200	100.900
PuHE	35	1.925	0.973	0.350	3.829
EDU	35	85.475	12.722	69.815	109.711
FED	35	81.332	15.105	62.325	108.361
STN	35	65.267	14.663	33.789	87.600
PHY	35	0.077	0.026	0.043	0.152
IMS	35	66.057	26.036	10.000	95.000
RGDPC	35	462.074	119.553	320.781	763.938
PvHE	28	1.560	0.125	1.232	1.800

Note: computed from raw data. LEB: life expectancy at birth; UMR: under-five mortality rate; IMR: infant mortality rate; PuHE: public health expenditure; EDU: education (both sexes); FED: education (females); STN: access to improved water; PHY: physicians per 1000 people; IMS: immunization uptake levels; RGDPC: real per capita income; PvHE: private health expenditure.

As shown in Table 1, enrolment in primary schools was high during the period. Approximately 85% of children (male and female) who were eligible to enter primary schools enrolled during the period. For females, the gross enrolment rate was 81%. As of 2014, the male-female gap in primary school enrolment ratio (gross) stood at 1.35%. This suggests that girl-child education has gained prominence over the past three decades. Further, the average number of people with access to improved and safe drinking water was 65.27% (SD = 14.66%) for 1980–2014. As of 2014, closed to 88%

of the population had access to safe drinking water. Improved and safe drinking water minimizes water borne diseases.

Similarly, the mean number of physicians (per 1000 population) was 0.077 (SD = 0.026). This suggests that, on the average, a physician in Ghana served approximately 13,000 people during the period. The minimum and maximum density of physicians was 0.043 and 0.152 respectively. Over the years, Ghana has produced a sizeable number of doctors. However, the economic downturn and the implementation of the structural adjustment programs resulted in mass exodus of physicians, and some other healthcare staff in the 1980s and the early 1990s. As expounded by [Dovlo and Nyongator \(1997\)](#), Ghana lost about 61% of physicians who graduated during 1985–1994 to other countries. The situation worsened in 1990 where a physician served 22,970 people ([Dovlo and Nyongator 1997](#)).

Over the past two decades, the number of physicians in the country has improved, perhaps, due to better conditions of service and the establishment of additional medical schools. As of 2014, the number of physicians per 1000 people stood at 0.107 ([Ghana Health Service 2015](#)). This suggests that a doctor in Ghana now serves about 9381 people. Aside from being low, the distribution of these doctors between rural and urban as well as northern and southern parts of the country is uneven. The recent opening of private medical colleges is expected to pave way for the private sector to collaborate with public universities to train more healthcare personnel to improve the doctor-patient ratio.

3.2. Public Health Expenditure, Income, and Health Outcomes

This section presents the results from the OLS and 2SLS estimation. As outlined in the methods section, three health outcome indicators, namely infant mortality rate, under-five mortality rate, and life expectancy at birth are used as dependent variables. The independent variables are real per capita income, public health expenditure, physicians per 1000 people, access to improved water, education (both sexes), female education (in the case of IMR and UMR), immunization, and private health expenditures. The OLS regression estimates are presented in Table 2.

In Panel A of Table 2, we estimated the effect of public health expenditure on health outcomes without accounting for the effect of private health expenditures. In Panel B, private health expenditure is included in the regressions.

In Panel A, five of the explanatory variables in the infant and under-five mortality, as well as life expectancy at birth, regressions are statistically significant, and all the models are well fitted given their high R-squares (i.e., above 0.9). Real per capita income, physician per 1000 people, access to improved water, and immunization are statistically significant at 1% level, and their signs were expected, except the sign of physician density in the life expectancy regression.

Public health expenditure is 5% and 1% significant in mortality and life expectancy regressions respectively and with the expected signs. The income elasticity of infant and under-five mortality ranges from -0.44 to -0.53 , while that of public health expenditure ranges from -0.022 to -0.023 . In the life expectancy regression, the elasticities are 0.06 and 0.02 for income and public health expenditure respectively. The elasticity for the density of physicians is -0.036 in both mortality regressions and -0.032 in the life expectancy regression. Immunization is statistically significant at 1% level in the mortality regression, and 5% in the life expectancy regression. The immunization elasticity ranges from -0.054 to -0.058 for mortality and 0.008 for life expectancy.

In Panel B, only three of the independent variables are statistically significant in influencing mortality rates. Real per capita income is statistically significant at 1% with elasticities -0.41 and 0.50 , respectively, for infant and under-five mortality rates. Public health expenditure is insignificant in the mortality regressions; its negative sign was expected. Other significant variables are private health expenditure and access to safe drinking water.

Table 2. Public Health Expenditure and Health outcomes.

	Panel A			Panel B		
	IMR (1)	UMR (2)	LEB (3)	IMR (4)	UMR (5)	LEB (6)
RGDPC	−0.440 *** (0.030)	−0.529 *** (0.037)	0.055 *** (0.016)	−0.410 *** (0.034)	−0.499 *** (0.043)	0.051 *** (0.017)
PuHE	−0.023 ** (0.010)	−0.022 ** (0.011)	0.015 *** (0.005)	−0.013 (0.012)	−0.012 (0.014)	0.013 ** (0.006)
PHY	−0.036 *** (0.010)	−0.036 *** (0.012)	−0.032 *** (0.007)	−0.026 (0.017)	−0.030 (0.021)	−0.011 (0.011)
STN	−0.447 *** (0.043)	−0.515 *** (0.046)	0.103 *** (0.010)	−0.558 *** (0.093)	−0.611 *** (0.110)	0.057 (0.052)
EDU	— —	— —	0.018 (0.028)	— —	— —	0.090 ** (0.043)
FED	−0.027 (0.045)	−0.023 (0.050)	— —	−0.041 (0.071)	−0.050 (0.085)	— —
IMS	−0.054 *** (0.009)	−0.058 *** (0.010)	0.008 ** (0.004)	−0.020 (0.046)	−0.021 (0.054)	−0.036 (0.034)
PvHE	— —	— —	— —	−0.085 ** (0.035)	−0.094 ** (0.043)	0.009 (0.017)
Constant	9.031 *** (0.137)	10.30 *** (0.169)	3.076 *** (0.090)	9.282 *** (0.253)	10.532 *** (0.313)	3.22 *** (0.138)
Obs	35	35	35	28	28	28
R ²	0.99	0.99	0.97	0.99	0.99	0.96
F	2350.99	2421.05	441.03	2548	2399.86	130.01
C-H	0.082	0.073	0.138	0.078	0.07	0.495

Note: *, **, *** denote significance at 10%, 5%, and 1% levels respectively. C-H presents probabilities from Cumby-Huizinga no autocorrelation test. Robust Standard errors in parenthesis.

In the life expectancy regression, real income per capita and public health expenditure are significantly positive with elasticities 0.05 and 0.01 respectively. Access to safe drinking water and private health expenditure are not statistically significant. Education (both sexes) recorded elasticity of 0.09 in the life expectancy regression at 5% level. Female education is insignificant in any of the mortality regressions.

