HEALTH ECONOMICS
Health Econ. **16**: 257–273 (2007)
Published online 26 September 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hec.1157

GOVERNMENT HEALTH EXPENDITURES AND HEALTH OUTCOMES

FARASAT A. S. BOKHARI[a,*], YUNWEI GAI[a] and PABLO GOTTRET[b]

[a] *Department of Economics, Florida State University, USA*
[b] *Health Systems Development Cluster, World Bank, Washington, DC, USA*

SUMMARY

This paper provides econometric evidence linking a country's per capita government health expenditures and per capita income to two health outcomes: under-five mortality and maternal mortality. Using instrumental variables techniques (GMM-H2SL), we estimate the elasticity of these outcomes with respect to government health expenditures and income while treating both variables as endogenous. Consequently, our elasticity estimates are larger in magnitude than those reported in literature, which may be biased up. The elasticity of under-five mortality with respect to government expenditures ranges from -0.25 to -0.42 with a mean value of -0.33. For maternal mortality the elasticity ranges from -0.42 to -0.52 with a mean value of -0.50. For developing countries, our results imply that while economic growth is certainly an important contributor to health outcomes, government spending on health is just as important a factor. Copyright © 2006 John Wiley & Sons, Ltd.

Received 2 February 2005; Accepted 8 June 2006

KEY WORDS: under-five mortality; maternal mortality; Millennium Development Goals; government health expenditures; elasticity

INTRODUCTION

Over 11 million children die annually in the developing world, 90% of whom are under the age of five. Country levels of under-five mortality rates vary from 4 to over 250 deaths per 1000 live births. Five diseases account for more than 50% of these deaths – pneumonia, diarrhea, malaria, measles, and HIV/AIDS. Above 20% of under-five deaths happen in the first week of birth, and can be attributed primarily to malnutrition in the mother and fetus, and poor antenatal care (UN, 2002).

In a global effort to eradicate poverty, including finding solutions to hunger, malnutrition and disease, 189 countries reaffirmed their commitment to the United Nations Millennium Declaration in September 2000. Emanating from such a declaration is a set of eight goals (now called, the Millennium Development Goals (MDGs)) where each has one or more targets with multiple indicators to assess progress over the period from 1990 to 2015, when these targets are expected to be met. For instance, among the health-related indicators, the target is to reduce under-five mortality by 75%, maternal mortality by 65%, and prevalence of underweight among children by 50% (UN, 2004).

Linkages between wealth and health have been shown to be strong in the literature (see, for instance, Gangadharan and Valenzuela (2001), and Pritchett and Summers (1996) and the literature review therein). Thus, in the Millennium Declaration direct support from the richer countries in the form of aid, debt relief and investment is to be provided to help developing countries. While it is expected that with economic growth better health will follow, simple projections based on income elasticity calculations show a modest effect. Even with an assumed growth rate of 8% per year between 1990 and

*Correspondence to: Department of Economics, Florida State University, Tallahassee, FL 32306, USA. E-mail: fbokhari@fsu.edu

2015 in a typical developing country, maternal mortality rate reduces by only 40%. The obvious question that arises then is, what else can be done?

This paper focuses on the impact of government health expenditures on health outcomes, particularly two health outcomes – under-five mortality (U5M) rates and maternal mortality (MM) rates. We choose to study these two variables because government health expenditures are not monolithic and often consist of budgets for sub-sectors within the health care sectors such as primary care, secondary care, etc. To the extent that we can consider under-five mortality an example of an outcome in primary care, and maternal mortality an example of an outcome from secondary care (often provided in hospitals), we can assess the impact of total government health expenditures across different sub-sectors (data for government health expenditures by sub-sectors were not available).

The link between government health expenditures and health outcomes is not necessarily present. First, an increase in public health expenditures may result in a decrease in private health expenditures – a household may divert its funds towards other uses once the government increases its provision of basic health care. Second, the incremental government expenditures may be employed on the intensive rather than the extensive margin. An example of intensive expenditures would be if expensive and low productivity inputs are bought with marginal funds in which case the impact of these expenditures on health outcomes may be small (Jalan and Ravallion, 2003). Third, even if extra funds are applied extensively to health care (e.g. more staff at hospitals, adequate stocking of medications), but complementary services, both inside and outside the health sector, are not there (e.g. lack of roads or transportation to hospitals and clinics, subsidized prices for medication, etc.) the impact of extra government health expenditures may be little or none (for a more extensive discussion on this point, see Wagstaff (2002a)).

It is important to recognize that total government health expenditures consist of internal funds as well as external donor funds provided by multilateral institutions such as the World Bank, United Nations, etc. This source of external funding is *on-budget*, i.e. since it is provided directly to the government, it is already part of government health expenditures. In addition, countries also receive bilateral funds for specific health projects (administered by non-governmental organizations (NGOs)) from member countries of the Development Assistance Committee (DAC) of the Organization for Economic Co-operation and Development (OECD). These funds are typically *off-budget*, in the sense that they are not part of government health expenditures (see p.10, Driscoll and Evans (2005)).[1] Since off-budget donor funds can impact health outcomes directly and they may also be correlated with government health expenditures, it is important to include them in the model. Thus, unless otherwise stated, our use of the term 'donor funding' is restricted to these bilateral funds (for health projects) from DAC countries and are separate from government health expenditures.

Furthermore, these donor funds may also marginally affect the impact of government health expenditures on health outcomes. This is because there is an inherent uncertainty in donor funds and while the actual amount to be spent by donors in the coming year is not known by the governments, the amount pledged in the past years is known. Thus, if governments allocate funds across sectors (health, education, infrastructure, etc.) or within the health sector (primary care, secondary care, etc.) based on the *expected* level of donor funding, then *deviations* from the expected level can cause mis-allocation of internal funds thereby affecting the impact of government health expenditures on health outcomes. In our model, we also account for deviations from the expected level of donor funding.

Empirical literature on the link between public spending and health outcomes is sparse. Earlier studies (summarized in Musgrove, 1996) find no evidence that public spending on health has any impact on child mortality. Alternatively, other studies do find limited evidence of the impact of government health expenditures on outcomes (Anand and Ravallion, 1993; Bidani and Ravallion, 1997). Most

[1] Since the turn of the century, increasingly more bilateral funds are used for direct budget support rather than be off-budget. For more information on recent trends see Gottret and Schieber (2006).

DOI: 10.1002/hec

relevant to this paper are three recent studies by Filmer and Pritchett (1999), Wagstaff (2002b) and Wagstaff (2004). Each of these studies uses methods, models and data comparable to ours. Filmer and Pritchett (1999) use data from the early 1990s and estimate multivariate regression model of child mortality on per capita income (I), government health expenditures (Gh) and other controls. They find that the coefficient on Gh is negative but statistically insignificant, both in the OLS estimation as well as when taking into account any reverse causality between outcomes, and Gh and I via two-stage least squares methods.[2] Based on the incremental R^2 value they show that Gh contributes less than 1/7 of 1% when accounting for health outcome differences across countries once they control for income per capita and other covariates.

On the other hand, Wagstaff (2002b, 2004) includes more recent data from 1995 and 2000 in his analysis. However, Wagstaff (2002b) treats Gh as an exogenous variable and finds that Gh does have a statistically significant (negative) coefficient and that the elasticity of U5M with respect to Gh is in the range of 0.08 to 0.15. While Wagstaff (2002b) does not account for endogeneity (due to reverse causality) of the Gh term, he in fact argues that his result is biased up (i.e. closer to zero than the true, larger in magnitude, negative value). However, when Wagstaff (2004) does treat Gh as an endogenous variable, the elasticity with respect to Gh is not statistically significant.[3]

In contrast, we estimate equations similar to the ones used in these papers but treat both variables as endogenous. Based on Hausman tests we reject the null hypothesis that the correlation between these two variables and the error term is zero (or small enough to be ignored), individually or jointly. Thus, while our results are consistent with Wagstaff (2002b, 2004) and Filmer and Pritchett (1999) they provide a much stronger evidence linking government health expenditures to health outcomes. Using instrumental variables techniques (GMM-H2SLS) we estimate that the elasticity of under-five mortality with respect to government expenditures ranges from -0.25 to -0.42 with a mean value of -0.33. For maternal mortality the elasticity ranges from -0.42 to -0.52 with a mean value of -0.50.

