# Investing in Maternal, Newborn and Child Health: Analysis of the Costs, Benefits and Returns

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# Executive Summary

This study investigates in a preliminary way the costs and benefits of large scale investment in health innovation in relation to reproductive, maternal, newborn and child health (RMNCH), for six economies which are members of APEC: China, Indonesia, Papua New Guinea, Peru, the Philippines and Vietnam. The project is a collaborative one between the World Health Organization (WHO) and the Centre for Strategic Economic Studies at Victoria University, Melbourne (CSES). In terms of the collaboration, WHO's Department of Health Systems Financing has provided the specification and costing of the suite of interventions to improve RMNCH in the selected economies, and the estimation the number of maternal and child deaths saved over 2013-15 as a result of these interventions. CSES has developed the assessment of the implications of the interventions in terms of reduced maternal and child morbidity, as well as the modelling framework for assessing the benefits of improved health outcomes and for calculating cost/benefit ratios and rates of return.

The interventions specified and modeled by WHO are of substantial scale. Estimated additional costs to be invested over the three years exceeds US$2.4 billion, and the interventions save the lives of just on 100,000 of mothers and children over this period, at an average cost per life saved (including both mothers and children) of about $24,300. While the main variable modeled in the WHO analysis is lives saved, such a large scale investment in better maternal and child health care will have many other health benefits in terms of the reduction in morbidity arising from adverse events during pregnancy and early childhood. In spite of the scale of intervention the total population of the six economies is so large that the cost over the three year period amounts to only $1.27 per capita (weighted average summed for three years).

To assess the full benefits of the intervention, the reduction in the ongoing burden of morbidity and mortality borne by many mothers and children as a result of maternal and early childhood events needs to be examined further. We concentrate in this report on two other effects: the morbidity beyond the initial period averted by the interventions in that period and the lower long-term incidence of non-communicable diseases (NCDs) as a result of the interventions. The former (the 'consequential effects') are the direct and ongoing health impacts, for both mothers and children, of adverse events occurring during the antenatal and postnatal stage. For women, they are sometimes referred to as postpartum maternal morbidities. The latter (the 'long-term health effects') are the long-term health impacts of these events, for both mother and child, and particularly the increased incidence of NCDs in later life to which these adverse events can give rise. Together with lives saved, these two aspects of the improved health outcomes comprise the base from which the economic and social benefits are assessed.

The next stage of this study is to provide an initial estimate of economic and social benefits of the various improved health outcomes arising from the interventions: reduced maternal and child deaths, reduced chronic morbidity for both mothers and children and lower incidence of NCDs later in life. In a preferred methodology three types of benefits – economic benefits in the form of higher GDP arising from increased labour force participation and productivity; other social benefits arising from the social value of life and from, for example, the non-economic role which mothers play in families and broader

communities; and the financial benefits arising from lower health costs and higher taxation revenues – would be studied. While the last two forms of benefit are important and need to be pursued it has not been possible to include them in this study. This focus only on the economic benefits is recognised as a major limitation. Thus, for example, the only benefit included from a child's life being saved is the value of future output generated when the child enters the labour force at age 20. No social value arising from the child's first twenty years of life is included. In addition we do not include here the dynamic effects of improved health: that is, the likelihood that more healthy communities give rise to self-reinforcing patterns of investment in physical and human capital, generating higher rates of economic growth.

The key cost/benefit results are summarised in the table below. While the total additional cost of the interventions over 2013-15 is estimated at $2,412 million, the net present value (at a 3% real discount rate) of the benefits covered here is $73,255 million, or 30.4 times the cost of the interventions. The calculated internal rate of return is 17.0%, although this is a less reliable measure for such long term investments. By any standards a benefit/cost ratio of about 30 is a sign of a very high return investment. The sensitivity of the results to the discount rate is also demonstrated, with both the net present value of the benefits and the benefit/cost ratio falling by about half if a 5% real discount rate is used. By contrast the net present value of the benefits rises to over $100 billion at a 2% real discount rate, and the cost/benefit ratio to over 40.

**Summary of Key Results of Cost Benefit Analysis**

| Measure | Estimated value |
|---|---|
| Total additional cost of interventions, 2013-2015 (US$m) | 2412 |
| Net present value of benefits, @ 3% discount rate (US$m) | 73255 |
| Benefit/cost ratio (3% discount rate) | 30.4 |
| Net present value of benefits, @ 5% discount rate (US$m) | 34083 |
| Benefit/cost ratio (5% discount rate) | 14.1 |
| Internal rate of return | 17.0% |

It must be stressed that these are very preliminary estimates, from the viewpoint of both of the collaborating parties. While changes to the methodology and more refined assumptions could vary the results significantly, not all of the potential benefits have been modeled in this study and in many respects the assumptions we have used are conservative. For example, we have not included any social value for the life of a mother or child saved or for morbidity avoided other than that expressed through future labour force participation. If we were to include a social value of a life saved equal to 50% of annual GDP per capita and a social value of a year of chronic morbidity avoided at 20% of per capita GDP the net present value of the total benefits shown in the table (at a 3% discount rate) would increase by about 60%.

The implications of better maternal and child health explored here are so profound that it is likely that any reasonable variation of these assumptions will show high returns. That is, they would show that effective investments in RMNCH are among the best investments that any society can make.

# Introduction

It is beyond doubt that the health of mothers and children is vital to society and to the economy. How healthy women are when they embark on pregnancy, and during pregnancy, will be vital for the future health and development of the child, as will the conditions in which the child lives in the early years of life. The mother's health during pregnancy can also heavily influence her own future health, and hence her ability to be able to look after her family and to contribute to the broader community. What could be a better investment than in effective programs to improve the health of mothers and children? Yet around the world large numbers of mothers and children still die or live in poor health in large numbers. If action to avoid this is such a good investment, as well as being a moral imperative, why is the level of action insufficient to achieve much better outcomes?

In this project we address one part of this puzzle, by looking in some detail at interventions in maternal, newborn and child health (RMNCH) as an economic and social investment. How good are they really? What estimates can we make of the returns to these investments? Can a better understanding of those returns provide stronger incentives to governments and their finance ministries, as well as to the private sector, to undertake greater investment in RMNCH? The collaborating partners in this study are the World Health Organization (WHO) and the Centre for Strategic Economic Studies (CSES) at Victoria University, Melbourne, and it builds on previous work by the partners.

In 2009, WHO published, in conjunction with a range of agencies, an important document entitled *Investing in Maternal, Newborn and Child Health: The Case for Asia and the Pacific*. The central argument was that:

- the 'business-as-usual' approach to maternal and child health was failing many mothers and children around the world, including in the Asia Pacific region, and urgent action was needed to achieve the Millennium Development Goals 4 and 5;
- the situation could be greatly improved through proven, cost-effective innovations; and
- additional investment of US$3 per capita in 15 countries in Asia and the Pacific would make a significant contribution to achieving MDG 4 and 5 but that a larger investment (of US$10 per capita) would be required to achieve those goals for this region.

While this statement defined a number of 'best buy' intervention packages, provided specific estimates of their implementation costs and stressed the magnitude of the benefits to be achieved, it did not seek to quantify these benefits in detail. As a result it did not provide a quantitative assessment of the economic and social returns to the proposed investment in maternal, newborn and child health. This study begins the process of filling that gap.

In recent years, the APEC Life Sciences Innovation Forum (LSIF) – in conjunction with CSES and other partners – has given considerable attention to understanding spending on health innovation as an investment in development. In particular, it has undertaken modelling work to begin to measure the costs and benefits of defined programs of investment in health innovation, and hence to estimate the

rate of return to such investment. An initial study for the developing countries of APEC as a whole, undertaken in 2008 and addressing chronic diseases, found evidence of strong returns to such investments, with benefits up to 15 times costs. This study used unpublished data provided by WHO on projections of the burden of disease for these countries (consistent with Mathers and Loncar 2006), and the data on the cost of innovations per DALY assembled in the 2006 World Bank/WHO/NIH study (Jamieson et al. 2006). Further work to develop the analysis has been carried out since 2008.

