INFANT AND CHILD MORTALITY IN DEVELOPING COUNTRIES: ANALYSING THE DATA FOR ROBUST DETERMINANTS

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Abstract

Is development best achieved by going for growth, or does specific attention need to be paid to directly improving human welfare? In contrast to the *Human Development Reports* of the UNDP, the World Bank has stressed the growth approach. Recent work has reinforced this position by arguing that health spending is extremely ineffective in reducing infant or child mortality, which is mainly explained by a country's income per capita. This paper contests this position through testing the robustness of determinants of infant and child mortality. We have estimated over 420,000 equations which show that, whilst income per capita is a robust determinant of infant and child mortality, so are indicators of health, education and gender inequality. Some health spending, such as immunisation, is thus shown to be a cost effective way of saving lives. Our results are consistent with the view that much health spending in developing countries may be poorly targeted or otherwise ineffective, but do not support the position that public health strategies should not be given too great a role in pursuing improvements in human welfare.

1. INTRODUCTION

There is widespread agreement that development should be measured by variables other than GNP per capita. Health variables, such as infant or maternal mortality, and education indicators, such as literacy, should be used to indicate a country's developmental status. The focus on non-income dimension of development was promoted through the Basic Needs agenda in the 1970s, and the composite Physical Quality of Life Index. Since 1990, UNDP has strongly advocated a similar position in its *Human Development Reports* (*HDRs*),

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embodying the multi-dimensional view of development in the Human Development Index (HDI). The International Development Targets, and the successor Millennium Development Goals (MDGs), explicitly adopt a range of social goals, including reductions of two-thirds in infant and under five mortality by 2015, as poverty reduction targets.[1] But to agree that measures of development should incorporate non-economic variables is not the same as agreeing that achieving development requires looking beyond a growth-oriented development strategy. Even if the objective is to maximise welfare as measured by social indicators, this objective may arguably best be obtained by focussing on growth.

Two broad positions may be identified in this debate. In addition to directing attention to non-economic welfare measures, the *HDRs* have typically pointed out that countries at comparable levels of income per capita can have considerable variation in their HDIs, suggesting that poor performers can raise welfare (i.e. improve social indicators) without waiting for growth to do so. The 1996 HDR (and subsequent work in that vein by Ramirez *et al.*, 2000) went further to argue that, whilst investing in human capital can lay the basis for subsequent growth, countries which have focused exclusively on economic growth have, in the end, achieved neither sustained growth nor human development.

These views have been countered by Ravallion (1997) from the World Bank's research department. Ravallion admits that the relationship between social indicators and income per capita is imperfect, but there is a relationship. Hence sustained improvements in welfare are best brought about by increasing income - the main issue is, he suggests, not whether growth is good or bad growth, but to get enough growth of any sort.[2] A number of

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[1] Infant mortality is the probability of death in the first 12 months of life, and child mortality the probability between first and five birthdays. Under five mortality is the probability of death between birth and fifth birthday. Under five mortality thus conflates infant and child mortality. Since the determinants of these two are seen to be rather different demographers are not keen on under five mortality as a measure.

[2] For a longer discussion of these contrasting positions see White (1999).

other pieces of work emanating from the World Bank also emphasise a growth-led development strategy. For example, Dollar and Kraay's (2000) analysis of pro-poor argues that spending on basic services is not pro-poor.[3] Of direct relevance to our paper is analysis by the World Bank's research department (Filmer and Pritchett, 1997) on the determinants of infant and child mortality. Specifically they argue that virtually all inter-country variation in child mortality is explained by a set of development indicators including GNP per capita. They seek to show that adding health expenditure to the model adds little explanatory power. They therefore warn against supporting expanding public health services as a means to improving welfare, thus implicitly supporting the view that growth is the answer. This paper challenges these results.

We are well aware that this debate is not a new one. McKeown (1976) sought to argue that medical advances had played little role in mortality reductions in England since the eighteenth century. Whilst there is agreement that "specific therapeutic medical treatments have played a minor role in mortality reductions in Western countries.. relatively little else of the McKoewn thesis has survived" (Preston, 1996: 532). The weight of the evidence suggests that public health measures, such as smallpox vaccination and the purification of milk, played an important role (see Preston, 1996 for a review of the debate). Analysis of various developing countries also showed "the pivotal role played by government programmes in speeding mortality improvements" (Preston, 1996: 533). The only real debate concerned the sources of low and declining mortality in Sri Lanka, with the "best estimate" suggesting that close to half the reduction from 1930 to 1960 can be attributed to the anti-malaria programme (Preston, 1996: 533). Our purpose here is to restate and strengthen the case for active social policy by presentation of robust regression analysis applied to cross-country regressions in Part 4.

[3] This result is hardly surprising since they are seeking to explain income growth of the poor, which is unlikely to be affected by current government social spending.