EMPIRICAL MODEL

Let Y_{mi} be the mth MDG health indicator ($m = 1, 2, \ldots, M$) in country i (e.g. under-five mortality, maternal mortality, proportion of population using effective malaria prevention and treatment measures, etc.) and assume that it is related to government expenditures on health (Gh), income (I), level of donor funding (D), deviation in donor funding from its historic average ($\tilde{D}$) and, the level of education and basic infrastructure such as network of roads and level of improved water sources and sanitation (E, R, S). When modeling the relationship between these variables and MDG health indicators, it is important to be cognizant of certain other factors as well. First, the impact of Gh on any specific indicator may vary by country. This could be because each country has a different level of income, general education and infrastructure in place (network of roads, access to improved water sources and sanitation) which may in fact have a marginal impact on the relationship between government health expenditures and health outcomes. Therefore, when modeling the impact of government expenditures on health indicators, it is important to account for this heterogeneity across countries.

Second, some of the indicators may also be causally related to each other while the relationship among other indicators may be only spurious. For instance, under-five mortality rates, an MDG health indicator, may be causally related to the proportion of population in malaria-risk areas using effective malaria prevention and treatment measures, another MDG health indicator. Separately modeling an

[2] Based on the Hausman tests, Filmer and Pritchett (1999) argue that income can be treated as an exogenous variable but in their main estimation they treat it as an endogenous variable.

[3] In fact, Wagstaff (2004) interacts the Gh term with a categorical variable with five values and the computed elasticity is not significant for any but one of the categories.

DOI: 10.1002/hec

indicator without accounting for the effect of other indicators on the first one, may lead to omitted variables bias and misinterpretation of the estimated coefficients.

Third, there may also be some reverse causality between the other included covariates and the MDG health indicator, such as between income and the health indicators: not only is the income of individuals likely to affect their health status, but their health status may also determine their income (Wagstaff, 2002b; Pritchett and Summers, 1996). Similarly, government expenditures on health and other sectors may also be endogenous to the MDG indicators because governments may respond by changing their spending on health, education, etc. (Wagstaff, 2002b, 2004). All of these issues introduce complications for the modeling exercise. To account for them in a systematic manner, we first specify a generic version of the model for an MDG indicator that considers the relationship to all these variables. This is an important exercise since it (i) outlines precisely which coefficients are identified in the reduced form regressions, and (ii) facilitates interpretation of the reduced form regression coefficients.

Thus, for the mth MDG health indicator (and suppressing the subscript i for country) let

$$Y_m = \exp(\alpha_{m1}) E^{\alpha_{m2}} R^{\alpha_{m3}} S^{\alpha_{m4}} D^{\alpha_{m5}} I^{\alpha_{m6}} \mathrm{Gh}^{(\alpha_{m7}+\alpha_{m8}\tilde{D}+\alpha_{m9}R)} \prod_{l=1}^{M} Y_l^{\theta_{ml}} \exp(u) \quad \text{where } l \neq m \tag{1}$$

Two features of this equation are worth noting. First, the mth MDG health indicator is a function of $E, R, S, I, D, \tilde{D}, \mathrm{Gh}$ (abbreviation explained above) and also it is a function of (some of the) other MDG health indicators, $\prod_l Y_l^{\theta_{ml}}$ (i.e. $\theta_{ml} \neq 0$ for all l). Ignoring these additional terms can lead to biased estimates of α's if they (a) are correlated with the included variables, and (b) also affect the indicator on the left-hand side of the equation. The condition for (a) is true by assumption since Gh affects health outcomes, and hence other MDG health indicators, $\prod_l Y_l^{\theta_{ml}}$, are also correlated with Gh. The condition for (b) may also be true in some cases. For instance, under-five mortality rates and proportion of population in malaria-risk areas may be causally related.

Second, while Gh has a direct effect on health outcomes, this may be mitigated or enhanced depending on (1) if donor funding is close to or far from the expected level of donor funding (measured via $\tilde{D}$), and (2) the level of infrastructure in the country (here measured via network of roads variable). Consequently, the elasticity of the mth MDG health indicator with respect to Gh is not α_{m7} but rather $\alpha_{m7} + \alpha_{m8}\tilde{D} + \alpha_{m9}R$.

Semi-reduced forms

Taking the log of both sides, the mth MDG health indicator equation for the ith country can be written as (subscript i suppressed)

$$\begin{aligned} \ln Y_m = {} & \alpha_{m1} + \alpha_{m2} \ln E + \alpha_{m3} \ln R + \alpha_{m4} \ln S + \alpha_{m5} \ln D + \alpha_{m6} \ln I \\ & + \alpha_{m7} \ln \mathrm{Gh} + \alpha_{m8}(\ln \mathrm{Gh} \times \tilde{D}) + \alpha_{m9}(\ln \mathrm{Gh} \times R) + \sum_l \theta_{ml} \ln Y_l + u_m \end{aligned} \tag{2}$$

where if we write out all the M-equations and reorganize them, we can represent them conveniently in the matrix notation (for the ith observation) as

$$\Theta \mathbf{y} = \mathbf{A}\mathbf{x} + \mathbf{U} \tag{3}$$

where $\mathbf{y}' = [\ln Y_1 \;\; \ln Y_2 \;\; \ldots \;\; \ln Y_M]$, Θ is a $M \times M$ square matrix with the normalizing 1 on the leading diagonals and $-\theta_{lk}$ on the off-diagonal entries, $\mathbf{x}'$ is the vector of covariates, $\mathbf{x}' = [1 \;\; \ln E \;\; \ln R \;\; \ln S \;\; \ldots \;\; \ln \mathrm{Gh} \;\; \tilde{D} \times \ln \mathrm{Gh} \;\; R \times \ln \mathrm{Gh}]$, $\mathbf{A}$ is the $M \times 9$ matrix of α coefficients, and $\mathbf{U}'$ is the vector of error terms $\mathbf{U}' = [u_1 \;\; u_2 \;\; \ldots \;\; u_M]$. Separate equations for $\ln Y_1, \ln Y_2, \ldots$ are now readily available by pre-multiplying Equation (3) by Θ^{-1} so that $\mathbf{y} = \Theta^{-1}\mathbf{A}\mathbf{x} + \Theta^{-1}\mathbf{U}$, where they are functions of the log of the exogenous variables (E, R, S, D), income (I) and of government expenditures and its interaction terms $(\mathrm{Gh}, \tilde{D} \times \ln \mathrm{Gh}, R \times \ln \mathrm{Gh})$ alone, and not of each other. Denote $\Theta^{-1}\mathbf{A}$ by $\mathbf{B}$, then $\mathbf{B}$ is a $m \times 9$ matrix

DOI: 10.1002/hec

of coefficients (where the mth row entries are given by $\beta_{m1}, \beta_{m2}, \ldots \beta_{m9}$) and the mth equation is

$$\ln Y_m = \beta_{m1} + \beta_{m2} \ln E + \beta_{m3} \ln R + \beta_{m4} \ln S + \beta_{m5} \ln D + \beta_{m6} \ln I + \beta_{m7} \ln \mathrm{Gh} + \beta_{m8}(\tilde{D} \times \ln \mathrm{Gh}) + \beta_{m9}(R \times \ln \mathrm{Gh}) + v_m \tag{4}$$

Interpretation of coefficients

It is important to note that the β coefficients in the m-equations in (4) above are not the elasticity measurements in the traditional sense, i.e. they are not the same as the α's of Equation (1). For instance, whereas $\alpha_{m7} + \alpha_{m8}\tilde{D} + \alpha_{m9}R$ gives the direct percentage change in indicator Y_m due to a 1% change in Gh holding everything else constant (including other indicators), $\beta_{m7} + \beta_{m8}\tilde{D} + \beta_{m9}R$ gives the *net* percentage change in indicator Y_m associated with a 1% change in Gh, holding only I, E, R, S, D and $\tilde{D}$ constant, but not the other indicators. Further, without imposing more structure on the model and finding instruments for each indicator separately, it is not possible to estimate the coefficients of the **A** matrix. Thus, in our setup these coefficients are unidentified.

