the
Education
Commission

Background Paper
The Learning Generation

Estimating the Economic Returns of Education From a Health Perspective

Marco Schäferhoff, PhD, Prof. Dean T. Jamison, PhD,
Elina Pradhan, Elina M. Suzuki, Sebastián Martínez
SEEK Development

Estimating the economic returns of education from a health perspective

Study prepared for:

The International Commission on Financing Global Education Opportunity

29 April 2016

Prepared by:

SEEK Development

Project leads: Marco Schäferhoff PhD, and Prof. Dean T. Jamison PhD

Team: Elina Pradhan MS, Elina M. Suzuki MS, Sebastián Martínez MA

Correspondence to:

Marco Schäferhoff

SEEK Development, Strategic and Organizational Consultants

Berlin 10405, Germany

mschaeferhoff@seekdevelopment.org

SEEK development

STRATEGIC AND ORGANIZATIONAL CONSULTANTS

Table of Contents

Table of Contents 2

Executive Summary 3

1. Introduction 5
2. Modeling the effects of educational attainment on health 6
   - Data and methods 6
   - Results 7
   - Discussion 13
3. Calculating health-inclusive rates of return to education and benefit cost ratios 14
   - Methods 14
   - Results 16
   - Discussion 19
4. Conclusions and recommendations 20
5. References 22
6. Appendixes 25
   - Appendix I: Countries included in regression analysis 25
   - Appendix II: Descriptive statistics 28
   - Appendix III: Technical appendix – hierarchical linear model 30
   - Appendix IV: Incorporating education's effect on mortality into IRRs 31
   - Appendix V: Cost of education by level 38

Executive Summary

Objective

This study estimates the effects of education on under-five mortality and adult mortality in low- and middle-income countries, and calculates the economic returns to education resulting from declines in under-five mortality and adult mortality, while also taking into account the effects of education on income. It also calculates the effects of education on fertility.

Key findings

Education has a substantial and highly significant impact on both adult and under-five mortality, with female schooling being particularly critical for achieving reductions in mortality.

- Improvements in female educational attainment drive declines in both female and male adult mortality, and under-five mortality.
- A one-year increase in mean years of schooling for girls is associated with reductions in female and male adult mortality of 3.7% and 2.2% in low- and middle-income countries between 1970 and 2010, respectively, while under-five mortality declines by 4.2%.
- Of the impressive reductions in mortality seen in low-income and middle-income countries between 1970 and 2010, 14% of reductions in under-five mortality, 30% of reductions in adult female mortality, and 31% of reductions in adult male mortality can be attributed to gains in female schooling.
- An analysis of levels of schooling shows that the health benefits of additional schooling are higher for earlier years of schooling. The marginal impact of schooling at the primary level is higher compared to the impact at the secondary level.
- Quality also has a substantial effect on health outcomes, but better data and further research is needed to better understand this relationship, particularly in low- and middle-income countries.

The rate of return of education increases substantially when the returns of education resulting from reductions in adult mortality and under-five mortality are added to the standard social rate of return. Health-inclusive returns from education are higher in low- and lower-middle-income countries.

- The mortality-related returns from education significantly augment “standard” social rates of return (“earnings returns”) of investing in an additional year of schooling. If benefits from the reductions in adult mortality and under-five mortality are included, the monetary valuation of the rate of return of investing in an additional year of schooling in a low-income country (LIC) increases from 10.6% to 16.3% (a 53% increase), while the health-inclusive social rate of return in a lower-middle-income country (LMIC) increases to 9.3%, compared with 7.0% when only earnings are considered (a 34% increase).
- In upper-middle-income countries (UMICs), with much lower initial mortality rates than LICs and LMICs, the returns resulting from mortality reductions are smaller but still substantial. Our

estimates suggest that health-inclusive social rates of return amount to 4.7%, compared with 3.0% from earnings only.

Every dollar invested in female schooling would return $9.9 in low-income and $3.7 in lower-middle income countries in terms in earnings and reductions in under-five and adult mortality.

Returns on investments can also be expressed as a benefit-cost ratio: Every dollar invested in female schooling in low- and lower-middle income countries would return $9.9 and $3.7, respectively, in earnings and reductions in under-five and adult mortality. Returns in upper middle-income countries amount to $1.5 per dollar invested.

Educational gains are associated with significant declines in fertility.

An extra year of female schooling is also associated with a 2.4% decline in births over a woman's lifetime (total fertility) in LICs and LMICs. This estimate is based on the most recent data and supports the results from previous studies on the effects of education on reducing fertility.

Conclusions and recommendations

By including the impact of education on health, this study shows that the existing quantitative estimates of the rate of return to education, although high, are systematically underestimated. Although investments in education are not undertaken specifically to improve health, they produce substantial health returns. Based on our results, we make five recommendations:

- Donors and countries alike should realize that the returns to education are substantially higher than normally understood and should reflect this in their investment decisions.
- The results strongly indicate that female education matters more than male education in terms of achieving health outcomes. Investments should be targeted toward girls' education for a substantial return on health. Increased efforts are needed to close remaining gender gaps.
- Because of the substantial health effects resulting from school attendance, it is important to get children into school, even while waiting for further improvements in quality.
- Policymakers should take into account the importance of the cross-sectoral nature of global development challenges. The highly positive benefit-cost ratio that takes into account the health impact of education provides a compelling rationale for much stronger cross-sectoral collaboration between the education and health sectors. Implications for financing should be considered.
- Our study points to specific data gaps, particularly regarding data on the quality of education (test scores). There has been a recent shift in the global dialogue on quality of education to include discussion of learning outcomes, in low- and middle-income countries. However, at the same time, there remain substantial gaps when it comes to data on the quality of education and learning (among other data and knowledge gaps). These gaps go largely back to the fact that donor investments in global public goods for education (GPGs) are currently very limited. As such, donors should increase their support for GPGs to allow for better research and progress measurement.

1. Introduction

The International Commission on Financing Global Education Opportunity (the "Commission") engaged SEEK Development to assess the investment case for education by analyzing the economic returns to education investments from a health perspective.[1] Our study specifically aims to estimate the effects of education on under-five mortality, adult mortality and fertility. In addition, it calculates the economic returns to education resulting from declines in under-five mortality and adult mortality, while also taking into account the effects of education investments on income.

Based on our analysis, we also developed policy-relevant recommendations that help to guide education investments and make the case for increased education investments. Our study comes at a critical juncture for education and health, as the global community moves forward in the context of the new Sustainable Development Goals (SDGs), which have stressed the importance of taking into account the cross-sectoral nature of global development challenges.

Our study adds to the evidence that education is an important determinant of health and a crucial mechanism to enhance the health and wellbeing of individuals. For example, studies show that education plays a critical role in reducing the HIV transmission in women by improving HIV prevention and care. Keeping adolescent girls in secondary school significantly attenuates the risk of HIV infection,[2] while early childhood development has a lifelong impact on the mental and physical health of individuals.[3] Education has been further shown to reduce the need for health care, the associated costs of dependence, lost earnings and human suffering, while promoting healthy lifestyles and supporting human development, relationships, and personal, family, and community wellbeing.

Different studies have assessed the effect of education and child mortality and fertility, showing an association between educational attainment and reductions in both health outcomes.[4] Our study goes beyond previous work by utilizing improved and updated data and more importantly by controlling tightly for country-specific effects – both in level and in rates of change of mortality.

This study is organized around four sections: We first present the results of our regression analysis, which examines the effects of increases in mean years of schooling, as well as schooling quality, on under-five mortality, adult female mortality, and adult male mortality. The findings from our analysis inform the following sections, which use the estimated effect size developed in Section 1 to determine the rates of return and benefit-cost ratios of education.

The second section explores the effects of augmenting the traditional rates of return analysis for education with its (mortality-related) health effects. Section 3 considers the benefit-cost ratio of education from both an earnings-only and health-inclusive perspective and addresses the question: what

---

[1] Our study builds on a previous analysis, which we developed for the Oslo Summit on Education for Development (July 2015). See Schäferhoff et al. 2015.
[2] Baird et al. 2013; De Neve et al. 2015; Behrman 2015.
[3] Center on the Developing Child at Harvard University. The foundations of lifelong health are built in early childhood. Available at: www.developingchild.harvard.edu. Accessed March 8, 2016.
[4] For a systematic meta-analysis, see Schäferhoff et al. 2015. See, for example, also Caldwell 1980; Filmer and Pritchett 1999; Gupta and Mahy 2003; Gakidou et al. 2010; Kuruvilla S. et al. 2014; Wang et al. 2014; Jamison, Murphy and Sandbu 2016.

would be the returns to investing $1 in education in low-, lower-middle-, and upper-middle-income countries? Finally, we lay out recommendations based on our findings, and consider what next steps the global education community might take to ensure all countries make substantial progress towards global education targets.

2. Modeling the effects of educational attainment on health

Data and methods

We estimated the effects of educational attainment over time, measured in mean years of schooling for adults aged 25 and over. This age group was selected to ensure that the data was unlikely to contain censored observations.[5] Data on mean years of schooling was obtained through the Barro and Lee dataset, which includes 92 low- and middle-income countries, each of which included observations at five-year intervals between 1970 and 2010. Mortality rates were defined as the probability of dying between age 0 and age 5 (5q0) for under-five mortality, and the probability of dying between age 15 and age 60 (45q15) for adult mortality. The UN World Population Prospects (2015 revision) was used for all fertility and mortality estimates (Table 1).[6]

Table 1: Sources of data used in this study

Variable	Description	Data source
Educational attainment (mean years of schooling)	Mean years of total schooling among the population aged 25+. Both overall- and sex-specific estimates were used.	Barro and Lee data set, version 2.0[7]
Standardized achievement test scores	Aggregate standardized test scores, developed by Patrinos and Angrist based on global and regional achievement tests.	World Bank EdStats Global Achievement database[8]
Under-five mortality (5q0)	Probability of dying between birth and exact age 5. Expressed as deaths per 1000 live births.	UN World Population Prospects[9]
Adult mortality (45q15)	Expressed as deaths under age 60 per 1000 alive at age 15 calculated at current age-specific mortality rates. Both overall and sex-specific estimates were used.	UN World Population Prospects[10]
Fertility	Total fertility rate (children per woman).	UN World Population Prospects[11]
GDP per capita	Per capita expenditure-side real GDP (PPP-adjusted).	Penn World Tables, version 8.1 (released April 2015)[12]