We begin in Part 2 with some preliminary data analysis. This analysis confirms that the link between income and infant mortality is an imperfect one – thus raising the question of what may be done to strengthen it. It also shows that there has been a historical decline in infant mortality over and above that which can be explained by income growth. To identify other factors, in Part 3 we present a brief review of the literature on the determinants of infant and child mortality. This review shows that these variables have been regressed on a wide range of independent variables with differing results. Following the approach that has been adopted in the growth literature (Sala-i-Martin, 1997) the appropriate response to such a situation is to test the robustness of the coefficients of the variables of interest by estimating all possible regression equations. This analysis, presented in Part 4, finds a robustly significant impact on both infant and child mortality from some of the health variables in our data set. Part 5 concludes.

2. SOME PRELIMINARY DATA ANALYSIS

Table 1 shows infant and child mortality for developing countries classified by region. All regions have recorded declines in both indicators. With respect to infant mortality, three regions – the Middle East and North Africa, South Asia and sub-Saharan Africa – had similar levels in the 1960s. But by the 1990s the rate for Africa was nearly double that in the Middle East. These discrepancies in performance, also evident in the child mortality data, have several explanations. Of course the Middle East benefited from oil wealth which, with some lag (about which we will say more in a moment), has been transformed into improved social indicators. But Africa has suffered serious economic decline, with falling income per capita for the region as whole since the 1980s.

Table 1 Infant and child mortality by region (period averages)

	1960s	1970s	1980s	1990s	Change	
					Absolute	Per cent
Infant mortality rate						
East Asia & Pacific	94	65	48	39	-55	-58.6
Europe & Central Asia	n.a.	n.a.	35	26	n.a.	n.a.
Latin America & Caribbean	95	73	52	35	-60	-62.9
Middle East & North Africa	153	117	76	54	-100	-64.9
South Asia	151	132	106	81	-70	-46.2
Sub-Saharan Africa	151	126	107	96	-55	-36.3
High income	26	16	10	7	-19	-73.7
Child mortality rate						
East Asia & Pacific	79	44	23	13	-67	-84.1
Europe & Central Asia	n.a.	n.a.	n.a.	2	n.a.	n.a.
Latin America & Caribbean	50	32	15	11	-39	-78.0
Middle East & North Africa	86	62	34	13	-74	-85.4
South Asia	87	74	53	34	-54	-61.5
Sub-Saharan Africa	104	92	74	64	-40	-38.2
High income	7	5	2	1	-5	-82.6

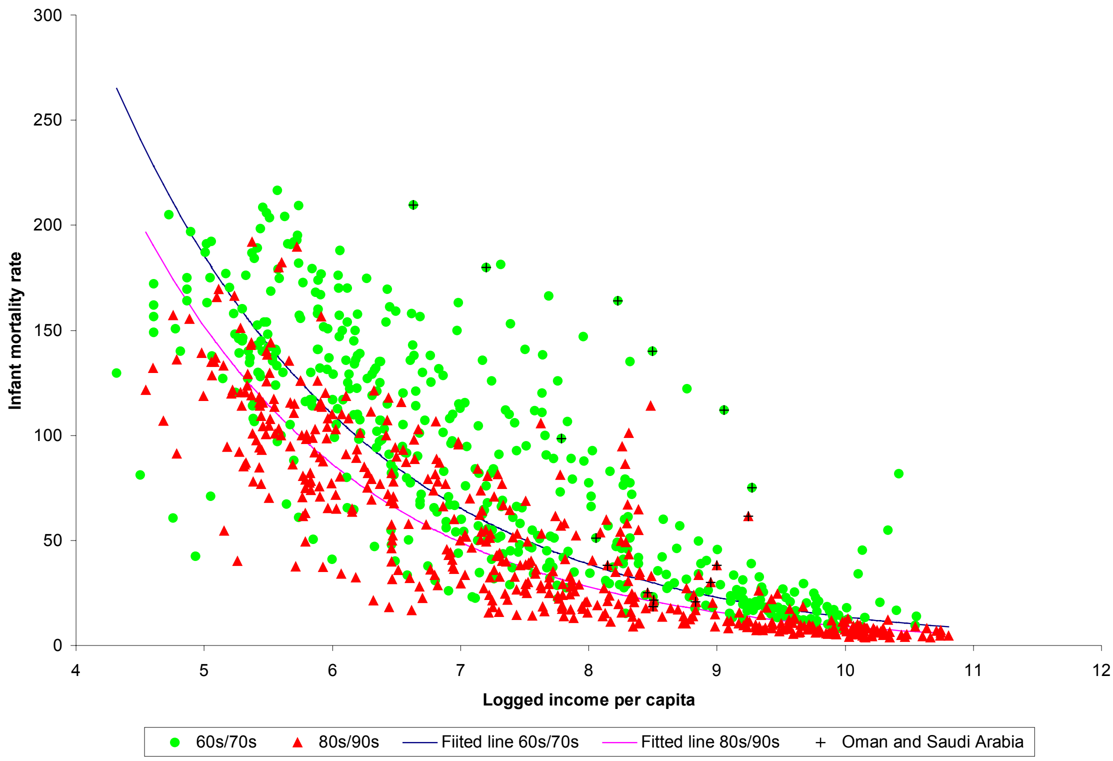
Source: World Bank, *World Development Indicators CD-Rom, 2001*