Overall, the OLS estimates show that increases in income improve health outcomes by reducing mortality and increasing life expectancy at birth. The elasticity coefficient means that a 1% increase in income has the potential to reduce infant and under-five mortality by 0.44% and 0.53% respectively in the absence of privately financed health expenditure. After accounting for private health expenditure, these elasticities decline to 0.4% and 0.5% for infant and under-five mortality rates respectively. Similarly, a percentage point increase in income causes life expectancy at birth to rise by 0.06% in the absence of private health expenditures. The elasticity falls by 0.01% in the presence of private health expenditures. Further, public health expenditure is effective in reducing mortality in the absence of private health expenditures. The elasticities show that infant and/or under-five mortality rate falls by approximately 0.02% following a 1% increase in public spending on health. In the case of life expectancy, a 1% increase in spending results in about 0.01% increase in life expectancy. Other factors causing improvement in health outcomes are the availability of healthcare personnel (such as physicians), improved water source, private health expenditure, and immunization uptake.

While the OLS is an unbiased estimator, it can behave badly if there are possibilities of reverse causation in the model. The presence of simultaneity problem results in biased and inconsistent estimates, and may reduce the effect of health expenditure. Moreover, health expenditures are not devoid of measurement errors due to different accounting systems across and within countries at

different periods. The other independent variables may also have measurement errors. Therefore, IV estimation technique using 2SLS is employed. This estimation method is able to handle issues relating to endogeneity (Filmer and Pritchett 1999; Green 2003). The share of the elderly in the entire population, one-year lag of real per capita income and public health expenditure are used as instruments for real per capita income and public health expenditure. That is, we use public health expenditure in period $t-1$, real per capita income in period $t-1$, and the share of population aged 65 (or older) as instruments. The results of the 2SLS regression are presented in Table 3.

Table 3. Effect of Public health expenditure on health outcomes.

	Panel A			Panel B		
	IMR (1)	UMR (2)	LEB (3)	IMR (4)	UMR (5)	LEB (6)
RGDPC	−0.434 *** (0.034)	−0.525 *** (0.043)	0.053 *** (0.020)	−0.440 *** (0.037)	−0.536 *** (0.046)	0.058 *** (0.018)
PuHE	−0.041 *** (0.012)	−0.044 *** (0.014)	0.021 ** (0.009)	−0.038 *** (0.013)	−0.042 *** (0.016)	0.018 *** (0.007)
PHY	−0.029 *** (0.009)	−0.029 *** (0.010)	−0.031 *** (0.006)	−0.021 (0.014)	−0.024 (0.016)	−0.012 (0.009)
STN	−0.492 *** (0.024)	−0.561 *** (0.028)	0.099 *** (0.017)	−0.056 *** (0.085)	−0.608 *** (0.100)	0.052 (0.045)
EDU	— —	— —	0.014 (0.030)	— —	— —	0.072 ** (0.034)
FED	0.021 (0.043)	0.033 (0.050)	— —	0.051 (0.068)	0.06 (0.081)	— —
IMS	−0.042 *** (0.006)	−0.044 *** (0.007)	0.006 (0.005)	−0.035 (0.036)	−0.041 (0.042)	0.033 (0.027)
PvHE	— —	— —	— —	−0.085 *** (0.033)	−0.094 ** (0.041)	0.009 (0.014)
Constant	8.949 *** (0.175)	10.194 *** (0.216)	3.133 *** (0.109)	9.153 *** (0.248)	10.381 *** (0.307)	3.258 *** (0.140)
Obs	34	34	34	28	28	28
R *	0.99	0.99	0.97	0.99	0.99	0.96
F	3186	3210	264	1967.86	1862.56	151.95
Hansen J	0.312	0.311	0.591	0.571	0.49	0.945
C-H	0.143	0.128	0.182	0.101	0.089	0.123

Note: *, **, *** denote significance at 10%, 5%, and 1% levels respectively. C-H is Cumby-Huizinga test for no autocorrelation. Values for Hansen J and C-H are probabilities. Robust Standard errors in parenthesis.

The Hansen J statistics indicate that the instruments are uncorrelated with the error term, and are correctly excluded from the equations. That is the instruments correctly explain the instrumented variables (i.e., public health expenditures and income) but not affected by changes in health outcomes, and are uncorrelated with the error term. This means that the instruments used are valid, and that the 2SLS estimates are consistent and reliable.

Like the OLS regression, real per capita income has shown consistent significance at 1% in all the regressions. Similarly, public health expenditure is significant at 1% in all regressions, except the life expectancy regression in Panel A. Comparing Panel A estimates in Tables 2 and 3, one could observe that there are slight changes in the elasticity coefficients. The income elasticity of infant mortality dropped from −0.440 in OLS to −0.434 in 2SLS, whereas that of under-five mortality dropped from −0.529 to −0.525. Also, the income elasticity of life expectancy dropped from 0.055 in OLS to 0.053 in 2SLS with a change in significance level. While income elasticity dropped in 2SLS regressions, the elasticity coefficients of public health expenditure increased. Specifically, elasticity for public

health expenditure in the IMR regression rose from -0.023 to -0.041 , whereas that of under-five mortality doubled. The elasticity in the life expectancy regression rose from 0.015 to 0.021 (see Panel A of Tables 2 and 3). Regarding the other variables in Panel A, female education is not statistically significant in any of the mortality regressions, and the elasticity coefficients are wrongly signed. Like the OLS estimates, education (both sexes) is also insignificant in the life expectancy regression.

Immunization is statistically significant at the 1% level in only the mortality regressions with elasticities -0.042 and -0.044 for IMR and UMR respectively. These elasticities are less than those obtained under the OLS. Access to improved and safe drinking water is also statistically significant at 1% in both mortality and life expectancy regressions in Panel A of Table 3. While the coefficients of improved water source for mortality in the 2SLS regression increased, that of life expectancy declined from 0.103 in the OLS to 0.099 in the 2SLS. In addition, the density of physician is statistically significant at 1% in all the regressions in Panel A of Table 3 with an elasticity of -0.029 for mortality (IMR and UMR). In the life expectancy regression, the elasticity is wrongly signed. The coefficients in the 2SLS are slightly lower compared to those obtained from the OLS regression.

Similar to Panel B of Table 2, we introduce a new explanatory variable, i.e., private health expenditure, into the regression. Consistently, real per capita income and public health expenditure are statistically significant at the 1% level in all the regressions. Income elasticity of mortality ranges from -0.440 to -0.536 , whereas it is 0.058 for life expectancy. The means that if income should increase by 10%, mortality will fall by 4.40% to 5.36%, while life expectancy will increase by 0.58%. These elasticities are higher than those obtained under the OLS. The public health expenditure elasticity ranges between -0.038 and -0.042 for mortality, and 0.018 for life expectancy. This shows that a 10% increase in public health expenditure will cause IMR and UMR to fall by 0.38% to 0.42%, and increase life expectancy at birth by 0.18%. The coefficients are higher here than the OLS estimates in Panel B of Table 2.