This study investigates in some detail the costs and benefits of large scale investment in health innovation in relation to maternal, newborn and child health, for six economies which are members of APEC: China, Indonesia, Papua New Guinea, Peru the Philippines and Vietnam. In terms of the collaboration, WHO has provided the specification and costing of the suite of interventions to improve RMNCH, and the estimation the number of maternal and child deaths saved over 2013-15 as a result of scaling up these interventions. CSES has developed the assessment of the implications of the intervention coverage scale-up in terms of reduced maternal and child morbidity, as well as the modelling framework for assessing the benefits of improved health outcomes and for calculating cost/benefit ratios and rates of return. It is important to stress that this is a preliminary study and the results should be interpreted as indicative only.

## The Health of Mothers and Children: Some Specific Features

In embarking on this study it is necessary to recognise clearly the specific characteristics of mothers and children, which go beyond their situation as individuals. First, mothers play a pivotal role in families and in wider communities, as well as in the workforce, and there is extensive evidence that maternal morbidity and mortality has powerful effects on the welfare of children and other family members (e.g. Reed et al. 2000; Ronsmans 2010; Atrash 2011). These strong 'external' effects, going well beyond the individual welfare and direct economic contribution of the mother, need to be fully incorporated into the assessment of benefits. For example, Ronsmans et al. (2010) showed that, in a large sample from Bangladesh over 1982-2005, the cumulative probability of surviving to age 10 was 24% for children who have lost their mother, compared to 89% for children whose mothers were still alive at their $10^{th}$ birthday, while the impact on survival rates of the loss of the father was negligible. Another example is the well-documented role of women in local economic development, often through managing small businesses, in some cases with the use of micro-finance. Maternal mortality and/or morbidity are likely to reduce opportunities for growth of such businesses, limiting the growth of the local region.

Secondly, health and development in early childhood are known to have serious consequences for adult health and human capital, on the basis of both scientific studies of the early development process (e.g. Shonkoff et al. 2012) and of empirical studies of actual data sets (e.g. Victora et al. 2008). For example, Victora et al. (2008) found, from an analysis of cohort studies from five developing countries, that poor health due to under-nutrition was strongly associated with shorter adult height, less schooling, reduced economic productivity and – for women – lower offspring birth weight. Again, the channels through which early childhood morbidity influences economic, social and health outcomes in later life are diverse and complex, and require careful documentation.

Thirdly, there is growing evidence that the health status of the mother (even antenatal) and of the young child are important for the child's propensity to suffer from chronic diseases – such as diabetes, cardiovascular disease and cancer – later in life. Part of this link is due to infections (e.g. the link between TB and diabetes and the fact that up to one third of cancers may result from infections). But more complex mechanisms are being explored in the relatively new science of epigenetics, the study of how environmental factors like diet, stress and maternal nutrition can change gene function without altering the DNA sequence in any way. Important scientific progress has recently been announced, through the ENCODE Project (The ENCODE Project Consortium 2012), which has identified at least four million gene switches which play critical roles in controlling how cells, organs and other tissues behave. The impact of environmental factors on these switches may provide an important mechanism by which the child's (and the mother's) experiences around the birth period affect their propensity for chronic disease later in life. This link between RMNCH and increased propensity for chronic diseases later in life needs to be taken into account as far as is possible given the current state of knowledge.

Full consideration of these and other factors are necessary in a full analysis of the returns to investment in RMNCH. In this preliminary study it is only possible to take account of some of them.

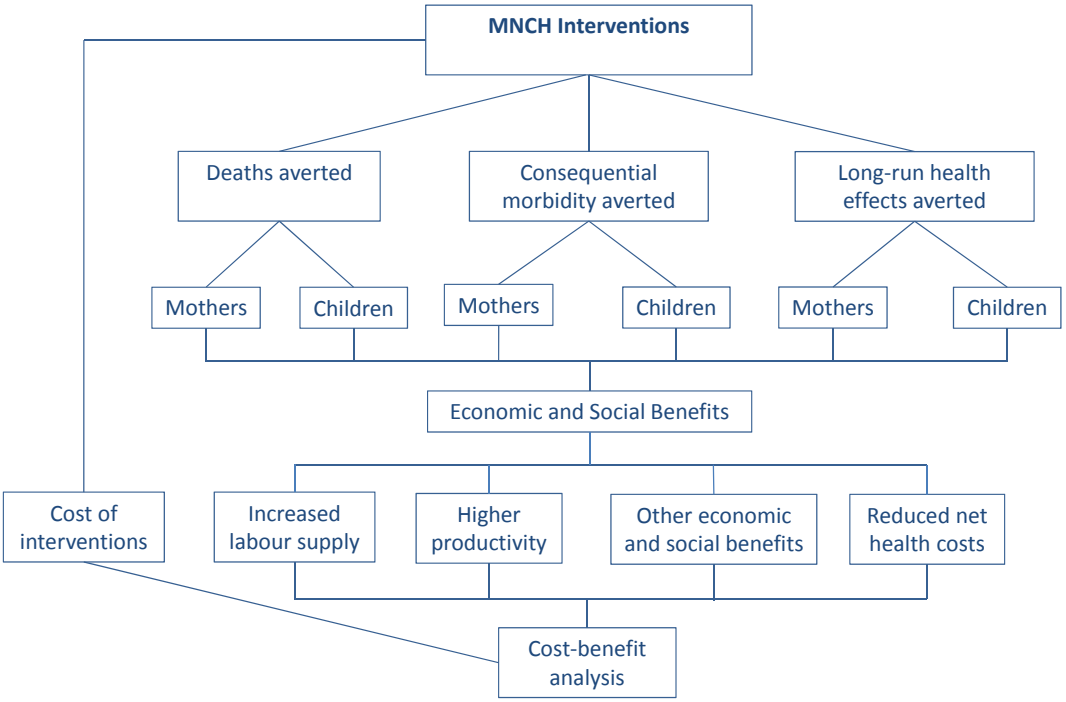
## Project Methodology: Model Framework

The basic structure of the approach is summarised in Figure 1. There are four main components of the study, which are described in the next four sections of this report.

The first involves the specification of the intervention package to be studied, with a designated set of health innovations, the estimation of the maternal and child deaths averted over a defined time period as a result of these interventions and the estimation of the full costs of the interventions. The top box in Figure 1 covers the specification and costing of the intervention package, and this component includes the deaths averted for both mothers and children. The interventions are modelled as taking place in 2012, with the impacts occurring over 2013-15. Thus the deaths averted here are for those three years.

The second component starts from the fact that the immediate deaths averted are only part of the health impact of the interventions, which will also reduce substantially the ongoing burden of morbidity and mortality borne by many mothers and children as a result of maternal and early childhood events. Thus in this component of the study an attempt is made to quantify both the consequential and the long-terms health impacts of the interventions. We concentrate on two other effects, as shown in Figure 2: the morbidity beyond the initial period averted by the interventions in that period and the lower long-term incidence of non-communicable diseases (NCDs) as a result of the interventions. The former (the 'consequential effects') are the direct and ongoing health impacts, for both mothers and children, of adverse events occurring during the antenatal and postnatal stage. For women, they are sometimes referred to as postpartum maternal morbidities. The latter (the 'long-term health effects') are the long-term health impacts of these events, for both mother and child, and particularly the increased incidence of NCDs in later life to which these adverse events can give rise. All three aspects of the improved health outcomes comprise the base from which the economic and social benefits will be assessed.