The comparison of Middle Eastern and African countries sheds some initial light on the link between economic growth and infant mortality. First, mortality rates have continued to come down in Africa despite falling income,[4] indicating that mortality decline can take place independent of income growth. Second, large reductions in mortality continued to be achieved in Middle Eastern countries after the substantial increase in income from oil in the 1970s. These continued reductions are evidence of both an “exogenous component” of mortality decline which operates independent of income growth, and of the lag in the link between income and mortality. In the 1970s and eighties oil producers were identified as “outliers” which had bad social indicators for their level of income, this fact sometime being attributed to poor income distribution in those countries. In fact, Arab countries have in general used their oil wealth to finance social provision for their citizens, and this fact also lies behind falling mortality. But it took time for these social investments and their benefits to be realised. Hence countries such as Oman and Saudi Arabia were outliers in the IMR-income

[4] Indeed, in spite of the spread of HIV/AIDS, which has contributed to the reversal in a history of

relationship, but are no longer so. For example, in the early 1960 Oman had an IMR of 210, compared to around 140 for the two countries with the nearest income per capita (Côte d'Ivoire and Morocco), but by the second part of the 1990s the infant mortality rate was 22 compared to 20 in the two nearest countries in income terms (Uruguay and Cyprus). More formally, the observations for Oman and Saudi Arabia are marked with a + in Figure 1 (discussed below), which shows that they have moved toward the regression line over time.

Figure 1 Shifting relationship between infant mortality and income per capita



Further evidence comes from analysis of data of infant and child mortality and income across countries, which shows four things. First, there is a strong correlation between these two variables. Second, the link has not weakened over time. But there are two "buts". The first is that there is considerable variation around the line. Countries with comparable levels of income per capita can have markedly different mortality rates. UNDP's line has been to promote policies which would turn poor performers in this regard into good ones. Finally,

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falling mortality in the worst affected countries.

the regression relationship has shifted over time, giving exogenous changes in mortality not explained by income growth. These points can be seen from Figure 1, which is based on data for 115 countries each with eight observations, using seven five year periods from 1960-64 to 1990-94 and the last being 1995-97. Only countries with data on infant mortality and income for all periods are included, so that shifts in the regression relationship cannot be accounted for by countries being added to, or dropped from, the sample.[5]

The estimated coefficient from the simple double-log regression of IMR on income per capita is –0.52.[6] The data clearly show that there has been a "downward drift" in the observations over time, which applied to all income groups. That is, for an given income per capita, a country will have a lower infant mortality rate at that income than it would have twenty years ago. This fact is captured by estimating separate regression lines for the two periods, the first sub-sample comprising the observations from the sixties and seventies and the second sub-sample those from the eighties and nineties.[7]

Table 2 shows the expected value of infant mortality corresponding to different levels of income per capita as given by the two curves.[8] Within two decades countries could have expected "exogenous decreases" in infant mortality of around 20 per cent. That is, a decrease that did not come from income growth, or from factors associated with income growth, since these would have been picked up by income in the simple regression.

Table 2 Infant mortality for a given income per capita in different periods

Income per capita (US$)	Expected value of infant mortality from	Difference in estimates

[5] Countries of the former Soviet Union are thus excluded.
[6] Allowing for the panel nature of the data by estimating a random effects model yields a higher elasticity of –0.67.
[7] In fact a single double-logged equation was estimated using both a slope and intercept dummy. The former was insignificant (though is highly significant if the slope dummy is omitted), but the latter significant with a t-statistic of 2.00. Though significant the value of the slope dummy is small, being a shift of -0.042 on a coefficient of –0.523.
[8] This technique is somewhat similar to that used by Preston (1975) in his analysis of life expectancy.

	fitted line for sixties and seventies	fitted line for eighties and nineties	Absolute	Percentage
150	185	151	-34	-18.2
500	98	76	-22	-22.3
1,000	68	52	-17	-24.5
2,000	48	35	-13	-26.7
5,000	30	21	-9	-29.4

Our preliminary data analysis thus suggests two things. First, that at least some reduction in infant mortality comes from factors other than income growth. Second, that the strength and timing of the link between income and reduced mortality varies across time and space. We turn now to analyse these points in more detail.