[5] For example, years of schooling for a fifteen-year-old student would underestimate their full educational attainment, because they are still in school.
[6] Appendix I contains a full list of countries included in the analysis.
[7] Available from: http://www.barrolee.com/
[8] Available from: http://databank.worldbank.org/data/reports.aspx?source=Education%20Statistics:%20Education%20Global%20Achievement
[9] Available from: http://esa.un.org/unpd/wpp/Download/Standard/Mortality/
[10] Available from: http://esa.un.org/unpd/wpp/Download/Standard/Mortality/
[11] Available from: http://esa.un.org/unpd/wpp/Download/Standard/Fertility/
[12] Available from: http://www.rug.nl/research/ggdc/data/pwt/pwt-8.1

We developed hierarchical linear models (HLMs) to understand the impact of schooling on mortality and fertility (Equation 1). Our HLMs assume that the data is grouped by hierarchical levels and that variance is shared in the levels of aggregation of the data. Because of this assumption, HLMs allow for the simultaneous study of the relationship that observations have within a same level, as well as the relationship they have across levels. When compared to fixed-effects models, hierarchical models allow for an additional level of analysis because of the random coefficients specific to each unit of observation and to every level to which they belong. This is analogous to estimating different regression lines for every level, as well as for the set of observations overall.[13]

Equation 1: Hierarchical Linear Model

$$\boldsymbol{y_{it} = \beta_0 + \beta_1 educ_{it} + \sum_{a=1}^{t} \beta_{2a} time_t + \beta_3 Log(GDP_{PC}) + \beta_{2i} time_t + u_i + \epsilon_{it}} \text{ --- } \mathbf{(1)}$$

Controlling for time and income (GDP per capita), we modeled the effects of educational attainment (female schooling, male schooling, and overall schooling) on under-five mortality, adult female mortality, and adult male mortality.[14] Preston (1975, 2007) shows that national income plays a critical role in improving health outcomes. He further argues that factors exogenous to income have played a crucial role in improving mortality. An influential paper by Pritchett and Summers (1996) pointed to education as well as income among the important factors influencing mortality decline. As highlighted by Jamison, Murphy and Sandbu (2016), technological progress has played a driving role in improving health outcomes in recent years. In line with these authors, we also loosened the assumption of homogeneity of technical advancements across countries. By allowing the impact of time or technological progress to vary every five years, and by allowing for a country-specific impact of technological progress on mortality in addition to controlling for GDP, we provide conservative estimates of the impact of education on mortality and fertility. Appendix III provides additional details on the model.

Results

Education has a substantial and highly significant impact on adult and under-five mortality, and fertility. Female schooling is particularly critical for achieving reductions in mortality and fertility.

We modeled the effects of education based on three different schooling variables: mean years of schooling for girls, boys, and both sexes. The results of our analysis, which examined female and male adult mortality separately, make an important contribution to the existing evidence base.[15] While several studies have examined the effects of female schooling on child mortality, we are aware of only one other cross-national study (from 1998) that estimated the macro effects of schooling on adult mortality.[16]

---

[13] Jamison, Murphy and Sandbu (2016) provide a range of comparative models on under-five mortality and assess their statistical properties. They concluded the HLM structure to best fit data of this sort, and we therefore develop their modelling approach here.

[14] Appendix II contains descriptive statistics for countries included in the regression, including means and standard deviations for mortality and fertility rates, years of schooling, and test scores.

[15] Very few studies have focused on any potential impacts that educational attainment may have on adult mortality. To our best knowledge, the most recent study that specifically assesses the effects of schooling on adult-mortality is from 1998.

[16] Wang and Jamison 1998.

Other studies have focused on the relationship between schooling and adult health, but primarily do so for a single country or small set of countries.[17]

Table 2 shows the results of our hierarchical models where each column represents the results for the five dependent variables—overall adult mortality, adult male mortality, adult female mortality, under-five mortality, and fertility. Panel A shows results for models where we consider the impact of average male and female schooling on the five health outcomes. Panel B and C table the impact of female and male schooling, respectively, while controlling for male-to-female years of schooling ratio.

Table 2 demonstrates that improvements in female educational attainment drove declines in mortality and fertility in low- and middle-income countries between 1970 and 2010: A one-year increase in a country's mean years of schooling (both sexes) is associated with a 2.5% reduction in male adult mortality and 3.1% reduction in female adult mortality, a 3.3% reduction in under-five mortality, and 2.4% reduction in the total fertility rate (TFR), in low- and middle-income countries. Furthermore, the effect of male schooling on adult and under-five mortality and TFR is small and often not significant. In contrast, improvements in female schooling are associated with large declines in both female and male adult mortality, accounting for much of the observed effects of education on health. A one-year increase in mean years of schooling for girls is associated with reductions in female and male adult mortality of 3.7% and 2.2%, respectively, while under-five mortality declines by 4.2%, and the TFR by 2.4%. The comparison of the effect of male (small/no effect) and female schooling (large effect) on adult mortality, under-five mortality, and fertility clearly shows that the education-related declines in mortality between 1970 and 2010 in low- and middle-income countries were driven by increases in female schooling.[18]

Table 2: The impact of schooling on health outcomes – results from the hierarchical linear models

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent Variables					
Panel A:					
Mean years of schooling, both sexes	-0.030 ***	-0.025 **	-0.031 ***	-0.033 **	-0.024 ***
Ln[GDP per capita]	-0.057 ***	-0.040 **	-0.083 ***	-0.127 ***	-0.047 ***
Panel B:					
Mean years of schooling (female)	-0.030 ***	-0.022 **	-0.037 ***	-0.042 ***	-0.024 ***
Schooling ratio (male:female)	0.016	0.019 *	0.010	-0.009	-0.011
Ln[GDP per capita]	-0.052 **	-0.034 *	-0.079 ***	-0.127 ***	-0.047 ***
Panel C:					
Mean years of schooling (male)	-0.015	-0.014	-0.010	-0.015	-0.015 *
Schooling ratio (male:female)	0.018 *	0.020 **	0.013	-0.008	-0.011
Ln[GDP per capita]	-0.058 ***	-0.039 **	-0.084 ***	-0.127 ***	-0.047 ***
			Period: 1970–2010	Countries: 80	Observations: 688

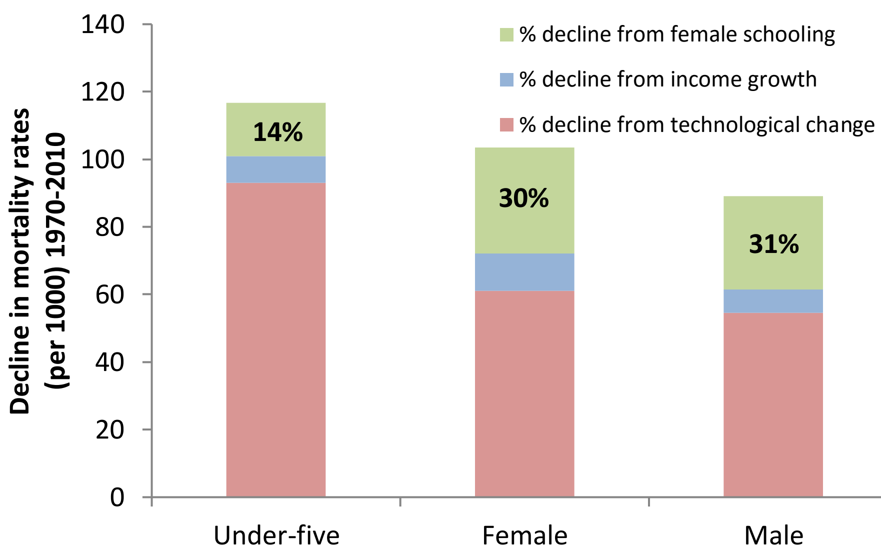
[17] Matsumura and Gubhaju (1991) on Nepal; Shkolnikov et al. (1998) on Russia; Hurt, Ronsmans, and Saha (2004) on Bangladesh; Yamano and Jayne (2005) on Kenya; de Walque et al. (2005) on Uganda; and Rowe et al. (2005) on Nepal.
[18] Our results on the effects of schooling on fertility are in line with those of other studies. Three studies found that an increase in female schooling was associated with between 0.15-0.36 fewer births over a woman's lifetime.

A substantial portion of the reductions in adult and under-five mortality observed between 1970 and 2010 can be attributed to gains in female schooling

Based on the results of our hierarchical linear model, we developed estimates of the proportion of mortality reductions between 1970 and 2010 that can be attributed to improvements in female schooling. Adult female, adult male, and under-five mortality all saw impressive reductions over this period, with particularly dramatic improvements seen in under-five mortality. Between 1970 and 2010, the global under-five mortality rate declined by 64%, from 139 deaths under five per 1,000 live births to 50 in 2010. In low-income countries, gains have been particularly strong since 1990: under-five mortality declined by more than 50%, from 186 deaths per 1,000 live births to 91, during this twenty-year span. The adult mortality rate also recorded a notable decline between 1970 and 2010, falling 38% globally, from 247 to 153. Reductions in adult female mortality were particularly substantial, declining by 43% over the forty-year period.

Our decomposition analysis shows that of the reductions in mortality seen in low-income and middle-income countries between 1970 and 2010, 14% of reductions in under-five mortality, 30% of reductions in adult female mortality, and 31% of reductions in adult male mortality can be attributed to gains in female schooling (Figure 1).[19] As Figure 1 also shows, income, and particularly technological progress, substantially impacted mortality over this period, a finding in line with other studies.[20]

Figure 1: Decline in mortality (1970-2010) attributable to female schooling



[19] In the decomposition analysis, we first calculate the difference in mean covariates in the sample in 2010 compared to 1970. Then, we calculate the overall reduction in mortality when education increases by the difference in mean from 2010 to 1970, which is the impact estimate from the HLM model multiplied with the different in mean of that covariate. The fraction attributable to any particular covariate is then the overall reduction in mortality because of the changes in that particular covariate, divided by the overall change in mortality over the period. For example,

$$\text{Fraction attributable to education} = \frac{\beta_{ed} * \Delta Educ}{\beta_{ed} * \Delta Educ + \beta_{gdp} * \Delta GDP + \beta_{2010} * \Delta T} \quad where\ \Delta \text{Educ} = \overline{Educ_{2010}} - \overline{Educ_{1970}}.$$

[20] Jamison et al. 2016.

Our initial analysis of levels of schooling shows that the health benefits of additional schooling are higher for earlier years of schooling.

