A scoping review of cost benefit analysis in reproductive, maternal, newborn and child health: What we know and what are the gaps?

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Abstract

Growing evidence suggests that early life investments in health are associated with improved human capital and economic outcomes. Various recent global studies have simulated the expected economic returns from alternative packages of interventions in reproductive, maternal, newborn and child health (RMNCH). However, very little is known about the comparability of estimates of the economic returns of RMNCH interventions across studies in low and middle income countries. Our study aims to fill this gap. We performed a comprehensive scoping review of the recent literature (2000-2013) on the economic returns (i.e. benefit-cost ratios) of RMNCH-related interventions, conducted in low and middle income countries. A total of 36 studies were identified. They were read in full and information was abstracted on both the estimates of benefit-cost ratios, the methodological approach and assumptions used. The estimated economic returns fluctuated considerably across settings as the associated costs of disease patterns, social behaviours and health systems varied. Yet, greater sources of variation stemmed from differences in methodology. The observed methodological inconsistencies limit the accuracy and comparability of the estimated returns across various contexts. The reviewed studies suggest that the benefit-cost ratios are favourable in the majority of cases, providing further support to a growing body of economic literature that suggests investments early in life, such as those interventions related to RMNCH, are good investments. Beyond advocacy purposes, for the reviewed literature to be used by policymakers to inform their decisions on investments, a consistent methodological approach should be adopted.

Key words: Cost-benefit analysis; economic returns; Millennium Development Goal (MDG) 4; maternal, newborn and child health; reproductive

Key Messages

• We provide a critical overview of benefit cost ratios (BCRs) of interventions related to reproductive, maternal, neonatal and child health (RMNCH) across low and middle income countries and find BCRs to be positive in most settings, providing support to the growing body of economic literature that suggests investments early in life are good economics.
• However, methodological inconsistencies cloud the results and pose concerns for policy makers in reaching informed decision on prioritisation of investments across various spectrums of RMNCH interventions.
• Health policy research will benefit immensely if the cost benefit studies in RMNCH can ensure methodological robustness.
Introduction

It is increasingly being recognised that early childhood interventions can be one of the most effective policies to break the intergenerational cycle of poverty (Camacho 2008; Jack and Lewis 2009). A growing body of evidence details the benefits of early life health investments (Adair et al. 2008; Bleakley 2010; Currie and Vogl 2013, Knudsen 2004; Shonkoff and Phillips 2000; Grantham-McGregor et al. 2007), with established relations to future schooling, employment and earnings. Yet, notwithstanding substantial reductions in maternal and child deaths achieved worldwide in the last two decades, rates of reduction are insufficient to achieve the Millennium Development Goals (MDGs) 4 and 5 by 2015 (Stenberg et al. 2014) and equity issues remain a concern (UN 2015).

Concurrently, investment decisions are becoming increasingly complicated given the global economic downturn following the 2007–08 financial crisis and the growing pressures on foreign aid budgets (ADB 2012). While the need is obviously present, competing demands for resources could lead to a prioritization of investments into other areas such as education and infrastructure. It is, therefore, pertinent to ask what would be the return from a dollar of investment in reproductive, maternal, newborn and child health (RMNCH) if the wide array of benefits of early life health could be quantified and compared against the costs.

Various studies have assessed the broad costs and health impact of RMNCH (Carrera et al. 2012; Jimenez Soto et al. 2012), while others have estimated the economic returns from basic packages (Stenberg et al. 2014) or individual interventions (Baird et al. 2012; Sharief et al. 2006; Jeuland and Whittington 2009; Kohler 2012; Rajkumar et al. 2012). However to date, no review of the evidence-based economic returns across the spectrum of RMNCH interventions is currently available. Estimates of the returns vary across different contexts and interventions (Alkire et al. 2012; Behrman et al. 2004; Horton et al. 2009; Rajkumar et al. 2012), and substantial gaps still exist as to why this is the case. This paper, therefore, aims to provide an overview of the literature on economic returns from investments in RMNCH in low and middle income countries. The review draws exclusively from the literature on cost-benefit analysis (CBA) of RMNCH related interventions.

CBA is one of the economic evaluation techniques available in the literature, which also include cost effectiveness analysis (CEA). We focus on the CBA literature rather than CEA for two main reasons. First, in the last decade several studies have already examined the cost-effectiveness of RMNCH interventions across the globe (Bhutta et al. 2013a,b; Darmstadt et al. 2005). Second, as a tool to allocate resources, CBA provides more transparent guidelines to policymakers. Unlike CEA, which has applications only in health, CBA is more generally applicable, allowing a comparative assessment of investments across diverse sectors such as health, agriculture and infrastructure.

CBA aims at systematically identifying, measuring and comparing the benefits and costs of an investment project, program or policy intervention (Campbell and Brown 2003). In general, costs and benefits should be measured from the perspective of both the direct stakeholders (i.e. the referent groups who directly benefit from the intervention, such as vulnerable women and children) and the society as a whole. A detailed explanation of which costs and benefits to include and the associated pricing rules for CBA are provided elsewhere (Campbell and Brown 2003; Drummond et al. 2015). However, we should note here that CBA uses monetary units to measure both costs and benefits. This provides policy-makers with a means to quantify the economic returns of proposed policies and interventions, and objectively assess whether they provide ‘good value for money’. One of the most commonly used measures of economic returns is the benefit-cost ratio (BCR), which can be interpreted as the economic benefit for each dollar invested. For example, a BCR of 2 will imply that the proposed intervention will deliver $2 in benefits for every $1 invested.

We aim at providing a snapshot of the magnitude of BCRs that can be expected from various RMNCH interventions and highlight the methodological challenges faced by researchers. For these purposes we have undertaken a comprehensive scoping review of the CBA literature on RMNCH. We collate the available BCRs from various studies related to CBA, with a view to conduct a preliminary investigation into how far these BCRs can guide policymakers in making informed decisions.

Methods

This scoping review has two objectives: first, to provide an overview of the range of the economic returns of RMNCH interventions in low and middle income countries. Second, with a view of assessing the comparability of their estimates, the review also examines the methodological issues underlying the various studies. We define the scope of our review as follows: first, we review only studies that have quantified the economic returns from RMNCH investments, that is, studies that undertook a cost-benefit analysis of RMNCH interventions. Our focus is thus on studies that compare the costs and benefits (health and non-health) of RMNCH investments as measured by monetary units. Second, we only include studies conducted in low and middle income countries since 2000. Third, we do not attempt to review the economic returns to investing in the control/eradication of diseases, such as HIV/AIDS or Malaria. We do, however, include studies on such themes to the extent to which the economic returns of providing care to women and children are measured. Fourth, we include studies that provide information on both their estimates of economic returns and the methodological approach used. Fifth, our search was limited to studies written in English. Literature was drawn from both economic (i.e. Econlit and JStore) and general academic databases (i.e. Pubmed and Science Direct) and the grey literature. The search terms, applied to various boolean operators, are summarised in Table 1.

The literature search was undertaken between July and October 2013. In addition to the keyword searches, references of identified papers were examined to find additional studies, and Google search was used to find non-published reports. The original search identified about 45 studies on interventions related to RMNCH out of which a total of 36 studies were finally selected, following the exclusion criteria mentioned above. This list was discussed with three RMNCH experts to assess whether key studies from the literature were missing. No additional studies were suggested for inclusion. The lead author read all the identified papers in full, while the two co-authors read a selection of papers each. The three authors built an abstraction template, which was subsequently used to produce Supplementary Table A.1 (see Supplementary web appendix). The data extracted from the reviewed papers include: author/year, methods, intervention, outcome, benefits, costs and benefit-cost ratios. For methods, we aimed at obtaining information on the study objective, study setting and design, sample and data, sensitivity analysis and key assumptions in regard to coverage and choice of discount rates.