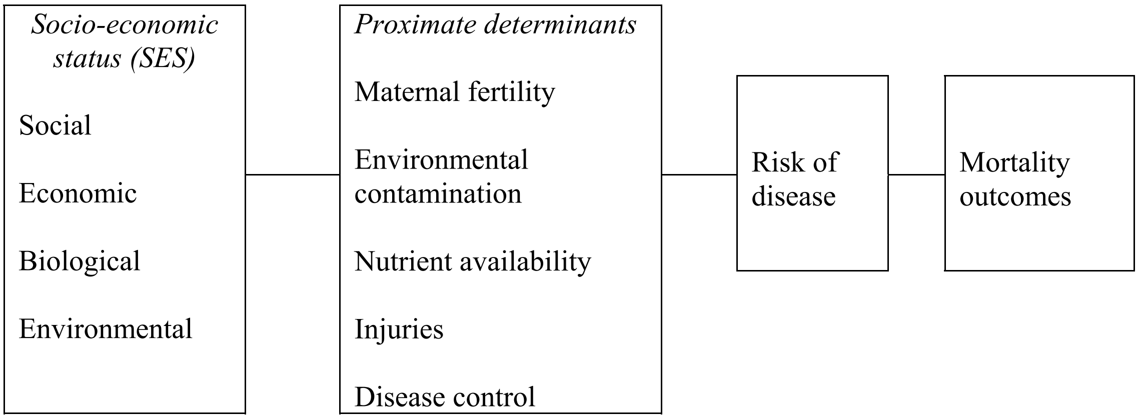
3. EXISTING LITERATURE AND THEORETICAL FRAMEWORK

Theoretical framework

There is a substantial literature in child health outcomes, as measured by both mortality and morbidity, which mostly adopts something like the Mosley-Chen (1984) framework, depicted in Figure 2. Myers (1994) comments that this framework "combines social science and medical perspectives in a parsimonious way" (1994: 52-53). The insight of this approach is that underlying socio-economic status (SES) manifests itself in (measurable) proximate determinants. The values of these variables influence the risk of disease, which link to the probability of death.

The Mosley-Chen model motivates the idea that countries with the same income per capita will have differing mortality rates since the relationship is mediated in several ways. For example, analysis of household data show a very strong relationship between mortality and both preceding and succeeding birth interval. Hence higher fertility, which implies a shorter birth interval, is associated with higher mortality. Fertility, in turn, is associated with income, but imperfectly so as both cultural factors and livelihood strategies (crucially the availability of alternative safety nets) play a role. So public policy to reduce fertility, either through promotion of reproductive health or through the provision of reliable safety nets, will bring down mortality.

Figure 2 The Mosley-Chen framework for analysing mortality



In practice, some aspects of socio-economic status variables may be used in empirical estimation, either because they are seen to have direct impacts, or because data on these are more readily available than the corresponding proximate variables. We identify the actual variables to be used with reference to existing empirical work.

Empirical findings

The literature on infant and child mortality spans medical studies of different interventions, anthropological studies of child rearing practices and regression analysis.[9] Our attention here is restricted to the latter (see Hanmer and White, 1998 for discussion of the other areas). Regression analysis of the determinants of under five mortality may take one of four approaches: (1) cross-country regressions, in which mortality is defined at the level of the country as a whole; (2) cross country regressions for a single country with data for different administrative units (e.g. districts); (3) analysis of survey data, mortality being defined with reference to either a mother or individual child; and (4) time-series analysis for a single country, using the national mortality rate as the dependent variable. The second area of

[9] Infant mortality is the probability of death in the first 12 months, child mortality that between the first and fifth birthdays, and that before the fifth birthday is under five mortality. These probabilities are

analysis became dominant with the availability of data first from the World Fertility Survey (WFS) and later the demographic health survey (DHS), both of which have taken place in many countries. These studies show fairly consistent patterns between demographic determinants and mortality (e.g. a child's sex and birth spacing) and rather less consistency in socio-economic determinants. Early papers illustrating both these points using WFS data are by Hobcraft *et al.* (1984 and 1985 respectively); see also , for example, Desai and Alva (1998) for a recent analysis arguing that mother's education is a significant determinant of mortality only in some countries. However, our concern here is with cross-country regressions, with the results of a selection of studies being summarised in Table 3.

Cross-country regressions typically combine income per capita with a range of other variables for both SES and proximate determinants. One of the earliest and most common of additional variables has been a measure of female education, typically female literacy, which is often found to have a significant negative effect. This is consistent with the view strongly advanced by Caldwell (e.g. 1986) that female education is an important mediating variable. Since there is a high correlation between the female literacy and total literacy then total literacy may work just as well. Many studies distinguish both male and female education, sometimes finding both to be significant. Alternatively other measures of women's status may be used, which may indicate how much say mothers have over the allocation of resources. Boehmer and Williamson (1996) find that several measures of women's status to have a significant impact.