Figure 1. Summary of Project Methodology




The third component is an assessment of the economic and social benefits derived from all of these improved health outcomes and the valuation of those benefits. This study focuses mainly on the implications of deaths and morbidity averted on labour supply, productivity and GDP. In further work it would be appropriate to examine further other economic and social benefits, as well as the reduction in net health costs incurred as a result of improved health outcomes.

The final component brings together the estimated cost of the interventions and the estimated benefits accruing, to provide an analysis of benefits relative to costs. Two methods are used here – a comparison of the net present value of the benefits (for a given discount rate) with the total costs, to give a benefit/cost ratio, and an estimate of the internal rate of return to the investment in the intervention package.

## The Interventions: Specification, Direct Impact and Cost

In their 2009 study (WHO 2009), the authors identified three core packages of interventions to improve RMNCH in the Asia-Pacific region – a core package, an expanded package and a comprehensive package. The outcomes from these packages were outlined in broad terms, through the extent to which they contributed to the achievement of relevant Millennium Development Goals. The additional investment required to implement these packages were also quantified, in terms of additional cost per capita, with reference to more specific estimates contained in WHO 2008. These estimates drew on the wider WHO-

CHOICE estimates (e.g. Adam et al. 2005; Edejer et al. 2005) and subsequent modelling work. Subsequent work was carried out to estimate the costs and impact of scaling up a key set of interventions in 49 low-income countries. The current set of interventions modelled here and the estimates of their effectiveness and cost draw on and apply this earlier work to the specific case in hand. Some of the key features of the interventions and estimates, and the assumptions used in generating them, are outlined in the paragraphs below.

1. Estimates are produced for a set of economies that are selected based on specific criteria: (a) APEC membership and (b) countdown economies (i.e., those with a high RMNCH burden). Six economies are therefore included: China, Indonesia, Papua New Guinea, Peru, the Philippines and Viet Nam.

2. A set of RMNCH interventions with high effectiveness is scaled up. The list of interventions is consistent with what was scaled up for the High Level Taskforce on Innovative Financing (2009)[1] and the estimates produced for the UNSG Global Strategy.[2]

3. The analysis on cost and impact is carried out using the OneHealth tool,[3] which incorporates epidemiological models for predicting health impact, such as FamPlan and the Lives Saved (LiST) tool. Outputs from the OneHealth tool are combined with WHO-CHOICE price data on inpatient day cost and outpatient visit costs.

4. Baseline coverage for the scale-up trajectories is set for 2012 (current year). The OneHealth tool includes default baseline coverage for most interventions, from 2010 or earlier. For this analysis it is assumed that OneHealth default baseline coverage data indicates coverage in 2012. When no baseline data are available in OneHealth for an intervention, the following procedures apply: (a) for maternity care, World Health Statistics (WHS) 2011[4] data on coverage of skilled birth attendants is used as proxy for baseline coverage; (b) for some interventions, the baseline of another, similar, intervention is used as a proxy when it can be assumed that conditions for delivery are similar (e.g., newborn sepsis - full supportive care, and newborn sepsis - injectable antibiotics), and (c) for most interventions when no other data are available a zero coverage at baseline is assumed.

5. Scale-up trajectory: We do not have access to actual coverage targets from economies. Coverage is therefore assumed to be scaled up during 3 years: 2013-2015. Targets in 2015 are set such that economies incrementally see a relative increase of 20% for most interventions. For example, if current coverage is 73%, the target in 2015 is set at 87.6%. This is based on a logic of economies continuing the current trajectory with a last push in final years of scale-up prior to 2015 which is the MDG target year. Some exceptions to this general rule include:

a) For family planning: coverage is increased by 1.5% in total over the three years (0.5% per year) if current TFR < 2.0 and total coverage of family planning (modern + traditional) is <70%. Otherwise current coverage is maintained.

[1] http://www.internationalhealthpartnership.net/taskforce.html
[2] http://www.who.int/pmnch/topics/maternal/201009_globalstrategy_wch/en/index.html
[3] http://www.internationalhealthpartnership.net/en/tools/one-health-tool/
[4] http://www.who.int/whosis/whostat/2011/en/index.html

b) When current coverage of an intervention is >95%, current coverage is maintained.

c) When an incremental increase in coverage by a factor of 20% appears unrealistically high in 2015 (i.e., a target coverage of >95% is reached and is not consistent with modelled coverage for other similar interventions in the same package), coverage is set to a target similar to a tracer intervention for that package (applies to e.g., immunization and care at birth).

d) When baseline year coverage is set to 0%, target coverage in 2015 is set to 10%.

6. Assumptions on treatment regimens (for commodity costs):

The OneHealth tool includes defaults on drugs and supplies provided as part of health service interventions, based on standard treatment guidelines from WHO and other UN agencies. The tool also includes default prices based on global market prices. The analysis made use of these global defaults for treatment regimens and commodities provided as part of preventive care.

7. Assumptions on price data:

For commodity related costs, default prices in the OneHealth tool were used. For costs related to outpatient visit costs and inpatient days, the analysis uses country-specific estimates for costs associated with service provision of inpatient days and outpatient visits, as available through the WHO-CHOICE database,[5] with the following assumptions:

- for outpatient visit costs at hospital level, use estimates for primary level hospital (public)
- for outpatient visit costs at clinic level, use estimates for health centre with no beds (public)
- for outpatient visit costs at outreach level, use estimates for health centre with no beds (public)
- for outpatient visit costs at community level, assume that costs are one-third of estimates for health centre with no beds (public)
- for inpatient bed days costs at clinic level, use estimates for primary level hospital (public)

Estimates used are in 2008 US$.

7. Outputs produced for the six economies from the WHO analysis based on OneHealth scale-up simulations include:

- additional impact estimates (mortality reduction) for the aggregate package of health services, by year (including the number of child deaths and newborn deaths prevented, maternal deaths prevented, under five child mortality rate, and maternal mortality ratio). Estimates are additional, meaning that they only reflect the incremental coverage scale-up of interventions over time. Thus, while interventions maintained at high coverage save lives every year compared to a scenario in which they had not been scaled up, the current scenario for analysis uses the status quo as the comparative baseline. That is to say that if an intervention is already at high coverage of 95% then

[5] http://www.who.int/choice/en/

the analysis assumes that coverage is maintained over time and there is no incremental coverage increase, thus no mortality reduction is achieved since incremental coverage increase is zero.

- estimates of costs, by year, including (a) commodity costs, and (b) health service delivery costs. Costs are presented in 2008 US$ and do not take into account inflation.
- estimates of service requirements (inpatient days and outpatient visits), by year – and related service delivery costs based on multiplying by WHO-CHOICE estimated costs by country.

A summary of these outputs is provided in Table 1 for the six economies as a whole, and more detail is provided by economy in Table 2.

**Table 1. Summary of costs and impacts from intervention package**

| Total for Six Economies | 2013 | 2014 | 2015 | Total |
|---|---|---|---|---|
| RMNCH commodity cost ($million) | 97.7 | 192.9 | 286.2 | 576.7 |
| Service delivery costs (outpatient visit costs and inpatient days) ($million) | 315.3 | 612.1 | 908.0 | 1835 |
| Total RMNCH cost ($million) | 413.0 | 805.1 | 1194.1 | 2412.2 |
| Total cost per capita ($) | 0.22 | 0.43 | 0.63 | 1.27 |
| Increased inpatient days (million) | 7.3 | 14.5 | 21.7 | 43.6 |
| Maternal deaths prevented (number) | 252 | 502 | 739 | 1,493 |
| Child deaths prevented (number; 0-4 yrs) | 16,624 | 32,828 | 48,409 | 97,861 |
| Of which: (number; 0-1 yrs) | 7,747 | 15,309 | 22,674 | 45,730 |

Source: WHO estimates from OneHealth tool simulation
Costs are presented in 2008 US$.

