COPENHAGEN CONSENSUS CENTER

HEALTH

INFANT MORTALITY

PERSPECTIVE PAPER

Benefits and Costs of the Infant Mortality Targets for the Post-2015 Development Agenda

Günther Fink

POST-2015 CONSENSUS

Benefits and Costs of the Infant Mortality Targets for the Post-2015 Development Agenda

Post-2015 Consensus

Günther Fink
Harvard School of Public Health

Working paper as of November 25, 2014

Highlights

Within the area of Infant mortality a valuable target is:

- Reduce neo-natal (0-27 days) mortality by 70% (2013-2030) which has a likely benefit-to-cost ratio of 11.7 to 18.2

Compared to other health areas, the potential impact of this target is large, preventing close to two Million infant deaths per year. However, the additional resources needed to achieve such improvements are also sizeable, and raising the necessary financial resources may require major changes in global health financing.

Foreword

Defining optimal targets at a local or global level is a challenging task; in many settings, a "global optimum" or "ideal world" scenario is relatively easy to define: for most people, a world with no military conflict, with no domestic violence and with no environmental pollution would certainly be preferred to the world as it is today. The same clearly also holds for child mortality – eliminating all infant and child deaths is without any doubt the goal the world should pursue in the long run. The results presented in this paper are not meant to challenge this broad and important long run objective; instead, the objective of this paper is to support the global efforts towards this longer term goal by identifying and assessing improvements achievable in the realm of infant mortality in the relatively short 2015-2030 period.

Introduction and Background

With only a few months left in 2014, global attention to the post-2015 development agenda is increasing. One of the most salient issues on the new agenda is health. As the High-Level Panel of Eminent Person (HLPEP) notes in their most recent draft "..[i]nvesting more in health, especially in health promotion and disease prevention, like vaccinations, is a smart strategy to empower people and build stronger societies and economies"(United Nations 2014, p. 38). The HLPEP further argues that solutions for child mortality are simple and affordable, and that therefore all preventable deaths should be averted by 2030, as stated in goal 3.2 of the latest Open Working Group for Sustainable Development Goals proposal (Open Working Group 2014). While the Open Working Group remains fairly vague in their definition of what "all preventable deaths" means in terms of specific targets, the HLPEP is more specific and proposes to aim "…for an upper threshold of 20 deaths per 1000 live births in all income quintiles of the population" "(United Nations 2014, p. 38).

In this paper, we try to assess the overall feasibility of this proposal as well as the relative cost-effectiveness of actions required to achieve this objective. Our analysis if divided into three parts: in the first part, we provide background information on current global mortality conditions as well as the progress made over the past 40 years; in the second part of the paper, we use all currently available data to estimate what kind of improvements in neonatal and infant mortality seem feasible within the 15-year time horizon covered by the new sustainable development goals (2015-2030).

In the third part of the paper, we zoom in on neonatal mortality (deaths in the first 28 days of children's life), which accounts for over 40 percent of total under-5 mortality today, and will become the main area to tackle for most countries if major progress in under-5 mortality is to be made over the next 15 years. We describe the specific interventions required to reach further reduction in this area, and assess their relative cost-effectiveness. Based on the most recent literature, we argue that further reductions of 70% in neonatal mortality are feasible over the 2015-2030 period, and that the required interventions are likely to be highly cost-effective, with an estimated cost of US$ 274 per disease adjusted life year (DALY) saved, and an estimated benefit-cost ratio of 18. The main challenge with this target is that the global investment required to achieve such reductions is large; the comprehensive health system adjustments needed to provide high quality pre- and post-natal care and a safe birth environment in all developing countries will require an additional global investment of more than US$ 15 billion per year. While this figure corresponds to only a very small proportion of the joint budget of the developed world (the US federal budget alone exceeded US$ 3 trillion in 2014, Germany's budget exceeded US$ 1.5 trillion), it is an amount that by far exceeds currently available resources for global health, and not an amount most developing countries will be able to cover by their own budgets.

Under-5 Mortality Today and Global Progress Made over the Period 1990-2013

Several recent papers and reports have highlighted the major progress made in the realm of child mortality over the past 40 years. While close to 18 Million children died before reaching their fifth birthday globally in 1970, the same was true for less than 7 Million children in 2013 (UN Inter-agency Group for Child Mortality Estimation (IGME) 2014). Given that the number of children born has increased over the same period, the actual reduction in the risk of mortality is even larger: total global under-5 mortality rate - defined as the number of deaths per 1000 children born alive under age-5 - declined from 142 per 1000 in 1970 to 44.2 in 2013, a reduction of 70% (Haidong Wang, Chelsea A Liddell et al. 2014)).