Improved water source is significant at 1% level in the mortality regressions with elasticities -0.056 and -0.608 for IMR and UMR respectively. This means that a 10% increase in the population with access to safe drinking water will reduce mortality by 0.56% among infants and 6.08% among children below age five. These elasticities are lower than the OLS estimates. Again, education is statistically significant at 5% with elasticity 0.072 for life expectancy. The implication is that raising literacy levels by 10% will lead to 0.72% increase in life expectancy at birth in Ghana. However, this elasticity is less than that obtained under the OLS.

While insignificant in life expectancy regression, private health expenditure is significant at 1% and 5% for IMR and UMR respectively. The elasticities are -0.085 for IMR, and -0.094 for UMR. These coefficients are the same in the OLS regression, except that the significance level (for IMR) and the standard errors differ. Thus, the average elasticity of private health expenditure for IMR and UMR is -0.09 . The meaning is that a 10% increase in private health expenditure will lead to a decline in mortality by 0.9%.

3.3. Cost (Income) Effectiveness Analysis Results

The gains in health outcomes are calculated using the coefficients reported in Panel A of Tables 2 and 3. The OLS (see Table 2) and 2SLS (see Table 3) estimates serve as lower and higher bounds respectively for public health expenditure. For real per capita GDP, the coefficients in Table 2 are considered upper bound since they are higher.

We conduct our analysis for three scenarios. First, the effectiveness of each input is calculated based on the assumption that 1000 live births occur annually. Of this number, the coefficients are used to estimate the lives that can be saved and the associated cost per life saved. In the case of life expectancy, the calculations are done for a year, on the assumption that everyone has a year to live. Costs and income are then calculated using per capita public health expenditure and income for 1980–2014.

In the second case, we employ the averages of the variables to conduct the analysis. That is, for 1980–2014, the mean values of inputs (i.e., income and public spending) and output (i.e.,

health outcomes) are used to calculate the lives saved and the associated costs. The cost and income estimates in scenarios 1 and 2 are thus same. In the third scenario, we use only the currently observed values for all the relevant variables in 2014. That is, we use 2014 statistics to obtain the estimates for extra public health spending, income, and the lives gained as well as their associated cost. All estimates of income and public health expenditure are in per capita terms (constant 2005 US\$).

Scenario 1

Table 4 presents the cost-effectiveness estimates for the first scenario. The estimates represent the gains in health outcomes associated with 10% extra government spending on health and a 10% increase in real per capita income. As already highlighted via the elasticities in Table 3, the health gains from extra income are greater than that from public health spending.

Table 4. Average Cost/Income–Effectiveness Ratios.

Input		Lives Saved per Additional 10% Spending/Income		Additional Cost (10% Increase) US\$	Cost/Income per Life Saved Per Capita US\$	
		High (1)	Low (2)		High (4)	Low (5)
IMR	PuHE	4.1	2.3	0.89	0.39	0.22
	RGDPC	44	43.4	46.21	1.06	1.05
UMR	PuHE	4.4	2.2	0.89	0.4	0.2
	RGDPC	52.9	52.5	46.21	0.88	0.87
LEB	PUHE	0.0021	0.0015	0.89	593.33	423.81
	RGDPC	0.0055	0.0053	46.21	8718.87	8401.82

Note: Figures in Column (4) are obtained by dividing column (3) by column (2). Similarly, dividing column (3) by column (1) gives column (5). It applies to all tables in the section.

Thus, while on the average, an extra 10% of real per capita income saves about 44 and 53 infants and under-fives, respectively, in every 1000 live births, public health expenditure saves less than 5 children. Gains in life expectancy are estimated to be 0.0021 life years or 0.77 days for public health spending and 0.0055 life years (i.e., 2.01 days) for income. The associated costs per life saved differ. More specifically, the cost of avoiding an infant's death, in every 1000 live births, via government spending is estimated to be between US\$0.22 and US\$0.39, whereas that for saving a child below age five ranges from US\$0.20 to US\$0.40. Likewise, for extra life year gained the associated cost is between US\$423.81 and US\$593.33. In the case of income, on the average, averting one childhood death requires an amount ranging from US\$0.87 to US\$1.06. Again, one requires per capita income ranging from US\$8,401.82 to US\$8,718.87 to gain one life year, as seen in Table 4.

Scenario 2

The assumptions made in the first scenario are relaxed here. The estimates are also calculated using the averages of the both input and output variables. That is, we evaluate the elasticities at the means of the health outcomes, income, and public health spending. The estimated life gains and their associated costs are presented in Table 5.

The life gains from an extra 10% income and public health spending are lower when evaluated at the means. On the average, an extra 10% of real per capita income now saves about 3 infants and about 6 under-fives, while public health expenditure reduces childhood mortality by between 0.163 and 0.491. Gains in life expectancy are also estimated to be between 0.086 life years or 31.39 days and 0.120 life year (43.8 days) for public health spending. Income produces between 0.303 life years (i.e., 110.60 days) and 0.315 life years (115 days). These estimates are also used to produce cost per life saved during 1980–2014. They suggest that the cost for saving an infant, at the means, via government health spending is between US\$3.06 and US\$5.46. For under-five mortality, the cost per life saved is US\$1.81 to US\$3.62. At the means, the cost of gaining extra life year in Ghana is estimated to be approximately US\$7 to US\$10 through government health spending. In the case of income, averting one childhood

death requires an amount ranging from US\$7.82 to US\$15.02. Again, Table 5 shows that one requires per capita income of approximately US\$146 to US\$152 in order to gain one life year, on the average.

Table 5. Average Cost/Income–Effectiveness Ratios **.

Input		Lives Saved Per Additional 10% Spending/Income		Additional Cost (10% Increase) US\$	Cost/Income per Life Saved Per Capita US\$	
		High (1)	Low (2)		High (4)	Low (5)
IMR	PuHE	0.291	0.163	0.89	5.46	3.06
	RGDPC	3.119	3.077	46.21	15.02	14.82
UMR	PuHE	0.491	0.246	0.89	3.62	1.81
	RGDPC	5.909	5.864	46.21	7.88	7.82
LEB	PUHE	0.12	0.086	0.89	10.34	7.42
	RGDPC	0.315	0.303	46.21	152.51	146.7

Note: ** The cost/income calculations use averages of the input and output variables.