In extracting information on study setting, we identified the region/country as well as the urban-rural location, if relevant. We
categorized the study design as randomized control trials (RCT), simulation based studies, observational and quasi-experimental studies. We classified the sample population, according to the key RMNCH population categories, such as women of reproductive age, pregnant women, neo-nates and children under five. For data, we examined the source of data for the key assumptions, as specified by the study (i.e. some simulation studies state that they draw on existing literature or estimates from UN Agencies). Consistent with the standard practice in this literature, we also extracted basic information on intervention, coverage and discount rate (Bärnighausen et al. 2011), and also examined whether the studies conducted a sensitivity analysis and the key parameters used for these purposes. After a preliminary assessment of key studies, it was clear that there was no uniformity in the definition and reporting of which costs and benefits were included and very limited information was available on how these items were assessed (i.e. the pricing rules used). Therefore, in the template we aimed at describing the items included under benefits and costs, as reported by each study. Regarding extraction of information on costs and benefits, we did not follow any particular criterion. We have only reported the information that the studies have documented, which broadly covers direct costs like program costs or health system costs and in certain cases indirect cost like loss of productivity. Benefits broadly comprise reduction in mortality and morbidity, number of lives saved, increased earnings, increased productivity, intergenerational benefits, the value of time saved and cost-savings in health and education. The lack of uniformity in the information extracted reflects the methodological limitations of the literature, which are discussed in more detail below.

Since ours is a scoping review, several limitations apply. First, we did not undertake a formal assessment of the quality of the studies. However, we have examined in detail the methods used to estimate costs and benefits. As discussed below, this analysis reveals that overall the quality of the available evidence seems to be rather low. Second, our search might have missed studies not included in academic databases and not easily available on the internet. If studies with negative economic returns tend to have negative publication bias, this could in turn affect our results.

**Results and Discussion**

In line with the objectives of this review, our findings and discussion are examined according to two broad themes, that is, the economic returns as measured by the BCRs and the methodological issues raised by the reviewed studies.

Table 2, draws on the abstraction template provided in the Supplementary Appendix to provide a summary of the reviewed studies. It can be seen that large BCRs have been estimated for RMNCH investments, particularly with respect to family planning and nutrition interventions. However, due to differences in methodologies, caution needs to be exercised when comparing results from different studies.

<table>
<thead>
<tr>
<th>Table 1. Summary of search terms</th>
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<tr>
<td>Separated by ‘OR’</td>
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<tr>
<td>cost benefit; economic return; investment; economic evaluation</td>
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**Benefit-Cost Ratios (BCRs)**

**Results**

In this section we provide a snapshot of the magnitude of the economic returns by reporting the BCR from RMNCH interventions, as illustrated in Table 2. In general, simulation-based exercises for the Asia-Pacific region and Africa show high economic returns of investing in a priority package of maternal, newborn and child health interventions (Foster et al. 2012; Sheehan et al. 2012). Under different sets of assumptions, alternative packages led to BCR ranging from $14 to $30 per dollar invested. Recent simulations (Stenberg et al. 2014) for 74 countdown countries show more modest estimates even though the economic returns are still high – (at 3% discount rate) $8.7 per dollar of investment by 2035 reaching $38.7 in 2050. Moreover, rates of return from each dollar spent are higher in lower-middle income countries ($11.3) and low income countries ($7.2) as opposed to upper-middle income countries (excluding China) ($6.1). We classify the interventions by their position on the RMNCH continuum of care (PMNCH 2011).

**Reproductive Health**

Seven studies report BCRs for interventions related to reproductive health and pregnancy-related care, with results ranging from $0.39 to $150 (Bollinger 2011; Kennedy et al. 2013; Kohler 2012; Mills and Shillcutt 2004, Onwujekwe et al. 2013; Peffer et al. 2002; USAID Health Policy Initiative 2009). The results imply benefits obtained from each dollar spent on the relevant interventions range from $0.39 to $150. Studies focused on Sexually Transmitted Infections (STIs) and Prevention of Mother-to-Child Transmission (PMTCT) of HIV, in various settings within sub-Saharan Africa (SSA), report BCRs varying between $0.39 and $146 (Bollinger 2011; Mills and Shillcutt 2004; Peffer et al. 2002). Such wide variation in BCR is also noted for the family planning interventions, with BCRs ranging between $9 and $150, but across more diverse settings, extending from the Solomon Islands and Vanuatu, to Thailand and SSA (Kennedy et al. 2013; Kohler 2012; Onwujekwe et al. 2013; USAID Health Policy Initiative 2009).

**Pregnancy and Childbirth**

Less variation is found for Malaria prevention and management (Jamison et al. 2008, 2012; Mills and Shillcutt 2004; Rajkumar et al. 2012), with a relatively uniform pattern of benefits ranging from $12-$35. Some of the highest returns are reported for nutritional interventions of pregnant mothers (Behrman et al. 2004, Casey et al. 2011; Rajkumar et al. 2012; Sayed et al. 2008), with BCRs ranging from as low as $6.70 for iron and folic acid supplements and deworming during pregnancy in Thailand (Casey et al. 2011) to as high as $520 for iodine supplements for women of childbearing age in low income countries of Asia and Africa (Behrman et al. 2004) and $648 for deworming pregnant women in Ethiopia (Rajkumar et al. 2012). A package of interventions addressing low birth weight (LBW) in low income countries, particularly in South Asia, is estimated to provide BCRs in the range of $0.58-$35 (Behrman et al. 2004), while a package of interventions addressing stunting in high income countries with BCRs ranging between $0.93 to $13.8 (Jamison et al. 2008) and lower-middle income countries with BCRs ranging between $3.36 to $15.0 (Jamison et al. 2012).
### Table 2. Overview of the economic returns to RMNCH investments