The distribution of income, as well as its level, may be expected to matter. Accordingly, several studies have found a significant impact from inequality. Interestingly Waldmann (1992), finds that inequality still exerts an adverse impact on mortality even once the real income of the poor is also included in the regression - though none of the hypothesis as to why this may be so are supported by the data.

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usually expressed per thousand live births.

An important channel through which improving socio-economic status can operate on reducing mortality is through health and education. We have already mentioned that both female and male education are often included. In addition a variety of health indicators have been used, such as contraceptive prevalence and the number of persons per physician, finding a significant impact from health provision on under five mortality. The exception is the study by Filmer and Pritchett (1997), in which health expenditure is significant only at the 10 per cent level. As mentioned in the introduction, strong policy conclusions are drawn by Filmer and Pritchett from their analysis. Given these contrasting results, what conclusions should in fact be drawn?

Table 3 reports more than twenty variables which have been used as determinants of infant and child mortality. Other studies not shown here have used yet more variables. The significance of most of these variables, including income per capita, varies between studies. That is, the results are not robust. Findings vary according to both model specification and the sample used. Lack of robustness with respect to model specification means that a variable appears to be significant when included with some sets of regressors, but not with others. This problem has been apparent in regression analysis of the determinants of growth for some time, and the technique used has been to examine robustness by examining all possible sets of regressors (also called fragility analysis). This brief review suggests that the literature on the determinants of infant and child mortality would benefit from such an approach, and it is to this we now turn.

4. SOME REGRESSION RESULTS

Methodology

In this section we test which variables have a robust effect on child and infant mortality using the method introduced by Sala-i-Martin (1997).[10] He specifies a regression equation of the following form:

$$Y \quad = \quad \alpha \quad + \beta_{I,j}\, I + \beta_{M,j}\, M \quad + \quad \beta_{Z,j}\, Z \quad + \quad \varepsilon \qquad (1)$$

where Y is a vector of dependent variables (in our case child and infant mortality, CMR and IMR respectively, both of which are for 1995); I is a set of variables always included in the regressions, M are other variables of interest and Z a vector of additional variables which may potentially be important explanatory variables of infant or child mortality. Defining I variables reduces the number of regressions which have to be performed, which is equal to

$$Number\ of\ equations = \frac{(M+Z)!}{(M+Z-k)!\,k!}\ M \qquad (2)$$

where k is the number of regressors included in each equation.[11]

We estimated equation (1) using three data sets. A number of variables are excluded from the first data set on account of missing observations, thus allowing a larger sample size. For reasons of comparability across estimated equations, we only include observations for which all variables in that data set are available. In this data set the intercept and the log of GNP per capita were taken as I variables (i.e. included in all regressions). The M variables (those we are particularly interested in, which in our case are all indicators of social policy) in the three data sets are[12]:

[10] There are a number of tests for robustness which may be used. The first, as used by Levine, is to say a variable is fragile if it is insignificant in just one of the estimated regressions. This test is clearly a very tough one (which would be passed by none of the variables in our analysis). A second alternative, also used by Sala-i-Matin is to examine what proportion of times a variable is significant, taking it to be robust if it is so in 90 or 95 per cent of cases.

[11] In order to have a manageable number of regressions we have restricted each equation to four regressors (plus the I variables), which accounts for the formula given here.

[12] We would like to have also included a measure of income inequality. Although such data are available for an increasing number of countries these turn out not to be the same countries for which our other data were available, so the income inequality measure was excluded.

- education variables: literacy in 1995 (LIT95), female literacy in 1995 (FLIT95), male primary school enrolment in 1960 (PSERM60), female primary school enrolment in 1960 (PSERF60), male primary school enrolment in 1990 (PSERM90), female primary school enrolment in 1990 (PSERF90), male and female secondary school enrolments in 1960 (SSERM60 and SSERF60), and male and female secondary school enrolments in 1990 (SSERM90 and SSERF90)

- health variables: DPT immunisation rate in 1995 (DPT95), polio immunisation in 1995 (P95), measles immunisation (M95), TB immunisation in 1995 (TB95), percentage of births attended by trained health staff (BIRTHADD), proportion low birth weight children (LBW, 2nd data set only), HIV/AIDS prevalence rates (AIDS, 2nd data set only), access to safe water (WACC, 2nd data set only), access to sanitation (SACC, 2nd data set only), population per physician (3rd data set only), population per nurse (3rd data set only) and the ratio of physicians to nurses (DNRATIO, 3rd data set only).

- gender equality variables:[13] the ratio of female to male primary school enrolment in 1990 (PSERFM), the ratio of female to male secondary school enrolment in 1990 (SSERFM), the ratio of female to male life expectancy (LEFM) and the same ratio for literacy (LITFM).

The other variables included in the data set (the Z variables) are population, an African dummy, contraceptive prevalence, the crude birth rate (lagged by five years), total fertility rate, the ratio of child to infant morality and the degree of urbanisation.