Scenario 3

Using observed values of the variables as of 2014, we estimate the gains in health outcomes. The results show that 10% extra government spending on health will reduce child mortality rates by 0.141 to 0.282. That is, 10% extra public health spending will cause IMR to fall from 44.2/1000 live births to about 44 per 1000 live births. Similarly, UMR will decline from the observed 64/1000 in 2014 to 63.7/1000 live births. Furthermore, gains in life expectancy from 10% extra public health spending is between 0.092 life years (33.60 days) to 0.129 life years (47.09 days). That is, an extra 10% public health spending will increase the observed life expectancy of 61.312 life years in 2014 to 61.44 life years. Additionally, extra 10% income produces between 0.325 life years (119 days) and 0.337 life years (123 days) which correspond to raising life expectancy from 61.312 life years in 2014 to 61.65 life years. The results are presented in Table 6.

Table 6. Average Cost/Income–Effectiveness Ratios.

Input		Lives Saved Per Additional 10% Spending/Income		Additional Cost (10% Increase) US\$	Cost/Income per Life Saved Per Capita 2005 US\$	
		High (1)	Low (2)		High (4)	Low (5)
IMR	PuHE	0.181	0.102	1.63	15.98	9.01
	RGDPC	1.944	1.918	76.39	39.83	39.3
UMR	PuHE	0.282	0.141	1.63	11.56	5.78
	RGDPC	3.386	3.36	76.39	22.74	22.56
LEB	PUHE	0.129	0.092	1.63	17.72	12.64
	RGDPC	0.337	0.325	76.39	235.05	226.68

Note: The cost/income calculations use current observed values of the input and output variables in 2014.

Similarly, the childhood deaths averted through 10% extra income range from 1.9 to 3.4 per 1000 live births. That is, increasing real per capita income by 10% will cause IMR to fall from the observed 44.2 in 2014 to 42.3, whilst UMR will decline from 64 to about 60.6 per 1000 live births.

Looking at the estimates in Table 6, one can conclude that, approximately, between US\$6 and US\$16 averts one childhood death via extra 10% government health expenditure. An additional life year is gained at the cost of US\$13 to US\$18. On the part of income, gaining an extra life year is possible at about US\$226 to US\$236. Also, the income per mortality averted is between US\$22 to US\$40 for 2014.

4. Discussion

The effect of public health expenditure on health outcomes has been estimated using two different approaches. The effect was estimated by controlling factors such as real per capita GDP, physician per 1000 people, access to safe drinking water, education (both sexes), female education, immunization, and privately financed health expenditure.

The results suggest that rising real per capita income results in lower child mortality and improves life expectancy at birth. Specifically, increasing real per capita income by 10% causes 4.34% to 5.25% decline in childhood mortality and 0.53% increase in life expectancy in Ghana. This is in the absence of private health expenditures. After accounting for private health expenditures, real per capita income contributes about 0.6% to improvements in life expectancy, and an average of about 5% to mortality decline in Ghana. The estimates imply that for every 1000 live births, a 10% rise in real per capita income could save 43.4 and 52.5 infant and under-five lives respectively while providing 0.0053 life years or 1.935 days annually.

Evaluating the elasticities at the sample averages for the period 1980–2014 suggests that if real per capita income rises by 10% (i.e., US\$46.21), IMR and UMR will fall by 4.3% and 5.3% respectively. That is, IMR will decline from the period average of 70.9 to 67.8 deaths per 1000 live births, while UMR will drop from its period average of 111.7 to 105.84 deaths per 1000 live births. For life expectancy, the gain is 0.303 life years or an equivalent of 110.7 days. Clearly, the effect of income on health is great. In a like manner, the foregoing analysis may be done for the period 1987–2014 where private health expenditure is considered.

Contrary to earlier results reported by [Compah-Keye et al. \(2013\)](#) from Ghana, we find that income has played an important role in improving health conditions during the period. This is consistent with findings from cross-national studies such as [Filmer and Pritchett \(1999\)](#); [Gupta et al. \(2002\)](#); [Fayissa and Gutema \(2005\)](#); [Bokhari et al. \(2007\)](#); [Rajkumar and Swaroop \(2008\)](#); and [Kamiya \(2010\)](#). Recent studies by [Bayati et al. \(2013\)](#), [Rad et al. \(2013\)](#), and [Makuta and O'Hare \(2015\)](#) also find that income is a significant predictor of better health outcomes. Similar findings have also been reported from a single country analysis ([Akinkugbe and Mohanoe 2009](#)). Thus, income plays a crucial role in improving health outcomes via indirect channels. People with higher incomes tend to have better living conditions, which may affect their health conditions positively ([Auster et al. 1969](#)). The level of income determines the amount and type of goods and services (e.g., healthcare, food, and housing) to be consumed in the country. The rising per capita income in Ghana that occurred during 1980–2014 enabled individuals to have command over more goods and services, including health inputs. This has improved living conditions for the population. It is important to note, however, that high income may also be detrimental to health. First, high income may create consumption patterns that are not beneficial to health. This is particularly so in situations where people have the resources to compensate for the adverse effects of their consumption patterns through simultaneous use of more healthcare. Secondly, increased income may entail occupations with little or no exercises and/or more pressure, and this could endanger health ([Auster et al. 1969](#)).

The variable of interest, public health expenditure, has consistently proved to be a significant predictor of health outcomes in Ghana. Government health spending exerted a strong negative influence on child mortality (i.e., IMR and UMR) for the period. Its effect on life expectancy was also significantly positive. More precisely, the results show that, overall, infant and under-five mortality in Ghana will fall, respectively, by 0.41% to 0.44% following a 10% increase in public spending on health. Similarly, the gain in life expectancy at birth is between 0.18% and 0.21% for the two samples. The magnitudes of the elasticities obtained here are similar to cross-sectional results obtained by [Makuta and O'Hare \(2015\)](#); [Grekou and Parez \(2014\)](#); and [Filmer and Pritchett \(1999\)](#). In fact, [Filmer and Pritchett \(1999\)](#) found that a percentage increase in public health expenditure contributes 0.19% to under-five mortality decline. In SSA, [Makuta and O'Hare \(2015\)](#) and [Grekou and Parez \(2014\)](#) found elasticities between 0.1 and 0.6, and highly significant.

Comparing the elasticities for income and public health spending, one can observe that the elasticities for public health expenditure are lower than those obtained for income but statistically significant in all the 2SLS regressions. Thus, though the positive effect of income on health outcomes is more pronounced than that of public health spending, the latter is still important for health improvement. In their analysis of the effect of governance on the effectiveness of public health and education spending, [Rajkumar and Swaroop \(2008\)](#) argue that inefficient institutional arrangements and poorly targeted programs are some of the prime suspects for low elasticities for public (health) spending. For instance, a benefit incidence analysis conducted by [Boachie and Ramu \(2018\)](#) found that the rich utilized more services from public hospitals relative to the poor. This may potentially reduce overall spending elasticities, given that morbidity and mortality rates are usually higher among poor groups ([O'Donnell et al. 2008](#)). Further, corruption and poor infrastructural development (e.g., poor road networks) will make public health and/or other social expenditures less effective ([Bokhari et al. 2007](#); [Wagstaff 2002, 2004](#)). Indeed, many parts of the country have very poor road networks, most of which are not passable in the rainy season. These could be some of the reasons for the low elasticities for public health spending.