However, since we are primarily interested in estimating the total impact of government health expenditures on a given health MDG indicator, obtaining consistent (and precise) estimates of the **B** matrix (i.e. the β coefficients) is sufficient. For instance, $\beta_{m7} + \beta_{m8}\tilde{D} + \beta_{m9}R$ gives the percentage change in Y_m due to both, a direct change due to Gh *plus* the indirect change, where the indirect change comes from the change in other indicators ($Y_l, l \neq m$), which in turn contribute to the net change in Y_m through θ's (i.e. the '$\sum_l \theta_{ml} \ln Y_l$' term in Equation (2)). To give a concrete example, consider the equation of the MDG health indicator for under-five mortality. A small change in government health expenditures may be associated with a direct change in U5M as well as a change in other indicators such as (i) proportion of 1-year-old children immunized against measles, (ii) proportion of population in malaria-risk areas using effective malaria prevention and, (iii) other MDGs (see Figure 1). Clearly, any change in the latter indicators would also cause a change in U5M. Thus, $\beta_{m7} + \beta_{m8}\tilde{D} + \beta_{m9}R$ provides the net impact of increased government health expenditures on under-five mortality, the direct *plus* the indirect impact via, (i)–(iii), and it is the sum of these that is of primary interest. Thus, henceforth whenever we use the term 'elasticity' of an outcome indicator with respect to a covariate, it is in reference to the net elasticity and not the true partial elasticity with respect to that covariate.

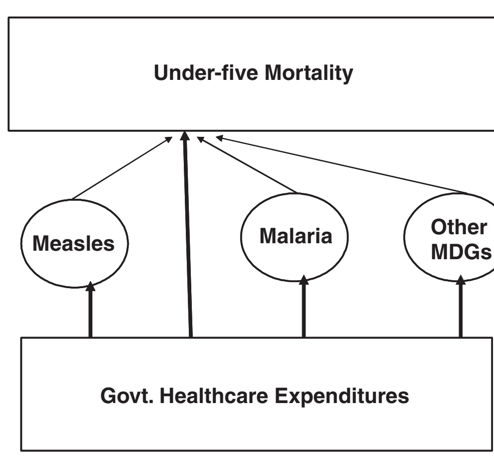

Figure 1. Inter-relationship between MDGs and Gh

DOI: 10.1002/hec

Endogeneity

The set of m-equations in (4) should be viewed as semi-reduced form equations, because while the indicators ln Y_1, ln Y_2, ... are no longer functions of each other, and hence are in the so-called 'reduced form', the government expenditures (Gh), and income (I) may be endogenous. Micro theory suggests a circular relationship between the income and health status of an *individual or a family* – morbidity and ill health of the individuals in a family impact their ability to work, and thus their income, and in general can cause the household to fall into poverty – but many of the conditions of poverty (lack of clean water, sanitation, access to health services, education, etc.) also lead to high levels of ill health. Thus, at least at the micro-level, poverty and ill health have a circular relationship since either one can be the cause as well as the consequence of the other. Whether such a circular relation exists at the macro-level between GDP per capita and health indicators of a country is largely an empirical question.

Similarly, it is possible that the government health expenditures variable may be correlated with the error term. This is due to the possibility that governments may implicitly respond to poor health outcomes in prior years by adjusting the health care spending in the current year. Here the source of endogeneity is not any reverse causality *per se* – government budgets are set at the beginning of a year (with perhaps some deviations by the end of the year), while the health indicators are measured at the end of the year – but rather due to the omitted variables bias (i.e. mis-specification of the model in the set of m-equations in (4)). Specifically, if current health outcomes are correlated with past health outcomes and if the current government health expenditure is implicitly a function of prior health outcomes, then the set of m-equations in (4) are mis-specified in that the terms

$$\sum_{l,\tau}^{M,t-1} \delta_{ml\tau} \ln Y_{l\tau} \tag{5}$$

are missing from the right-hand side of each of these equations. This implies that ignoring this source of endogeneity will result in an estimate of the coefficient on Gh that is biased up (i.e. if negative, then smaller in magnitude than the true value). The standard method to deal with endogenous variables is via the use of the instrumental variables in a class of different estimation methods (2SLS, GMM, etc.). The choice of the instruments is determined by their correlation to the endogenous variables (here Gh and I) and their lack of correlation with the error term or the lack of correlation with the Y_m variable. We discuss these in the next section.

DATA SOURCES AND VARIABLE DEFINITIONS

Variable names and their definitions are given in Table I, along with summary statistics. The variable U5M is defined as under-five mortality per 1000 live births, and ranges from 4 to 286 with a mean value of 73.5, and MM is measured as maternal mortality per 100 000 live births, with a range of 2–2000 and a mean value of 345.4. Our measure of income is GDP per capita. Education is defined as the percentage of population age 15 or above who are illiterate, sanitation is the percentage of population with access to improved sanitation facilities, and roads are paved roads (in km) per unit area of a country (in km^2). Data on government health expenditures and (bilateral and off-budget) donor funding for health are also in per capita terms. All currency measurements are converted to constant 2000 international dollars.

Complete data were available for 127 observations for the calendar year 2000, and were obtained from multiple sources. 'SIMA', the World Bank's in-house, on-line database was used as the primary data source. This database includes, among others, information from World Development Indicators (WDI), Millennium Indicators Database (MID), World Health Report, and the Human Development Report by UNICEF. Missing observations on the variables were obtained from original data sources,

DOI: 10.1002/hec

Table I. Variable names and summary statistics

Variable	Definition ($N = 127$)	Log of variable		Raw data	
		Mean[a]	STD	Mean	STD
ln U5M	ln Under-five mortality per 1000 live births	3.74	1.18	73.5	68.9
ln MM	ln Maternal mortality ratio per 100 000 live births	4.84	1.67	345.4	425.1
ln I	ln GDP per capita[b]	8.26	1.11	6963	7988
ln Gh	ln Govt Health Exp per capita[b]	4.62	1.55	311	510
ln E	ln Education (% of Pop. aged $\geq$ 15 not literate)	2.14	1.69	21.2	22.2
ln R	ln Roads (Paved roads per unit area)	1.59	2.50	31.1	66.6
ln S	ln Sanitation (% Pop. w./access to improved sanitation)	4.20	0.53	74	26.7
ln D	ln Donor Funding per capita for Basic Health 1998[b]	−1.41	3.59	2.96	6.35
ln Gh $\times \tilde{D}$	(ln GH) $\times$ ($\lvert D - \tilde{D}_{1993-1997} \rvert$)	8.72	17.70	–	–
ln Gh $\times R$	(ln GH) $\times$ (R)	187.57	436.52	–	–

[a] Log of zero was set equal to zero if the non-zero values were greater than one. However, if non-zero values were less than one, then log of zero was set equal to the log of the non-zero minimum value.
[b] Converted to constant 2000 international dollars (Int \$2000).

the CIA fact-book, other UN websites (such as UNESCO), Penn World Tables and sometimes from a specific country's department of statistics and published reports. Data on government health expenditures for 2000 were obtained using the WHO's World Health Report 2004 (WHR-2004).

Information on donor funding was obtained from the Creditor Reporting System (CRS) Aid Activity database. This database lists donor funding data by two funding categories: multilateral funding and funding by DAC countries. Multilateral funding consists of contributions made by all donors (not just DAC members) to international agencies, institutions or organizations (e.g. World Bank). These agencies in turn provide funding to governments, and hence the health component of this funding is already included in the government health expenditures. For DAC countries, the database provides information on funding that is bilateral, i.e. where a donor country directly provides aid to a recipient country (their multilateral aid contributions are excluded from this variable). Except for a very small part, these bilateral donor funds (such as US/AID) are not given to recipient governments, and hence are not part of government health expenditures. Thus, for our donor funding variable, we use this latter variable.

Note that the data on donor funding is the amount that is *pledged* by the DAC countries for specific health projects. The actual amount received is typically with a lag of a couple of years and the amount dispersed may still be different from the amount pledged. For this reason we use the lagged value of the variable, i.e. for the analysis for the year 2000, the donor funding variable is per capita donor funding from DAC countries for health promised in 1998 (in Int \$2000). Similarly, for computing deviation in donor funding from its historic average value (i.e. the variable $\tilde{D}$), we used the country specific average donor funds between 1993 and 1997.[4] Summary statistics of the log of these variables as used in the model are given in Table I.

Instruments

Since income and government health expenditures are potentially endogenous, relevant and valid instruments would need to be (1) correlated with these variables, and (2) not correlated with the error terms (or the outcome measures). Thus, for income we use the consumption–investment ratio of a country as an instrument because it is likely to be correlated with GDP per capita (our income measure) but not with U5M and MM. Similarly, for government health expenditures (and its interaction with $\tilde{D}$

[4] For both of these variables, we experimented using various lags and it did not change our main results.