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[13] An earlier version of this paper found that gender inequality, expressed as the ratio of the gender and human development indices (GDI/HDI) to be a robust determinant for infant and child mortality. However, it appeared preferable to break the index down to its component parts.

The estimation procedure is as follows. For each M variable, we estimated all possible combinations of four of the remaining group of 24 independent variables (i.e. all 17 M and all 7 Z variables). This means that for each M variable 10,626 (=24!/(20! 4!)) equations are estimated. The I variables (LGNP and a constant) are included in all equations. From these estimates, the mean estimate of $\beta_{(M)}$ and the average variance of these estimates are calculated as:

$$\beta_{(M)} = \Sigma \beta / n$$
$$\text{variance} = \Sigma \text{variance} / n \qquad (3)$$

where n is the number of estimates of estimated coefficients (10,626 in this case). A variable is said to be robust if 95 per cent of the estimated coefficients have the same sign. Equivalently, the statistics from equation (3) are used to test whether the $\beta_{(M)}$ is significantly different from 0 using the standard z tests (which therefore assumes that the estimated βs are normally distributed). A one-tail test (thus giving an absolute critical value of 1.64) of the null hypothesis (that β=0) is carried out. If the null is rejected (i.e. $|z| > 1.64$) then the coefficient in question is said to be robust.

However, before applying the above procedure to the M variables, we tested whether LGNP has a robust effect, as only under such circumstances is it justified to include LGNP as a fixed variable (i.e. an I variable). This test was carried out using the approach outlined above, but with the difference is that only the constant is an I variable. Hence, for LGNP 12,650 = (25!/(21! 4!)) equations have been estimated. The results shown in Table 4 show that LGNP has a robust effect on both CMR and IMR, hence it is valid to use it as an I variable. The table also shows the cumulative distribution (CDF) which is the per cent of estimates laying to one side of the zero. In the case of GNP this figure is 99 per cent for CMR and 100 per cent for IMR.

Results

Table 4 also reports the results for the other M variables in the first data set. The variables are listed in order of their significance in each case. In addition to income per capita, variables from each of three areas - health, education and gender inequality - are found to be robust. For health, TB immunisation significantly reduces both infant and child mortality, and immunisation against measles reduces child mortality. Let us be clear what these results mean. Whilst it is possible to find a regression in which, say TB immunisation, has an insignificant impact on child mortality, such regressions are only 3 per cent of the over 10,000 regressions we estimated which include that variable. It is important to bear in mind the distinction between data analysis and data mining. The data miner knows the result they are looking for and stops when they find it (and reports that result), whereas the data analyst is looking for the story which is most consistent with the data.[14] Robust regression is a tool of a data analyst, which in this case clearly shows that the view that health interventions matter for child survival is the story most consistent with the data.

None of the 1960 education variables are robustly significant, but both male and female primary enrolments in 1990 are robust determinants of child mortality and, rather surprisingly, male secondary enrolments are robust determinants of infant mortality. Gender disparity in literacy has robust effect on both infant and child mortality and gender disparity in life expectancy an adverse impact on child mortality. The sign in the former case is negative as expected (the higher the ratio of female to male literacy the lower the child mortality), but the sign in the latter case is “wrong”.

Table 4 Robustness tests for data set 1

Variable	Child Mortality Rate			Variable	Infant mortality rate		
	β	CDF	z-stat.		β	CDF	z-stat.
PSERM90	-0.46	1.00	-2.65	LGNP	-11.54	1.00	<-3.99
LGNP	-8.58	0.99	-2.41	LITFM	-0.68	1.00	-2.65
LEFM	2.27	0.99	2.20	TB	-0.49	1.00	-2.58
LITFM	-0.57	0.99	-2.26	SSERF90	-0.43	0.97	-1.81
M95	-0.51	0.98	-2.15	SSERM90	-0.37	0.96	-1.76

[14] Since Mukherjee *et al.* (1998) and White (2002) for further discussion of these ideas.

PSERF90	-0.36	0.97	-1.81	PSERM90	0.31	0.95	1.68
TB	-0.37	0.97	-1.95	M95	-0.35	0.92	-1.43
SSERM90	-0.34	0.95	-1.66	PSERM60	-0.20	0.92	-1.43
SSERFR90	-0.16	0.88	-1.15	DPT95	-0.41	0.90	-1.30
PSERM60	-0.14	0.84	-1.01	SSERFR90	-0.17	0.89	-1.21
PSERFR90	-0.26	0.84	-0.98	PSERF90	-0.22	0.86	-1.07
DPT95	-0.30	0.83	-0.96	PSERFR90	-0.25	0.82	-0.92
PSERF60	0.13	0.80	0.85	LEFM	0.91	0.80	0.84
P95	-0.20	0.74	-0.65	FLIT95	-0.28	0.77	-0.75
SSERF90	-0.11	0.68	-0.48	P95	-0.13	0.67	-0.43
LIT95	-0.16	0.65	-0.39	BIRTHADD	0.56	0.55	0.13
BIRTHADD	1.32	0.61	0.29	LIT95	0.04	0.54	0.09
FLIT95	-0.07	0.53	-0.07	PSERF60	0.00	0.50	0.00