**Table 2. Summary of intervention costs, inputs and deaths averted, by economy**

| | 2013 | 2014 | 2015 | Total |
|---|---|---|---|---|
| **Total additional intervention costs (US$ million)** | | | | |
| PNG | 3.1 | 6.2 | 9.5 | 18.7 |
| China | 223.2 | 432.7 | 637.8 | 1,293.7 |
| Indonesia | 88.1 | 170.5 | 251.2 | 509.8 |
| Peru | 27.4 | 54.7 | 82.6 | 164.7 |
| Philippines | 49.1 | 97.1 | 147.0 | 293.2 |
| Viet Nam | 22.2 | 43.8 | 66.1 | 132.0 |
| **Total** | **413.0** | **805.1** | **1,194.1** | **2,412.2** |
| **Total additional cost, per child death averted (US$)** | | | | |
| PNG | 7,497 | 7,518 | 7,656 | 7,584 |
| China | 32,556 | 32,017 | 31,900 | 32,051 |
| Indonesia | 15,412 | 15,257 | 15,424 | 15,366 |
| Peru | 61,237 | 61,073 | 62,085 | 61,604 |
| Philippines | 25,457 | 24,852 | 25,092 | 25,072 |
| Viet Nam | 17,456 | 17,459 | 17,833 | 17,644 |
| **Total** | **24,844** | **24,523** | **24,667** | **24,649** |
| **Additional inpatient days (incremental; '000 days)** | | | | |
| PNG | 28 | 57 | 88 | 173 |
| China | 1,613 | 3,168 | 4,678 | 9,459 |
| Indonesia | 2,282 | 4,493 | 6,659 | 13,433 |
| Peru | 426 | 850 | 1,284 | 2,560 |
| Philippines | 1,436 | 2,882 | 4,363 | 8,680 |
| Viet Nam | 1,560 | 3,085 | 4,605 | 9,249 |
| **Total** | 7,344 | 14,534 | 21,677 | 43,555 |
| **Additional outpatient visits (incremental; '000 days)** | | | | |
| PNG | 518 | 1,053 | 1,627 | 3,197 |
| China | 28,209 | 54,275 | 80,613 | 163,096 |
| Indonesia | 7,670 | 14,152 | 20,494 | 42,315 |
| Peru | 1,041 | 2,029 | 3,089 | 6,159 |
| Philippines | 6,894 | 13,337 | 20,245 | 40,475 |
| Viet Nam | 1,275 | 2,491 | 4,357 | 8,122 |
| **Total** | **45,606** | **87,337** | **130,423** | **263,366** |
| **Additional child deaths prevented from intervention scale-up (0-4 years; number of deaths)** | | | | |
| PNG | 408 | 822 | 1,239 | 2,469 |
| China | 6,856 | 13,516 | 19,993 | 40,365 |
| Indonesia | 5,715 | 11,178 | 16,283 | 33,176 |
| Peru | 448 | 895 | 1,331 | 2,674 |
| Philippines | 1,927 | 3,908 | 5,858 | 11,693 |
| Viet Nam | 1,270 | 2,509 | 3,705 | 7,484 |
| **Total** | **16,624** | **32,828** | **48,409** | **97,861** |
| **Additional maternal deaths prevented from intervention scale-up (number of deaths)** | | | | |
| PNG | 13 | 28 | 44 | 85 |
| China | 31 | 64 | 96 | 191 |
| Indonesia | 134 | 259 | 375 | 768 |
| Peru | 21 | 43 | 63 | 127 |
| Philippines | 42 | 86 | 128 | 256 |
| Viet Nam | 11 | 22 | 33 | 66 |
| **Total** | **252** | **502** | **739** | **1,493** |

Source: WHO estimates from OneHealth tool simulation. Costs are presented in 2008 US$.

It is important to note that these cost and impact estimates are *incremental.* That is, they indicate the additional resource requirements provided over the three years, and the additional health impacts expected to result from the application of these resources.

The scale of the interventions modeled is evident from Table 1. Total expenditure over the three years exceeds US$2.4 billion, and just on 100,000 lives of mothers and children are saved, at an average cost per life saved (including both mothers and children) of about $24,300. Other indications of the scale of the interventions is that, again over the three years 2013-15, an additional 43.6 million inpatient bed-days and an additional 263.7 million outpatients visits are provided. Such a large scale investment in better maternal and child health care will have many other health benefits other than the saving of lives, which is the variable modeled here, in terms of the reduction in morbidity arising from adverse events during pregnancy and early childhood. These benefits in addition to lives saved will be discussed further in the body of this report. In spite of the scale of intervention the total population of the six economies is so large that the cost over the three year period amounts to only $1.27 per capita (population weighted average summed for three years).

It should be stressed that these estimates are preliminary only, as with other estimates in this report.

There are many complexities involved in making estimates related to a single package of interventions across economies as different as the six studied here. It should be noted that health impact estimates presented here may appear “low”, in particular for maternal health. Part of the reason for this is that most of the six countries included for analysis already have high coverage of skilled birth attendance, and so there is little incremental coverage increase for the maternal impact model to act on.

Moreover, the OneHealth tool was not developed for the primary purpose of multi-country modeling at global level but the tool was rather designed for country level analysis where program managers review country defaults, and make adjustments by inputting data where missing. The analysis here makes use of default data in the tool, and the default inputs for intervention costs may not always correspond with the country-specific national standards. For this and other reasons the estimates summarized in Tables 1 and 2 should be treated as a preliminary basis for analysis only.

## Quantifying the Consequential and Long-term Health Impacts

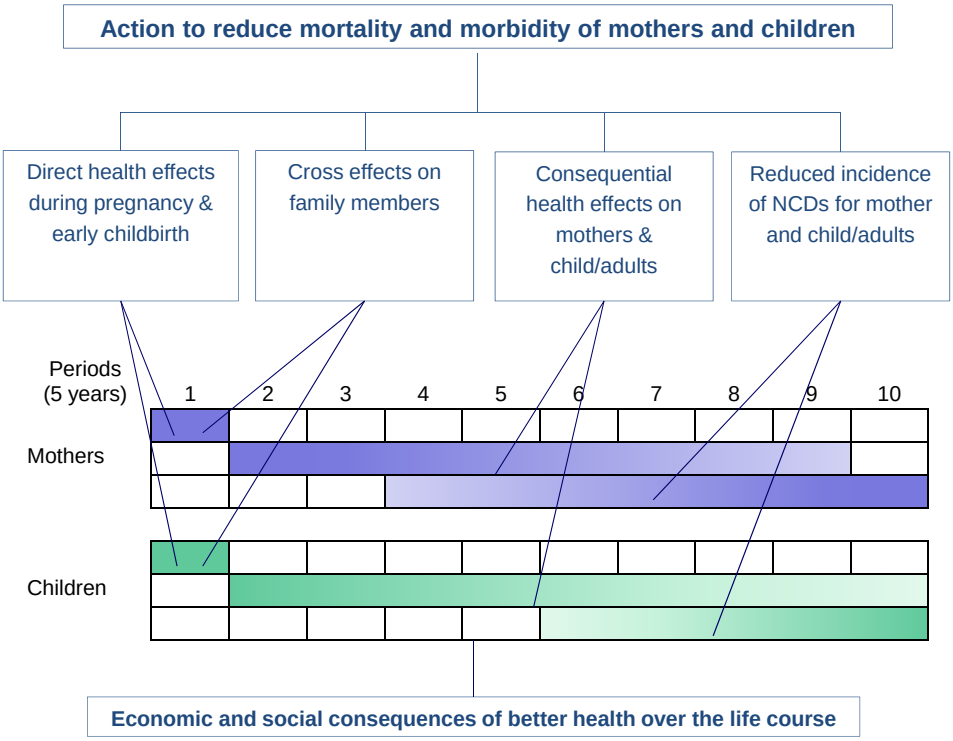
The deaths of mothers and children averted, summarised above, are a central part but by no means all of the health benefits achieved through the interventions detailed above. As a result a central component of the study is to try to assess the full complement of the health benefits arising from the interventions. Our preferred methodology for this task is shown more detail in Figure 2.