As shown in Table 1, the global progress in child mortality has been accompanied with a shift in the distribution of deaths within the first five years: while early neonatal mortality (deaths in the first 7 days of children's lives) accounted only for about 22% in 1970, it accounts for 32% of total mortality today; less than 29% of total under-5 deaths today occur among children after the first 12 months of their life.

Table 1: Global Trends in Neonatal, Infant and Under-5 Mortality

	1970	1990	2013	% change 1970-1990	% change 1990-2013
Early neonatal deaths (0-6 days)	3,886.0	3,256.8	2,001.4	-16.2%	-38.5%
Late neonatal deaths (7-28 days)	1,999.8	1,207.9	610.7	-39.6%	-49.4%
Post neonatal deaths (29-364 days)	5,636.5	3,853.7	1,847.8	-31.6%	-52.1%
Childhood deaths (1-4 years)	6,088.4	3,826.8	1,816.0	-37.1%	-52.5%
Total under-5 deaths	17,610.7	12,145.2	6,275.9	-31.0%	-48.3%

Source: Wang et al (2014), own calculations. Numbers in columns 1-3 are in thousands.

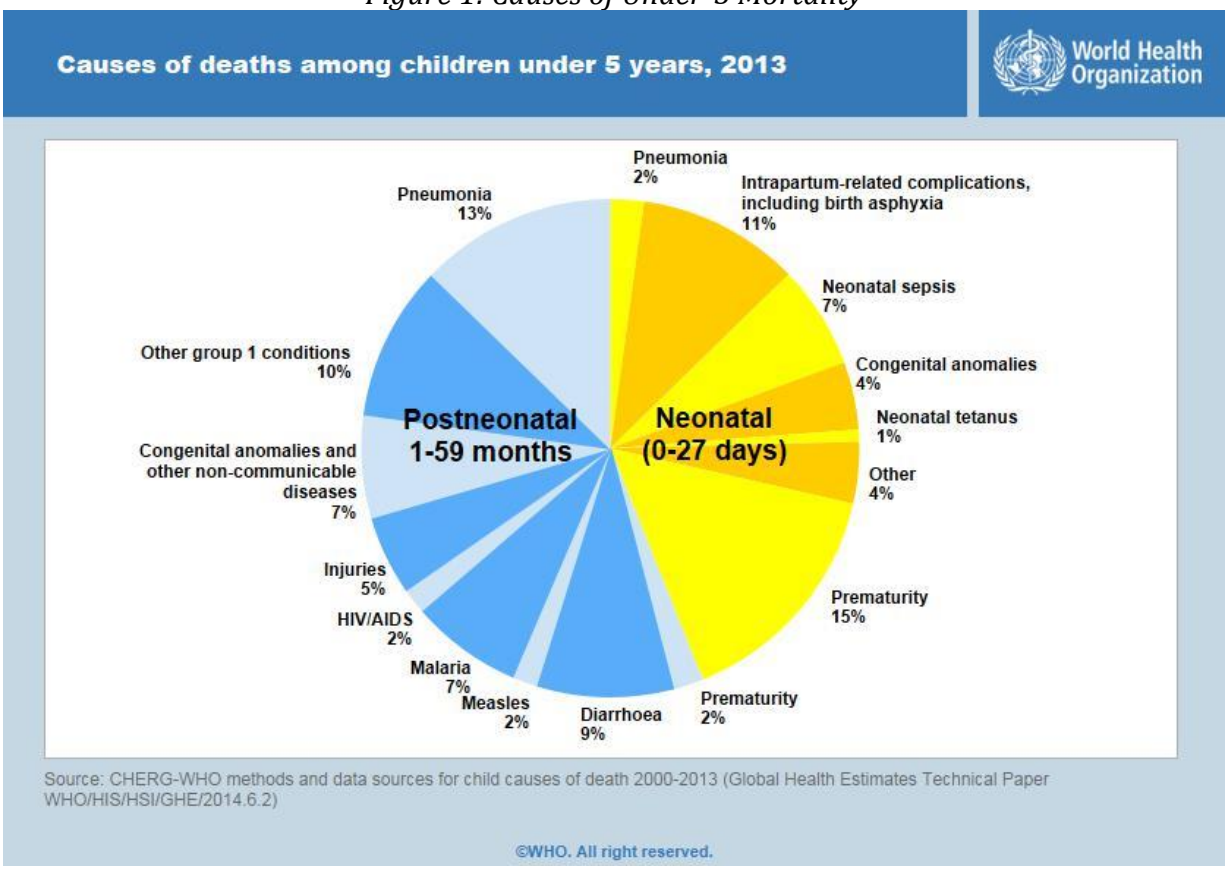
Figure 1 shows the current child mortality burden by cause of death, and strongly highlights the relatively large share of current under-5 mortality occurring in the neonatal period (first 28 days). Rather remarkably, the single most common cause of deaths among under-5 children today globally is prematurity,[1] accounting for an estimated 17% of the total global burden of under-5 deaths. Pneumonia, diarrhea and malaria – as the most common infectious diseases - account for 15%, 9% and 7%, respectively, while HIV is estimated to only account for 2% of total under-5 deaths globally today.