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Countries/Regions</th>
<th>Outcomes</th>
<th>Benefits per dollar invested (Benefit-Cost Ratios)</th>
<th>Author (Year)</th>
</tr>
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<tbody>
<tr>
<td>Single Interventions</td>
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</table>
| Deworming                             | Kenya                                                  | • Mean hours worked increased by 12% overall, and by 17% among early school leavers.  
• Employment for manufacturing work rose three-fold; wage earnings for out-of-school workers increased by 20%; profits for small non-agricultural businesses increased.  
• Miscarriages reduced by 66%.  
• Primary school participation increased by 7.5 percentage points | $41.73-$123.44                                    | Baird et al (2012)                                      |
| Deworming                             | Kenya                                                  | • Averted In children more the 1.2 million disability adjusted life-years (DALYs) per 20% coverage increase.                                                                                             | $10.00                                           | Jamison et al. 2012    |
| Deworming                             | Low income countries, primarily Sub-Saharan Africa and South Asia | • The benefit comes from the potentially avertible productivity loss in the population (South Asia and Sub-Saharan Africa) which comes from the impact of worms (anthelmintics) on anaemia and reduced cognitive ability. | $6.00                                             | Horton et al (2008)    |
| Deworming                             | Ethiopia                                               | • Decreases iron deficiency in children by 50% and increases child IQ by 7.5. Potentially reduced six-month mortality rate by 20%.                                                                       | $378.19 without distribution cost $61.85 with distribution cost | Rajkumar et al (2012)  |
| Deworming pregnant women              | Ethiopia                                               | • Increases IQ in 50% of anaemic children by 7.5 points.                                                                                                                                             | $648.41                                          | Rajkumar et al (2012)  |
| Antiretroviral therapy (ART) for HIV   | 98 low and middle income countries, 80% in Africa      | • Saves an estimated 18.5 million life-years.  
• Gain in labour productivity.  
• Orphan care cost averted.  
• End-of-life treatment cost averted.                                                                 | $2.40                                             | Resch et al (2011)   |
<p>| Prevention of mother to child transmission (PMTCT) of HIV | Mozambique                                             | • City wise each year 132 infant deaths would be averted by use of Nevirapine.                                                                                                                         | $1.08 when no infant formula supplied | Peffer et al (2002) |</p>
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</thead>
<tbody>
<tr>
<td>PMTCT of HIV. Single dose nevirapine (universal)</td>
<td>Sub-Saharan Africa only</td>
<td>• Benefits come from mortality reduction.</td>
<td>A. $52.00 B. $39.00 C. $21.00- $26.00 D. $49.90</td>
<td>Mills and Shilkut (2004)</td>
</tr>
<tr>
<td>PMTCT of HIV (non-sexual transmission)</td>
<td>Sub-Saharan Africa</td>
<td>• Years of life gained.</td>
<td>$15.00-$146.00</td>
<td>Bollinger (2011)</td>
</tr>
<tr>
<td>Childhood immunisation – Hepatitis B vaccine</td>
<td>Low income countries, primarily Sub-Saharan Africa and South Asia.</td>
<td>• Approximately 150,000 deaths averted, or 3 million DALYs, with a 25% incremental coverage increase over 40 years.</td>
<td>$10.00</td>
<td>Jha et al (2012)</td>
</tr>
<tr>
<td>Childhood immunisation – Bacillus Calmette–Guérin (BCG) vaccine</td>
<td>World population. Only Sub-Saharan Africa and Asia reported here.</td>
<td>• Averted child and adult mortality reduced medical spending, increased productivity and work capacity. • Societal benefit comes from one year of complete elimination of tuberculosis risk for one individual.</td>
<td>Age 0-15 years: Asia: Boys: $30.61 $45.01 Sub-Saharan Africa: Boys: $97.86, Girls: $159.81</td>
<td>Bishai and Mercer 2001</td>
</tr>
<tr>
<td>Childhood immunization – Haemophilus influenzae type B (Hib) vaccine 3 doses</td>
<td>Philippines</td>
<td>• Prevent 353 cases per year in a birth cohort of 100, 000 with 85% vaccination coverage.</td>
<td>$1.17 - $2.60 direct Government cost, $43.47 - $0.49 for societal direct cost $88.94 - $1.00 for societal indirect cost assuming vaccine price to be 20 Philippine pesos (PHP).3</td>
<td>Limcangco et al (2001)</td>
</tr>
<tr>
<td>Childhood immunisation – Rotavirus vaccine</td>
<td>Egypt</td>
<td>• Save 2873 lives and prevent the loss of 94,993 DALYs. • Prevent 1,140,496 episodes of diarrhoea, 438,395 outpatient visits, and 47,508 hospitalisations.</td>
<td>$0.635 - $0.0384</td>
<td>Ortega et al (2009)</td>
</tr>
<tr>
<td>Measles vaccine</td>
<td>Ethiopia</td>
<td>• Benefits come from deaths averted (cost per death averted is slightly above US $200).</td>
<td>$1.85 - $2.36</td>
<td>Rajkumar et al (2012)</td>
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<tr>
<td>Malaria prevention – Insecticide-treated nets (ITNs) and Intermittent Preventive Treatment in pregnancy (IPTp)</td>
<td>Sub-Saharan Africa</td>
<td>- ITNs use by children could yield up to 19% reduction in all-cause mortality in those aged 1-59 months.   - IPTp preventing preterm birth and intrauterine growth restriction.</td>
<td>ITNs: $10; IPTp: $12.10</td>
<td>Mills and Shillcut (2004)</td>
</tr>
<tr>
<td>Malaria prevention – ITNs Ethiopia</td>
<td>Ethiopia</td>
<td>Pregnant women using ITNs leads to 28% reduction of low birth weight (LBW).</td>
<td>$25.63</td>
<td>Rajkumar et al. (2012)</td>
</tr>
<tr>
<td>Subsidy on antimalarial drug ACT</td>
<td>Low income countries, primarily Sub-Saharan Africa and South Asia</td>
<td>Annual benefits: 300,000 (mostly child) deaths averted or 10.5 million DALYs.</td>
<td>$35.00</td>
<td>Jamison et al. (2012)</td>
</tr>
<tr>
<td>Folic acid fortification</td>
<td>South Africa</td>
<td>- Decline in neural tube defects (NTDs) by 30.5%.   - Deaths due to NTDs reduced by 65.9% for perinates and 38.8% for infants.</td>
<td>$30.00</td>
<td>Sayed et al. (2008)</td>
</tr>
<tr>
<td>Iron fortification</td>
<td>Bangladesh, Bolivia, Egypt, Honduras, India, Mali, Nicaragua, Oman, Pakistan, Tanzania</td>
<td>Decrease iron deficiency anaemia by 9% population-wide.   - Productivity increases through averted iron deficiency anaemia; fewer cognitive deficits from childhood and increased manual occupations for adults.</td>
<td>$6.00 for physical productivity gains only $36.00 with added cognitive benefits</td>
<td>Horton and Ross (2003)</td>
</tr>
<tr>
<td>Iron fortification</td>
<td>India</td>
<td>- Added 10 mg daily of iron to the diet through iron fortified salt.   - Decrease in iron deficiency anaemia of 7.9 percentage points for children and 7.8 percentage points for women.  - Increased productivity and labour work due to reduced anaemia.</td>
<td>$2.40 for women and children $5.10 accounting for increased productivity of men</td>
<td>Horton et al. (2011)</td>
</tr>
<tr>
<td>Iron fortification</td>
<td>South Asia and Sub-Saharan Africa</td>
<td>Benefits in terms of immediate impact on GDP is $3.78 per capita.   - Benefits in terms of future GDP (cognitive gains) are in the range of $1.03- $0.38, based on labour share of GDP at 40%.</td>
<td>$8.00</td>
<td>Horton et al. (2008)</td>
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<tr>
<td>Iodized fortification - salt</td>
<td>South Asia and Sub-Saharan Africa</td>
<td>• Benefits come from averted economic loss per birth to a woman with goiter which averages 1.5%. Present value of benefits per capita ranges from $1.47 to $0.60.</td>
<td>$30.10</td>
<td>Horton et al. (2008)</td>
</tr>
<tr>
<td>Iodine &amp; iron fortification – salt and oil</td>
<td>Ethiopia</td>
<td>• Iodized oil and fortified salt use by pregnant women and children 6-24 months increases child IQ by 13.5 points. • A 13% reduction in LBW through fortification with both iron and iodine. • Iodized salt fortified with iron increases IQ in 30% of anaemic children by 7.5 points • For pregnant women, reduces under-5 mortality by 5%.</td>
<td>Iodized oil in pregnancy: $486.26 Oil in pregnancy and for children (6-24 months): $109.68 Iodized salt: $81.00 Salt with iodine and iron: $2.53</td>
<td>Rajkumar et al. (2012)</td>
</tr>
<tr>
<td>Multiple micronutrient supplementation: Sprinkles® for children</td>
<td>Pakistan</td>
<td>• Reduced under-5 mortality; 112 deaths fewer diarrhoea-related deaths with 6% lower diarrhoea prevalence, attributed to zinc component. • Increased cognitive ability with 2.1 point higher IQ due to lower iron deficiency anaemia yielding increased productivity and adult wages.</td>
<td>$37.00</td>
<td>Shaneef et al. (2006)</td>
</tr>
<tr>
<td>Iron and folate children (6–24 months)</td>
<td>Ethiopia</td>
<td>• Increases IQ in 30% of anaemic children by 7.5 points</td>
<td>$23.79</td>
<td>Rajkumar et al. (2012)</td>
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<tr>
<td>Vitamin A supplements for children upto 5 years</td>
<td>South Asia (SA), Sub-Saharan Africa (SSA), East Asia (EA), Latin America and Caribbean (LAC)</td>
<td>• Reduced under-five mortality</td>
<td>-</td>
<td>Horton et al. (2009)</td>
</tr>
<tr>
<td>Vitamin A supplements, children 1–59 months</td>
<td>Ethiopia</td>
<td>• Aversion of 23% of child deaths (under-5).</td>
<td>$12.57</td>
<td>Rajkumar et al. (2012)</td>
</tr>
<tr>
<td>Zinc supplements, treatment for diarrhoea for children upto 5 years</td>
<td>SA, SSA, EA, CA, LAC</td>
<td>• Reduced under-five mortality</td>
<td>coverage 0-40% SA $13.75, EA $13.75 $9.60, CA &lt; $13 &lt; $6 LAC &lt; $8 &lt; $5</td>
<td>Horton et al. (2009)</td>
</tr>
<tr>
<td>Zinc supplements, preventative</td>
<td>Ethiopia</td>
<td>• For children aged 6-24 months reduced child deaths due to diarrhoea by 50% and potentially overall under-5 deaths by 17%,</td>
<td>$2.85</td>
<td>Rajkumar et al. (2012)</td>
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<tbody>
<tr>
<td>Promotion of optimal breastfeeding</td>
<td>Ethiopia</td>
<td>• With proper breastfeeding practices; early initiation, exclusive breastfeeding to 6 months, appropriate complementary feeding, could save 73,000 child (under-5) lives.</td>
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<td></td>
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<td>$27.12</td>
<td>Rajkumar et al. (2012)</td>
</tr>
<tr>
<td>Handwashing</td>
<td>Ethiopia</td>
<td>• Reduces child and maternal mortality</td>
<td>$7</td>
<td>Rajkumar et al (2012)</td>
</tr>
<tr>
<td>Treatment of severe-acute malnutrition, facility-based</td>
<td>Ethiopia</td>
<td>• Height returned to normal after treatment, after being on 2 standard deviations below average.</td>
<td>$2.04</td>
<td>Rajkumar et al (2012)</td>
</tr>
<tr>
<td>Supplementary food for malnourished children</td>
<td>Ethiopia</td>
<td>• Provisions for up to three months reduced deaths among moderately malnourished children by 70%.</td>
<td>$1.43</td>
<td>Rajkumar et al (2012)</td>
</tr>
<tr>
<td>Iron and folic-acid supplements and deworming in pregnancy</td>
<td>Vietnam</td>
<td>• Weekly dosing with iron and folic-acid supplements, plus periodic deworming, decreased the prevalence of iron deficiency anaemia from 38% to 20%, and hookworm infection from 76% to 22%. • Productivity gains from increased cognitive ability. • Reductions in health care costs associated with reduced maternal and infant mortality and morbidity, and reduced NTDs.</td>
<td>$6.70</td>
<td>Casey et al. (2011)</td>
</tr>
<tr>
<td>Iron and folic-acid supplements in pregnancy</td>
<td>Ethiopia</td>
<td>• Supplementation for women in pregnancy reduces LBW by 13%.</td>
<td>$8.10</td>
<td>Rajkumar et al. (2012)</td>
</tr>
<tr>
<td>Family planning, modern methods</td>
<td>Vanuatu, Solomon Islands</td>
<td>• Meeting family planning needs by 2020, increasing contraceptive prevalence to 65% in Vanuatu and 37.6% in the Solomon Islands would: • Reduce unintended pregnancies by 68% in Vanuatu and 50% in the Solomon Islands. • Avert 2,573 maternal and infant deaths. • Slowed population growth would decrease dependency ratios.</td>
<td>$9.00-$16.00</td>
<td>Kennedy et al. (2013)</td>
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<tr>
<td>Intervention</td>
<td>Countries/Regions</td>
<td>Outcomes</td>
<td>Benefits per dollar invested (Benefit-Cost Ratios)</td>
<td>Author (Year)</td>
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| Family planning, modern methods | Multiple. Primarily Sub-Saharan Africa. | • Fewer infant and maternal deaths.  
• Increased per-capita income growth. | $90.00-$150.00 | Kohler (2012) |
| Family planning, modern methods | Primarily countries in the Asia Pacific and African region. | • Progress towards all MDGs; reduced child mortality, improved maternal health, reduced burden of HIV/AIDS, malaria and other diseases, ensuring environmental sustainability.  
• Reduced costs for meeting the MDGs by reducing the size of the target populations in need of services | El Salvador: $1.30  
Kenya: $4.00 | USAID Health Policy Initiative (2009) |
| Emergency obstetric care | Low income countries primarily Sub-Saharan Africa and South Asia | • Surgery to address difficult childbirth, trauma and obstetric complications could avert 16 000-21 200 DALYs per 20% coverage increase. | $10.00 | Jamison et al. (2012) |
| Emergency caesarean section for obstructed labour (cEmOC) | 49 countries. We report results for selected few only | • Scale-up of cEmOC to meet the need sees DALYs averted through reduced maternal deaths and morbidity due to fistula.  
• DALYs averted:  
  - Bangladesh: $5.4  
  - Cambodia: $3.8  
  - Gabon: $69.9  
  - India: $15.0  
  - Indonesia: $15.8  
  - Malawi: $2.7  
  - Oman: $38.8  
  - Pakistan: $9.9  
  - Uganda: $4.9  
  - Vietnam: $7.1  
  - Zimbabwe: $0.6 | Bangladesh: $5.4  
Cambodia: $3.8  
India: $15.0  
Indonesia: $15.8  
Malawi: $2.7  
Oman: $38.8  
Pakistan: $9.9  
Uganda: $4.9  
Vietnam: $7.1  
Zimbabwe: $0.6 | Alkire et al. (2012) |
| Packages of Interventions | China, Indonesia, Peru, Philippines, PNG, Vietnam | • Prevented an additional 97 861 under-5 child deaths.  
| Packages of Interventions | Africa and Asia with a case study of Guinea | • Averted DALYs:  
  - 15 156 due to maternal causes;  
  - 172 460 for newborns;  
  - 82 602 for children under-5. | A: $23.60  
B: $23.70  
C: $14.10 | Foster et al (2012) |