The figure divides the future potential life-span of a mother or child into an opening period, in which the interventions take place and have their immediate effects (here 2012-2015) followed by nine periods of five years. The estimates of the deaths averted in the first period, for both mothers and children, have already been provided. In principle we should allow for the cross-effects of the mortality or morbidity of

the mother or the child on the health of other family members (see the discussion above), but this is not possible in the current study.

Here we concentrate on two other effects: the morbidity beyond the initial period averted by the interventions in that period and the lower long-term incidence of non-communicable diseases (NCDs) as a result of the interventions. The former (the 'consequential effects') are the direct and ongoing health impacts, for both mother and child, of adverse events occurring during the antenatal and postnatal stage. For women, they are sometimes referred to as postpartum maternal morbidities. The latter (the 'long-term health effects') are the long-term health impacts of these events, for both mother and child, and particularly the increased incidence of NCDs in later life to which these adverse events can give rise. Our approach to these matters is discussed in the four sub-sections below.

Figure 2. Summary of Methodology to Estimate the Full Health Impacts of the Interventions




### *The Consequential Health Impacts: Mothers*

It is widely acknowledged that maternal deaths are but the 'tip of the iceberg' in terms of the consequences for women of poor maternal health or adverse events during childbirth. A significant proportion of pregnancies lead to ongoing, debilitating morbidity and the number of women suffering such ongoing morbidity is a substantial multiple of the numbers of women who die in childbirth. Examples include obstetric fistula, perineal damage, prolapsed uterus, stress incontinence, puerperal infection and sepsis, haemorrhage, hypertensive disorder (pre-eclampsia) and fits, anaemia, infertility and ectopic pregnancy, depression and suicide. There is no doubt that the prevalence of such morbidities is high, especially in many poorer countries, but for various reasons good data on these

morbidities is very limited. These reasons include the focus on maternal deaths, the diverse nature of the morbidities involved and the fact that this is often hidden, unreported suffering, with the women concerned having little cultural status and no voice in many communities.

Maternal morbidity is any illness or injury caused or aggravated by pregnancy or childbirth (Reed et al. 2000; Ashford 2002). While the importance of maternal morbidity was widely recognised in the 1980s and early 1990s, the Global Burden of Disease estimates for 1990 (Murray and Lopez 1998) provided the basis for the first aggregate estimates of the prevalence of maternal morbidity, and this work was analysed and updated by Burkhalter (2000a and 2000b). The state of knowledge at that time was summarised by Ashford (2002) in a widely cited article: of the 120 million women in developing countries who give birth each year 15-20 million (13-17%) develop severe disabilities, so that for every woman who dies 'at least 30 women suffer serious illness or debilitating injuries' (Ashford 2002). But it was also recognised that the data were very limited and that the burden of disease approach did not cover important aspects of maternal morbidity (AbouZhar 1998; Koblinsky et al. 2012; Hardee et al. 2012).

In terms of aggregate assessment of maternal morbidity the knowledge base has not changed greatly up to 2012. In 2006, Filippi et al. characterised the situation in similar terms, citing the same sources. In 2012, Hardee et al. concluded that, of 136 million women who give birth each year, 1% had a 'near-miss' event, 7% suffer serious complications and 20 million suffer from long-term disabilities, but these estimates were also based on the same sources. In interpreting these data, especially in the present context of the impact of continuing disability on the economic and social engagement of women, the precise meaning of the terms used (such as 'long-term disabilities') is critical.

As Koblinsky et al. (2012) point out, there is a good deal of inconsistency in the use of terms in this area. A critical distinction is between *acute maternal morbidities* and *postpartum maternal morbidities*. Acute maternal morbidities are serious and often life-threatening problems arising in pregnancy and up to the end of the postpartum period of 42 days. They are often described as obstetric complications, absolute maternal indicators, severe acute maternal morbidities (SAMMs) or near-misses. Postpartum maternal morbidities are 'the long-term physical or mental consequences resulting from pregnancy, childbirth, acute maternal morbidities or the management thereof, and are most often referred to as long-term chronic morbidities and other problems experienced postpartum' (Koblinsky et al. 2012). Such postpartum morbidities can be chronic, in the sense of not being life-threatening but greatly impairing functioning and the quality of life, or milder and hence with more limited impact on overall functioning.

Morbidities which are chronic in this sense have very real social and economic costs, and hence our main focus here is on chronic postpartum maternal morbidities. Nevertheless acute morbidities are also relevant, and the acute morbidities will often be the source of chronic morbidities. Indeed, much of the subsequent work on this issue has focused at the acute end, described as severe acute maternal morbidity (SAMM) and defined as 'a very ill pregnant or recently delivered woman who would have died if it had not been that luck and good care was on her side' (Say et al. 2004). These authors undertook a major survey of the literature over 1997-2002, identifying 30 studies on various aspects of SAMMs which they analysed. While the studies varied in many ways, using disease-specific criteria for SAMMs

they found that the prevalence rate for SAMMs (proportion of pregnant women with the condition) ranged from 0.8% to 8.2%. Most of the studies were cross-sectional and undertaken in tertiary hospitals, and resourcing levels in the hospital were found to matter: in resource-poor hospitals, 4-8% of pregnant women experienced SAMMs. However the rates were lower if other criteria were used, and one conclusion of the study was the need to set standard criteria for identifying SAMM cases.

While there has been a subsequent developing literature on acute maternal morbidities, relatively little work has been done on postpartum maternal morbidities. However an important study has been undertaken by a group of researchers on the experiences of women in Matlab, Bangladesh, including an analysis of morbidities beyond the postpartum period (Ferdous et al. 2012). The analysis was based on a physical examination of 1037 women who had given birth in 2006-07 in the Matlab area, which is a rural area of Bangladesh with a strong safe motherhood intervention program and a network of delivery services linked to Matlab hospital. The sample consisted of about equally of two groups of women, those diagnosed by hospitals in the region as having some form of complication (perinatal death, acute or less severe maternal complication or a C-section) and a random sample of uncomplicated births. The main purpose of the study is to analyse the incidence of different forms of morbidity relative to a base of uncomplicated births, and the authors point out that it should not be taken as a random sample of births.

The study found that 42% of the mothers studied had a more or less severe maternal morbidity at about 9 weeks, and that for most morbidities (but not for example for perineal tears) the incidence of such morbidities is higher for those with birthing complexities. But most were mild, probably reflecting the fact that, for those with complications, the sample was dominated by mothers diagnosed with a complication in the Matlab hospital system who presumably received treatment in hospital after diagnosis. The results imply about 40 severe/less severe complications and about 160 postpartum morbidities/disabilities for every maternal death (Stanton and Brandes 2012), although this should not be taken as an unbiased estimate of incidence within the overall population (Ferdous et al. 2012). Nor does the study provide any further detail on the severity of the morbidities.

What is beyond dispute is that maternal deaths are indeed only the tip of the iceberg and that there is a very high incidence of chronic maternal morbidity, but especially in poor regions in which diagnosed and treatment is limited. The data are not adequate to make a strong evidence-based assessment of the extent of ongoing chronic morbidities likely to seriously inhibit the mother's future economic and social involvement. On the critical issue for this study of the ratio of chronic postpartum morbidities to maternal deaths there are few data points and varying use of terms, from the finding of Ashford (2002) that there were at least 30 women with serious illness or debilitating injury for every maternal death to the finding cited in the previous paragraph of about 160 postpartum morbidities/disabilities for every maternal death.