All of these numbers are a reflection of the rather remarkable progress made to reduce the global mortality from infectious diseases. The challenging part about the new mortality

[1] Prematurity is defined as delivery prior to 37 weeks of gestation.

patterns is that the changing nature and composition of child mortality requires actions and interventions beyond current efforts if major progress with respect to mortality is to be achieved in coming years: as of 2013, all major infectious diseases combined (diarrhea, HIV, malaria, measles, pneumonia) account only for 35% of under-5 mortality today; this means that the global burden of under-5 mortality would still exceed 4 Million deaths per year even if the world was to eradicate all of these infectious diseases and the number of births per year was to remain constant.

Figure 1: Causes of Under-5 Mortality



Trends and Projections: What Improvements Are Feasible?

As highlighted in the first part of the paper and in Table 1, the overall global progress in under-5 mortality has been rather remarkable, with reductions of more than two thirds since 1970, and reductions of close to 50% since 1990. Over the same period, the geographic distribution of child mortality has also shifted. While only one third of under-5 deaths occurred in Africa in 1990, Africa accounts for more than 50% of under-5 deaths today. Going forward, Africa is likely to account for an even larger fraction of child deaths both due to continued high fertility rates and the generally slower rates of progress made for child mortality.

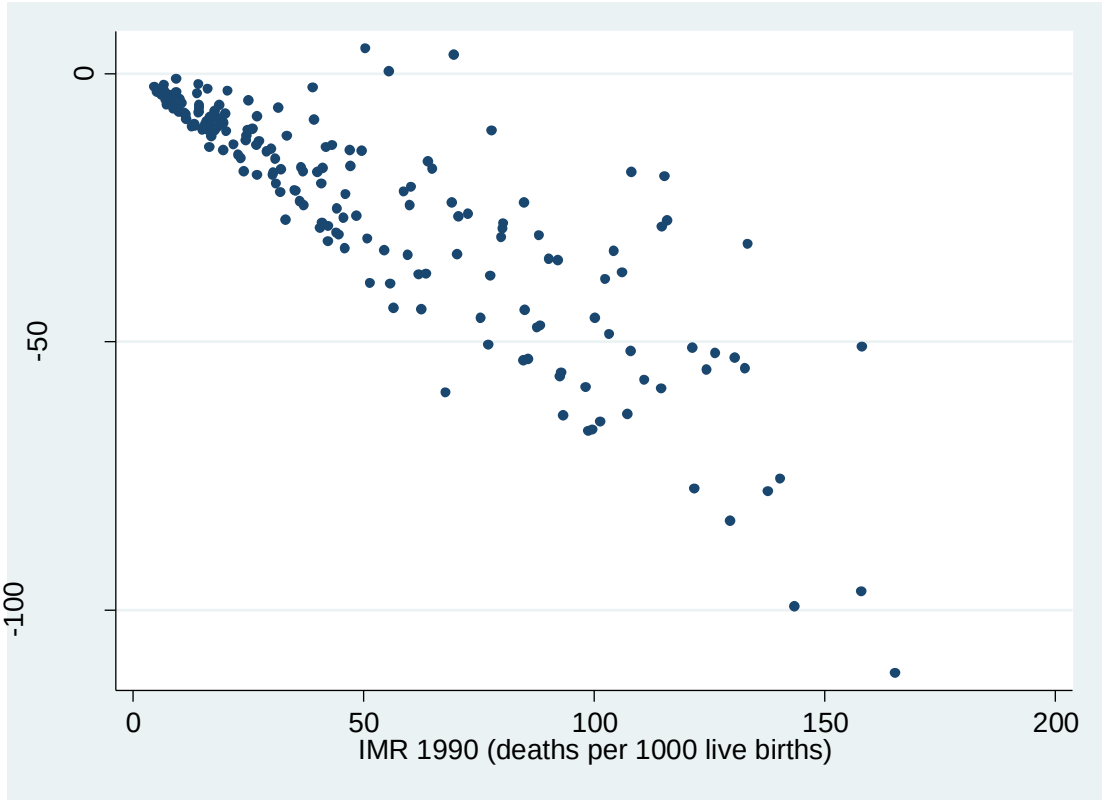
Table 2: Regional Distribution of Child Death by Age Group