In addition to analyzing the overall impact of one additional year of average schooling in a country, we considered whether differential effects accrue at different levels of schooling (Table 3). We conducted a quadratic analysis, which relaxes the assumption that each additional year of schooling has the same impact on health, and hence allows for the evaluation of the relative change in mortality with changing years of attainment.[21] Our analysis indicates that additional years of schooling have sustained effects on all the health outcomes we examined. The coefficient on the squared years of female schooling term is positive and significant for all health outcomes, indicating that the relative effect of education on health outcomes declines with increasing years of educational attainment – this means that the marginal impact of schooling at the primary level is higher compared to the impact at the secondary level.

Table 3: The impact of schooling levels on health outcomes

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent Variables					
Panel D:					
Mean years of female schooling (linear)	-0.081 ***	-0.071 ***	-0.089 ***	-0.143 ***	-0.100 ***
Mean years of female schooling (quadratic)	0.005 ***	0.005 ***	0.005 ***	0.010 ***	0.008 ***
Ln[GDP per capita]	-0.043 **	-0.026	-0.070 ***	-0.112 ***	-0.032 **
Mean years of female schooling					
(effect size)					
3 years	-0.049 ***	-0.041 ***	-0.056 ***	-0.082 ***	-0.053 ***
4 years	-0.039 ***	-0.031 ***	-0.046 ***	-0.061 ***	-0.037 ***
5 years	-0.029 ***	-0.022 **	-0.035 ***	-0.041 ***	-0.021 ***
6 years	-0.018 *	-0.012	-0.024 **	-0.02	-0.005
7 years	-0.008	-0.002	-0.013	0	0.01
Mean years of female schooling					
(effect size)					
LIC mean (1.37)	-0.066 ***	-0.057 ***	-0.074 ***	-0.115 ***	-0.078 ***
LMIC mean (3.81)	-0.041 ***	-0.033 ***	-0.048 ***	-0.065 ***	-0.040 ***
UMIC mean (5.51)	-0.023 **	-0.017 *	-0.029 **	-0.030 **	-0.013 *
Total mean (3.94)	-0.040 ***	-0.032 ***	-0.046 ***	-0.062 ***	-0.038 ***
			Period: 1970–2010	Countries: 80	Observations: 688

[21] Conducting a categorical levels analysis would have required data for the length of each level of schooling for each country in each time period (year). For example, one country may define primary school as having a five-year duration, while another may define it as seven years; furthermore, country definitions of levels of schooling change over time. Because we lacked accurate data on levels over time, it was not possible to run such an analysis.

Quality impacts health above and beyond the years of schooling, but better data and further research is needed to better understand the relationship, particularly in low- and middle-income countries.

In addition to the effect of years of schooling on health, we also evaluated the effects of educational quality on health outcomes. This analysis proved challenging for a variety of reasons. Most fundamentally, cross-country data on educational quality is extremely limited, particularly for low- and lower-middle-income countries. A number of researchers have used results from global or regional achievement tests (such as PISA, TIMMS, SACMEQ, PASEC, and LLECE[22]) to standardized estimates of educational quality, based on country performance on such exams. However, there remain significant gaps in terms of both longitudinal and country coverage, and concerns have been raised over the validity of using results from a limited set of test results as a proxy for education quality.

Because of the limited number of low- and middle-income countries with longitudinal quality data available, we expanded our analysis to also include high-income countries with data on quality in the Barro and Lee data set.[23] To evaluate the impact of education quality on health, we ran an augmented version of the Panel B hierarchical linear model, to which we added a variable measuring schooling quality (standardized achievement test scores).

Our findings largely underscore the robustness of the impact of years of schooling on health outcomes, and further suggest that quality can also have an additive and substantial impact on health outcomes (Table 4).

Panel E shows the results of the HLM model with education quality proxied by the composite test scores. Comparison of the returns to mean years of schooling in Panel E to Panel F, where the HLM model does not control for quality, shows that the impact of returns to schooling is about the same with or without controlling for test scores. In fact, improvements in test scores are predicted to reduce mortality and fertility further, above and beyond the improvements in years of schooling.

[22] Program for International Student Assessment (PISA); Trends in International Mathematics and Science Study (TIMMS); Latin American Laboratory for Assessment of the Quality of Education: Regional Comparative and Explanatory Study (LLECE); Southern and Eastern Africa Consortium for Monitoring Educational Quality SACMEQ; Program for the Analysis of CONFEMEN Education Systems (PASEC).

[23] Please see Appendix I B for a full list of countries used in the quality HLM regressions.

Table 4: The impact of school quality on health outcomes – results from hierarchical linear models

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent Variables					
Panel E:					
Test scores	-0.00246**	-0.00205*	-0.00240**	-0.00349**	-0.00024
Mean years of schooling (female)	-0.0160*	-0.011	-0.0238**	-0.0583***	-0.0308***
Schooling ratio (male:female)	-0.0185	-0.035	0.0044	0.178***	0.197***
Ln[GDP per capita]	-0.201***	-0.166***	-0.268***	-0.460***	-0.162***
Panel F:					
Mean years of schooling (female)	-0.0171*	-0.0119	-0.0245***	-0.0565***	-0.0308***
Schooling ratio (male:female)	-0.0126	-0.0299	0.0098	0.192***	0.197***
Ln[GDP per capita]	-0.0199***	-0.0165***	-0.266***	-0.451***	-0.162***
1970–2010 Countries: 103 Observations: 362					

Given the substantial difference in a one-unit change between educational attainment (one year of schooling) and test scores (a one-point increase in scores), we also present the results of both quantity and quality in terms of a one standard-deviation change above their mean values, to enable better comparability between the two (Table 5). The results of this analysis suggest that the impact of quality is substantial. A one standard deviation change in school quality (measured as standardized achievement scores) is associated with a 2.4% decline in the overall adult mortality rate, a 2.3% decrease in adult female mortality, and a 3.4% decrease in under-five mortality. In all cases, however, the impact of female educational attainment remains larger than school quality. For the three health outcomes where both years of schooling and test scores are significant – overall adult mortality, female mortality, and under-five mortality – the impact of female years of schooling ranges from 2 to 5.2 times the impact of quality.

Our estimates of the magnitude of the effect of education quality on under-five mortality substantially exceed those of Jamison, Jamison and Hanushek (2007), perhaps because (a) we estimate the impact on under-five mortality rather than on infant mortality, and (b) we have more observations from low- and middle-income countries than these authors. However, our sample would still benefit from additional observations for LICs, LMICs, and UMICs.

Table 5: The impact on health outcomes of a one standard-deviation change in education quantity and quality

	Dependent Variables				
	Ln[Adult mortality rate], both sexes	Ln[Adult mortality rate], male	Ln[Adult mortality rate], female	Ln[Under-five mortality rate]	Ln[Total fertility rate]
Independent Variables					
Test scores	-0.024**	-0.02*	-0.023**	-0.034**	-0.002
Mean years of schooling (female)	-0.048*	-0.033	-0.072**	-0.177***	-0.093***
Ratio (years:test scores)	2.02	1.67	3.08	5.18	39.83
Period: 1970–2010 Countries: 103 Observations: 362					

Our findings show that the impact of school quality on health outcomes are considerable and merit further scrutiny. It also highlights the limitations of the data, a challenge that should be considered when interpreting these results. Of the 103 countries included in the analysis, 59 countries have fewer than four years of observations. Of those with four or more observations, 35 – or 80% of the sample – are high-income countries. Further work is needed to develop robust measures of education quality that are comparable across countries and tracked over time.

Discussion

The results on under-five mortality are in line with previous analyses of the effect of schooling on under-five mortality, including that of Jamison, Murphy, and Sandbu (2016), who found that a one-year increase in female education was associated with a 3.6% decline in under-five mortality among 95 low- and middle-income countries between 1970 and 2004. Our previous analyses have also established a clear link between schooling and improved under-five health. A meta-analysis, conducted as part of our previous study for the Oslo Summit on Education, found that one additional year of female schooling was associated with between a 3.6% and 9.9% decrease in under-five mortality.[24] This shows that our estimate on under-five mortality, while still being substantial, is at the bottom end of the range of previous studies.

The strong impact education has on female mortality is striking, and contributes further evidence on the beneficial impacts of education to women's well-being. Schools are frequently used channels for health information, notably education on sexual and reproductive health. More educated people have better access and understanding of healthy behavior and practices. Moreover, the impact of education on women's empowerment and decision-making power is well-documented.[25] Hence, educated women not only have increased access to health services and information, but they are better able to make healthier choices because of their increased bargaining and decision-making power within their household.

Gains in female educational attainment have been impressive over the past forty years: The mean years of schooling attained by girls in low- and middle-income countries have increased from 2 in 1970 to more than 6 in 2010, while the ratio of male to female educational attainment has increased from 67% to 86%. As we have shown in our analysis, these impressive gains in female schooling were pivotal in reducing under-five mortality and adult mortality in the last 40 years. However, women's educational attainment continues to lag behind men's. In the low-income countries included in our analysis, mean educational attainment for women remained just 2.8 years in 2010, suggesting that many girls either do not attend or at least fail to complete primary school. Further reductions in mortality can be achieved not only with health-focused policies, but also education policies that address out of school children, and especially out-of-school girls.

[24] Schäferhoff et al. 2015.
[25] The World Bank Group 2014; International Center for Research on Women 2005.

3. Calculating health-inclusive rates of return to education and benefit cost ratios

Previous analyses have estimated the returns to education. Using household and labor market survey data, Montenegro and Patrinos (2013; 2014) have estimated the private returns accruing from increased schooling. They note that three major findings have held across analyses: (1) private returns to schooling tend to hold in the range of 10% per year of schooling; (2) returns are on average higher in low- and middle-income countries; and (3) returns to primary schooling are higher than returns to secondary schooling.[26] In most previous analyses, researchers assume that costs of schooling are absorbed by the government, therefore assuming that the only costs to students are the opportunity costs of foregone earnings, while any gains reflect the income differential between the earnings earned by students with different levels of educational attainment. The term 'social rates of return' has been frequently used to refer to the rate of return to education, when the full cost of schooling is incorporated. In a recent analysis of fifteen LICs, LMICs, and UMICs, Psacharopoulos, Montenegro and Patrinos (2016) further considered the full cost of schooling, and found that the 'social' rates of return to primary education were higher than those of secondary and tertiary education for both low- and lower-middle-income countries.[27]

Our analysis makes an important contribution to existing research on the rates of return to education by expanding the traditional focus on earnings returns to also consider some of the health-related externalities associated with increased educational attainment. By capturing reductions in mortality, our analysis provides a more comprehensive evaluation of returns to schooling and strengthens the investment case for education by costing health in addition to earnings returns.