(continued)
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<th>Intervention</th>
<th>Countries/Regions</th>
<th>Outcomes</th>
<th>Benefits per dollar invested (Benefit-Cost Ratios)</th>
<th>Author (Year)</th>
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</thead>
</table>
| Package of modern family planning, maternal and newborn care, malaria, PMTCT, immunization | 74 countdown countries                 | • Scale-up to 88% coverage 2013-2035 could save 147 million child deaths, 5 million maternal deaths and 32 million stillbirths.  
• 53% total child deaths prevented would come from scaling up family planning and 47% would be lives saved from scaling up promotive, preventive and curative health services. | Upto 2035, Low income: $7.20, Lower-middle income: $11.30, Upper-middle income (excluding China): $6.10, All 74 countries: $8.70 | Stenberg et al. (2014) |
| Child immunisation package: diphtheria, pertussis, tetanus, polio, measles, HepB, Hib, rotavirus, streptococcus. | Low income countries primarily Sub-Saharan Africa and South Asia | • Annual benefits: 1 million child deaths averted or 20 million DALYs | $20.00 | Jamison et al. (2012) |
| Package to prevent LBW by pregnancy care which addresses: A. asymptomatic bacteriuria, B. STDs, C. Complications in pregnancy | Developing countries                   | • Reduction in infant mortality to the value of $92.86  
• Increase in lifetime productivity due to averted LBW disability worth $239.31, representing 41% of total benefits.  
• Avoidance of medical costs for care of LBW valued at $41.80, and of subsequent illnesses and care for LBW infants and children at $38.10  
• Prevention of loss of lifetime productivity due to stunting worth: $99.34  
| Infant and child nutrition: A. Breastfeeding promotion in hospitals, B. Integrated child care, C. Pre-school nutrition program for the poor | Developing countries                   | • Reduction in infant mortality  
• Reduction in diarrhoea related morbidity  
• Increased cognitive ability through reduced stunting  
<table>
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<th>Intervention</th>
<th>Countries/Regions</th>
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<th>Benefits per dollar invested (Benefit-Cost Ratios)</th>
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<tr>
<td>Reducing micro-nutrient deficiencies:&lt;br&gt;A. Iodine for women of reproductive age&lt;br&gt;B. Vitamin A supplements for children&lt;br&gt;C. Iron supplements for pregnant women&lt;br&gt;D. Iron supplements for population</td>
<td>Developing countries</td>
<td>• Increased cognitive ability&lt;br&gt;• Reduced mortality&lt;br&gt;• Increased productivity</td>
<td>A: $15.00-$520.00&lt;br&gt;B: $4.30-$43&lt;br&gt;C: $6.10-$14.00&lt;br&gt;D: $176.00-$200.00</td>
<td>Behrman et al. (2004)</td>
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<td>Community-based child nutrition program</td>
<td>South Asia and Sub-Saharan Africa</td>
<td>• Saves 10 million DALYs per year for children under-5 years.&lt;br&gt;– Decline in rural infant mortality 17% (among treated) averted 4,119 child deaths. No reduction in neonatal deaths. -Larger declines for municipalities whose pre-programme levels of mortality were above the median, and those with higher illiteracy rates, and less access to electricity.</td>
<td>$12.50</td>
<td>Horton et al. (2008)</td>
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<tr>
<td>Maternal and Child Health (MCH) package in Progresa conditional cash transfer program; growth monitoring, deworming, ORS, antenatal care, immunisations, health education, targeted nutrition supplements</td>
<td>Mexico</td>
<td></td>
<td>$1.30-$3.60</td>
<td>Barham (2011)</td>
</tr>
<tr>
<td>Package for stunting: For mother and child: breastfeeding, complementary feeding, hand washing, micronutrient powders, vitamin A supplements, deworming, zinc for diarhoea treatment, care for severe acute malnutrition. For mothers only: folic acid supplements in pregnancy, iron and iodine fortification of staple foods</td>
<td>South Asia and Sub-Saharan Africa. Results reported for Bangladesh, India, Kenya and Ethiopia.</td>
<td>• Increased per capita consumption.</td>
<td>Bangladesh $24.00-$74.60&lt;br&gt;India $44.50-$138.60&lt;br&gt;Ethiopia $15.00-$46.80&lt;br&gt;Kenya $24.00-$75.90</td>
<td>Hoddinot et al. (2012)</td>
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<tr>
<td>Intervention</td>
<td>Countries/Regions</td>
<td>Outcomes</td>
<td>Benefits per dollar invested (Benefit-Cost Ratios)</td>
<td>Author (Year)</td>
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<tr>
<td>Package for stunting</td>
<td>SSA, Middle East and North Africa, South Asia, East Asia</td>
<td>* Increase in per capita consumption.</td>
<td>SSA Democratic Republic of Congo 3.5 Madagascar $ 9.8 Ethiopia $ 10.6 Uganda $ 13.0 Tanzania $ 14.6 Kenya $ 15.2 Sudan $ 2.3 Nigeria $ 24.4 Middle East and North Africa Yemen $ 28.6 South Asia Nepal $ 12.9 Burma $ 17.2 Bangladesh $ 17.9 Pakistan $ 28.9 India $ 38.6 East Asia Vietnam $ 35.3 Philippines $ 43.8 Indonesia $ 47.7</td>
<td>Hoddinot et al. 2013</td>
</tr>
<tr>
<td>Protection from child diarrhoea: vaccinations and sanitation</td>
<td>Developing countries</td>
<td>* Mortality and morbidity reduction by all-cause diarrhoea and cholera disease prevention, labour time savings, higher quality and quantity of water available.6</td>
<td>Borehole + pump: $3.17  Bio-sand filter: $2.93  Community cholera vaccination: $0.90  School cholera vaccination: $2.64</td>
<td>Jeuland and Whittington (2009)</td>
</tr>
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<td>Sanitation programs</td>
<td>African and Asian countries</td>
<td>* Prevention of premature deaths, costs of treating diseases; productive time lost due to illness, and time lost by caregivers.  * Avoids cost of additional time spent accessing toilets and water sources, absence of children (mainly girls) from school and women from workplaces.  * Avoids Potential loss of tourism revenues from economic impacts of gastrointestinal illnesses among foreign tourists.  * Aesthetic and lifestyle benefits from increased water use  * Averted deaths and health care costs due to diarrhoeal disease  * Time savings and productivity gains through ease of access to water supply and reduced burden of diarrhoeal diseases.</td>
<td>Intervention A only $4.00-$7.00  B only $2.3-$47.00  C only $40.00  D only $3.40</td>
<td>Rijsberman and Zwane (2012)</td>
</tr>
<tr>
<td>Sanitation programs-Hygiene education plus</td>
<td>Developing countries and regional estimates</td>
<td>* Increase in per capita consumption.</td>
<td>Intervention A only $8.80  B only $11.70  C only $11.00</td>
<td>Hutton (2008)</td>
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burden countries was estimated to have BCRs ranging from $3.5 in the Democratic Republic of Congo to $139 in India (Hoddinott et al., 2012, 2013), depending upon various assumptions. The package of interventions to combat LBW includes treatments for women with asymptomatic bacterial Infections, treatment for women with presumptive STD and drugs for pregnant women with a poor obstetric history (Behrman et al., 2004). Only two studies report returns from the management of child birth related complications such as obstructed labour (Alkire et al., 2012; Jamison et al., 2012) and give divergent estimates across various settings, ranging from $0.60 in Zimbabwe to $69.90 in Gabon (Alkire et al., 2012).