The estimates from the 2SLS regression for the full sample imply that, for every 1000 live births, a 10% increase in annual public health expenditure in Ghana will save 4.1 and 4.4 infants and under-fives respectively. The gains in life expectancy are estimated to be 0.0021 life years or an equivalent of 0.767 days per year. These gains in health outcomes are far lower than that produced by raising incomes of the same percentage point. For instance, at the sample average, 1980–2014, it is evident that a 10% rise in public health expenditure reduces IMR and UMR by 0.291 and 0.491 respectively. This means that IMR will fall from its period average of 70.903 to 70.612. Similarly, UMR will decline from 111.703 to 111.212. The same analysis may be performed when using 2014 statistics, or the effect of private health expenditures are taken into account.

The argument that public health expenditure is statistically insignificant in improving health outcomes is invalidated in this study. The high level of statistical significance of public health spending implies that government financing of healthcare services plays an important role in improving health outcomes in Ghana. Even though health sector budget has been low over the years, the GoG has financed and continues to finance health services like immunization and postnatal services for infants and under-fives. Similarly, children have been decoupled from their parents to enhance access to medical care under the National Health Insurance Scheme. In addition, most of the facilities owned by government, particularly regional and teaching hospitals, serve as referral centers. Additionally, in most parts of Ghana, especially rural areas, public health facilities dominate in service provision. In cases where private providers operate, the high costs may not allow easy access to such healthcare providers. Perhaps these explain the significance of government spending on health.

Our finding on public health spending is in tandem with some previous studies ([Bokhari et al. 2007](#); [Rajkumar and Swaroop 2008](#); [Akinkugbe and Mohanoe 2009](#); [Novignon et al. 2012](#); [Rad et al. 2013](#); [Heijink et al. 2013](#); [Makuta and O'Hare 2015](#)). These studies have reported estimates that are similar in sign, statistical significance, and/or magnitude. After running more than 200,000 regressions, [Hanmer et al. \(2003\)](#) find ample evidence that public expenditure on health plays an important role in improving health outcomes. It confirms recent conclusion made by [Boachie and Ramu \(2016\)](#) in their preliminary study on the effect of government health spending on health status in Ghana. The findings also resonate with those reported by [Mohapatra \(2016\)](#) and [Sirag et al. \(2016\)](#). Therefore, increasing public health expenditure would lead to improved health for the people.

The findings refute earlier results by studies, such as [Santerre et al. \(1991\)](#); [Musgrove \(1996\)](#); [Filmer and Pritchett \(1999\)](#); [Berger and Messer \(2002\)](#); and [Compah-Keyeke et al. \(2013\)](#), that public health spending is not a significant predictor of health outcomes. While public health spending caused more mortality in OECD countries (see [Berger and Messer 2002](#)), we find that it reduced mortality among children and improved life expectancy at birth in Ghana. The ineffectiveness of public sector

intervention in improving health status reported by most of the earlier studies could be due to their aggregation of the countries under study. Actually, most of these studies focused on cross-country analysis where differences in data accounting might exist. Again, many studies reporting insignificant elasticities for public health spending were done for developed countries where health inputs abound; such countries may experience little or no change in outcomes per the law of diminishing marginal returns. Further, some studies used small sample size. For instance, [Compah-Keye et al. \(2013\)](#) used data for 2000–2010 on Ghana, which is small for the OLS estimation. The present study on Ghana support findings by [Baldacci et al. \(2002\)](#); [Gupta et al. \(2003\)](#); and [Issa and Ouattara \(2012\)](#) that public health spending is effective in promoting health status at lower levels of development or in low-and middle-income countries than in developed or higher income countries, and that public spending is particularly important for the poor.

Looking at the control variables in the models, most of them proved to be robust determinants of health outcomes in Ghana. The results show that availability of skilled healthcare personnel play an important role in healthcare system performance. The quality and availability of medical care rest on human resources within the health sector. In this regard, we included physician per 1000 population as a proxy for medical staff. Our results have shown that the availability of physicians helps reduce mortality. Specifically, we find that if the density of physicians should increase by 10%, mortality among children would decline by 0.29%. That is, the presence of medical and other healthcare professionals is very important in improving child health. Healthcare professionals facilitate the flow of health-related knowledge and ideas, which in most cases are non-rival. The finding contradicts the results by [Kamiya \(2010\)](#) on childhood mortality.

Surprisingly, the elasticity for life expectancy with respect to physician density is negative. The results in Panel A of Table 3 suggest that raising physician per 1000 people by 10% would cause life expectancy at birth to decline by 0.32%, a result we find very surprising. Thus, the number of physicians does not improve life expectancy. A possible reason is that lifestyle and other health behaviors are outside the purview of the medical personnel. As they advise, the onus lies on the individual to follow such medical advice. It is possible that within the period, the (adult) population did not follow medical advice liturgically, or might have adopted bad health behaviors. Another possibility is the low quality of medical care. The quality of medical care depends on the health personnel, which is tied to the quality of training received and availability of equipment. Perhaps, industrial actions by university teachers and/or lack of adequate medical equipment for laboratory work, among others, deteriorated the quality of training hence the negative impact on life expectancy. Another possible reason is the high rate of industrial strikes and absenteeism among medical personnel. In Ghana, the labor laws allow aggrieved workers to withdraw their services until their demands are met (usually known as strike). This usually brings most of the activities in concerned government institutions to a standstill. For instance, in 1995, university teachers embarked on a serious strike that led to a situation where no doctor could pass out from the medical school ([Dovlo and Nyongator 1997](#)). Similarly, healthcare personnel on government payroll embark on strike, which affects the smooth operation of healthcare facilities.

Another important variable determining health outcomes in Ghana is improved water (i.e., access to safe drinking water). The estimates show that as more people get access to safe drinking water, childhood mortality declines and life expectancy improves. Precisely, a 10% increase in the population with access to safe drinking water has the potential to reduce childhood mortality by 4.92% to 6.08% while improving life expectancy by 0.9%. This supports earlier findings in the literature. Contaminated and unsafe drinking water, as well as unhygienic conditions, usually cause diseases such as dysentery, diarrhea, and cholera. Over the years, there has been an improvement in providing potable water to the people. The services of the Ghana Water Company have expanded to include more households. Government and many non-governmental organizations (NGOs) have funded the construction of boreholes in many rural communities to ensure access to potable drinking water.

Similarly, the past two decades saw the proliferation of private companies providing purified water to the people. This improvement in access to safe water partly explains our results.