Methods

The empirical work conducted as a first step in this analysis generated coefficients for the effect of one additional year of education on under-five mortality, on adult female mortality, and on adult male mortality. In this section, we use these coefficients to generate the monetary value of these changes. Earlier research by our team, funded by the Norwegian government, reviewed available evidence on the effects of education, and then estimated the economic returns resulting from the reduction in under-five mortality attributable to increases in female education.[28] Our analysis follows the general approach used in this previous study, but improves the methodical approach and expands it to incorporate both the monetary value of under-five and adult mortality reductions.[29]

---

[26] Montenegro and Patrinos 2013; Montenegro and Patrinos 2014.

[27] The authors noted that this characterization of rates of return overlooks many of the important returns that might also be associated with improved educational attainment. Furthermore, the social rates of return were highest for tertiary education in upper-middle-income countries .The authors note that given almost universal primary completion rates in upper-middle-income countries, there is an unsatisfactory 'control' group of non-completers to compare with, likely understating returns at the primary level. Psacharopoulos, G. et al. (2016).

[28] Schäferhoff, M. et al. 2015.

[29] Our methods build on those used by the Lancet Commission on Investing in Health (CIH), which used existing literature to propose a standardized approach to placing dollar values on mortality change. See Jamison et al. (2013a); Jamison et al. 2013b; Cropper et al. 2011, Viscusi 2015.

We took four broad steps to estimate the economic returns:

First, we used the effects of education on (a) under-five mortality, (b) adult male mortality, and (c) adult female mortality that we received from our cross-country regressions as the basis for our health-inclusive rate-of-return (RoR) and benefit-cost ratio (BCR) analysis. From the regressions, we obtained the level of mortality reductions, (Δms) resulting from one more year of female schooling, for each income group. For example, the average years of schooling in lower-middle-income countries is 6. Our RoR/BCR calculations for LMICs then estimated the rate of return of increasing years of schooling from 6 to 7.

Second, applying methods similar to Global Health 2035 and our Norad study, we placed dollar values on these mortality reductions (Δms). We calculated the expected health value at age a [hv(a)], expressed in dollars associated with the assumed one-year increase in education level using the information on dollar value of mortality reductions, combined with status-quo mortality rates and fertility rates.

Third, we calculated the earnings value for an increment in education. We received smoothed age-earnings profile for LICs, LMICs and UMICs from Psacharopoulos, Patrinos and Montenegro for different levels of schooling. We used standard earnings function analyses (drawn from Montenegro and Patrinos) to generate marginal increase in earnings at each age across each schooling level (as in our example above, where we estimated expected level of mortality reductions (Δms) resulting from 1 additional year of schooling for individuals with a starting level of 6 years). The earnings value of this increment in education for a person of age a, ev(a), is simply the difference between the age-earnings profiles of a secondary school graduate and a primary school graduate divided by the number of years of secondary schooling.

Fourth, we drew on cost data from the Commission (Appendix V) which provided estimates of the direct cost (c_1) for schooling at the respective grade levels in each income group. (The direct cost is that of teacher time, implicit rent on facilities and consumables such as textbooks.) We assumed that if a child is in school they forego earnings, so ev(a) will be negative at the age of entry for the additional year of schooling (A). c_1 (a) is assumed to be zero for a > A. Similarly, the opportunity cost (c_2) of attending one more year of school was calculated as the earnings foregone by attending one more year of school. Similar to direct cost, c_2(a) is zero for a>A.

Finally, we calculate RoR and BCR as follows:

Equation (1) expresses the net present value of net costs and benefits [$ePVNR(r_s)$], a standard RoR analysis:

(1) $ePVNR(r_s) = \sum_{a=A}^{65} \frac{ev(a)-c_1(a)-c_2(a)}{(1+r_s)^{a-A}}$

The 'standard' RoR (r_s) is simply the value of r_s such that $ePVNR(r_s)$= 0. We will always calculate standard RoRs to compare with health-inclusive RoRs, which we label hRoRs. Equation 2 gives the present value of net benefits when the benefit stream is augmented by the value of education's health effect:

(2) $hPVNR(r_h) = \sum_{a=A}^{65} \frac{ev(a)+hv(a)-c_1(a)-c_2(a)}{(1+r_h)^{a-A}}$

The health-inclusive RoR (r_h), hRoR is simply that value of r_h such that $hPVNR(r_h)$= 0.

To calculate the health-inclusive benefit cost ratios, we simply apply the annual discount rate of 3% of all costs and benefits. The health-inclusive BCR at discount rate (r) , hBCR(r) is:

$$hBCR(r) = \frac{\sum_{a=A}^{65}[ev(a)(1-r)^{a-A} + hv(a)(1-r)^{a-A}]}{\sum_{a=A}^{65}[c_1(a)(1-r)^{a-A} + c_2(a)(1-r)^{a-A}]}$$

Similarly, the earnings-only BCR is:

$$\mathrm{eBCR(r)} = \frac{\sum_{a=A}^{65}[ev(a)(1-r)^{a-A}]}{\sum_{a=A}^{65}[c_1(a)(1-r)^{a-A} + c_2(a)(1-r)^{a-A}]}$$

Please see Appendix IV B for detailed methods used for rate of return and benefit cost ratio calculations, and Appendix IV A for an example of how benefits to reductions in under-five and adult male/female mortalities are valued.

Results

The rate of return of education increases significantly when the returns of education resulting from reductions in adult mortality and under-five mortality are added to the standard rate of return.

The standard social rate of return or "earnings return" is the rate of return of schooling considering direct costs, opportunity costs and earnings benefits from schooling. Our initial calculations suggest that the earnings return of investing in an additional year of schooling in a low-income country is 10.6% (Table 6). These standard social rate of returns, however, do not consider the other social benefits of schooling. Here, we consider the added benefit of schooling on potential reductions in under-five mortality, adult male mortality and adult female mortality.

Including the health benefits due to additional year of schooling, the rate of return of investing in an additional year of schooling in a low-income country increases to 16.3% (14.3%-18.0%).[30]

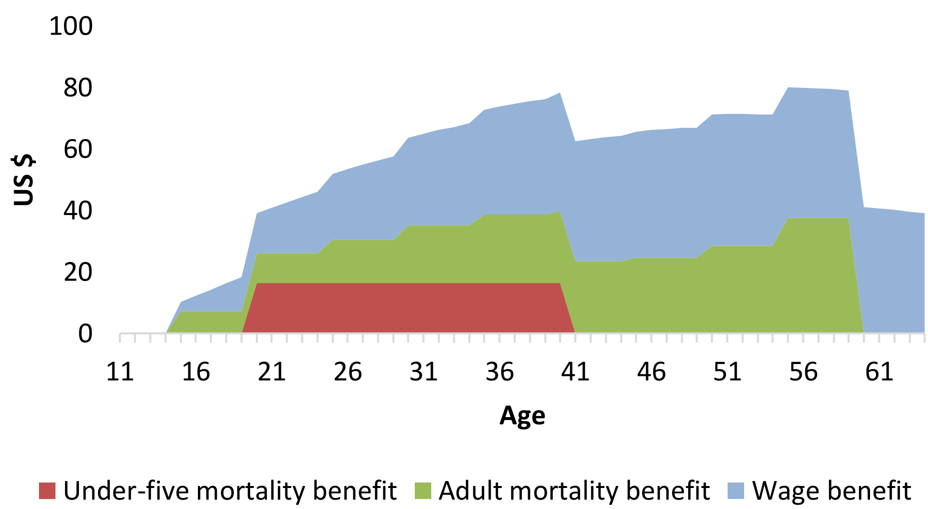
[30] All figures were calculated using a VSL of $130*GDP per capita. We conducted additional analyses using a VSL of $80*GDP per capita (lower bound) and $180*GDP per capita (upper bound). The figures in parentheses refer to these lower- and upper-bound estimates.

Table 6: Rate of return of an additional year of schooling in LICs, LMICs and UMICs

	Health-inclusive social rate of return	Without health benefits ("standard social rate of return")	Standard private rate of return
IRR			
LICs	16.3%	10.6%	16.3%
LMICs	9.3%	7.0%	8.9%
UMICs	4.7%	3.0%	4.9%
Benefits/costs included			
Health benefits	Yes	No	No
Earnings benefits	Yes	Yes	Yes
Direct cost of an additional year of schooling	Yes	Yes	No
Opportunity cost of attending an additional year of schooling	Yes	Yes	Yes

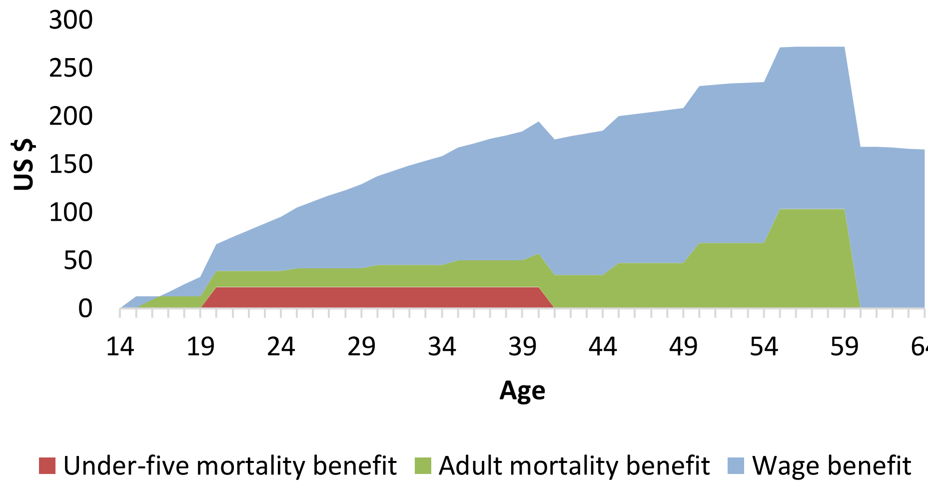
Figure 2 demonstrates that the health benefits accruing from education compare to and at certain ages even exceed earnings benefits in low-income countries. This is particularly true during the early ages of adulthood (20-40), when the benefits of reduced adult and under-five mortality are 19.9% larger than the earnings benefits. The protective benefit of education for reducing under-five mortality is particularly impressive in low-income countries, where under-five mortality rates remain high.

Figure 2: Benefit stream for LICs due to an additional year of schooling



The health-inclusive social rate of return calculations that consider health benefits show that that the returns resulting from lower mortality are high in lower-middle income countries, where the updated social returns with health, at 9.3% (8.4%-10.2%) are 34% (21%-46%) of the standard social rate of return (see Table 6 above, and Figure 3 below).