Newborn, Infancy and Childhood
A majority of studies provided BCRs for interventions addressing care for infants and children, relating mostly to nutrition (Behrman et al., 2004; Hoddinott et al., 2012, 2013; Horton et al., 2008, 2009, 2011; Rajkumar et al., 2012; Sharieff et al., 2006) and disease prevention and treatment (Baier et al., 2012; Bishai and Mercer 2001; Hutton 2008; Jamison et al., 2008, 2012; Jeuland and Whittington 2009; Jha et al., 2012; Lincangco et al. 2001; Miguel and Kremer 2004; Mills and Shillcut 2004; Ortega et al. 2009; Rajkumar et al., 2012; Rijsberman and Zwane 2012; Whittington et al., 2008). A recent estimate of optimal breastfeeding was found to have a BCR of $27.12 in Ethiopia (Rajkumar et al., 2012). Some of the most robust measurements relate to the nutrition of children. BCRs ranging from $1.40 to $16.20 per dollar spent were estimated for a package of nutrition-based interventions in low income countries in South Asia and SSA (Behrman et al., 2004). Iron (per capita) and Vitamin A supplements reported BCRs varying between $176 to $200 and $4 to $90.33, respectively, in similar settings (Behrman et al., 2004, Rajkumar et al., 2012, Horton et al., 2009). Therapeutic use of zinc shows benefits varying between less than $6 and $14 (Horton et al., 2009) with the preventive use of zinc reporting benefits of $2.85 in the only recent study (Rajkumar et al., 2012). Micronutrient fortification is found to be very cost beneficial, with the BCRs of home fortification, such as ‘sprinkles’, amounting to $37 in Pakistan (Sharieff et al., 2006) and salt fortified with iron standing at $81 in Ethiopia (Rajkumar et al., 2012).