	Under-5 deaths ('000)		Infant Deaths ('000)		Neonatal Deaths ('000)	
	1990	2013	1990	2013	1990	2013
Africa	4,076	3,208	2,508	2,166	1,086	1,120
Asia	7,735	2,784	5,682	2,228	3,211	1,490
Europe	167	50	140	42	89	28
Latin America	628	196	497	167	255	101
Northern America	47	31	39	27	24	18
Oceania	17	16	13	12	6	7
World	12,670	6,285	8,879	4,642	4,671	2,764

Source: UN Inter-agency Group for Child Mortality Estimation (2014)

In general, the last decades have seen a remarkable amount of convergence in health outcomes, with countries with initially high mortality achieving the largest improvements in health, even in settings with poor or negative economic growth. As a result of these trends, countries with the same levels of incomes experience substantially lower child mortality outcomes today compared to 40 years ago, a pattern which was highlighted in the seminal work by Preston (Preston 1975) and subsequent work by Soares (Soares 2005) and Bloom et al (Bloom, Canning et al. 2009). This pattern of convergence in mortality is illustrated in Figure 2, which shows the improvements in infant mortality over the period 1990-2013 as a function of infant mortality levels in 1990. As the figure shows, the relation between initial infant mortality rates (IMR) and subsequent changes in IMR is close to linear: the vast majority of countries with IMR > 100 in 1990 achieved improvements of 50 and larger, while improvements were (to some extent mechanically) much smaller for countries with higher initial levels. As a result of these improvements, only six countries have an IMR > 80 today (Angola, CAR, Chad, Congo DRC, Sierra Leone and Somalia), and only two countries (Angola and Sierra Leone) have an IMR > 100. In 1990, the same was true for 47 and 30 countries, respectively.

Figure 2: Changes in Infant Mortality 1990-2013



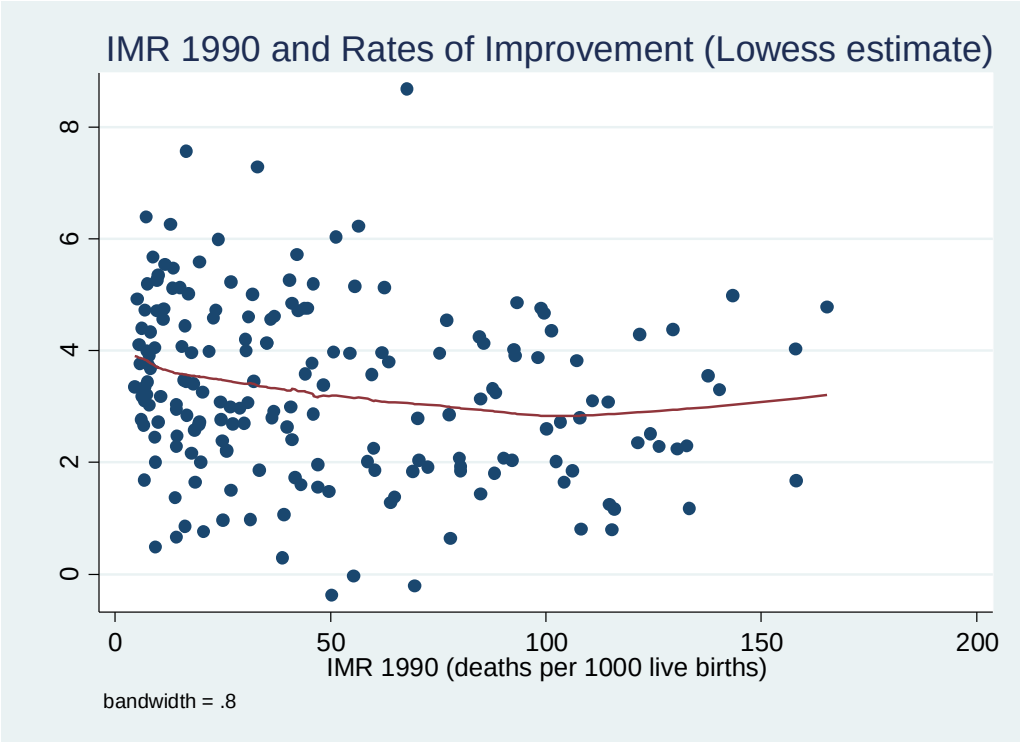
Source: Mortality data from IGME (2014); own calculations.