Analysis of the data shows that the positive relationship between the ratio of female to male life expectancy is due to the influence of a few data points. In some high mortality countries, such as Mozambique, Sierra Leone, Niger and Guinea-Bissau, the ratio of female to male life expectancy is also high (107-108). Conversely in one or two low mortality countries the ratio of female to male life expectancy is also low e.g. Argentina has a CMR of 3 per thousand and female to male life expectancy ratio of 102. The significance of the ratio of female to male life expectancy reflects thus the influence of a few atypical countries and we therefore omit it from the discussion of the determinants that follow. We also checked if any of the other results were the results of influence, but this did not appear to be the case.

Data set 2 contains four additional variables: the percentage of children of low birth weight (LBW), the incidence of AIDS (AIDS), access to water (WACC) and access to sanitation (SACC). Adding these variables reduces the data set from 79 observations to 56. Given their robustness, TB and LITFM are taken as I variables (in addition to the intercept and LGNP). The variables reported in Table 4 are now all treated as Z variables (together with the original Z variables), so that the four M variables are the four new regressors. We thus estimated 2,600 (=26!/(23! 3!)) regressions for each M variable. The results are shown in Table 5. None of the newly added variables appears to have a robust effect on either dependent variable.

Table 5 Robustness tests for data set 2

	Child Mortality Rate			Infant mortality Rate		
	β	CDF	z-statistic	β	CDF	z-statistic
LBW	-0.46	0.85	-1.02	-0.09	0.58	-0.19
AIDS	0.51	0.85	1.04	0.51	0.84	0.98
WACC	0.001	0.50	0.00	-0.03	0.57	-0.16
SACC	-0.03	0.58	-0.21	-0.13	0.81	-0.93

The third data set adds a further three variables: population per physician (DOCTOR), population per nurse (NURSE) and the ratio of doctors to nurses (DNRATIO). The last of these is intended to give proxy for the relative importance of primary health services. The data set is reduced to 38 observations. The I variables are as for data set 2, the new variables are M variables, and the remaining regressors Z variables. There are 3,654 (= 29! / (25! 3!)) equations to be estimated for each M variable. The results, shown in Table 6, indicate that DOCTOR does have a robust impact on both infant and child mortality (fewer people per doctor reduces mortality), thus further bearing out the argument that health services can make a difference.

Table 6 Robustness tests for data set 3

	Child Mortality Rate			Infant Mortality Rate		
	β	CDF	z-statistic	β	CDF	z-statistic
DOCTOR	0.001	1.00	3.33	0.001	1.00	2.50
NURSE	0.001	0.83	1.00	0.001	0.90	1.14
DNRATIO	-0.960	0.70	-0.52	0.470	0.59	0.23

Summary and interpretation

The robust regression approach involves estimating all possible sets of regressors. Although we imposed some limit on the range of specifications , we have estimated over 200,000 regressions for each of child and infant mortality. Our results bear out that income per capita is a robust determinant of both of these two variables, but so are indicators of each of health, education and gender inequality. Our results thus support the majority of empirical work which finds that health interventions can significantly affect infant and child health.

These findings are in contrast to those of Filmer and Pritchett (1997) who argue that health spending has only a weak effect. Indeed they use their results to show that health spending of between $50,000 and $100,000 is required to save a life, which compares with typical estimates of the cost effectiveness of medical interventions of between $10 and $4,000.[15] Our results may be used for a similar cost effectiveness calculation. Using mean values of the variables, our results suggest that just under one life is saved by the reduction in child mortality brought about by the immunisation of three children. Supposing that immunising one child (with all support costs) costs $10, then the cost per life saved is only $30.[16]

How can this difference in results be explained? Filmer and Pritchett use total health expenditure. As they themselves recognise, their results may thus pick up the ineffectiveness of much health spending, which may be poorly targeted and spent on the wrong things, rather than the ineffectiveness of medical interventions *per se*. This fact which makes their cost effectiveness calculation somewhat misleading. For example, spending may go largely toward tertiary institutions, which do little to bring down infant and child mortality. Also the cost of delivering health services differs widely between countries, and these differences may drown out the impact of health services, so that physical input and process measures, such as the number of doctors and immunisation rates respectively, are more likely to show some significant effect. Our results support these arguments since they show that some interventions, such as immunisation, can indeed make a difference. However, our proxy for the relative importance if primary health (DNRATIO) was not robust, suggesting that refocusing on primary level services is not in itself sufficient.