The economic returns from interventions related to disease prevention and treatment in children are considerable. Based on a randomized control trial in Kenya, deworming of school age children was found to return a very high BCR of $60 (Miguel and Kremer 2004). Water, Sanitation and Hygiene (WASH) related interventions effectively addressing diarrhoea were associated with moderately high BCRs, ranging from $2.70 to $47 (Hutton 2008; Jeuland and Whittington 2009; Rijsberman and Zwane 2012; Whittington et al., 2008), while insecticide treated bed nets for children has been found to have a BCR of $10 (Mills and Shillcut 2004). Similarly, high returns have been reported from childhood immunisation packages, with benefits standing at $20 in SSA (Jamison et al., 2012). Consistent with the high cost of providing food, relatively lower BCR has been reported for addressing severe acute malnutrition, standing at approximately $2.04 in Ethiopia (Rajkumar et al., 2012).

Discussion
The results on benefits per dollar invested summarized above indicate that large economic returns can be achieved by investing in RMNCH. Across the board there is strong evidence of high economic returns to early life investments. Large BCRs have been estimated for early-life investments, particularly with respect to family planning and nutrition related interventions. In fact, some of the most robust measurements of the economic returns of early-life interventions relate to the nutrition of mothers and children, which have been found to show large benefits for each dollar invested across different settings and methodologies. Impressive economic returns can also be expected from deworming programs - the most notable example being provided by the studies on deworming of the school age children in Kenya (Baird et al., 2012; Miguel and Kremer 2004). Simulation-based exercises for the Asia-Pacific region and Africa also show high economic returns of investing in a priority package of maternal, newborn and child health interventions. Even though particular caution needs to be exercised when intending to use simulated estimates, which are extremely sensitive to the choice of parameters and assumptions, including those related to the macro-economic environment, it is reassuring that positive BCRs have been consistently reported with respect to the simulated studies as well as more robust studies such as the one by Baird et al. (2012).

However, our findings reveal two important limitations in this literature that should be addressed in future studies. First, the majority of the reviewed papers were concentrated in SSA, with only a few studies in the most populous region of the world, Asia-Pacific, which still suffers from a considerable burden of RMNCH mortality and morbidity. Additionally, estimates of BCRs have largely targeted preventive interventions, generally provided through routine schedulable care, so very little evidence exists on the BCRs for curative care. Economic evaluations of other several essential RMNCH interventions, such as calcium supplementation to pregnant women or Kangaroo Mother Care, are also yet to be conducted.

Methodological issues
In this section we identify some of the specific methodological challenges faced by researchers in estimating the BCRs. Our review builds on several Copenhagen Consensus Challenge Papers (Behrman et al., 2004; Horton et al., 2008; Kohler, 2012), which provide useful discussions on some key issues related to the methodology of CBA in specific RMNCH domains. We report findings in regards to methodological issues along the following lines: measurement of benefits; measurement of costs; choice of discount rates; and source for key parameter data and sensitivity analysis.

Results
Measurement of benefits
The two studies on deworming of school children in Kenya (Baird et al., 2012; Miguel and Kremer 2004), based on randomized control trial have estimated positive externalities occurring from the treatment. Benefits included not only health gains such as improvements in self-reported health, but also direct economic outcomes such as increases in mean hours worked (by 12% in the treatment group and 20% among out-of-school wage workers) and school enrolment (by 0.3 years in the treatment group); improved standards of living through increased number of meals eaten; shifts to cash crops, and tripled employment in the manufacturing sector (Baird et al., 2012).

In the simulated studies on RMNCH packages, benefits are generally estimated as lives saved and morbidity averted (Foster et al., 2012; Sheehan et al., 2012; Stenberg et al., 2014) or as the ‘demographic dividend’ from reducing unwanted pregnancies (Stenberg et al., 2014). Similarly, benefits from nutrition-based interventions, for example, are often confined to only three main categories:
averred mortality (Behrman et al. 2004; Horton et al. 2008, 2009; Rajkumar et al. 2012; Sayed et al. 2008, Sharieff et al. 2006); the direct gain in productivity (Behrman et al. 2004; Horton et al. 2011; Rajkumar et al. 2012); or the indirect gain in productivity through increased cognitive ability (Behrman et al. 2004; Casey et al. 2011; Horton and Ross 2003; Rajkumar et al. 2012; Sharieff et al. 2006). Additionally, Behrman and colleagues (Behrman et al. 2004) considered a broader range of benefits coming from averted cost of illness and cross-generational impacts.

Regarding family planning interventions, to date, studies have been able to capture a range of benefits including: mortality effects on mothers and children and the impact on per capita income growth through reduced fertility (Kohler 2012); public sector savings in health and education (Kennedy et al. 2013); or the reduced cost of meeting the MDG targets by reducing the size of the target population (USAID Health Policy Initiative 2009).

In the AIDS, Malaria and vaccination literatures, benefits have been measured in terms of reduced mortality (Bollinger 2011; Jamison et al. 2008, 2012; Jha et al. 2012; Mills and Shillcut 2004; Peffer et al. 2002); reduced treatment cost and saving of medical expenditure (Bollinger 2011; Bishai and Mercer 2001; Limcangco et al. 2001; Resch et al. 2011); averted orphan care cost (Resch et al. 2011); or gains in labour productivity (Bishai and Mercer 2001; Limcangco et al. 2001; Resch et al. 2011).

Studies that seek to measure the benefits of WASH interventions (Hutton 2008; Rijssberman and Zwane 2012; Jeuland and Whittington 2009; Whittington et al. 2008) mostly report the economic value of the time savings, and the monetary benefits of deaths averted.

Measurements of costs

Discount Rate
As reported in Supplementary Table A.1, some studies do not use any discount rate (Barham 2011; Resch et al. 2011) and some use a single discount rate only (Alkire et al. 2012; Bishai and Mercer 2001; Ortega et al. 2009; Peffer et al. 2002; Sharieff et al. 2006). Additionally, while some studies mention that their results are not sensitive to the choice of discount rates (Resch et al. 2011) or that they are producing conservative estimates (Barham 2011), some provide no clear explanation in regards to their choice of discount rates (Peffer et al. 2002; Sayed et al. 2008; USAID Health Policy Initiative 2009).

Source Data for key parameters and sensitivity analysis

Discussion
The estimated BCRs fluctuate considerably across settings as structures and associated costs of disease patterns, social behaviours and health systems vary. Yet, greater sources of variation most likely stem from the methodological approaches undertaken by different researchers. The techniques adopted by different studies vary substantially and, as noted earlier, the literature lacks transparent and rigorous reporting on methods and key assumptions used, such as the valuation criteria for costs and benefits. These problems render the assessment and comparability of BCR estimates an almost impossible task.