DOI: 10.1002/hec

and R) the instrument that we use is the military expenditures of the neighboring countries (and its interaction with $\tilde{D}$ and R). To be explicit, we assume that in a fully specified system, government health expenditures and military expenditures are both choice (endogenous) variables. Thus, Gh_i is a function of own military budget (MB_i) and other variables. Similarly, own military budget, MB_i is a function of health outcomes (Y_i), military budget of other countries MB_j (rival countries) and other variables.[5] Then, in the reduced form, Gh_i would be a function of MB_j and this variable is not correlated with their own health outcomes. Thus, as an approximation, we use the military budget of all the neighboring countries (per capita) as an instrument for government health budget.

Two additional instruments are used based on average scores from World Bank annual assessments of countries across multiple criteria. The World Bank annually assesses (and scores) the quality of policies and institutions in 4 broad areas with 20 specific criteria. These criteria pertain to the economic growth and poverty reduction of countries that borrow from the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA).[6] Of these 20 criteria, four rate the countries on a scale of 1–5 or 1–6 on the following issues relating to Economic Management: Management of Inflation and Currency Accounting; Fiscal policy; Management of External Debt, and Management and Sustainability of Developmental Programs. If these scores reflect the true economic management of the country then they would be correlated with the economic growth of the country. Thus, we used the average score on these four criteria as an additional instrument for GDP per capita. Similarly, scores on three additional criteria partly assess the Policies for Social Inclusion and Equity: Gender Equity; Equity of Public Resource Use, and Policies for Building Human Resources. We used the average score on these three criteria as an additional instrument for government health expenditures.

While the instruments listed above seem plausible to us (and at least some of them have precedence in the literature), how useful they are as instruments is largely an empirical issue. We rely on the Staiger and Stock (1997) weak-instruments test and the standard over identification tests to empirically justify their use. The tests and their results are discussed in the next section.

RESULTS

We estimated Equation (4) for U5M and MM under a set of alternative assumptions about the potential endogeneity of income and the government health expenditures variable. Specifically, that (a) there is no correlation between any of the right-hand-side variables in Equation (4) and the error term (i.e. no endogeneity), (b) government health expenditures variable and its interaction terms are correlated with the error term (i.e. $\ln \mathrm{Gh}$, $\ln \mathrm{Gh} \times \tilde{D}$ and $\ln \mathrm{Gh} \times R$ are endogenous) but income is not correlated with the error term (i.e. $\ln I$ is exogenous), and (c) $\ln \mathrm{Gh}$, $\ln \mathrm{Gh} \times \tilde{D}$, $\ln \mathrm{Gh} \times R$ and $\ln I$ are all correlated with the error term (i.e. all four are endogenous). Further, for each of the three assumptions above, we estimated the equations both with and without accounting for the presence of an unknown form of heteroscedasticity. Results are summarized in Table II.

Under the assumption of no endogeneity, assumption (a), columns (1) and (2) provide OLS estimates for U5M and MM, respectively. Graphical analysis of the residuals, as well as more formal White tests indicated that mild heteroscedasticity is present. Thus, even if assumption (a) is valid, then while the coefficients are consistent (and unbiased), the standard errors are incorrect, and hence significance of the coefficients is meaningless. To account for the presence of an unknown form of heteroscedasticity, we re-estimated the equations for U5M and MM (again under assumption (a) using Cragg's (1983)

[5] In fact, we expect own military budget to be a function of only a few countries, particularly traditional rivals, but use the military budget of the neighbors as an approximation.

[6] The four broad areas are: (i) Economic Management; (ii) Structural Policies; (iii) Policies for Social Inclusion and Equity, and (iv) Public Sector Management.

DOI: 10.1002/hec

Table II. OLS and GMM estimates of (log of) under-five mortality (U5M) and maternal mortality (MM)

Dependent variable:	OLS		GMM							
	Assumption A: Gh exogenous & I exogenous		Assumption A: Gh exogenous & I exogenous		Assumption B: Gh endogenous & I exogenous		Assumption C: Gh endogenous & I endogenous		Assumption C: Gh endogenous & I endogenous	
Log of	U5M(1)	MM(2)	U5M(3)	MM(4)	U5M(5)	MM(6)	U5M(7)	MM(8)	U5M(9)	MM(10)
Intercept	8.4449[a]	8.7468[a]	8.7001[a]	8.3853[a]	7.2594[a]	6.3833[a]	8.3714[a]	9.6993[a]	8.5706[a]	9.9924[a]
	(0.6717)	(1.1214)	(0.5933)	(1.0180)	(0.8320)	(1.2879)	(1.2091)	(1.7613)	(1.2148)	(1.7460)
$\ln I$	−0.5028[a]	−0.3611[b]	−0.5194[a]	−0.3653[b]	−0.2126	0.0553	−0.4040[b]	−0.4401[c]	−0.3814[c]	−0.4059
	(0.1046)	(0.1747)	(0.0882)	(0.1500)	(0.1460)	(0.2157)	(0.2101)	(0.2723)	(0.2138)	(0.2888)
ln Gh	−0.1246	−0.2341[c]	−0.1146[c]	−0.1704[c]	−0.3905[a]	−0.6066[a]	−0.3412[a]	−0.5187[a]	−0.3488[a]	−0.5389[a]
	(0.0760)	(0.1270)	(0.0674)	(0.1013)	(0.1230)	(0.1828)	(0.1269)	(0.1776)	(0.1299)	(0.1851)
ln Gh $\times \tilde{D}$	0.0054[b]	0.0023	0.0064[b]	0.0015	0.0045[c]	0.0023	0.0070[b]	0.0065	0.0062[c]	0.0055
	(0.0026)	(0.0044)	(0.0023)	(0.0034)	(0.0027)	(0.0041)	(0.0034)	(0.0045)	(0.0035)	(0.0051)
ln Gh $\times R$	−0.0001	0.0001	−0.0001	0.0001[c]	−0.0002[c]	−0.0001	−0.0002	0.0002	−0.0002	0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
$\ln D$	0.0130	0.0498[c]	0.0159	0.0678[b]	0.0070	0.0341	−0.0132	−0.0058	−0.0127	−0.0070
	(0.0164)	(0.0274)	(0.0194)	(0.0284)	(0.0215)	(0.0329)	(0.0258)	(0.0352)	(0.0257)	(0.0348)
$\ln E$	0.1321[a]	0.3435[a]	0.1418[a]	0.3928[a]	0.1000[a]	0.3263[a]	0.0814[b]	0.2351[a]	0.0870[b]	0.2395[a]
	(0.0316)	(0.0527)	(0.0306)	(0.0534)	(0.0350)	(0.0636)	(0.0381)	(0.0777)	(0.0382)	(0.0771)
$\ln R$	−0.0840[a]	−0.1226[a]	−0.0757[a]	−0.1445[a]	−0.0627[a]	−0.0967[a]	−0.0646[a]	−0.1112[a]	−0.0667[a]	−0.1115[a]
	(0.0207)	(0.0346)	(0.0203)	(0.0280)	(0.0232)	(0.0357)	(0.0230)	(0.0359)	(0.0227)	(0.0350)
$\ln S$	−0.0311	−0.0824	−0.081	−0.0706	−0.0158	0.0798	0.0376	0.1816	0.0280	0.1684
	(0.0914)	(0.1527)	(0.0760)	(0.1228)	(0.0872)	(0.1516)	(0.1006)	(0.1511)	(0.0995)	(0.1493)
Age structure	–	–	–	–	–	–	–	–	−0.0207	−0.0285
	–	–	–	–	–	–	–	–	(0.0232)	(0.0449)
R^2	0.8900	0.8456	0.8887	0.8431	0.8783	0.8321	0.8776	0.8190	0.8785	0.8196
$\bar{R}^2$	0.8825	0.8351	0.8812	0.8325	0.8700	0.8207	0.8693	0.8067	0.8692	0.8057