Figure 3: Benefit stream for LMICs due to an additional year of schooling

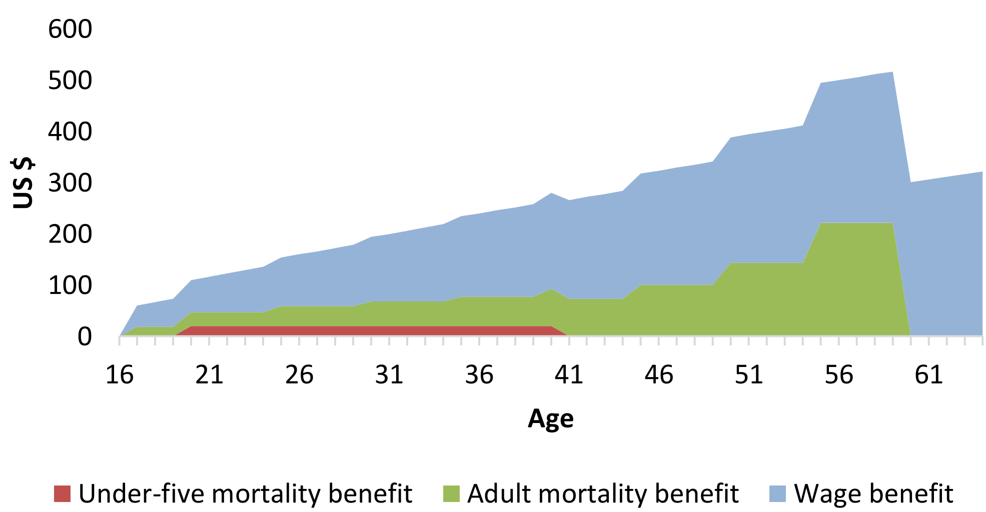


In UMICs, where mortality rates are relatively low, the returns resulting from reductions in under-five mortality are smaller, though returns from reduced adult mortality remain substantial.

In addition to calculating rate of returns for LMICs, we estimate that the standard social rate of return of increasing schooling by a year in UMICs is 3.0% (Table 6 above and Figure 4). The health-inclusive RoR is 4.7% (4.1%-5.3%) which is about 55% (36%-74%) of the returns from earnings.

The health-inclusive rates of return are relatively larger in LMICs as compared to UMICs, because of higher mortality in LMICs. In particular, the returns to under-five mortality are higher in LMICs than in UMICs, where under-five mortality rates are less than half that of LMICs. As shown in Figure 4, the earnings benefits of schooling are higher than the health benefits consistently across all ages in UMICs. In addition, compared to LMICs, the absolute value of health benefits and earnings benefits are higher in UMICs because of differences in GDP and VSL valuations across these two income groups.

Figure 4: Benefit stream for UMICs due to an additional year of schooling



Every dollar invested in female schooling would return $9.9 in low-income and $3.7 in lower-middle income countries in terms of earnings and reductions in under-five and adult mortality.

In addition to the internal rate of return, the returns to education can alternatively be conceptualized in the form of a benefit-cost analysis. Our results suggest that there is an enormous payoff to investing in education when investments are assessed from a health perspective. Every dollar invested in female schooling in low- and lower-middle income countries would return $9.9 and $3.7, respectively, in terms in earnings and reductions in under-five and adult mortality.

For our analysis, we assumed a discount rate of 3%, which is consistent with the discount rate used in other benefit-cost calculations in public health, including the 2013 Lancet Commission on Investing in Health. While benefits exceed costs for all income groups even when taking into account only the earnings effects of education, the additional benefits from health are significant, particularly in low- and lower-middle income countries.

In low-income countries, the health benefits of education represent an impressive 92% increase over the earnings-only benefit-cost ratio, while in lower-middle-income countries health augments the 'traditional' benefit-cost ratio by 44%. Put in other terms, 48% ($4.74) of returns would come from the effect of schooling on mortality in low-income countries, while 31% ($1.12) of the returns to education in lower-middle-income countries result from the effect on adult and under-five mortality. Even in upper-middle-income countries, where lower mortality rates and higher educational attainment might suggest smaller gains, the benefit-cost ratio increases by 47% when health is taken into account, with health gains representing 32% ($0.46) of the health-inclusive benefit-cost ratio.[31]

Table 7: Benefit-cost ratios (BCR) of an additional year of schooling in LICs, LMICs and UMICs

Income Group/ Country	% difference (health-inclusive vs earnings-only)	Health-inclusive BCR	Earnings-only BCR
LIC	92%	$9.89	$5.15
LMIC	44%	$3.65	$2.53
UMIC	47%	$1.45	$0.98
Benefits/costs included	Health Benefits	Yes	No
	Earnings Benefits	Yes	Yes
	Direct Cost	Yes	Yes
	Opportunity cost	Yes	Yes

Discussion

Our study shows that the existing quantitative estimates of the rate of return to education are systematic and quantitatively important underestimates. This finding results from the systematic inclusion of the dollar value of education's favorable effect on health. Although investments in education

[31] Using the example of Chile, Appendix IV demonstrates that the quadratic smoothing used to develop the age-earnings profiles may overestimate the opportunity costs of forgoing schooling at early ages.

are not undertaken specifically to improve health, they produce substantial health returns. In fact, returns from education investments on health are likely to be larger than reported in this study. While, to our very best knowledge, our study is the most comprehensive assessment of the monetized health benefits resulting from education, it underestimates the full effects of education on health. This is the case because it is focused on the impact of education on adult mortality and under-5 mortality. Other health outcomes – most importantly the effects of education on morbidity – are not considered in our study.

Nonetheless, the highly positive benefit-cost ratio that takes into account the health impact of increases in education provides a strong rationale for a much stronger *cross-sectoral collaboration* between the education and health sectors. Donors and countries alike should rethink their strategies, which in many cases still reflect an unduly siloed, inadequately cross-sectoral approach.

4. Conclusions and recommendations

This study shows that although investments in education are not undertaken specifically to improve health, they produce substantial health returns. Returns are particularly high in LICs and LMICs. As such, our evidence also exemplifies that important determinants of health lie outside of the health sector. Addressing these determinants requires *cross-sectoral collaboration* and linkages between education and health. Other research has shown that improved health is also linked to better education.

The need for cross-sectoral work is captured in the SDGs, and certain funders have already started to strengthen the links between the two sectors. For example, the Global Fund to Fight AIDS, Tuberculosis and Malaria has begun to finance education through supporting conditional cash transfers (CCTs) to keep girls in school in four Sub-Saharan-African countries with high HIV prevalence and incidence, with the objective to reduce HIV transmission. The government of Norway has strengthened cross-sectoral linkages through its global health and education "Vision 2030 initiative". Other donors should also rethink their strategies, which in many cases still reflect an overly siloed, insufficiently cross-sectoral approach to both education and health.

Based on our results, we make five recommendations:

- Donors and countries alike should realize that the returns to education are substantially higher than normally understood and should reflect this in their investment decisions.
- The results strongly indicate that female education matters more than male education in terms of achieving health outcomes. Investments should be targeted toward girls' education for a substantial return on health. Increased efforts are needed to close remaining gender gaps.
- Because of the substantial health effects resulting from school attendance, it is important to get children into school, even while waiting for further improvements in quality.
- Policymakers should take into account the importance of the cross-sectoral nature of global development challenges. The highly positive benefit-cost ratio that takes into account the health impact of education provides a compelling rationale for much stronger cross-sectoral collaboration between the education and health sectors. Countries and donors alike should consider implications for financing.

- In addition, our study pointed to specific data gaps, particularly regarding data on the quality of education (test scores). There has been a recent shift in the global dialogue on quality of education in low and middle-income countries, but, at the same time, there remain substantial gaps when it comes to data on the quality of education and learning (among other data and knowledge gaps). These gaps go largely back to the fact that donor investments in global public goods for education are very limited. As such, donors should increase their support for GPGs to allow for better research and progress measurement.

5. References

Baird, S. J. et al. (2012). “Effect of a cash transfer programme for schooling on prevalence of HIV and herpes simplex type 2 in Malawi: a cluster randomised trial”. *The Lancet*. 379: 1320-29.

Behrman, J. A. (2015). “The effect of increased primary schooling on adult women's HIV status in Malawi and Uganda: universal primary education as a natural experiment”. *Social Science & Medicine Journal*. 127: 108-115.

Caldwell, J.C. (1980). “Mass education as a determinant of the timing of fertility decline”. *Population and Development Review.* 6(2): 225-255.

Cropper, M., Hammitt, J.K., Robinson, L.A. (2011). "Valuing mortality risk reductions: progress and challenges". *Annual Review of Resource Economics, Annual Reviews.* 3(1): 313-336.

De Neve, J.-W. et al. (2015). “Length of secondary schooling and risk of HIV infection in Botswana: evidence from a natural experiment”. *The Lancet Global Health*. 3(8): e470-e477.

Feinstein, L. et al. (2006). “What are the effects of education on health?” in: *Measuring the effects of education on health and civic engagement: proceedings of the Copenhagen symposium* (OECD). Accessible online: http://www.oecd.org/edu/innovation-education/37425753.pdf: 171-354.

Filmer, D. & Pritchett, L. (1999). “Child mortality and public spending on health. How does money matter?” *Social Science and Medicine*. 49(10): 1309-23.

Gakidou, E., Cowling, K., Lozano, R., & Murray, CJ. (2010). “Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis”. *The Lancet*. 376(9745): 959-974.

Gupta, N. & Mahy, M. (2003). “Adolescent childbearing in sub-Saharan Africa: Can increased schooling alone raise ages at first birth?” *Demographic Research*. 8(4): 93-106.

Hurt, L.S., Ronsmans, C., & Saha, S. (2004). “Effects of education and other socioeconomic factors on middle age mortality in rural Bangladesh”. *Journal of Epidemiology and Community Health.* 58(4): 315-320.

International Center for Research on Women (2005). “A second look at the role education plays in women’s empowerment.” Accessible from: http://www.icrw.org/files/publications/A-Second-Look-at-the-Role-Education-Plays-in-Womens-Empowerment.pdf: 1-6.

Jamison, E.A., Jamison, D.T., & Hanushek, E.A. (2007). “The effects of education quality on income growth and mortality decline”. *Economics of Education Review*. 26: 772-89.

Jamison, D.T. et al. (2013a). “Global health 2035: a world converging within a generation”. *The Lancet.* 382: 1898-955.

Jamison, D.T. et al. (2013b). “Summary appendix 3” in: “Global health 2035: a world converging within a generation*”. The Lancet.* 382: 1898-955. Accessible from: http://www.thelancet.com/cms/attachment/2010532020/2032648078/mmc3.pdf.