For the purposes of this preliminary study, and in the light of the evidence reviewed above, we make the specific, and we believe conservative, assumption that for every maternal death there are *five* women whose disabilities are so serious as to severely restrict their future labour force participation. For half of these women our assumption is that they are not able to participate in the paid labour force at all,

whereas for the other half we assume that they can participate in a limited way, giving their ongoing disability. These assumptions both apply to the full period of workforce age for the women in question. One of the benefits of the interventions that we quantify below is that it lifts these restrictions on the labour force participation of these women, allowing them to participate fully in the work force.

Further work. To our knowledge there has not as yet been any detailed study of the available literature on maternal health with an emphasis on chronic morbidities which inhibit a woman's long term participation in the society and economy of which she is part. A set of studies to this end, focusing on each of the main maternal morbidities, seems an important next step. Two other issues that need to be addressed in this context are the use of maternal deaths as a scaling factor for chronic morbidity – it could be that as health policy focuses on maternal deaths the ratio of morbidity to deaths rises over time – and that most studies are undertaken in a hospital setting, and hence might understate the level of morbidity in countries where a significant proportion of births occur outside a hospital setting.

### *The Consequential Health Impacts: Children*

In a parallel fashion, it is known from many individual studies and long medical practice that adverse conditions prior to, during or after birth can have important implications for the long-term health and development of children. This is both in respect of the consequential effects, discussed here, and the increased incidence of non-communicable diseases discussed later. There are many different streams of research touching on this topic, and many different ways in which this analysis could be taken forward. Consistent with the methodology outlined in figures 1 and 2, we approach the issue through estimates of both the consequential and long-term health effects (as defined above) of poor early childhood health. We then seek to explore the economic implications of those health effects. An alternative approach, on which there is an extensive literature for developed countries, is to relate early childhood heath status to measures of adult health and earnings capacity. The appendix to this report contains a brief review of this literature, which confirms that childhood health significantly effects adult health and economic status.

In seeking to understand the health effects of early childhood status we again strike the problem that, while there is an extensive data effort in relation to child mortality, there is very little comprehensive data available on morbidity or the burden of disease in children arising as consequential effects of such conditions. Rudan et al. (2005) undertook a systematic review of all studies on the four major causal groups of mortality in children (pneumonia, diarrhoea, malaria and neonatal disorders) published during 1980-2000 (or about that period and published subsequent to 2000). They found that only 308 information units from over 17,000 papers were unbiased sources for estimates of the childhood disease burden. There were a small number of well-researched populations surrounded by large areas for which there was little available information, and no reliable population data for many countries. They also noted that the number of new studies had diminished over the last ten years studied. Olusanya (2007) also notes that the information gap is especially pronounced with regard to morbidity.

An important recent study is that of Mwaniki et al. (2012), which involved a detailed literature search to identify 153 studies documenting the longer-term consequences for children of 12 types of neonatal

insult including pre-term birth complications, intrapartum-related factors and other conditions such as jaundice and congenital infections. The authors used the definitions of severity from the Disease Control Priorities Project to construct a severity scale. The 153 studies documented 22,161 survivors of these intrauterine or neonatal insults, with one of the inclusion criteria being that there had been medical follow-up at least six months after the insults, to ensure that longer-term sequelae were being captured. Their central finding was that the overall median risk of at least one sequelae in any domain was 39.4%, with a pooled risk estimate (excluding HIV) of 37.0%, with a risk of at least one severe impairment 18.5% and over at least one moderate impairment 5.0%. The severity scale that they use is quite rigorous, so that all severe impairments, and many moderate ones, would be likely to inhibit effective labour market participation.

From our point of view the limitation of this important study is that we have no information to place the 22,161 survivors on which the analysis is based within a broader context of the birthing experience of the communities of which they are part. For example we do not know how many children died in the episodes covered by the 153 studies, or the number of live births. If there were, say, one death for every 20 survivors of these intrauterine or neonatal insults then the pooled risk estimate of an impairment would be 7.4 per child death, and the risk of at least one serious impairment at 3.9 per child death. If there were 40 survivors for every death the implied risk of an impairment would be 14.8 per child death and the risk of at least one serious impairment 7.8 per child death, while with 60 survivors per death the level of serious impairment would be 11.7 per child death.

Faced with limited evidence and a focus on linking chronic morbidity or impairment to labour force participation, we make the following interim assumptions for this study:

- for every child death there are 2.5 children with a sufficient serious chronic impairment to stop them working at all when adult;
- for every child death there are 1.25 children with a chronic impairment which enables them to work with a disability but limits their productivity; and
- for every child death there are 1.25 children with both a chronic impairment and lower human capital (see the Appendix) such that they are able to work but with sharply diminished productivity.

Each of these assumptions relate to the lifetime labour force involvement of the children in question from the time at which they become adult (assumed to be at age 20 years). This is clearly another area in which extensive further work is required.

### *The Long-term Health Effects: Children and Mothers*

There is growing awareness that antenatal and early childhood health plays a key role in the incidence of NCDs later in life. The evidence for this link is both diverse and developing, and relates different early childhood experiences to different diseases. It takes three main forms:

- epidemiological studies, based on longitudinal studies and other methods;

- natural experiments, such as the Dutch and Chinese famines; and
- growing understanding of the medical transmission methods for such effects (fetal programming, epigenetics and others)

These effects are of fundamental importance for understanding the current 'epidemic' of chronic disease, as well as the long run effects of improved maternal and child health. While they cannot be done justice in this report, there needs to be some recognition of these important links in our initial estimates of the returns to investment in improved maternal and child health. The three types of evidence are touched on briefly below, and the assumptions made for this study are specified.

There have been a wide range of epidemiological studies linking early childhood health and the later onset of chronic disease. In a pioneering study in 1986, Barker and Osmond showed that, over local authority areas in the UK, there was a strong correlation between infant mortality rates and the incidence of ischaemic heart disease about fifty years later. Many subsequent studies have developed these links further, such as Barker et al. (2007) for hypertension and Barker et al. (2010) and Eriksson et al. (2010) for lung cancer. Portha et al. (2011) note that:

> A substantial body of evidence suggests that an abnormal intrauterine milieu elicited by maternal metabolic disturbances as diverse as undernutrition, placental insufficiency, diabetes or obesity, may program susceptibility in the fetus to later develop chronic degenerative diseases, such as obesity, hypertension, cardiovascular diseases and diabetes. (Portha et al. 2011, p. 1)

One other way in which evidence has been provided of these links is through study of the natural experiments that are provided through large scale famine, such as the Dutch wartime famine of 1944-45 and the Chinese famine of 1959-61 associated with the Great Leap Forward. For example, Painter et al. (2005) studied a cohort of individuals born around the time of the Dutch famine, and found more heart disease, raised lipids, altered clotting and more obesity for those exposed to the famine in early gestation that for those not exposed. Among many studies of the Chinese famine reporting broadly similar results, Li et al. (2010) found significantly higher levels of hyperglycemia and type 2 diabetes in the fetal-exposed cohort and in those exposed in early childhood relative to the non-exposed cohort.