Grossman (1972) and Wagstaff (1986) argue that education is an important variable in the health production function since it determines the efficiency with which health inputs are used. In this study, two categories of education are included as proxy for literacy: primary school enrolment rates for females and both sexes. We find that female education is insignificant in all the mortality regressions and the signs are positive. One reason is that of female participation in the labor market. As females get educated, it increases their chances to enter the labor market, and to higher earnings. During the period, improvement in education among females enabled a number of them to enter the labor market. Therefore, the time spent on producing homecare for children may reduce which might explain the positive elasticities (Santerre et al. 1991). Another reason is that the educational curriculum might have neglected “health education and promotion”. The insignificant effect of education in some of the regressions could also be attributed to the measurement of the variable. Education was measured using participation (i.e., enrolment rates); however, not all people who enroll in primary schools, or even higher levels of education complete. Thus, in the absence of data on literacy, completion rates would have been an ideal measure for education. However, one can argue that using participation rate as a measure of literacy is justified since few students may drop out of school. As shown in Panel B of Table 3, a 10% rise in literacy rate causes life expectancy to rise by 0.72%, which represents 0.0072 life years (i.e., 2.63 days) per year.

Moreover, we find immunization to be an important factor causing mortality decline among children in Ghana. The estimates show that raising immunization uptake levels by 10% results in 0.4% decline in mortality. The implication is that childhood mortality can be reduced by adopting preventive health services such as vaccination. While the finding is in tandem with Akanni (2012) findings, for instance, it contrasts that of Kamiya (2010). Immunization against measles had no statistically significant effect on life expectancy though it was correctly signed.

The effect of private health expenditure on mortality is negative. The results imply that a 10% increase in private health expenditure contributes to a reduction in mortality by an average of 0.9%. Novignon et al. (2012) reported similar results from a cross-country study. Relative to public health spending, the effect of private spending on outcomes was lower in their study. As shown in Table 3, the elasticity for private health expenditure is higher than that of public health expenditure in the mortality regressions. This could be due to the reduction in the number of observations from 34 to 28. Despite the reduced sample, public health expenditure remained a robust determinant of health outcomes in all the regressions.

Cost (and income) effectiveness ratios have been produced under three different scenarios, and we find, in all scenarios, that the extra lives gained via income are higher. That is, gains in life expectancy and mortality decline are higher under income route than public health spending route. In all the three scenarios, the minimum cost per death averted from public spending is US\$0.22, whereas the maximum is US\$16. For life expectancy, an extra 10% government health spending produces extra life year at a cost of US\$7 to US\$593. The implication is that government can spend a maximum of US\$16 to avert one childhood death, whereas extra life year requires US\$593. This suggests that averting childhood mortality is relatively cheaper than gaining an extra life year. The reason is that childhood mortality is less influenced by lifestyle and other health behavioral decisions. Therefore, government interventions in health are likely to improve child health substantially than adult health (Santerre et al. 1991). The per capita income required to avert one childhood death, from all the scenarios, ranges from US\$1 to US\$40. For each extra life year gained, per capita income of US\$146 to US\$8,718 is required. The income estimates suggest that avoiding one childhood death will require per capita income of US\$40 or less. In the case of an extra life year, per capita income of US\$8,718, or a minimum of US\$146 is needed. Again, it is clear that avoiding one childhood death requires fewer resources than gaining an extra life year.

Our cost-effectiveness estimates or ratios differ from those in the literature. For instance, in an extensive cross-sectional analysis conducted by Bokhari et al. (2007), raising per capita public health spending by 10% was associated with 3.33% reduction in under-five mortality, which translated into 33.3 lives in every 1000 live births in Ghana. In the case of Bangladesh, an extra 10% public health spending saved 34.1 lives in every 1000 live births. When the authors evaluated the elasticities at the observed per capita values it was shown that an extra 10% public health spending reduced UMR from 82/1000 live births to 79.2/1000 live births signifying that 2.8 lives were gained from the extra 10% spending of US\$2.6 (constant 2000 US\$).

The cost-effectiveness ratios presented in Filmer and Pritchett (1999) also suggest that government needs to spend between US\$50,000 and US\$100,000 annually to save a child. From medical interventions, the average cost per life saved was between US\$10 and US\$4000 (Filmer and Pritchett 1999). Later estimates from Hanmer et al. (2003) found that the cost of saving one child through immunization is around US\$30. Additionally, the implied cost per life saved in every 1000 live births in Bokhari et al. (2007), for instance in Bangladesh, was 2000 Int. US\$0.07 (or US\$0.93 when the elasticity is evaluated at 82/1000 live births). This cost per life saved was based on current per capita government health spending of US\$26 (constant 2000US\$) observed at the time for Bangladesh. The cost-effectiveness ratios for a life year gained are also lower relative to those from Heijink et al. (2013) which ranges between US\$10,000 and US\$50,000 for 13 western countries.

The differences in the gains in health outcomes resulting from extra public spending and the associated cost can be attributed to differences in independent variables and estimation techniques adopted. Most of the earlier estimates were obtained from cross-national studies and/or used total health expenditure in calculating the cost-effectiveness ratios (e.g., Heijink et al. 2013). Another reason is that the price of healthcare is relatively lower in the developing world where healthcare may be viewed as curing as compared to caring in developed countries. Similarly, differences in baseline or years considered for calculations may account for these differences in costs.

Robustness Check

To check the robustness of our results, a cointegration analysis is conducted. The autoregressive distributed lag (ARDL) estimator by Pesaran et al. (2001) and the fully modified OLS (FM-OLS) due to Phillips and Hansen (1990) are employed to obtain the long-run coefficients after establishing a cointegration relationship between health outcomes and the explanatory variables using the bounds test. The estimators are chosen to address the shortfalls in the OLS and two-stage least squares, and the procedures associated with their application are outlined in the literature elsewhere. The long-run estimates from the ARDL and FM-OLS estimators (see Appendix A) do not invalidate the findings on public health expenditures and income in Tables 2 and 3. Specifically, the ARDL and FM-OLS estimates show that public health expenditures have significant positive effect on health, even after controlling for other factors. Similar to the results in the previous sections, the effect of income dominates that of public health expenditure. Both income and government intervention are important in improving health outcomes in Ghana. All the speed of adjustment, ECT_{t-1} , in the ARDL models are below 30% suggesting that health improvements may be achieved over a relatively longer duration.

5. Conclusions and Policy Implications

We have explored the effect of public health expenditure on health outcomes in Ghana, and the cost per life saved has been estimated. After controlling for income and some other determinants of health, we find that public health expenditure is important for health improvement in Ghana. Overall, increasing public health expenditure by 10% saves 0.102–4.4 lives in every 1000 live births whilst increasing life expectancy at birth by 0.77–47 days in a year. The cost per childhood mortality averted, for all scenarios, ranges from US\$0.20 to US\$16, whereas the cost per extra life year gained ranges from US\$7 to US\$593.33. Comparing the estimates, and given income poverty and rising inequalities, public health spending remains an important and cheaper route to reduce mortality and increase life

expectancy. Other factors that improved health outcomes during the period include immunization, access to safe drinking water, physician density, and education (both sexes).