Narrowly defined benefits
Most of the reviewed studies adopt a confined approach to measure benefits, which is a major methodological issue affecting this literature. Often the availability of data and ease of data collection has influenced the valuation of benefits. Rarely are rich experimental data-based studies reported in the literature, with the exception of a deworming study in Kenya (Baird et al. 2012; Miguel and Kremer 2004). In these studies, the benefit calculations are based on a range of social outcomes, with efforts undertaken to include externalities such as improvements in standards of living for the neighbours of those receiving treatment, to capture the full impact of subsidising deworming treatments. In the reviewed studies under consideration, in most cases, only private benefits can be gauged, leaving broader societal gains unmeasured. Behrman and colleagues (2004) Behrman et al. 2004 attempted to include broader societal gains such as cross generational effects of an intervention in their estimates of benefits. However, they admit their inability to present separate estimates of private and social BCR. Without estimating all the associated costs and benefits, irrespective of who wins (i.e. who bears additional benefits) and who loses (i.e. who bears additional costs), the study will not be able to assess if the proposed intervention is an efficient use of resources (i.e. the sum of all benefits is higher than the total costs) (Campbell and Brown 2003).

Often the benefits of an intervention will be complex and multi-dimensional. For example, the benefits of large scale family planning encompass issues related to climate change, environmental sustainability and political stability in addition to its life cycle, intergenerational and distributional effects (Kohler 2012). To date, studies have been able to capture only a narrow range of benefits, and most often exclude externalities associated with health system strengthening, even though the associated costs might have been included. These concerns and other complex issues, including how to value...
welfare of an individual who may not be born as a result of the intervention – a question on which no consensus exists to date (Kohler 2012) – renders empirical evaluation of benefits a huge challenge. Similar concerns pervade the AIDS, Malaria and vaccination literatures, where benefits have been measured narrowly. Broader macroeconomic impacts of these diseases are not measured, including important community externalities, such as ‘herd effects’ in the case of vaccination. Often a dynamic model is needed to capture such effects, relaxing assumptions such as a constant infection rate (Bärnighausen et al. 2011), which no study has yet been able to capture. Similarly, studies that seek to measure the benefits of WASH interventions (Hutton 2008; Jeuland and Whittington 2009; Rijssberman and Zwan 2012; Whittington et al. 2008) rarely report sound empirical evidence to quantify the economic value of time savings, and the monetary benefits of deaths averted, often relying on extrapolations based on limited experimental data. These challenges have a considerable effect on the reliability of the estimates. Moreover, often benefits are prevalence-based (Bishai and Mercer 2001; Limcangco et al. 2001; Ortega et al. 2009; Sayed et al. 2008) rather than incidence-based (Baier et al. 2012; Behrman et al. 2004; Horton et al. 2008; Miguel and Kremer 2004). The latter approach takes account of downstream benefits of an intervention instead of just relying on cost savings, and hence, such results are more reliable (Horton et al. 2008).

It should however be acknowledged that expressing the economic impact of an intervention in monetary terms is a challenging task. The challenge is typically illustrated by the vexing problem of assigning value to averted mortality (Behrman et al. 2004). A number of approaches have been used, with the dominant one being the ‘Human Capital Approach’ (Bishai and Mercer 2001; Casey et al. 2011; Foster et al. 2012; Horton and Ross 2003; Horton et al. 2011; Sheehan et al. 2012; Rajkumar et al. 2012; Shariff et al. 2006); followed by the revealed preference approach of looking at wage-risk trade-offs (Barham 2011); the stated preferences (contingent valuation) approach of utilising willingness-to-pay (Onwujekwe et al. 2013); and using resource costs of the most effective alternative means of postponing mortality (Behrman et al. 2004). Several Copenhagen Challenge Papers converted incremental cost-effectiveness ratios to BCRs by selecting statistical valuations of a life (Jamison et al. 2012; Jha et al. 2012; Mills and Shillcut 2004). Researchers hardly reach consensus on what the best approach is and ethical issues remain contentious. This is so complex that Hoddinott and colleagues (Hoddinott et al. 2012; 2013) avoided estimating the monetary benefit of lives saved, relying instead on valuing the benefits of reduced stunting through its direct effect on permanent consumption, despite leading to a substantial underestimation of measured benefits.

A related issue is weighting – what should be the value of a year of life at different ages (Horton et al. 2008). Some authors adopt the practice of not weighting Disability-Adjusted Life Years (DALYs) differentially (Jamison et al. 2012), while others employ age-weighting (Alkire et al. 2012). Similar questions arise when conducting cross-country analysis and one must value life across high and low income countries. The key issue is whether or not to assume that the value of a statistical life and a DALY varies with the level of income. The Copenhagen Consensus 2012 (CC12) Challenge Papers used DALYS valued at $1,000 per year for low income countries (Kohler 2012; Jamison et al. 2012), to assure consistency with regard to critical assumptions which accept the ‘rule of thumb’ value that health investments are good value if the cost is less than three times per capita GDP (Mills and Shillcut 2004). A valuable critique of various aspects of this approach to valuing is provided in Canning (2009) who asserts the validity of these critical assumptions remains an open question.

Narrowly defined costs

Regarding the measurement of costs, very few studies adopt a societal perspective in measuring costs, with most common reason being a lack of adequate data. With a few exceptions (Bishai and Mercer 2001; Casey et al. 2011; Kennedy et al. 2013; Limcangco et al. 2001; Ortega et al. 2009; Peffer et al. 2002), the majority of studies do not specify clearly which perspective has been taken. In cases where a broader perspective is claimed, often the actual analysis does not include important private costs (e.g. out-of-pocket expenditure) (Bishai and Mercer, 2001) or social costs (e.g. environmental impact) (Bishai and Mercer 2001, Limcangco et al. 2001), quite often ignoring opportunity costs (e.g. time and travel costs of patient and care giver) or excluding costs of raising funds for governmental programs, and including transfers in cases that do not reflect the true resource cost to the society (Hoddinott et al. 2013).

For the studies that take a program cost approach, the delivery mechanism is extremely important. For example, the BCR for deworming pregnant women in Ethiopia is high ($648) due to the cost of supplying deworming drugs when treated as a stand-alone program, whereas being part of an outreach program would entail zero marginal distribution cost resulting in an even higher BCR (Rajkumar et al. 2012). However, the assumptions regarding the delivery mechanism are not always stated explicitly, especially in the simulation-based studies, and delivery costs are sometimes assumed constant. Market delivered interventions such as fortification tend to have lower unit costs than supplementation since costs such as those of distribution, ensuring adherence to recommended frequency intake or screening the population should be included in the latter (Horton et al. 2008). Careful consideration of these issues is necessary for measuring costs and yet has rarely been done.

Analogous to benefits, some costs are difficult to quantify and often not incorporated. For example, estimating the costs associated with health system strengthening across multiple settings is often challenging (Kohler 2012; Mills and Shillcut 2004). Health system costs are highly idiosyncratic and difficult to standardise across countries, which poses considerable challenges to multi-country studies. Additionally, cultural differences, such as women’s autonomy in contraceptive decision making vary greatly and will have an impact on the recommended policies and the associated costs required to bring about the required behavioural changes.

Costs often do not reflect changes in inflation leading to underestimation (Kohler 2012; Sheehan et al. 2012). Conversely, typically in the evaluation of vaccinations, costs do not account for savings that can occur when vaccines are combined and delivered in a single vial, and hence tend to overstate costs (Bärnighausen et al. 2011). Moreover, it is frequently not clear whether the costs measured are average costs, marginal costs or incremental costs.