The development of epigenetics (the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence) is increasingly providing a scientific basis for the empirical observation of a link between fetal, early childhood or other environmental factors and susceptibility to NCDs later in life. For example, Choi and Frisco (2010) note that:

> Over the past decades, epigenetic studies mainly have been focused on embryonic development, aging, and cancer. Presently, epigenetics is highlighted in many other fields, such as inflammation, obesity, insulin resistance, type 2 diabetes mellitus, cardiovascular diseases, neurodegenerative diseases, and immune diseases. Because epigenetic modifications can be altered by external or internal environmental factors and have the ability to change gene expression, epigenetics is now considered an important mechanism in the unknown etiology of many diseases. (Choi and Frisco 2010, p. 8)

The process of fully understanding these linkages and developing well documented quantitative estimates of the impact of adverse developments in relation to prenatal or early childhood health or during pregnancy and childbirth is a long term and complex one. For this study we make a simple assumption: that, for mothers and children who suffer a serious disability during motherhood or early childhood, the life course incidence of NCDs is increased by 20% relative to those without such disability. Intervention to prevent the disability will have the benefit of reducing that future increased incidence. We quantify this assumption by making use of WHO estimates of the burden of disease in APEC developing economies, in terms of disability adjusted life years lost, provided for our 2008 LSIF study (CSES and IPR 2008).

As NCD incidence is strongly age specific, this means that as a result of the interventions the burden of NCDs is reduced, for mothers, by about 1.5 DALYs per 100 population in 2020 rising to 6.0 DALYs per 100 population in 2060, and for children the reduction in about 1.0 DALYs per 100 population in 2020 rising 3.5 in 2060. We further assume that a DALY avoided is equivalent, for individuals of working age, to labour force participation of half a year. These are clearly only interim assumptions, which need to e developed much further in subsequent work.

## Quantifying the Economic and Social Benefits

The third component of this study is to provide an initial estimate of economic and social benefits of the various improved health outcomes arising from the interventions: reduced maternal and child deaths, reduced chronic morbidity for both mothers and children and lower incidence of NCDs later in life. Our preferred methodology for undertaking this task is provided in Figure 3. This indicates three types of benefits – economic benefits in the form of higher GDP arising from increased labour force participation and productivity; other social benefits arising from the social value of life and from, for example, the non-economic role which mothers play in families and broader communities; and the financial benefits arising from lower health costs and higher taxation revenues. While the last two forms of benefit are important and need to be pursued it has not been possible to include them in this study. This focus only on the economic benefits is recognised as a major limitation. Thus, for example, the only benefit included from a child's life being saved is the value of future output generated when the child enters the labour force at age 20. No social value arising from the child's first twenty years of life is included. In addition we do not include here the dynamic effects of improved health: that more healthy communities might give rise to self-reinforcing patterns of investment in physical and human capital, hence generating higher rates of economic growth and related socio-economic and demographic benefits.

Figure 3. Summary of Preferred Methodology to Estimate the Economic and Social Benefits of the Improved Health Outcomes

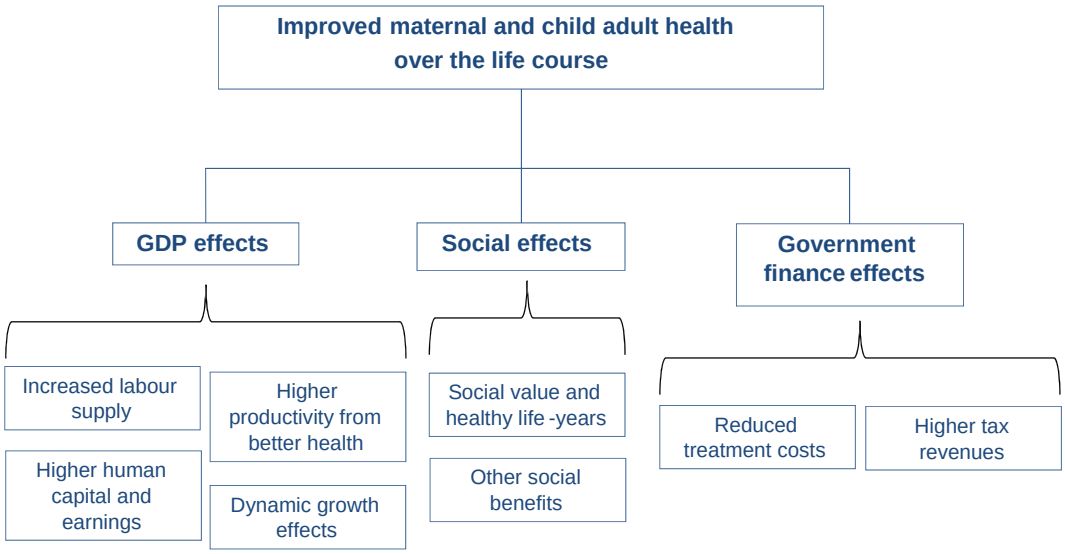



Table 3 summarises the elements of the preferred methodology that are included in the current estimates, noting the exclusion of the cross-effects of better maternal health on child health and vice-versa, in addition to the other exclusions noted above. Thus we focus only on labour supply and productivity effects arising from lives saved, disability avoided and higher human capital made possible by the avoidance of disability.

**Table 3. Elements of the Preferred Methodology Included in and Excluded from the Current Estimates**

| Health Impacts | Economic and social benefits |
|---|---|
| *Included* | |
| Direct effects | Increased labour supply – lives saved |
| Consequential health effects | Increased labour supply – disability avoided |
| Reduced incidence of NCDs | Increased productivity – disability avoided |
| | Increased productivity – higher human capital |
| *Excluded* | |
| Cross-effects | Dynamic growth effects |
| | Social value of a life |
| | Other social effects |
| | Health expenditure and revenue effects |

To quantify the economic benefits to be included, as specified in Table 4, a simple model has been created for the six economies as a whole, running from 2016 to 2065. For individuals whose lives are saved the key elements of the model are their labour force participation and productivity when they are

of workforce age. We assume that the participation rate for mothers is 80% and for children is 85% (from age 20 years), that the productivity of mothers is 80% of GDP per capita (because they are likely to have lower than average human capital from a paid employment point of view) and that that of healthy children (when working as adults) is equal to per capita GDP. For individuals for whom chronic morbidity is averted, the key elements of the model are the labour force participation of mothers and children (when they are old enough to work), relative to their assumed prior situation with disability, and their productivity when at work expressed in relation to GDP per capita, again in relation to their assumed prior situation with disability and lower human capital.

Table 4 summarises the assumptions made in the various cases for mothers and children for whom the health interventions avert chronic morbidity. For mothers there are two cases, assumed to be equal in magnitude: one in which the morbidity prior to the intervention was so severe that she was unable to work at all, and another in which the morbidity prior to the intervention enabled the woman to work on a limited basis, with productivity equal to only 50% of GDP per capita. In both cases they are assumed to be able to work without morbidity after the intervention up to the age of 55 years, with the participation rate and productivity level (80% and 80% of per capita GDP) assumed for healthy mothers. For children there are three cases: one (assumed to be 50% of children) in which the disability precluded any ability to work when adult, and two others (each 25% of children with prior disability) in which the children had some ability to work when adult, although limited by disability and, in the third case, by both disability and reduced human capital. In all three cases these children, without morbidity, are assumed to be fully able to work after the intervention, with the participation rate and productivity level of healthy children (85% and GDP per capita), up to the end of the model period in 2065, by which time they would be about 50 years of age.