The findings have some implications for health policy. First, the positive relationship between health outcomes and public health expenditure calls for government to increase its spending on the health sector. Per capita health spending by government may be, at least, US\$45 (constant 2005 US\$). The increased government allocation will help expand the “Community Health Planning Services (CHPS compound)” concept to many rural areas to enhance access to and use of primary healthcare services. The spending will also make available essential equipment and drugs in health facilities, and would reduce the “no-bed syndrome” in the healthcare system. Moreover, policymakers should be committed to the Abuja declaration, which entreats African governments to allocate a minimum of 15% of their entire budget to the health sector. Overall, government health spending may focus on reducing mortality among children.

Furthermore, efforts should aim at raising income levels. That is, government policies should consider increasing the productive capacity of the economy to raise per capita income. For instance, encouraging the export sector (local production) would generate more jobs to improve incomes and raise real per capita GDP. Higher income will also raise government’s spending capacity on social services. Also, increasing incomes coupled with declining inequality may enhance people’s ability to consume more quality goods and services, including healthcare. By this, policies should aim at creating educational and vocational opportunities for people to develop and grow their skill sets and access jobs such that the people contribute to and benefit from the growing income. Thus, a holistic policy that aims at promoting income growth should endeavor to address problems in income distribution.

Scaling-up immunization programs will help reduce infant and under-five deaths towards converging to the global average. Additionally, it is recommended that the number of physicians and other healthcare personnel in the country be increased. By this, establishing more medical schools without compromising the quality of medical education would be beneficial. Private sector players in the educational sector may be allowed to train medical personnel. Increased supply of physicians and other healthcare personnel would enhance health human resources in the country.

Given the results, due consideration should be given to education and should incorporate health education as well. Thus, policies should gear towards improving enrolment and completion rates in schools, at least to the primary school level, to help raise literacy levels. Therefore, government should provide and/or improve teaching and learning materials at the basic and secondary levels to enhance enrolment and completion rates, especially in areas where there is acute poverty and inadequate educational resources. Such strategies should not ignore teachers. Teachers, especially those in (rural) areas where enrolment, completion and performance rates are low, may be given incentives such as study leave, transportation, and accommodation packages. It is important that educational curriculum incorporates health education and promotion at all levels.

In sum, the findings provide support for policymakers to choose a combination of strategies to improve health outcomes. This is because relying solely on income to improve health may restrict some people in society, i.e., the poor and other vulnerable groups, from accessing and utilizing healthcare services. At the same time, using public health expenditure as the primary strategic tool has serious budget implications. Hence, appropriate policy measures, such as those that target income growth and social spending, may be combined to improve the overall health situation in Ghana. Largely, public health expenditure is effective in improving health, and government must increase the allocations to the health sector to address the challenges that occurred under the health-related MDGs. This will facilitate the attainment of the health-related targets of the Sustainable Development Goals (SDGs) by 2030.

It is worth noting that there remains scope for further research on the health expenditure-health outcome nexus. First, several factors do affect the health of an individual and/or that of an entire population. For instance, lifestyle and health behaviors like physical activity, and alcohol and tobacco consumption were uncaptured due to data paucity. These health behaviors have a high

potential to affect health outcomes and may constrain the health effect of the spending. Additionally, the efficacy of government health spending may be influenced by the quality of governance and existing institutional structures and level of infrastructural development; these issues were not addressed by the study. Leakages of monetary resources and/or nonmonetary resources (e.g., hospital supplies) in the health sector were also untouched. These issues may affect the efficacy of public health spending. Furthermore, since government is a major financier of both development and recurrent expenditures in the health sector, it would be of great utility to assess the relative roles of development and recurrent expenditures on health in Ghana.

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Appendix A. Robustness Results

The study also specifies Equation (3) in an autoregressive distributed lag (ARDL) conditional error correction form, seen in Equation (A1), to obtain the long-run estimates after establishing cointegration relationship. It is also a log-log specification.

$$\Delta Y_t = \eta + \sum_{i=1}^p \Psi \Delta Y_{t-i} + \sum_{i=0}^p \Theta_s \Delta X_{t-i} + \Gamma_1 Y_{t-1} + \Gamma_s X_{t-1} + \varepsilon_t \quad (\text{A1})$$

The intercept and the error term in the regression are, respectively, η and ε_t . p is the optimal lag length and Δ is a difference operator. Y_t is same as defined in Section 2.2, the number of regressors is denoted by s , and a vector of the explanatory variables is defined by X . Equation (3) is also estimated using the Fully Modified OLS (FM-OLS) estimator. The ARDL results are shown in Tables A1–A4, while the FM-OLS estimates are presented in Table A5. Prior to the estimation, we checked the order of integration of the variables using the augmented Dickey–Fuller and the Dickey–Fuller GLS unit root test procedures. The test results are available on request.

Table A1. ARDL Bounds Test for Cointegration Results.

	Equation	F-Statistic	S	Critical Values		
1	IMR = f(RGDPC, PuHE, PHY, STN, FED, IMS)	37.94	6	%	I (0)	I (1)
2	UMR = f(RGDPC, PuHE, PHY, STN, FED, IMS)	10.75	6	10	1.99	2.94
3	LEB = f(RGDPC, PuHE, PHY, STN, EDU, IMS)	926	6	5	2.27	3.28
				1	2.88	3.99
4	IMR = f(RGDPC, PuHE, PHY, STN, FED, IMS, PvHE)	31.57	7	10	1.92	2.89
5	UMR = f(RGDPC, PuHE, PHY, STN, FED, IMS, PvHE)	15.37	7	5	2.17	3.21
6	LEB = f(RGDPC, PuHE, PHY, STN, EDU, IMS, PvHE)	622	7	1	2.73	3.90

Notes: S denotes the number of regressors. The null hypothesis of no level effect is rejected if the F-statistic is above the upper bound, and is inconclusive if the statistic lies between the bounds.

Table A2. Diagnostics for ARDL Results.

Equation	Autocorrelation *	Heteroscedasticity **	Normality ***
1	0.518 (0.605)	28.847 # (0.149)	0.627 (0.731)
2	1.709 (0.219)	0.356 (0.978)	0.913 (0.633)
3	3.437 (0.072)	0.703 (0.762)	0.01 (0.995)
4	3.303 (0.175)	0.235 (0.992)	0.428 (0.807)
5	0.095 (0.911)	0.302 (0.982)	3.935 (0.140)
6	0.016 (0.90)	1.038 (0.471)	0.325 (0.850)

Note on statistics: * Breusch–Godfrey LM; ** Breusch–Pagan–Godfrey; and *** Jarque–Bera. Probabilities in parentheses. All models estimated satisfy the stability criteria. # Obs*R² statistic.

Table A3. ARDL Long-Run Estimates: Public Health Spending and Health Outcomes.