Jamison, D.T. et al. (2013). “Human health: the twentieth-century transformation of human health – its magnitude and value”. *How much have global health problems cost the world?,* Lomborg, B. (eds.): 207-246.

Jamison, D.T., Murphy, S., Sandbu, M. (2016). “Why has under-5 mortality decreased at such different rates in different countries?” *Journal of Health Economics.* 48: 16-25.

Kuruvilla, S. et al. (2014): “Success factors for reducing maternal and child mortality”. *Bulletin of the World Health Organization*. 92: 533–54.

Matsumura, M., & Gubhaju, B., (2001). “Women's status, household structure and the utilization of Maternal Health Services in Nepal ”. *Asia-Pacific Population Journal*. 16(1): 24-44.

Montenegro, C.E., & Patrinos, H.A. (2013). “Returns to schooling around the world” *World Bank Group: background paper for the world development report 2013*: 1-24.

Montenegro, C.E., & Patrinos, H.A. (2014). “Comparable estimates of returns to schooling around the world.” *World Bank Group: policy research working paper.* 7020: 1-39.

Preston, S. H. (2007). “The changing relation between mortality and level of economic development”. *International journal of epidemiology.* 36(3): 484-490.

Preston, S. H. (1975). “The changing relation between mortality and level of economic development”. *Population studies* 29(2): 231-248.

Pritchett, L., Summers, L. (1996): “Wealthier is healthier”. *Journal of Human Resources.* 31/4: 841-868.

Psacharopoulos, G., Montenegro, C.E., and Patrinos, H.A (2016). “Estimating social returns to education: some suggestions.” Briefing prepared for the International Commission on Financing Global Education Opportunity (unpublished).

Rowe, M. et al. (2005). “How does schooling influence maternal health practices? Evidence from Nepal”. *Comparative Education Review*. 49(4): 512-533.

Schäferhoff, M., Evans, D., Burnett, N., Komaromi, P., Kraus, J., Levin, A., Obure, C.D., Pradhan, E., Sutherland, S.C., Suzuki, E., Jamison, D.T. (2015). “Estimating the costs and benefits of education from a health perspective”? Prepared for the Oslo Summit on Education for Development, 6-7 July 2015.

Shkolnikov, V.M. et al. (1998). “Educational level and adult mortality in Russia: an analysis of routine data 1979 to 1994”. *Social Science & Medicine*. 47(3): 357-69.

de Walque, D. et al. (2005). “Changing association between schooling levels and HIV-1 infection over 11 years in a rural population cohort in south-west Uganda”. *Tropical Medicine & International Health*. 10(10): 993-1001.

Wang , J. & Jamison, D.T. (1998). “Regression residuals as performance measures: an assessment of robustness in the context of country-level data. Draft.” Presented at the Annual meeting of the American Research Association, 13-17 April 1998: 1-35.

Wang, H. et al. (2014). “Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013”. *The Lancet*. 384(9947): 957-79.

The World Bank Group (2014). “Voice and agency: empowering women and girls for shared prosperity.” Accessible from: http://www.worldbank.org/content/dam/Worldbank/document/Gender/Voice_and_agency_LOWRES.pdf.

Viscusi, W.K. (2015). "The role of publication selection bias in estimates of the value of a statistical life," *American Journal of Health Economics*. 1(1): 27-52.

Yamano, T., & Jayne, T.S. (2005). “Working-age adult mortality and primary school attendance in rural Kenya”. *Economic Development and Cultural Change*. 53(3): 619-653.

6. Appendixes

Appendix I: Countries included in regression analysis

A. Years of schooling (quantity) analysis

Low-income countries

1. Benin
2. Burundi
3. Cambodia
4. Central African Republic
5. Liberia
6. Malawi
7. Mali
8. Mozambique
9. Nepal
10. Niger
11. Rwanda
12. Sierra Leone
13. Tanzania
14. The Gambia
15. Togo
16. Uganda
17. Zimbabwe

Lower-middle-income countries

1. Armenia
2. Bangladesh
3. Bolivia
4. Cameroon
5. Cote d'Ivoire
6. Egypt
7. El Salvador
8. Ghana
9. Guatemala
10. Honduras
11. India
12. Indonesia
13. Kenya
14. Kyrgyz Republic
15. Laos
16. Lesotho
17. Mauritania
18. Moldova
19. Morocco
20. Pakistan
21. Philippines
22. Republic of the Congo
23. Senegal
24. Sri Lanka
25. Sudan
26. Swaziland
27. Syrian Arab Republic
28. Tajikistan
29. Ukraine
30. Vietnam
31. Yemen
32. Zambia

Upper-middle-income countries

1. Albania
2. Belize
3. Botswana
4. Brazil
5. Bulgaria
6. China
7. Colombia
8. Costa Rica
9. Dominican Republic
10. Ecuador

11. Fiji	12. Gabon
13. Iran	14. Iraq
15. Jamaica	16. Jordan
17. Kazakhstan	18. Malaysia
19. Maldives	20. Mauritius
21. Mexico	22. Mongolia
23. Namibia	24. Panama
25. Paraguay	26. Peru
27. Serbia	28. South Africa
29. Thailand	30. Tunisia
31. Turkey	

B. Quality analysis

Low-income countries

1. Malawi	2. Mali
3. Mozambique	4. Niger
5. Tanzania	6. Togo
7. Uganda	8. Zimbabwe

Lower-middle-income countries

1. Armenia	2. Bangladesh
3. Bolivia	4. Cameroon
5. Egypt, Arab Rep.	6. El Salvador
7. Ghana	8. Guatemala
9. Honduras	10. India
11. Indonesia	12. Kenya
13. Kyrgyz Republic	14. Lesotho
15. Mauritania	16. Moldova
17. Morocco	18. Philippines
19. Senegal	20. Swaziland
21. Syrian Arab Republic	22. Ukraine
23. Yemen, Republic	24. Zambia

Upper-middle-income countries

1. Albania	2. Botswana
3. Brazil	4. Bulgaria
5. China	6. Colombia
7. Costa Rica	8. Dominican Republic
9. Ecuador	10. Iran, Islamic Republic
11. Jordan	12. Kazakhstan
13. Malaysia	14. Mauritius

15. Mexico	16. Namibia
17. Panama	18. Paraguay
19. Peru	20. South Africa
21. Thailand	22. Tunisia
23. Turkey	

High-income countries

1. Argentina	2. Australia
3. Austria	4. Bahrain
5. Belgium	6. Canada
7. Chile	8. Croatia
9. Cyprus	10. Czech Republic
11. Denmark	12. Estonia
13. Finland	14. France
15. Germany	16. Greece
17. Hong Kong	18. Hungary
19. Iceland	20. Ireland
21. Israel	22. Italy
23. Japan	24. Korea, Republic
25. Kuwait	26. Latvia
27. Lithuania	28. Luxembourg
29. Macao	30. Netherlands
31. New Zealand	32. Norway
33. Poland	34. Portugal
35. Qatar	36. Russian Federation
37. Saudi Arabia	38. Singapore
39. Slovak Republic	40. Slovenia
41. Spain	42. Sweden
43. Switzerland	44. Trinidad and Tobago
45. United Kingdom	46. United States
47. Uruguay	48. Venezuela

Appendix II: Descriptive statistics

Table 1: Adult mortality rates – mean (standard deviation)

	1970			2010			1970-2010		
	Female	Male	Both sexes	Female	Male	Both sexes	Female	Male	Both sexes
LIC	395.1 (64.7)	449.4 (63.1)	422.1 (63.0)	278.5 (89.3)	322.5 (81.8)	299.8 (84.2)	354.3 (110.2)	406.0 (110.3)	379.9 (108.8)
LMIC	287.7 (63.0)	344.9 (62.4)	316.6 (58.8)	191.8 (130.9)	265.6 (102.3)	228.6 (113.8)	232.7 (110.5)	302.0 (94.5)	267.5 (99.7)
UMIC	221.9 (74.6)	271.2 (70.9)	246.7 (70.7)	121.7 (76.3)	196.2 (83.5)	159.2 (77.2)	163.7 (86.5)	236.9 (88.6)	200.9 (84.4)
LICs, LMICs, and UMICs	286.5 (95.2)	339.9 (95.2)	313.4 (93.5)	183.0 (118.4)	250.8 (102.3)	216.8 (107.8)	232.6 (124.4)	299.5 (115.2)	266.3 (117.4)

Table 2: Under-five mortality rates and total fertility rates – mean (standard deviation)

	1970		2010		1970-2010	
	U5MR	TFR	U5MR	TFR	U5MR	TFR
LIC	248.1 (55.3)	6.9 (0.7)	90.4 (32.0)	5.0 (1.3)	179.1 (76.4)	6.2 (1.1)
LMIC	172.6 (51.5)	6.5 (0.9)	53.0 (30.7)	3.3 (1.2)	101.2 (55.0)	4.7 (1.7)
UMIC	112.6 (48.6)	5.5 (1.3)	23.6 (12.5)	2.4 (0.7)	56.1 (40.0)	3.6 (1.5)
LICs, LMICs, and UMICs	166.2 (73.1)	6.2 (1.1)	49.6 (35.6)	3.3 (1.4)	100.7 (72.3)	4.6 (1.8)

Table 3: Mean years of schooling (standard deviation)

	1970			2010			1970-2010		
	Female	Male	Both sexes	Female	Male	Both sexes	Female	Male	Both sexes
LIC	0.4 (0.4)	1.3 (0.8)	0.8 (0.5)	2.8 (1.4)	4.5 (1.7)	3.6 (1.5)	1.4 (1.2)	2.9 (1.7)	2.1 (1.4)
LMIC	1.3 (1.1)	2.5 (1.2)	1.9 (1.1)	5.9 (2.9)	7.1 (2.4)	6.4 (2.6)	3.7 (2.8)	5.0 (2.6)	4.3 (2.7)
UMIC	2.8 (1.5)	3.6 (1.5)	3.2 (1.5)	8.2 (1.8)	8.7 (1.6)	8.4 (1.7)	5.5 (2.5)	6.2 (2.3)	5.8 (2.4)
LICs, LMICs, and UMICs	1.7 (1.5)	2.7 (1.5)	2.2 (1.5)	6.1 (3.0)	7.1 (2.5)	6.6 (2.7)	3.9 (2.9)	5.0 (2.6)	4.4 (2.7)

Table 4: Mean real GDP per capita (standard deviation)

	1970	2010	1970-2010
LIC	$1166 ($467)	$1323 ($841)	$1117 ($672)
LMIC	$1701 ($811)	$3389 ($1467)	$2335 ($1298)
UMIC	$3457 ($1671)	$9822 ($3778)	$5993 ($3112)
LICs, LMICs, and UMICs	$2282 ($1539)	$5442 ($4393)	$3505 ($2965)

Table 5: Mean years of female schooling and test scores (standard deviation)[32]

	1970-2010
Female Schooling	8.01 (3.03)
Test scores	46.11 (9.76)

[32] For countries included in quality regression analysis.