The much lower rates of infant mortality today naturally raise the question of how much of an improvement could or will be possible over the coming few years. One way of answering this question pursued in the recent literature (see, e.g., Haidong Wang, Chelsea A Liddell et al. 2014) is to simply extrapolate recently observed annual percentage improvements in child mortality to the coming two decades. On average, IMR improved by 3% annually over the 1990-2013 period. If the same annual improvements can be achieved over the period 2013-2030, average IMR would be 20.5 globally in 2030. While this number may seem close to the overall target of 20 deaths per 1000 outlined by the HLPEP (2014), it is important to highlight that our calculations do not take mortality after age one into account (which would mean an additional 5-10 deaths per 1000); they also just reflect a global average, which is very different from setting this common objective for all countries, and even more different form setting this objective for "all income quintile" of the same countries due to the generally rather steep wealth gradients in mortality observed in the developing world.

At a country level, current differences in mortality outcomes are large, and these differences are likely to persist in future years. Assuming constant rates of annual improvements between 2015 and 2030, more than 30 countries will have infant mortality rates in excess of 30 per 1000 in 2030 (and many more will have under-5 mortality rates above this level). One could clearly argue that faster improvements should be possible for countries with high current IMR; while this is definitely possible in principle, this has not

been the case in recent years. Figure 3 shows the annual rates of improvement in IMR between 1990 and 2013 as a function of 1990 infant mortality rates – there is very little evidence that countries with higher initial rates have been able to improve faster in terms of their annual improvement or growth rates. Overall, annual improvements in excess of 3 or 4% per year seem very hard to reach, which means that unified targets across countries (such as 20 or 30 deaths per 1000) will almost certainly make a large number of countries fail, unless major technological innovation or major shifts in global health financing should occur.

Figure 3: Annual Rates of Improvements in Infant Mortality 1990-2013 versus Infant Mortality in 1990



An alternative approach to assess what is feasible for countries is to look at the likely distribution of income per capita in 2030. Given the relatively large amounts of private and public health resources needed to achieve positive health outcomes, the cross-sectional relationship between infant mortality rates and income per capita is rather strong (-0.53 in levels, -0.79 when taking the natural logarithm of income).

One of the primary concerns with a uniform target is that countries with low incomes might not be able to achieve low rates of infant mortality. To assess this concern empirically, we divide a sample of 162 low and middle income countries covered by both the IGME (UN Inter-agency Group for Child Mortality Estimation (IGME) 2014) and the Penn World Tables 8.0 (Feenstra, Inklaar et al. 2013) into five income quintiles; countries in the lowest quintile have incomes per capita of US$ 2220 or less; countries in the top quintile have incomes of US$ 25,500 or higher. Table 3 quite nicely illustrates the strong

associations between income per capita and health: average infant mortality rates are 55 in the lowest quintile, and only 4 deaths per 1000 in the top bracket.

What is more remarkable though is the large heterogeneity in mortality outcomes in the bottom two brackets. In the lowest income quintile (< US$ 2220 per capita in 2013), the country with the best performance by far in 2013 was El Salvador, with an estimated IMR of 13.5; the only other country with an IMR of < 30 is Kyrgyzstan; both countries do, however, constitute outliers, with few other countries achieving levels below 40.

In the second bracket (US$ 2300-5150), outcomes look on average much more positive, with four countries having achieved IMR < 15 (Jamaica, Moldova, Sri Lanka and Syria), and several more having achieved rates below 30.