**Table 4. Key Assumptions for Individuals for whom Chronic Morbidity is Averted**

| Status before intervention | Status after intervention | Share of number with disability | Participation rate (after Intervention) | Productivity (% of per capita GDP) | |
|---|---|---|---|---|---|
| | | | | Before | After |
| ***Mothers:*** | | | | | |
| Unable to work (disability) | Fully able to work | 50% | 80% | 0 | 80 |
| Limited work with disability | Fully able to work | 50% | 80% | 50 | 80 |
| ***Children (when adult):*** | | | | | |
| Unable to work (disability) | Fully able to work | 50% | 85% | 0 | 100 |
| Able to work (reduced human capital) | Fully able to work | 25% | 85% | 60 | 100 |
| Able to work (disability and reduced human capital) | Fully able to work | 25% | 85% | 30 | 100 |

## Overall Benefit/Cost and Rate of Return Assessment

There are thus three main streams of economic benefits assessed in this study, in terms of increased GDP arising from the higher labour force participation and increased productivity of individuals whose health is improved as a result of these interventions: from the activities of individuals whose lives were saved, of individuals who do not suffer from the chronic morbidity arising from maternal and early childhood events and of individuals who suffer less chronic disease in later life. In assessing the overall value of these benefits we use the estimated average per capita GDP of the six economies as a benchmark, and assume that this per capita GDP level rises by 2% per annum in real terms in the future. The analysis is conducted entirely in real terms and so is not distorted by the effects of inflation.

**Table 5. Summary of Key Results of Cost Benefit Analysis**

| Measure | Estimated value |
|---|---|
| Total cost of interventions, 2013-2015 (US$m) | 2412 |
| Net present value of benefits, @ 3% discount rate (US$m) | 73255 |
| Benefit/cost ratio (3% discount rate) | 30.4 |
| Net present value of benefits, @ 5% discount rate (US$m) | 34083 |
| Benefit/cost ratio (5% discount rate) | 14.1 |
| Internal rate of return | 17.0% |

The benefits are expressed as an increased annual flow of increments to GDP out to 2065. They are reported here in net present value (NPV) terms using a central (real) discount rate of 3% but with a sensitivity case with a 5% discount rate also shown. In our view a 3% real discount rate is certainly sufficient for this case, in which we are evaluating public interest investments in the welfare of future generations. For major developed economies the long term government borrowing rate is currently less that 2% in real terms. Because many of the benefits accrue well into the future, especially in the case of children, the assumption made about the discount rate has a big impact on the NPV and on the benefit/cost ratio. As noted earlier, the total cost of the interventions over 2013-15 is estimated at $2,412 million or $1.27 per capita over the population of the six economies of about 1.9 billion. As shown in Table 5, the NPV at 3% of the benefits covered here is $73,255 million, or 30.4 times the cost of the interventions. The calculated internal rate of return is 17.0%, although this is a less reliable measure for such long term investments. By any standards a benefit/cost ratio of over 30 is a sign of a very high return investment. The sensitivity of the results to the discount rate is also demonstrated, with both the NPV of the benefits and the benefit/cost ratio falling by about half if a 5% real discount rate is used. By contrast the NPV of the benefits rises to over $100 billion at a 2% real discount rate, and the cost/benefit ratio to over 40. If no discount rate is used the ratio of benefits to costs is about 85.

It must be stressed again that these are very preliminary estimates, from the viewpoint of both of the collaborating parties. While changes to the methodology and more refined assumptions could vary the results significantly, not all of the potential benefits have been modeled in this study and in some respects the assumptions we have used are conservative. For example, we have not included any social

value for the life of a mother or child saved or for morbidity avoided other than that expressed through future labour force participation. If we were to include a social value of a life saved equal to 50% of annual GDP per capita and a social value of a year of chronic morbidity avoided at 20% of per capita GDP the NPV of the total benefits shown in Table 5 (at a 3% discount rate) would increase by about 60%.

The implications of better maternal and child health explored here are so profound that it is likely that any reasonable variation of these assumptions will show high returns. That is, that they would show that effective investments in RMNCH are among the best investments that any society can make.

# Appendix

## Review of Research on the Impact of Early Childhood Health on Economic and Health Outcomes in the Developed Countries

Much of the research focuses on the impact of early childhood circumstances on longer term health and economic outcomes has been undertaken for the developed countries, in part because of the availability of longitudinal surveys of health status and a wide range of socio economic indicators. A brief review of some of this work is provided in this appendix.

One of the pioneers of this research was David Barker, who has published extensively on this topic. His research has been based on a number of longitudinal studies. His early work established the association between birth weight and coronary heart disease for a cohort of 16,000 Hertfordshire men and women. This showed death rates from coronary heart disease halving between the lower and upper ends of the birth weight distribution (e.g. Barker 1997). This paper reviews evidence, assembled by his team and others, of the association between child health indicators and a range of diseases in adult life, including insulin resistance (leading Type 2 diabetes) and raised blood pressure (hypertension). Further work indicates that the association between low birth weight and coronary heart disease is most strongly related to a combination of low birth weight and rapid weight gain.

A study relevant to the human capital implications of poor child health is Barker's analysis of a group of 4360 men born in Helsinki, Finland during the period 1934-44, which related their height at 1 year with their educational attainment and personal income as adults (Barker et al. 2005). This showed a strong association between height, highest level of education, personal taxable income and nature of occupation.

The potential for the confounding influences of family characteristics on this association, between birth condition indicators and educational attainment and adult earnings, has led researchers to more carefully consider the causal relationship between poor child health and adult health status and earnings. Considered here are just three papers reporting on different attempts to establish this causal relationship.

Behrman and Rosenzweig (2004) base their analysis on data on monozygotic female twins from the Minnesota Twins Registry, the largest birth-certificate-based twins registry in the United States. Analysis using twins controls for a range of genetic and other family endowment effects. The study focuses on the relationship between foetal growth and schooling attainment and labour market payoffs. Moreover they argue that studies which do not control for genetic and endowment effects underestimate the size of foetal growth on schooling attainment by 50%. It finds that foetal growth (oz. per week of pregnancy) is significantly and positively associated with schooling attainment. A one pound increase in birth weight would increase schooling by one third of a year, and such an increase translates into an increase in adult earnings of 7%.

Case et al. (2005) seek to establish which of three hypotheses, each seeking to explain the relationship between child health and adult health and earnings, holds. The three hypotheses are (i) *foetal origins*

*hypothesis* as put forward by Barker which suggests that nutrition in utero can effect health and economic status in middle age, (ii) *life course models* which emphasise the lasting effects on adult health of child illness and (iii) *pathway models* which suggest adult health is determined largely by adult socio-economic status (SES).To the extent that adult SES is influenced by early life circumstances, then this hypothesis suggests low SES in childhood indirectly leads to poor health in adulthood.

Their study is based on the UK 1958 National Child Development Study.[6] The results of this detailed survey enabled the authors to control for many family characteristics, such as parental income, education and social class. It also had access to data for a number of intrauterine indicators including birth weight and maternal smoking. It concluded that children with low birth weight had significantly lower educational attainment (number of O level exams passed) and that the impact of these intrauterine indicators on adult health status became more significant with later age, thus supporting the foetal origins hypothesis. It also found support for the suggestions put forward in the life course models, that child ill health, as represented by the number chronic conditions at age 7 and 16, significantly adversely effects adult health.

Both factors – chronic childhood ill health and poor uterine environment – had an adverse influence on employment and economic status (occupational status). Their study provides however less support for the pathways model.

Smith (2008) however argues that the control variables used by Case et al. (2005) are insufficient to rule out the possibility that the observed relationship is the product of unobserved characteristics of the family or home environment. He conducts a study based on health data reported by siblings to eliminate family effects using the PSID demographic data. However this data base only provides relatively high level childhood health data and in particular lacks the birth condition indicators available to the Case et al. (2005) study. Nonetheless Smith's study confirms a version that childhood health significantly effects adult health and economic status. Indeed his study estimates that within siblings, those reporting good to excellent child health had 25% higher earnings. This could be considered a further confirmation of the life course model.

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[6] National Child Development Study (NCDS), Centre for Longitudinal Studies, Bedford Group for Lifecourse and Statistical Studies, Institute of Education, http://www.cls.ioe.ac.uk/.

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