[15] Cornia and Mwabu (1997) also present the relative impact of different variables on mortality, but their calculations take no account of cost differences.
[16] It is difficult to get a meaningful figure for the "cost of immunisation" which depends on *inter alia* the availability of health infrastructure and population density.

We should be clear that our results do not suggest that “money does not matter”. Growth is clearly important. GNP per capita proved robust, although many of the other variables we included pick up the channels through which higher income operates to reduce mortality. Indeed, we fully recognise that growth is necessary to sustain expenditure on health services. The main missing channel from our model specifications was the effect of income on private consumption, which makes possible better nutrition and greater access to services. This thus explains why income has a direct effect even though the other channels through which it operates (e.g. lower fertility and more health and education) are included in the model.

But we also find that education has an affect independent of income, supporting the idea that it is an important mediating variable between income and mortality. Whilst higher income is needed to sustain the expansion of quality education, attention has to be paid to providing that education so that economic progress is translated into broader social development. In this context it is worth noting that inequalities in female and male literacy are bad for child survival prospects. Our results thus also support the well-established view that female education matters for child health. There is thus a clear role for social policy in education, as well as health provision, if development targets to reduce infant and child mortality are to be realised.

5. CONCLUSION

Should countries wanting to promote human welfare focus on growth, or are specific social interventions advisable? It might be thought obvious that whilst growth is necessary to sustain welfare improvements, it alone is not necessary. An active social policy to address basic needs will bring about a more rapid improvement in social indicators. However, recent work by the World Bank has argued that health spending is a poor means of improving infant and child morality. Our paper refutes that position. We show that not only is there considerable variation in country mortality rates not explained by differences in income per capita, but also that mortality reductions have been achieved independent of income growth. In explaining why this is so, we show specific health interventions to be robust determinants of these variables. Moreover, the results suggests that interventions such as immunisation are a cost effective way of saving lives. These results are not inconsistent with the view that health spending is poorly targeted, which would explain why health spending is insignificant in other studies, whereas our measure of health services delivery are significant. Other factors, such as cost differences may play a role in explaining the insignificance of health expenditure in mortality regressions. We believe that the contention that health expenditure is an inefficient means of improving child health is unproven. To the contrary, our results support the importance of social policy if poverty reduction goals are to be achieved. However, further work is required to identify the most effective interventions.

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Table 3 Summary of results from cross-country mutlivariate regression analyses

Study	Sample	Dependent variable	Variables included
Boehmer and Williamson	96 developing countries	IMR	Income per capita (negative); and added one at a time: female illiteracy (+ve), female education (-ve), ratio female to male education (-ve), gender equality (-ve), age married (-ve), contraceptive prevalence (-ve), fertility (+ve), child birth rate (+ve), female suffrage (-ve), female parliamentary representation (-ve), female participation rate (-ve), relative female participation rate (-ve), percent women working as unpaid family members, ratio women to men working as unpaid family members
Cornia and Mwabu	Sub-Saharan Africa	IMR	Income per capita (-ve), female literacy (-ve), access to health, access to safe water, immunisation rate (-ve).
		U5M	Income per capita (-ve), female literacy (-ve), access to health, access to safe water, immunisation rate (-ve).
Filmer and Pritcheet	98 countries	U5M	Income per capita (-ve), health expenditure, female education (-ve), income inequality, urban, muslim (+ve), ethnic fragmentation (+ve), tropical country, access to water, regional dummies (coefficients not reported)
Flegg	46 developing countries	Log IMR (OLS)	Gini (+ve), female illiteracy (+ve), nurses (-ve), physicians (-ve), income
		TSLS	Gini (+ve), female illiteracy (+ve), nurses (-ve), physicians, fertility, income
Isenman	59 developing countries	IMR	Income (-ve), literacy (-ve)
Mwabu	39-68 developing countries	IMR	Average CPI, income per capita (-ve), compliance/no. of conditions, population density (-ve), regional dummmies (+ve for Africa), reform dummies
		CMR	Average CPI, income per capita (-ve), compliance (-ve)/no. of conditions, population density (-ve), regional dummmies (+ve for Africa), reform dummies
Pritchett and Summers	Developing countries over 1960 to 1985	IMR (five year differences)	Income per capita (-ve), education (-ve), year (-ve)
Rogers	56 countries	IMR	Income (-ve), Gini (+ve)

	Developing country sub-sample		Income (-ve), Gini
Singh	25-32 developing countries	IMR	Female education/literacy (-ve), female labour participation (-ve), GNP per capita, % women headed households (+ve), % attended births (-ve), religious dummy.
Subbarao and Raney	72 developing countries	IMR	Female enrolment (-ve), male enrolment, family planning services (-ve), income per capita (-ve), population per physician (+ve), rate of urbanisation (+ve), regional dummies

Notes: (+ve) and (-ve) indicate significant positive and negative relationship respectively, otherwise variable not significant; OLS - ordinary least squares; TSLS - two stage least squares.