The aggregation of costs is also a major issue. Several studies on WASH interventions have ventured to estimate costs based on data, reported in a recent review (DFID 2013), to be derived from a limited number of studies in disparate settings based on the authors’ assumptions rather than a systematic estimate of the mean cost or a measure of certainty. Moreover, most studies do not have adequate data on useful lifetime or annual operations and maintenance costs, with limited scope to account for differences in regional costs. Often studies lack transparent descriptions of how costs are used to generate point estimates, and any efforts to assess the quality of the underlying methods of collecting cost data are generally absent.
Estimates of both costs and benefits will be sensitive to the scale and coverage of interventions (Kohler 2012). Yet, assumptions on coverage and scale are often not explicitly stated. Coverage is especially important for the measurement of costs – primarily because the marginal cost generally increases with coverage (Behrman et al. 2004; Horton et al. 2009; Rajkumar et al. 2012). In other contexts, coverage may be a lesser concern, as with interventions like doubly fortified salt, where coverage mattered only for the last 10% of the population (Horton et al. 2011). The cost–coverage interaction is sensitive to the type of intervention. For example, vaccination interventions have a high set up cost but marginal cost declines with increased coverage at least initially; while interventions like educational campaigns for condom use can be affordably targeted to urban population but cost increases as relatively inaccessible rural areas are covered. Unfortunately, some of the reviewed studies do not make any explicit reference to coverage and fail to discuss the implication of various coverage levels for the BCRs (Sayed et al. 2008).

**Discount rate**

A critical issue in CBA is the choice of an appropriate discount rate, which can make substantial differences to the results, particularly for investments for which there exist considerable time lags (Behrman et al. 2004). Unfortunately the literature is fraught with disagreement among researchers regarding an appropriate discount rate, although discount rates of 3–10% are common in the social sciences (Kohler 2012). Other issues also arise such as using different discount rates for interventions which avert death as compared to those which improves future productivity, since in the former case benefits are realised immediately while in the latter they accrue with a lag (Horton et al. 2008). The reviewed studies do not always pay adequate attention to these issues. The main concern is not that some report BCRs which are undiscounted (Barham 2011; Resch et al. 2011) or use a single discount rate only (Alkire et al. 2012; Bishai and Mercer 2001; Ortega et al. 2009; Peffer et al. 2002; Sharieff et al. 2006) – although such approaches remain bad practice – but that quite often they do not justify the selection of a particular discount rate. This remains a major limitation of the reviewed literature.

**Lack of experimental data and weak sensitivity analysis**

The use of simulated data raises the possibility that many of the estimated BCRs are model-driven and cannot be replicated in real-life situations. This concern is compounded by the overall lack of experimental data available to estimate the wide range of benefits noted above. As widely noted in the medical literature and more recently in the economics literature, without such experimental data and robust study designs and statistical analysis, it is highly plausible that the produced estimates are subject to various sources of bias (Baird et al. 2012; Kohler 2012).

In addition to the above set of problems, contrary to recommended practice (Drummond et al. 2015; Sharieff et al. 2006), often critical information about the simulated data is not reported. Considerable ambiguity exists in discerning whether the effectiveness data come from systematic overviews, whether search strategy and exclusion/inclusion rules have been clearly specified or whether regional variations in costs, infrastructure or capacity have been accounted. The implications of potential biases are rarely mentioned. Horton and Ross (2003) are one exception and report that the productivity gains they have estimated rely on a few ‘well controlled’ studies and if the effects were only half as large as the benefits would be considerably lower. Results from simulation-based studies are also bounded by restrictive study assumptions such as the chosen time horizon and ‘disability multiplier’ (Foster et al. 2012). The latter uses mortality parameters to model the number of surviving persons with disability. For example, drawing on the maternal health literature to assume that for each woman who dies of obstructed labour, as many as 20–30 will suffer an obstetric fistula (Foster et al. 2012).

The problems associated with the lack of reliable data and use of restrictive assumptions can be partially addressed through sensitivity analysis. On occasion, studies do not conduct any sensitivity analysis at all (Sayed et al. 2008; Horton et al. 2011; Casey et al. 2011). In cases where such analyses are reported, many fail to identify the parameters used in their sensitivity analyses and often do not explicitly state the assumptions on specified uncertainty ranges (Ortega et al. 2009). While variations in these parameters are often assessed, concerns remain over whether these specifications accurately reflect the reality in low and middle income countries (Horton et al. 2008; Jamison et al. 2012).

This literature might have more fundamental flaws in the sense that even if studies report sensitivity analysis in full (Behrman et al. 2004; Jeuland and Whittington 2009; Sharieff et al. 2006) one would get such a wide range of estimates that a policy maker would be left with little solid information about the real BCR. For example, Jeuland and Whittington (2009) report BCRs ranging from $0.40 to $7.67 for school based cholera vaccination in developing countries.

**Conclusion**

The complexity and variety of RMNCH related interventions pose substantial challenges to the assessment of the associated economic returns. These interventions involve cross-sector collaborations and provide large, often intangible, non-health benefits. The scarcity of rich experimental data, restrictive study assumptions and a lack of consensus on the methodological approach limit the comparability of the various studies and has led to some uncertainty over the exact magnitude of the large reported BCRs. This suggests that one should take these ratios as indicative rather than definitive. Nonetheless, the policy implications of economic returns from investments in RMNCH should not be understated, with even the most conservative estimates of the benefits and costs yielding favourable BCRs across most settings.

Addressing the methodological limitations of the various studies remains the most pressing task for future research. However, the geographical imbalance of studies and the neglect of some critical RMNCH interventions should also be addressed. Further CBA of interventions in various settings across the developing world would increase the generalizability of the estimated BCRs. Additionally, economic evaluations of several essential RMNCH interventions which, have not been conducted yet would remain of much interest.

A growing literature demonstrates that the health events in early life can have considerable long term consequences for adult health, cognition, earnings and welfare. It is clear from this review that health interventions timed for this critical period pass the cost/benefit test. Consistency of methods is necessary, however, for comparability of results and to provide policymakers and development partners with the information required to prioritize their investments.

Guidelines for undertaking economic evaluation of health care interventions already exist in the form of a critical appraisal checklist for economic evaluation in general (Drummond et al. 2015).
A first step to ensure consistency of methods would be to elaborate and gain consensus on such a checklist specific to CBA. This would require drawing on the existing general guidelines for economic evaluation in health, while incorporating CBA specific methodological issues, such as pricing rules for outputs and inputs under different market conditions. These guidelines along with increasing transparency in reporting study methods and the underlying assumptions will substantially contribute to improving the evidence-base for investments in RMCNH.

Supplementary data
Supplementary data are available at HEAPOL online

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Notes

2. Societal benefit (productivity plus medical benefit) from 1 year of complete elimination of TB risk for one individual assuming TB costs globally equal those of established market economies.

3. $US1 PHP35 (1998 exchange rate)

4. The set of assumptions used in calculating DALYs: DALYs (r,K, β), where r the discount rate, K modulation of age-weighting formula (0 age weights off, 1 age weights on), and β age weighting parameter. DALYs (3,0,0) indicates a 3% discount rate and no age weighting. DALYs (3,1,β) indicates a 3% discount rate and country-specific age weights.

5. Included interventions in package: A. Antenatal care, Skilled birth attendance, Basic family planning, Essential newborn care, Promotion of exclusive breastfeeding, Immunization, Vitamin A supplementation, Oral Rehydration, IMCI, Hygiene, Bed nets. B. all the above plus complementary and therapeutic feeding, zinc supplementation, new vaccines, long-term family planning methods. C. All the above plus emergency obstetric and neonatal care, antiretroviral for HIV and PMTCT, water and sanitation.

6. The consumer surplus on the increased water use that occurs because of the fall in the effective price of water due to the more convenient, new water source.

7. All benefits are reported at average parameter values.

References