Appendix III: Technical appendix – hierarchical linear model

Hierarchical linear models, also known as multilevel models, are a complex version of an Ordinary Least Squares model, and assume the data is grouped by hierarchical levels and that variance is shared in the levels of aggregation of the data. Because of this assumption, hierarchical linear models allow for the simultaneous study of the relationship that observations have within a same level, as well as the relationship they have across levels. To achieve this outcome, two models need to be developed: one that reflects the relationship within lower level units, and one that describes how the lower level observations vary between units.

Formally, a two-level model is represented as:

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_{ij} + r_{ij}$$

where: Y_{ij} is the dependent variable measured in the first level, i, nested in the second level, j; X_{ij} is the independent variable in the first level, i; β_{0j} is the intercept for the second level, j; and r_{ij} is the random error associated for level i, within level j.

To estimate β_{0j} and β_{1i}, the following equations are used:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}G_i + U_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}G_j + U_{1j}$$

where: β_{0j} is the intercept for the jth, second level unit ;β_{1j} is the slope for the jth, second level unit;G_j is the second level independent variable;γ_{00} and γ_{10} are the overall mean intercept for G ; γ_{01} is the coefficient associated with G relative to the first level intercept, while γ_{11} is the coefficient associated with G relative to the first level slope; similarly, U_{0j} explains the random effects of the second level jth unit adjusted for G on the intercept and U_{1j}does the same for the slope.

The last two coefficients, U_{0j} and U_{1j}, are regarded as the additions HLM provide compared to standard linear models. When expressed in the reduced form:

$$Y_{ij} = \gamma_{00} + \gamma_{10}X_{ij} + \gamma_{01}G_j + \gamma_{11}G_jX_{ij} + U_{1j}X_{ij} + U_{0j} + r_{ij}$$

It is clear how the HLM can be considered as an improvement because errors are no longer independent across level-1 units. This is, U_{0j} and U_{1j} represent the dependency that first level observations have inside of every second level grouping.

Intuitively, the hierarchical model allows for an errors and intercepts to change depending on the group the observations belong to in the second level. Hence, the assumption is that the random coefficients presented in the equations above do not depend on the fixed independent variables.

Appendix IV: Incorporating education's effect on mortality into IRRs

Introduction

This Appendix deals with the addition of the estimated coefficients generated by empirical work (as well as estimates on the value of changes in mortality) into the Internal Rate of Return of education analysis. Pradhan et al. (2016) estimated the effect of one additional year of education on under-5 mortality (C_5), on the adult female mortality (C_F), and on adult male mortality (C_M). The techniques most appropriate differ between under-five and adult mortality, but in both cases they involve assigning to different women's ages four separate numbers with having one additional year of education: value of changed earnings, value of changed under-five mortality rates, value of change adult female and male mortality rates. This section describes our approach to valuation of changes in mortality rates.

A. Example of health valuation of an additional year of schooling

Value of Changes in the Under-5 Mortality Rate

Here we consider a cohort of 1000 females receiving one additional year of schooling in a country (province) where the income per capita is y, the TFR is f and the under-5 mortality is q_5. We also need the value of an under-five death averted.

Following the (current) methods used by the Lancet Commission on investing in health, we value an under-five death averted at 50% of an adult death averted and we value adult deaths averted (the so called VSL) as $80y\ to\ 180y\ as\ a\ range$.

Over the lifetime of these 1000 women if current fertility rates prevail, they will have $1000f$ children, out of whom $1000 \cdot f \cdot q_5$ will die before their 5th birthday. As an example, if $f = 3$ and $q_5 = 0.05$ (50 in a thousand), there will be 3000 children born of whom 150 will die. The reduction in the number of under-5 deaths would be, if all the women had 1 additional year of education, $1000 \cdot f \cdot q_5\ = 150c_5$. If in turn $c_5 = 0.04$, then the reduction in number of deaths will be 6. The value of this reduction will be: $0.5 \cdot\ VSL \cdot 6$.

Continuing with the example, if the country is lower middle income, with a GDP_{pc} of $2,000 per year, the $VSL, using\ VSL\ multiplier\ of\ 100$, is $200,000, and the VSL_{Child} =$100,000. The value of averting the 6 child deaths is $600,000, or $600 per woman. It is reasonable (if somewhat arbitrary) to divide this evenly across the 20 years following the completion of the year of schooling, say at the age of 15. Let the value of changed under-five mortality rates at the woman's age a denoted by $VCCM(a)$. In this example:

$$VCCM(a) = \begin{cases} 30 \text{ for } 15 < a \leq 35 \\ 0 \text{ for } a > 35 \end{cases}$$

Value of Changes in the Adult Mortality Rate

The coefficients C_F and C_M of female education on adult female and adult male mortality rates differ from each but the methods for calculating value is the same. This appendix therefore discusses only changes in adult mortality rates. By 'Adult Mortality Rate' we mean ${}_{45}q_{15}$, i.e., the probability that a person age 15 will die in the 45 years after their 15th birthday, i.e. when they are 60. We also use the notation AFM for ${}_{45}q_{15}$ for females and AMM for males.

$AFM \cdot C_f$ will be the reduction in the number of deaths associated with one year of education. Again, if AFM starts at 100 per thousand and if $C_F = 0.02$ the there would be a reduction of 2 in the number of deaths in the cohort over 45 years. Analogously to how we assessed the value of reduction in under-five mortality rates we could first value that reduction (using the same country context as before):

$$Value\ of\ 2\ deaths\ averted\ =\ 2 \cdot \$200{,}000$$

$$=\ \$400{,}000 \Rightarrow \frac{\$400}{women}$$

Spreading this uniformly over 45 years gives \$9 per woman per year. This is

$$VCAFM(a) = \$9, 15 < a \leq 60$$

This procedure, however, would bias the estimated IRR upward since most of the reduction in mortality rates will occur in older years where the absolute levels of mortality are higher. We can use either an approximate or an exact mechanism to adjust.

The more exact approach requires changing the death rates at each age based on the country's life table and initial value of AFM. Let $m(a)$ be the age specific mortality rate at age in the country life table. $s(a)$, the survival rate, is defined as s(a)=1-m(a) ($m(a) = {}_1q_a$).

Now if we start with 100 people age 15, there will be $1000 \cdot\ s(15)$ at age 16, and $1000 \cdot\ s(15) \cdot s(16)$ left at age 17, etc. The number of surviving at age 60 will be $S = 1000 \cdot \prod_{a=15}^{59} s(a)$. In this sense, $1000 - S$ is the number who died which equals AFM expressed per 1000. Let $\Delta\, AFM$ equal the change in AFM from a year of female education. This is, $\Delta\ AFM\ = C_f\ AFM$. Then, $\Delta\ S\ =\ -\Delta\ AFM$. Assume we reduce mortality rates at all ages by multiplying by α, $0 < \alpha < 1$. This will give us a new value of S, $S(\alpha)$, where $S(\alpha) > S$.

$$S(\alpha) = \prod_{i=15}^{59} 1 - \alpha \cdot m(i)$$

Now we have to choose α^* such that

$$S(\alpha^*) - S = -\Delta\ AFM$$

We now have values for $\Delta\ m(a)$

$$\Delta\ m(a)\ =\ m(a) - \alpha\ m(a)$$

$$=\ m(a)(1-\alpha)$$

Where α is probably on the order of 10^{-3}

Then, instead of equation (3) we have

$$VCAFM(a) = m(a)(1-\alpha)VSL$$

for when $15 < a \leq 60$.

For example, let $m(a) \approx 10^{-2}$, then

$$VCAFM(a) \approx 10^{-2} \cdot 10^{-3} \cdot 2 \cdot 10^{5} \approx 2$$

Mechanical Solution for $\boldsymbol{\alpha}^*$

To solve mechanically for α^* we proceed to use a simple maximization tool. Following the formula above, we choose a value for α close to the value of α^* and then minimize the difference between the two sides of the equation. On one side, we use data from the World Population Prospects, 2015, to determine the probability to die at age t, ${}_5q_t$, for $t = 15, 20, 25, 30, 35, 40, 45, 50, 55$). We then multiply for this value by our target $(1-\alpha)$ and subtract that from 1. The product of all these values across t is the right hand side of the solution.

The left hand side is $1-(1-\beta) \cdot M$, where β is the estimated coefficient from the empirical research, and M is the probability of a 15 year old surviving up to age 60 conditional on survival until age 15.

B. Calculating Health-inclusive Internal Rate of Return and Benefit Cost Ratio

The following section lays out the exact method used for calculating health-inclusive internal rate of return and Benefit Cost Ratio. We first consider the health benefits, followed by the earnings benefits, then the direct and opportunity costs of schooling. The health-inclusive social rate of return and benefit cost ratio consider all these benefit and cost streams whereas the standard social rate of return / earnings-only benefit cost ratio consider both direct and opportunity costs of schooling but only the earnings benefits.