Hausman χ^2-statistics			
3 Efficient vs 5 Consistent	$\chi^2_{(3)} = 7.328$, p-val $= 0.0621$	4 Efficient vs 6 Consistent	$\chi^2_{(3)} = 8.589, p - \text{val} = 0.0353$
3 Efficient vs 7 Consistent	$\chi^2_{(4)} = 8.796$, p-val $= 0.0664$	4 Efficient vs 8 Consistent	$\chi^2_{(4)} = 14.670$, p-val $= 0.0054$
5 Efficient vs 7 Consistent	$\chi^2_{(1)} = 1.545$, p-val $= 0.2139$	6 Efficient vs 8 Consistent	$\chi^2_{(1)} = 6.628$, p-val $= 0.0100$

'*First-stage*' *stats*	Dependent variables for 3 & 4			Dependent variables for 5 & 6			
	ln Gh	ln Gh $\times \tilde{D}$	ln Gh $\times R$	ln Gh	ln Gh $\times \tilde{D}$	ln Gh $\times R$	$\ln I$
R^2	0.9366	0.9846	0.9953	0.8274	117.48	0.9952	0.7945
Overall F-statistic	192.55	159.08	1039.55	108.80	0.9796	1033.82	123.72
Weak Insts. F-test	11.86	162.08	1322.57	10.51	135.14	1407.62	31.60

Note: Parameter standard errors given in parenthesis, [a]p-value 0.01 or less, [b]p-value 0.05 or less, [c]p-value 0.1 or less.

heteroscedastic OLS estimator (H-OLS), which is essentially a GMM estimator.[7] Results from this estimation are summarized in columns (3) and (4). Next, under assumption (b), i.e. $\ln \mathrm{Gh}$, $\ln \mathrm{Gh} \times \tilde{D}$ and $\ln \mathrm{GH} \times R$ are endogenous, we re-estimated the equations using the heteroscedastic two-stage least squares (H-2SLS) estimator, which is also a GMM estimator.[8] Results from this estimation are given in columns (5) and (6). Finally, under assumption (c), i.e. $\ln \mathrm{Gh}$, $\ln \mathrm{Gh} \times \tilde{D}$, $\ln \mathrm{GH} \times R$ and $\ln I$ are all endogenous, the equations were re-estimated and results from H-2SLS are given in columns (7) and (8). Columns (9) and (10) repeat the last two estimations, except that an additional variable, age structure, is included in the model (and is discussed later).

Using a series of Hausman statistics, we tested for endogeneity of the variables in assumptions (b) and (c) above. Thus, for U5M and assuming heteroscedasticity, Hausman tests were conducted to test the null of no endogeneity between specifications in columns (3) and (5), (3) and (7) and, incrementally between specification in columns (5) and (7) where in the last set the null is that $\ln \mathrm{Gh}$ and its interaction $\tilde{D}$ and R are endogenous but $\ln I$ is exogenous. To be explicit, the χ^2 statistic was computed as $(\beta_c - \beta_e)^{\mathrm{T}}(V_c - V_e)^{-}(\beta_c - \beta_e)$ where in the test between (3) and (5), the null is that (3) is efficient and (5) is consistent; for the second test, the null is that (3) is efficient and (7) is consistent, and for the last case, (5) is relatively efficient and (7) is consistent. Similar tests were conducted for MM, i.e. between (4) and (6), (4) and (8), and incrementally between (6) and (8). The Hausman test statistics (under heteroscedasticity) and their p-values are summarized in the middle of Table II. For five out of the six tests, we reject the null of no endogeneity. The one case where we could not reject the null was for the case of U5M when by assumption, income per capita is exogenous and the potential endogenous variables are Gh and its interactions with $\tilde{D}$ and R, i.e. in (5) vs (7).[9]

The reliability of the instrumental variables estimates (2SLS and GMM-H2SLS) and the Hausman tests rely on the use of good instruments. The heuristic justification of the instruments used for the endogenous variables was given earlier. To establish empirical relevance of these instruments we performed the Staiger and Stock (1997) weak-instruments test. In all 'first-stage' regressions, the joint F-test statistics for the additional instruments alone was always above the rule-of-thumb recommended value of 10. Test statistics are given near the bottom of Table II. Additionally, the validity of the instruments (under heteroscedasticity) was tested via the usual over identification tests. Thus, for specifications (7) and (8) for U5M and MM, the maintained null that the instruments are valid could not be rejected at the usual levels (in the case of U5M, the Hansen's J-statistic was 2.633 with a p-value of 0.6209 and in the case of MM, the test statistic was 3.465 with a p-value of 0.4832).

Based on these tests, we conclude that Gh (and its interaction with $\tilde{D}$ and R) as well as I are endogenous. Consequently, we discuss the results from columns (7) and (8) below.

Sanitation, roads and education

We expected the sign on the sanitation variable to be negative and significant for both the indicators. However, the coefficient is not significant in any of the estimations. A similar result (of non-significance) was observed elsewhere as well (Wagstaff, 2002b; Filmer and Pritchett, 1999). By contrast, the coefficients on the education and roads variables have the correct sign and are statistically significant. A 10% reduction in illiteracy reduces U5M by 0.81% and MM by 2.4%. Similarly, a 10% increase in

[7] The H-OLS, is a two-step GMM estimator that uses the additional moment conditions when there are excluded exogenous instruments and it is asymptotically more efficient than the usual 'robust' OLS estimator under heteroscedasticity. We also estimated the model using the more usual 'robust' standard errors (results not shown) and obtained results similar to those in columns (1) and (2).

[8] The H-2SLS, due to Davidson and Mackinnon (1993, p. 365) is a GMM estimator and is more efficient than the robust 2SLS (R-2SLS) estimator when heteroscedasticity is present.

[9] All the pairwise Hausman statistics were also computed under the additional assumption of homoscedastic error terms by using estimates from OLS (efficient) and 2SLS (consistent) estimators. The conclusions from the Hausman statistics were identical to those under assumed heteroscedasticity.

DOI: 10.1002/hec

the network of paved roads per unit area of the country reduces U5M by about 0.65% and MM by about 1.1%. Note that the OLS coefficients (columns 1 and 2) biased these results away from zero, thus exaggerating their impact on these two MDG outcomes. Nonetheless, these are large effects. For instance, in our sample, the mean value of MM is about 345 deaths per 100 000 live births and of U5M is 73 deaths per 1000 live births while the mean value of illiteracy is about 21% among population aged 15 years or older. This implies that in a given country, reducing the illiteracy rate from 21 to 18.9% would reduce the maternal mortality by about 8.28 deaths per 100 000 live births, and under-five mortality by about 0.59 deaths per 1000 live births or about 59 deaths per 100 000 live births.

Income

Elasticity with respect to per capita income is -0.40 and -0.44 for U5M and MM, respectively, and both are statistically significant. In a model that treated neither Gh nor I as endogenous variables, Wagstaff (2002b) reported the income elasticity of U5M in the range of -0.2 to -0.3 (OLS estimates on 1990 and 2000 data separately and FGLS on pooled data for the two years) and for a fixed effects model (based on the two year unbalanced panel) to be about -0.59. It is likely that because of the ignored endogeneity, Wagstaff's OLS estimates are biased up towards zero, but that in the country specific fixed effects estimation, the bias is reduced. Similarly, Pritchett and Summers (1996) estimated the elasticity for infant mortality and under-five mortality with respect to GDP per capita using data on 58 countries for the years 1965–1985 at five year differences (184 observations). Their OLS estimates were -0.19 and -0.17, respectively, and the instrumental variables estimate (with investment ratio as the instrument) were equal to -0.35 and -0.76 for infant and under-five mortality, respectively. However, they did not use Gh as one of the explanatory variables in their estimation. By omitting the Gh variable from the model, the GDP per capita variable picks up the impact of Gh as well. Hence, the IV estimate of Pritchett and Summers (1996) is much larger than ours in magnitude. In fact, in our estimation if we omit $\ln D$, ln Gh and its interactions with $\tilde{D}$ and R, then the OLS estimate for U5M gives a coefficient of -0.66 as well. Note that in the Pritchett and Summers paper they fail to reject the null hypothesis of no endogeneity. Finally, Filmer and Pritchett (1999) also estimated a model similar to ours including government health expenditures as well as GDP per capita in the equation and treated government health expenditures as endogenous (with military budget of the neighbors as one of the instruments). In their OLS as well as their 2SLS estimate they report the income elasticity of U5M to be about -0.6 but when Gh is omitted from the OLS regression, they report the income elasticity of U5M to be -0.412. All in all, while our point estimates are somewhat different from the studies cited above, they are consistent with each other in terms of the order of magnitude, sign and significance, despite the differences in included variables in the equations as well as the endogeneity of some of these variables.