	ARDL Long-Run Estimates					
	Panel A			Panel B		
	IMR (1)	UMR (2)	LEB (3)	IMR (4)	UMR (5)	LEB (6)
RGDPC	−0.274 *** (0.040)	−0.473 *** (0.028)	0.084 *** (0.003)	−0.412 *** (0.066)	−0.528 *** (0.043)	0.081 *** (0.002)
PuHE	−0.082 *** (0.012)	−0.077 *** (0.014)	0.003 * (0.001)	−0.119 *** (0.025)	−0.076 *** (0.014)	0.003 ** (0.001)
PHY	−0.019 *** (0.006)	−0.035 ** (0.011)	−0.012 *** (0.001)	0.018 (0.017)	0.004 (0.019)	0.002 * (0.001)
STN	−0.685 *** (0.044)	−0.585 *** (0.059)	0.089 *** (0.005)	−0.613 ** (0.162)	−0.543 *** (0.091)	0.052 *** (0.006)
EDU	— —	— —	−0.018 ** (0.006)	— —	— —	0.001 (0.006)
FED	−0.012 (0.040)	0.02 (0.048)	— —	0.260 ** (0.091)	0.227 ** (0.095)	— —
IMS	−0.034 ** (0.011)	−0.012 (0.009)	0.007 ** (0.001)	−0.113 (0.098)	−0.318 ** (0.076)	0.014 ** (0.005)
PvHE	— —	— —	— —	−0.002 (0.065)	−0.193 *** (0.043)	−0.002 (0.002)
Constant	8.651 *** (0.109)	9.904 *** (0.198)	3.185 *** (0.014)	8.763 *** (0.359)	10.651 *** (0.164)	3.285 *** (0.013)

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels respectively. Standard errors in parenthesis.

Table A4. ARDL Short-Run Estimates: Public Health Spending and Health Outcomes.

Variable	ARDL Short-Run Estimates					
	Panel A			Panel B		
	IMR (1)	UMR (2)	LEB (3)	IMR (4)	UMR (5)	LEB (6)
$\Delta(\text{imr}/\text{umr}/\text{leb}-1)$	1.156 *** (0.018)	1.098 *** (0.031)	0.989 *** (0.003)	1.190 *** (0.018)	0.900 *** (0.017)	0.973 *** (0.004)
ΔRGDPC	−0.015 * (0.008)	−0.029 * (0.015)	0.006 *** (0.001)	−0.064 *** (0.006)	— —	0.004 *** (0.001)
$\Delta(\text{RGDPC}-1)$	0.056 *** (0.008)	0.100 *** (0.015)	−0.005 *** (0.001)	0.087 *** (0.009)	— —	
$\Delta(\text{RGDPC}-2)$	0.036 *** (0.006)	— —	— —	— —		
ΔPuHE	−0.002 *** (0.001)	−0.085 *** (0.001)	— —	−0.015 *** (0.001)	−0.003 ** (0.001)	— —
$\Delta(\text{PuHE}-1)$	0.014 *** (0.001)	−0.009 *** (0.001)	— —	— —	— —	— —
$\Delta(\text{PuHE}-2)$	0.010 *** (0.001)	— —	— —	— —	— —	— —
ΔPHY	−0.001 (0.001)	−0.007 *** (0.002)	#	−0.009 *** (0.001)	−0.003 * (0.001)	— —
$\Delta(\text{PHY}-1)$	— —	— —	#	−0.006 *** (0.001)		
ΔSTN	−0.085 *** (0.010)	−0.082 *** (0.023)	0.005 *** (0.001)	−0.016 (0.010)	0.031 (0.018)	
$\Delta(\text{STN}-1)$	0.061 (0.015)	0.098 *** (0.022)	0.010 *** (0.001)	0.143 *** (0.010)		
$\Delta(\text{STN}-2)$	0.100 *** (0.009)	— —	0.007 *** (0.001)			
EDU	— —	— —	#	— —	— —	
ΔFED	−0.009 ** (0.004)	— —	— —	0.078 *** (0.004)	0.069 *** (0.007)	— —
$\Delta(\text{FED}-1)$	−0.013 ** (0.004)	— —	— —	−0.044 *** (0.003)	— —	
$\Delta(\text{FED}-2)$	0.014 *** (0.003)	— —	— —			
ΔIMS	0.005 *** (0.002)	−0.002 (0.002)	#	−0.042 *** (0.002)		#
$\Delta(\text{IMS}-1)$	— —	0.007 *** (0.002)	#	0.014 *** (0.001)		
PvHE	— —	— —	— —	0.014 *** (0.001)	−0.014 *** (0.003)	
ECT_{t-1}	−0.234 *** (0.010)	−0.285 *** (0.025)	−0.138 *** (0.001)	−0.252 *** (0.009)	−0.150 *** (0.010)	−0.135 *** (0.001)
Adj. R ²	0.99	0.97	0.99	0.99	0.98	0.99

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels respectively. Standard errors in parenthesis. # denotes extremely small coefficient, which becomes zero when rounded to 3 decimal places.

Table A5. FM-OLS Long-Run Estimates: Public Health Spending and Health Outcomes.

	FM-OLS Long-Run Estimates					
	Panel A			Panel B		
	IMR (1)	UMR (2)	LEB (3)	IMR (4)	UMR (5)	LEB (6)
RGDPC	−0.707 *** (0.036)	−0.948 *** (0.044)	0.071 *** (0.025)	−0.515 *** (0.010)	−0.653 *** (0.011)	0.053 *** (0.006)
PuHE	−0.114 *** (0.011)	−0.153 *** (0.013)	0.016 ** (0.007)	−0.034 *** (0.004)	−0.032 *** (0.004)	0.012 *** (0.002)
PHY	−0.243 *** (0.013)	−0.327 *** (0.016)	−0.042 *** (0.009)	−0.073 *** (0.005)	−0.108 *** (0.006)	−0.001 (0.003)
STN	0.508 *** (0.041)	0.857 *** (0.049)	0.099 *** (0.027)	−0.291 *** (0.029)	−0.156 *** (0.033)	0.032 ** (0.016)
EDU	— —	— —	0.014 (0.037)	— —	— —	0.122 *** (0.012)
FED	0.045 (0.052)	0.112 * (0.062)	— —	−0.003 (0.021)	−0.002 (0.024)	— —
IMS	−0.210 *** (0.010)	−0.276 *** (0.012)	0.006 (0.007)	−0.057 *** (0.015)	−0.126 *** (0.017)	−0.071 *** (0.009)
PvHE	— —	— —	— —	−0.034 *** (0.011)	−0.005 (0.011)	−0.003 (0.006)
Constant	6.538 *** (0.175)	6.793 *** (0.212)	2.993 *** (0.122)	8.663 *** (0.065)	9.564 *** (0.073)	3.358 *** (0.036)
Adj. R ²	0.86	0.79	0.95	0.96	0.96	0.95

Note: *, **, and *** denote significance at 10%, 5%, and 1% levels respectively. Standard errors in parenthesis.

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