1. Under five Mortality Benefit

$$b_2(a) = Benefit\ of\ increased\ schooling\ on\ under\ five\ mortality\ at\ age\ (a)$$

$$b_2(a) = \frac{gr * TFR * U5MR * \beta_{U5MR} * VSLm * GDP\ per\ capita}{2 * (40 - 20 + 1) * 1000}$$

Where,

$gr = Ratio\ of\ girls\ to\ boys\ attending\ one\ more\ year\ of\ school$

$TFR = Total\ Fertility\ Rate\ at\ base\ year$

$U5MR = Under\ five\ mortality\ rate\ at\ base\ year$

$\beta_{U5MR} = \text{Proportion reduction in U5MR because of one additional year of female schooling}$

$\text{VSLm} = \text{VSL multiplier} = [80,180]$

$$b_2 = \sum_{a=20}^{40} b_2(a)$$

2. Adult Male Mortality Benefit

$$b_3(a) = benefit\ of\ increaed\ schooling\ on\ adult\ male\ (m)\ mortality\ at\ age\ (a)$$

$$b_3(a) = \frac{gr * {}_5q_{a,m} * \beta_m * VSLm * GDP\ per\ capita}{5 * 1000}$$

Where,

$gr = Ratio\ of\ girls\ to\ boys\ attending\ one\ more\ year\ of\ school$

${}_5q_{a,m} = Male\ age - specific\ adult\ mortlality\ between\ age\ (a, a+5)$

$\beta_m = Proportion\ reduction\ in\ {}_5q_{a,m}\ because\ of\ one\ additional\ year\ of\ female\ schooling$

$\text{VSLm} = \text{VSL multiplier} = [80{,}180]$

$$b_3 = \sum_{a=15}^{60} b_3(a)$$

3. Adult Female Mortality Benefit

$$b_4(a) = social\ benefit\ of\ increaed\ schooling\ on\ adult\ female\ \ (f)\ mortality\ at\ age\ (a)$$

$$b_4(a) = \frac{gr * {}_5q_{a,f} * \beta_f * VSLm * GDP\ per\ capita}{5 * 1000}$$

Where,

$gr = Ratio\ of\ girls\ to\ boys\ attending\ one\ more\ year\ of\ school$

${}_5q_{a,f} = Female\ age - specific\ adult\ mortlality\ between\ age\ (a, a+5)$

$\beta_f = Proportion\ reduction\ in\ {}_5q_{a,f}\ because\ of\ one\ additional\ year\ of\ female\ schooling$

$\text{VSLm} = \text{VSL multiplier} = [80{,}180]$

$$b_4 = \sum_{a=15}^{60} b_4(a)$$

4. Earnings Benefit

$$b_5 = earnings\ benefit\ of\ increased\ schooling\ at\ age\ (a)$$

$$b_5(a) = \frac{ws(a) - wp(a)}{\#\ of\ years\ of\ secondary\ schooling}$$

$where,$

$ws(a) = Earnings\ of\ a\ secondary\ school\ graduate\ at\ age\ (a)$

$wp(a) = Earnings\ of\ a\ primary\ school\ graduate\ at\ age\ (a)$

5. **Direct Cost**

$$c_1 = Direct\ cost\ of\ one\ year\ of\ schooling$$

$$if\ a_p = Theoretical\ age\ of\ start\ of\ primary\ schooling, and\ s = Mean\ years\ of\ schooling\ at\ base\ year,$$
$$A = Age\ of\ attending\ one\ additional\ year\ of\ school = s + a_p + 1$$

$$c_1(a) = \begin{matrix} c_1 & if\ a = A \\ 0 & elsewhere \end{matrix}$$

6. **Opportunity Cost**

$$c_2 = Opportunity\ cost\ of\ attending\ one\ additional\ year\ of\ schooling.$$

$$if\ a_p = Theoretical\ age\ of\ start\ of\ primary\ schooling, and\ s = Mean\ years\ of\ schooling\ at\ base\ year,$$
$$A = Age\ of\ attending\ one\ additional\ year\ of\ school = s + a_p + 1$$

$$c_2(a) = \begin{matrix} c_2 & if\ a = A \\ 0 & elsewhere \end{matrix}$$

7. **INTERNAL RATE OF RETURN (r):**

The health-inclusive RoR (r_h), hRoR is simply that value of r_h such that $hPVNR(r_h)$= 0.

$$hPVNR(r_h) = \sum_{a=A}^{65} \frac{wv(a) + hv(a) - c_1(a) - c_2(a)}{(1 + r_h)^{a-A}}$$
$$Here, hv(a) = b_2(a) + b_3(a) + b_4(a),$$
$$wv(a) = b_5(a)$$

Hence, the health-inclusive rate of return is the value of r_h such that equation below holds true.

$$0 = \sum_{a=A}^{65} \left(\sum_{i=1}^{5} b_i(a) - \sum_{j=1}^{2} c_j(a) \right) * (1 + r_h)^{-a}$$

8. **BENEFIT COST RATIO:**

The health-inclusive benefit cost ratio is the ratio of costs and benefits discounted at an annual discount rate r. Hence, for each r (which in our estimation ranges from 1% to 5%), $BCR_{he}(r)$ is estimated as follows:

$$\mathrm{BCR_{he}(r)} \;=\; \frac{\sum_{j=2}^{5}\sum_{i=A}^{64} b_j(i) * (1-r)^{i-A}}{\sum_{j=1}^{2}\sum_{i=A}^{64} c_j(i) * (1-r)^{i-A}}$$

And, the earnings only BCR is simply:

$$\mathrm{BCR_{e}(r)} \;=\; \frac{\sum_{i=A}^{64} b_5(i) * (1-r)^{i-A}}{\sum_{j=1}^{2}\sum_{i=A}^{64} c_j(i) * (1-r)^{i-A}}$$

C. Annual Age Earnings Profile for Chile

The figures below show the annual age earnings profile for Chile for Primary school graduate and secondary school graduate. The overall fit of the quadratic form is about 70%, but the fit is poorer for younger ages. The quadratic fit may overestimate the earnings at younger ages, and hence the opportunity costs.

Figure 1: Age earnings profile for Chile: primary level

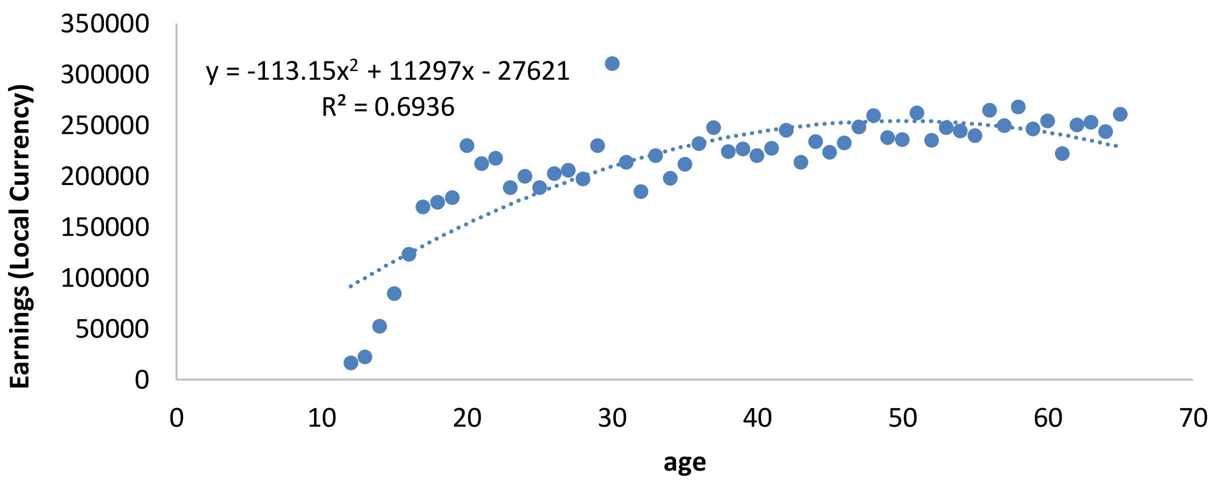
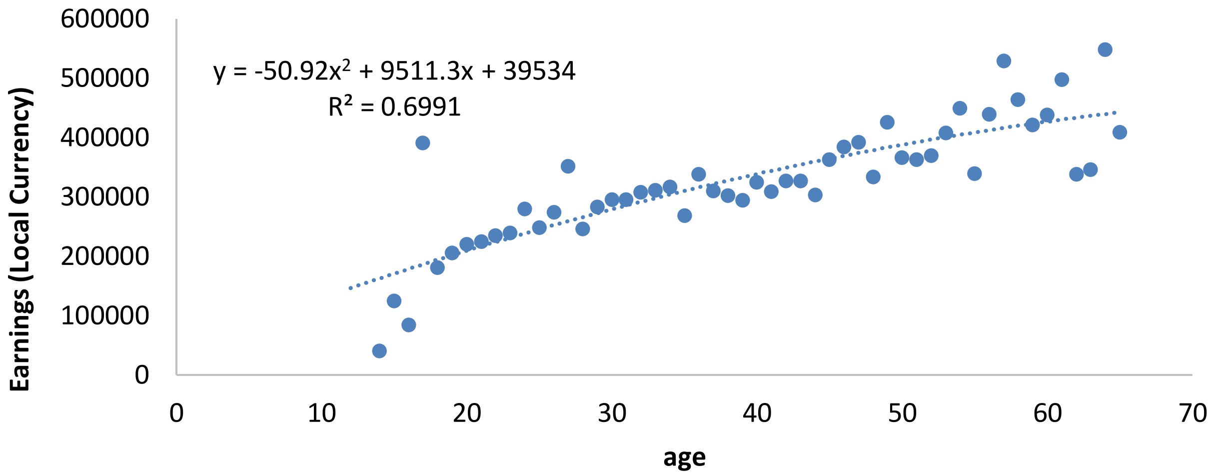


Figure 2: Age earnings profile for Chile: secondary level



Appendix V: Cost of education by level

The table below includes the estimated average (unweighted) per pupil costs by income group (YR2012, in 2012 US$). These cost estimates were provided by the Commission and were also used by Psacharopoulos, Patrinos and Montenegro (2016).

Table 1: Direct per-pupil costs of schooling (unweighted), 2012

	Low income	Lower middle income	Upper middle income
Primary	$68	$234	$1276
Lower secondary	$135	$299	$1415
Upper secondary	$303	$431	$1,293

As described in Appendix 4, we used the following direct costs in our IRR and BCR analysis: For LICs we used the costs for primary education; for LMICs we used the cost for lower secondary education; and for UMICs we used the mean of lower and upper secondary education. The level of schooling used for cost estimates was based on the income group's mean years of schooling. Both the mean and mean+1 years of schooling for LICs are primary school; both the mean and mean +1 years of schooling in LMICs are lower secondary; while in UMICs, the mean is lower secondary and mean +1 year of schooling is upper secondary level.

We calculated the opportunity cost of attending an additional year of school by averaging the opportunity cost (the earnings differential between the level of schooling at mean +1 year and one level below it) at each age in a given level of attendance. Thus, the opportunity cost for LICs was calculated by averaging the earnings differential between primary and no schooling attainment for children aged 6-11, while the opportunity cost for LMICs and UMICs was calculated by averaging the earnings differential between secondary and primary attainment for children ages 12-17. Data on earnings differentials, aggregating by income groups, was obtained from Psacharopoulos, Patrinos, and Montenegro (2016).

Table 2: Direct and opportunity cost of one additional year of schooling above the income-group mean (per pupil)

	Direct Cost	Opportunity Cost
LICs	$68	$54
LMICs	$299	$617
UMICs	$1354	$2522

the
Education
Commission

The International
Commission
on Financing Global
Education Opportunity

educationcommission.org