Government health expenditures and donor funding

The coefficient on Gh is negative and significant for both U5M and MM and increases in magnitude when we use the instrumental variable methods, as predicted by Wagstaff (2002b). Incidentally, Wagstaff's OLS estimate of elasticity of U5M with respect to Gh is -0.18 and when we dropped $\ln D$, $\ln \mathrm{GH} \times \tilde{D}$ and $\ln \mathrm{GH} \times R$ from the OLS estimation of U5M (results not shown) the coefficient we get is -0.16. This is remarkably close given that we used the 2000 data reported in WHR-2004 and Wagstaff used the data for 2000 reported in WHR-2002 and the two data sets are quite different. Our best point estimates of the coefficients on Gh for U5M and MM are -0.34 and -0.52, respectively. Due to the interaction with $\tilde{D}$ and R our elasticity estimates range from -0.25 to -0.42 with the mean value of -0.33. For maternal mortality the elasticity ranges from -0.42 to -0.52 with the mean value of -0.50 (see Table III for country specific elasticities).

Note that the elasticity of MM with respect to Gh is greater in magnitude than the elasticity of U5M for all countries. For a 10% increase in Gh the change in MM is typically 1.6–1.7% more than the

DOI: 10.1002/hec

Table III. Elasticity of U5M and MM with respect to government health expenditures

Country	U5M	*p*-value	Country	MM	*p*-value
Singapore	−0.4167	0.0121	Australia	−0.5187	0.0035
Netherlands	−0.3877	0.0090	Canada	−0.5187	0.0035
Japan	−0.3779	0.0083	Switzerland	−0.5183	0.0035
Austria	−0.3775	0.0083	Brazil	−0.5183	0.0035
Italy	−0.3657	0.0077	Algeria	−0.5181	0.0036
France	−0.3656	0.0077	Russian Federation	−0.5180	0.0036
United Kingdom	−0.3644	0.0076	Venezuela, RB	−0.5179	0.0036
Spain	−0.3610	0.0075	Mexico	−0.5173	0.0037
Lithuania	−0.3568	0.0075	Cameroon	−0.5172	0.0037
Trinidad Tobago	−0.3535	0.0073	Eritrea	−0.5170	0.0037
Hungary	−0.3532	0.0077	Kenya	−0.5167	0.0037
Mauritius	−0.3522	0.0081	Nigeria	−0.5164	0.0038
Germany	−0.3511	0.0072	Congo, Rep.	−0.5164	0.0038
Korea, Rep.	−0.3510	0.0072	Guatemala	−0.5163	0.0038
Portugal	−0.3509	0.0072	Tunisia	−0.5162	0.0038
St.VincentGrenadines	−0.3503	0.0082	South Africa	−0.5161	0.0038
Jamaica	−0.3497	0.0104	Morocco	−0.5160	0.0038
Lebanon	−0.3491	0.0075	Ethiopia	−0.5159	0.0038
India	−0.3483	0.0074	China	−0.5157	0.0039
Sri Lanka	−0.3478	0.0125	Congo, Dem. Rep.	−0.5157	0.0038
Romania	−0.3475	0.0072	Finland	−0.5154	0.0040
United States	−0.3473	0.0072	Sudan	−0.5154	0.0039
Sweden	−0.3473	0.0072	Mauritania	−0.5152	0.0039
Croatia	−0.3470	0.0073	St. Lucia	−0.5151	0.0040
Belarus	−0.3459	0.0072	Guyana	−0.5144	0.0040
Bulgaria	−0.3458	0.0072	New Zealand	−0.5143	0.0042
Ukraine	−0.3453	0.0072	Turkey	−0.5143	0.0041
New Zealand	−0.3444	0.0072	Philippines	−0.5135	0.0042
Comoros	−0.3441	0.0076	Bangladesh	−0.5134	0.0042
Estonia	−0.3437	0.0075	Lesotho	−0.5133	0.0042
Finland	−0.3437	0.0072	Madagascar	−0.5132	0.0042
China	−0.3429	0.0073	Ukraine	−0.5129	0.0044
Turkey	−0.3429	0.0074	Yemen, Rep.	−0.5128	0.0042
Moldova	−0.3428	0.0082	Estonia	−0.5127	0.0044
Georgia	−0.3428	0.0079	Malawi	−0.5125	0.0043
Dominica	−0.3418	0.0094	Turkmenistan	−0.5124	0.0043
Mexico	−0.3417	0.0073	Colombia	−0.5124	0.0043
Venezuela, RB	−0.3417	0.0072	Belarus	−0.5122	0.0045
Algeria	−0.3416	0.0072	Bulgaria	−0.5122	0.0045
Switzerland	−0.3414	0.0072	Indonesia	−0.5122	0.0044
Tunisia	−0.3413	0.0075	Chad	−0.5122	0.0043
Russian Federation	−0.3412	0.0073	Pakistan	−0.5120	0.0044
Australia	−0.3412	0.0072	Peru	−0.5114	0.0044
Canada	−0.3412	0.0072	Argentina	−0.5112	0.0044
Nigeria	−0.3412	0.0075	Comoros	−0.5111	0.0047
Brazil	−0.3411	0.0073	Georgia	−0.5109	0.0047
St. Lucia	−0.3411	0.0076	Tanzania	−0.5108	0.0045
Bangladesh	−0.3410	0.0079	Cote d'Ivoire	−0.5107	0.0045
Morocco	−0.3410	0.0075	United States	−0.5105	0.0048
Azerbaijan	−0.3410	0.0084	Sweden	−0.5105	0.0048
Philippines	−0.3408	0.0079	Uzbekistan	−0.5102	0.0047
Pakistan	−0.3407	0.0081	Romania	−0.5100	0.0049
South Africa	−0.3405	0.0076	Chile	−0.5100	0.0046
Guatemala	−0.3402	0.0077	Niger	−0.5100	0.0046
Cameroon	−0.3398	0.0076	El Salvador	−0.5099	0.0047
Eritrea	−0.3396	0.0077	Croatia	−0.5096	0.0050
Armenia	−0.3396	0.0103	Tajikistan	−0.5095	0.0047
Kenya	−0.3395	0.0077	Azerbaijan	−0.5094	0.0049
Congo, Rep.	−0.3388	0.0079	Ghana	−0.5094	0.0047
Uzbekistan	−0.3383	0.0088	Thailand	−0.5092	0.0048
Ethiopia	−0.3383	0.0080	Egypt, Arab Rep.	−0.5092	0.0048

DOI: 10.1002/hec

Table III. *Continued*

Country	U5M	*p*-value	Country	MM	*p*-value
Congo, Dem. Rep.	−0.3380	0.0081	Guinea-Bissau	−0.5091	0.0048
Sudan	−0.3377	0.0082	Ecuador	−0.5090	0.0048
Mauritania	−0.3374	0.0083	Moldova	−0.5088	0.0050
Indonesia	−0.3373	0.0087	Burkina Faso	−0.5085	0.0048
Lesotho	−0.3367	0.0087	Mali	−0.5082	0.0049
Guyana	−0.3366	0.0086	Panama	−0.5079	0.0050
Malawi	−0.3365	0.0088	India	−0.5078	0.0053
Turkmenistan	−0.3359	0.0090	Vietnam	−0.5073	0.0051
Madagascar	−0.3356	0.0089	Bolivia	−0.5066	0.0051
Thailand	−0.3355	0.0095	Sierra Leone	−0.5063	0.0052
Yemen, Rep.	−0.3353	0.0091	Guinea	−0.5061	0.0052
El Salvador	−0.3352	0.0095	Portugal	−0.5056	0.0058
Colombia	−0.3349	0.0092	Korea, Rep.	−0.5054	0.0058
Chad	−0.3341	0.0094	Lebanon	−0.5054	0.0058
St. Kitts and Nevis	−0.3341	0.0115	Germany	−0.5053	0.0059
Argentina	−0.3339	0.0096	Nepal	−0.5040	0.0056
Peru	−0.3336	0.0096	Mongolia	−0.5021	0.0059
Cote d'Ivoire	−0.3331	0.0098	Trinidad Tobago	−0.5018	0.0067
Ghana	−0.3330	0.0101	Dominica	−0.5014	0.0064
Tanzania	−0.3328	0.0099	Honduras	−0.5009	0.0061
Egypt, Arab Rep.	−0.3327	0.0101	Gabon	−0.4998	0.0063
Chile	−0.3326	0.0100	Hungary	−0.4995	0.0072
Niger	−0.3318	0.0102	St. Kitts and Nevis	−0.4992	0.0067
Ecuador	−0.3317	0.0104	St.VincentGrenadines	−0.4991	0.0072
Vietnam	−0.3315	0.0107	Togo	−0.4991	0.0065
Panama	−0.3314	0.0106	Gambia, The	−0.4990	0.0066
Guinea-Bissau	−0.3314	0.0105	Malaysia	−0.4988	0.0066
Tajikistan	−0.3313	0.0104	Armenia	−0.4987	0.0070
Burkina Faso	−0.3304	0.0108	Burundi	−0.4979	0.0067
Mali	−0.3299	0.0110	Uganda	−0.4978	0.0067
Guinea	−0.3283	0.0117	Costa Rica	−0.4976	0.0069
Bolivia	−0.3282	0.0116	Mauritius	−0.4975	0.0077
Sierra Leone	−0.3282	0.0117	Lithuania	−0.4969	0.0079
Nepal	−0.3263	0.0126	Kazakhstan	−0.4947	0.0074
Malaysia	−0.3253	0.0139	Cape Verde	−0.4930	0.0079
Costa Rica	−0.3241	0.0145	Spain	−0.4921	0.0094
Gambia, The	−0.3234	0.0144	Jordan	−0.4920	0.0081
Mongolia	−0.3232	0.0139	Rwanda	−0.4909	0.0083
Honduras	−0.3228	0.0142	Uruguay	−0.4894	0.0087
Togo	−0.3217	0.0149	Botswana	−0.4893	0.0087
Cape Verde	−0.3213	0.0164	United Kingdom	−0.4874	0.0110
Gabon	−0.3209	0.0151	France	−0.4858	0.0117
Burundi	−0.3202	0.0157	Italy	−0.4857	0.0117
Uganda	−0.3189	0.0161	Jamaica	−0.4853	0.0111
Kazakhstan	−0.3163	0.0178	Mozambique	−0.4845	0.0100
Jordan	−0.3154	0.0187	Benin	−0.4824	0.0106
Rwanda	−0.3126	0.0201	Zimbabwe	−0.4819	0.0108
Uruguay	−0.3112	0.0211	Albania	−0.4782	0.0122
Botswana	−0.3098	0.0217	Swaziland	−0.4777	0.0121
Albania	−0.3069	0.0264	Sri Lanka	−0.4763	0.0144
Mozambique	−0.3045	0.0256	Belize	−0.4729	0.0138
Benin	−0.3025	0.0273	Senegal	−0.4727	0.0139
Zimbabwe	−0.3022	0.0277	Cambodia	−0.4717	0.0143
Swaziland	−0.2970	0.0321	Austria	−0.4697	0.0192
Belize	−0.2925	0.0367	Japan	−0.4693	0.0195
Senegal	−0.2923	0.0369	Dominican Republic	−0.4633	0.0180
Cambodia	−0.2909	0.0383	Kyrgyz Republic	−0.4632	0.0180
Macedonia, FYR	−0.2869	0.0457	Haiti	−0.4631	0.0180
Dominican Republic	−0.2861	0.0454	Namibia	−0.4624	0.0183
Kyrgyz Republic	−0.2845	0.0468	Zambia	−0.4611	0.0190
Haiti	−0.2825	0.0485	Macedonia, FYR	−0.4610	0.0192
Zambia	−0.2810	0.0507	Netherlands	−0.4560	0.0283

DOI: 10.1002/hec

Table III. *Continued*

Country	U5M	*p*-value	Country	MM	*p*-value
Namibia	−0.2808	0.0503	Paraguay	−0.4542	0.0226
Paraguay	−0.2729	0.0618	Nicaragua	−0.4330	0.0373
Nicaragua	−0.2492	0.1045	Singapore	−0.4168	0.0700
Equatorial Guinea	−0.0356	0.8800	Equatorial Guinea	−0.2358	0.4494

change in U5M. Thus, for instance, for Bangladesh, a 10% increase in government health expenditures implies that they will increase from the current observed value of Int $26 per capita to Int $28.6 per capita. This in turn would give 3.41% reduction in U5M and 5.13% reduction MM, which in absolute terms takes U5M from 82 per 1000 (8200 per 100 000) to 79.2 per 1000 (7920 per 100 000) and MM from 380 per 100 000 to 360.5 per 100 000.

The coefficient on donor funding in the two equations has the correct sign, but is not statistically significant. For U5M, the estimated coefficient is -0.0132 while in the MM-equation the coefficient is -0.0058. One possible reason for this lack of significance is that donor funding just does not have any impact on these two health outcomes. However, the fact they these two coefficients are different by an order of magnitude across the two equations, suggests that perhaps donor funding does impact U5M but not MM and the lack of statistical significance in the U5M equation arises from attenuation bias. Recall that our measure of donor funding is not perfect, since, as explained before, bilateral donations are pledged in one year and dispersed in a different year (and could still vary from the pledged amount). This measurement error would cause an attenuation bias. However, for maternal mortality, it is likely that donor funding does not matter. The donor funds pledged by DAC for health are typically available for basic and primary care services, such as immunization, prevention and control of malaria, basic nutrition programs for children, etc. and to some extent for antenatal care but not for secondary care provided in hospitals. While good antenatal care is important, mothers also die of complications during delivery and since these donor funds are not used for investments in hospitals or referral systems, they do not effect maternal mortality.

Finally, the coefficient on the interaction term $\ln \mathrm{Gh} \times \tilde{D}$ is positive and statistically significant for U5M (but not statistically significant for MM). Since off-budget donor funding is typically available for primary care services and not so much for secondary care, we conjecture that governments tend to allocate funds for primary care based on the expected level of donor funding for the primary care sector. When the actual level of donor funding deviates from the expected level, then due to mis-allocation of internal funds, it reduces the impact of government health expenditures on health outcomes, specifically in the primary care sector more than in the secondary care sector.

Robustness to alternative specifications

We estimated numerous alternative specifications to check the robustness of our main results. These included, among others, (1) adding a dummy variable for donor countries (or restricting the sample to countries receiving donor funding), (2) alternative lagged values for the donor funding variable D, (3) alternative measures of $\tilde{D}$ variable, such as standard deviation, log of standard deviation, and coefficient of variation of country specific donor funding over the years 1992–1997 and, (4) including other right-hand-side variables such as age structure in the country.[10] None of these alternative specifications changed our main results in any significant way. Results from one such alternative

[10] Alternative lagged values of the donor funding variable were tried because, as mentioned earlier, donor funds are pledged in a given year and the actual amount dispersed, which can vary from the amount pledged, follows with a lag of a few years. The actual amount dispersed is not known nor does it necessarily come in exactly two years.

DOI: 10.1002/hec

specification are shown in the last two columns, (9) and (10), of Table II. Specifically, we included an age structure variable (measured as log of population age fourteen or less) and the results remain essentially the same.[11] The main impact of adding an age structure variable is that for some measures of this variable, the coefficient on income is statistically insignificant, especially in the maternal mortality equation. However, the coefficient on Gh typically stays the same. Further, since the coefficient on age structure itself is not significant (and the fact that adjusted R^2 is actually smaller in (9) and (10) compared to the values in (7) and (8)) this may be the case of adding an irrelevant variable to the model, which may be responsible for larger standard errors, and hence loss of significance for the coefficient on income variable.

DISCUSSION AND POLICY IMPLICATIONS

Progress since 1990 in achieving the MDGs has been uneven across countries and regions, and uneven among the goals themselves. For example, for U5M the developing world managed only a 2.5% average annual reduction in the 1990s, well short of the target of 4.2% required to reduce the indicator by two-thirds between 1990 and 2015. For MM the average-population weighted decline was 3.2%, far from the 5.4% annual reduction required to reach the three-quarters target (Wagstaff, 2004). The international community has called for actions across different sectors to see how progress towards the MDGs can be accelerated. In particular, there has been a request for increased donor assistance to increase health expenditures in Low-Income Countries. Given these developments it is relevant to question the impact of government expenditures and donor funding on improved health outcomes.

Earlier research often found no evidence linking government health expenditures to under-five mortality rates. Further, such findings have influenced policy makers to various degrees. For example, per the World Development Report (World Bank, 2004, pp. 11) ‘controlling for the effect on per capita income, the relationship between public expenditure on health and under-five mortality is not statistically significant’. The same report also states that some aid donors take the view that if government services are performing so poorly then why give more aid to those governments? We use new and possibly better data than those used by earlier studies and find that government health expenditures do improve health outcomes with substantial variation across countries.

These results must be interpreted with care. Generalizing results from this study, or from Filmer and Pritchett (1999) for that matter, without the appropriate caveats may lead to inappropriate policy implications or actions.

First, point estimates reported here should not be used in any projection models for policy purposes. Estimates from small samples often exhibit sensitivity to small changes in the data set and the estimates reported here are no exception. For instance, alternative measures of some of the variables, particularly, those on donor funding do lead to different point estimates (see discussion in the robustness section above). Further, some observations are extremely influential. A case in point is that of Equatorial Guinea, a country that is an outlier in terms of the amount of donor funding per capita that it receives (much higher compared to other countries). Deleting this one observation changes the mean elasticity of U5M with respect to Gh from -0.33 to -0.38. Yet this data point is valid and cannot be deleted arbitrarily. The main message to be taken from these estimates is that, contrary to findings reported in earlier research, government health expenditures do have an impact on health outcomes.

Second, while our coefficient on donor funding is not statistically significant, it must be borne in mind that this variable is for bilateral donor funds from DAC countries and is largely off-budget. However, on-budget donor funds (which are multilateral and administered by World Bank and other agencies) are

[11] We tried other measures for this variable as well, such as ratio of percent of population age fourteen or less, percent of population age 15–64 as well as log of these variables.

DOI: 10.1002/hec

already part of the government health expenditures variable, Gh, and elasticity with respect to Gh is large and statistically significant. Further, the coefficient on $\ln \mathrm{Gh} \times \tilde{D}$ is positive and significant (at least for U5M). This may be due to mis-allocation of internal funds in the presence of uncertainty about the level of off-budget donor funding. If so, then donors must give serious consideration to supporting governments' budgets directly in what is known by the donor community as budget support for an agreed program rather than directly financing projects, which may be crowding out the government's own resources under an environment of fungibility of resources. The budget support of existing government programs must be done with predictable financing committed over longer maturities. This is especially important given the recurrent nature of many of the health expenditures which are unfit to be financed with short-term grant financing.

Third, while the magnitude of elasticities is modest (0.33 and 0.50 on average) relying too heavily or primarily on increasing government health expenditures is also not a viable strategy. Aid donors should be especially cognizant of the limitations of the impact of government health expenditures lest the conditions of donations become unrealistic, restrictive and burdensome on local governments. For instance, reaching the millennium goal of reducing U5M and MM by 75 and 65%, respectively, via government expenditures alone implies an exorbitant orders of magnitude increase in government health expenditures regardless of how these government expenditures are ultimately financed. Further, health outcomes are also determined by factors other than just government health expenditures. Given governments' hard budget constraints, and the need to invest in these other determinants as well, governments ought to make serious analysis of the efficiency of their current expenditure patterns before increasing expenditures in health or other sectors. Recognition of the synergetic affects of spending in health and other sectors (water works, utilities, network of roads, education, etc.) is important, and thus increases in government health expenditures need to be complementary to, rather than a substitute for, spending in other sectors.

Finally, allocating larger funds for health spending may not be effective if the level of corruption in government leads to very small amounts trickling down for actual spending on health care needs. Similarly, spending more to increase hospital staff may not reduce under-five or maternal mortality if the quality and quantity of the network of roads prevents the population from easily accessing hospitals (Wagstaff, 2002a, 2004). Further, while the road network and level of corruption may influence whether health spending improves health outcomes, so do decisions about what and where to make services available. Many hospital services at the intensive margin are irrelevant to improving the health outcomes of the majority of the population at risk in the poorest countries because they are too costly to be provided to any but a small minority of the population. If funds are available for new hospital construction, then given the location of existing hospitals, network of roads and transportation costs, special consideration should be given to using the same funds to open multi-location, small, outpatient clinics. If a large share of government health expenditures is spent on covering sunk costs to adopt latest or duplicative technology in urban area hospitals (such as building additional level 3 neonatal intensive care units) then this would not necessarily improve the health outcomes for the majority. Providing good antenatal care in the community (and especially in rural areas) may be more effective in reducing both U5M and MM than many of the other high-end inpatient services. Thus, increasing government expenditures on health is not necessarily going to improve health outcomes unless the increases are accompanied by policies, institutions and instruments (such as the Public Expenditure Review and Management) that correctly identify inter, and intra-sectoral needs and allocate funds appropriately.

ACKNOWLEDGEMENTS

The findings, interpretations and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the Board of Executive Directors of the World Bank or the government(s) they represent. The funding for this project came from the World Bank and from a BNPP Trust Fund managed by the World Bank. We greatly appreciate the comments and feedback provided by Eduard Bos, Gary Fournier, George Schieber, Qiu Fang, Rick Smith and two anonymous referees. All remaining errors are our own.

REFERENCES

Anand S, Ravallion M. 1993. Human development in poor countries: on the role of private incomes and public services. *Journal of Economic Perspectives* **7**(1): 133–150.

Bidani B, Ravallion M. 1997. Decomposing social indicators using distributional data. *Journal of Econometrics* **77**: 125–139.

Cragg J. 1983. More efficient estimation in the presence of heteroskedasticity of unknown form. *Econometrica* **51**(3): 751–764.

Davidson R, Mackinnon JG. 1993. *Estimation and Inference in Econometrics*. Oxford University Press: New York.

Driscoll R, Evans AM. 2005. Second-generation poverty reduction strategies: new opportunities and emerging issues. *Development Policy Review* **23**(1): 5–25.

Filmer D, Pritchett L. 1999. The impact of public spending on health: does money matter? *Social Science and Medicine* **49**: 1309–1323.

Gangadharan L, Valenzuela MR. 2001. Interrelationships between income, health and the environment: extending the Environmental Kuznets Curve hypothesis. *Ecological Economics* **36**(3): 365–547.

Gottret P, Schieber G. 2006. External assistance for health. *Health Financing Revisited*: *A Practioner's Guide*. World Bank: Washington, DC, 123–160.

Hausman JA. 1978. Specification tests in econometrics. *Econometrica* **46**(6): 1251–1271.

Jalan J, Ravallion M. 2003. Does piped water reduce diarrhea for children in rural India? *Journal of Econometrics* **112**(1): 153–173.

Musgrove P. 1996. Public and private roles in health. Theory and finance patterns. *Discussion Paper No. 339*. World Bank, Washington, DC.

Pritchett L, Summers LH. 1996. Wealthier is healthier. *Journal of Human Resources* **XXXI**(4): 841–868.

Staiger D, Stock JH. 1997. Instrumental variables regression with weak instruments. *Econometrica* **65**(3): 557–586.

UN. 2002. United Nations Millennium Development Goals Data and trends, 2002: report of the Inter-agency Expert Group on MDG Indicators. *Discussion Paper*. Statistics Division, Department of Economic and Social Affairs of the United Nations Secretariat, available from http://millenniumindicators.un.org/unsd/mi/mdg_report.pdf

UN. 2004. Progress towards the Millennium Development Goals, 1990–2004. *Discussion Paper*. Statistics Division, Department of Economic and Social Affairs of the United Nations Secretariat, available from http://unstats.un.org/unsd/mi/mi_coverfinal.htm

Wagstaff A. 2002a. Heath spending and aid as escape routes from the vicious circle of poverty and health. Prepared for Bristish Association for the Advancement of Science meeting 2002.

Wagstaff A. 2002b. Intersectoral synergies and the health MDGs: preliminary cross-country findings, corroboration and policy simulations. Prepared for Development Committee on Accelerating Progress Towards the HNP MDGs.

Wagstaff A. 2004. Appendix. *The Millennium Development Goals for Health*: *Rising to the Challenges*. World Bank: Washington, DC.

World Bank. 2004. World development report 2004: making services work for poor people. *Discussion Paper*. World Bank, http://econ.worldbank.org/wdr/wdr2004/

DOI: 10.1002/hec