Table 3: Income per capita and distribution of infant mortality rates

	Income per capita 2011		Infant mortality rate 2013 (deaths per 1000)		
Quintile	From	To	Mean	Min	Max
1	291	2,217	55	14	107
2	2,339	5,146	36	8	102
3	5,219	12,155	17	6	69
4	12,403	25,081	10	2	47
5	25,556	124,720	4	2	13

Overall, these results suggest that infant mortality rates decline by about 5 deaths for every 1000 US$ of income per capita; the overwhelming majority of children today die in the bottom two quintiles, where average income per capita is about US$ 2500; even if these countries should develop well economically in the period 2015-2030, large improvements in the average resources locally available do not seem likely. At a very optimistic annual economic growth rate of 5%, the average country with an initial GDP per capita of US$ 2500 would achieve a GDP per capita of US$ 5700; on average, this would reduce IMR by 15 deaths per 1000, which would imply a rate of 40 deaths per 1000 in the lowest quintile, and a rate of 21 per 1000 in the second quintile of countries by 2030 – it seems rather obvious that the large majority of countries in the bottom two quintiles would not reach an IMR target of 20 per 1000 under this scenario.

Infant Mortality Interventions, Targets and Cost Effectiveness

As outlined in Table 1, the first five years of children's life are divided into three distinct periods from a mortality perspective: the neonatal period (days 0-28), the post-neonatal infant period (day 29-364) and the childhood period (1-4 years). All three periods differ substantially with respect to the relative importance of the underlying causes of death. As illustrated in Figure 1, infectious diseases remain the most common cause of death in the post-neonatal period. Three of these diseases (TB, HIV and malaria) are analyzed in separate Copenhagen Consensus Perspective papers, and shall not be discussed in further detail here.

Instead, the remainder of this paper focuses on neonatal mortality. Appendix Table 1 shows the global distribution of neonatal deaths across countries: in 2013, a total of 2.7 Million children died within the first 28 days of their life (see Table 2). As shown in Figure 1, the large majority of these deaths (75%) are due to three main causes: prematurity, interpartum-related complications (including asphyxia), and neonatal sepsis.

Several recent studies have highlighted that the majority of neonatal deaths (as well as under-5 deaths) occur in relatively few countries. In the case of neonatal mortality, eight countries – with a combined population of 3.5 billion, or 50% of the world population today, account for about two thirds of all neonatal deaths. Table 4 shows the relative importance of the three main causes of neonatal deaths in these countries. While the overall patterns appear fairly consistent, a few differences are worth highlighting: first, the relative contribution of prematurity in India is substantially higher than in other countries, likely related to frequently small maternal stature and the high prevalence of maternal undernutrition. Ethiopia fares worst with respect to interpartum complications, which is likely related to very low rates of births attended by skilled providers in the country.

Table 4: Country-specific Estimates of Main Causes of Neonatal Mortality

	Neonatal deaths per year	Estimated Percentage of Neonatal Deaths due to		
	(1000 deaths per year)	Prematurity (%)	Interpartum related complications including asphyxia (%)	Neonatal sepsis (%)
India	706.6	43.7	19.2	14.8
Nigeria	247.3	32.8	29.4	15.8
Pakistan	163.3	35.6	23.2	19.9
China	115.7	23.3	24.8	3.8
Ethiopia	89.7	24.5	33.7	18.0
DR Congo	87.2	34.1	28.7	16.2
Bangladesh	76.7	31.2	22.2	16.2
Indonesia	69.5	36.4	19.2	13.1

Source: WHO Global Health Observatory

It is important to highlight that – quite different from other diseases like malaria - all three major causes of neonatal mortality are hard to prevent through home or community-based activities. While the prevalence of prematurity can be lowered by micro-nutrient and energy supplementation (Bhutta, Das et al. 2014), major progress for prematurity-related mortality only seems possible via improved health services provided before, during and after delivery. Similarly, birth complications and sepsis can likely only be prevented (and treated) effectively if skilled staff attends births in a safe and clean environment.

Several recent studies have attempted to estimate the global cost of scaling up health services as summarized in Bhutta et al (2014). Most studies assess the cost of delivering a package of key pre- and perinatal services, including

1. **Antenatal care services**: folic acid supplementation to prevent congenital anomalies; multi-micronutrient and energy supplementation as well as malaria prevention in pregnancy to reduce the likelihood of low birth weight and prematurity.
2. **Care during child birth**: clean birth at facilities (reducing sepsis and tetanus) & antibiotics to treat infections.
3. **Care after birth**: Kangaroo mother care for preterm children; warmth, feeding/intravenous fluids, oxygen, antibiotics at secondary health centers for small neonates or neonates with health issues. Oral rehydration supplements for diarrhea, and antibiotics to treat pneumonia.

In terms of current coverage, access to antenatal care services has improved substantially in virtually all countries over the past two decades, which makes delivering supplements as

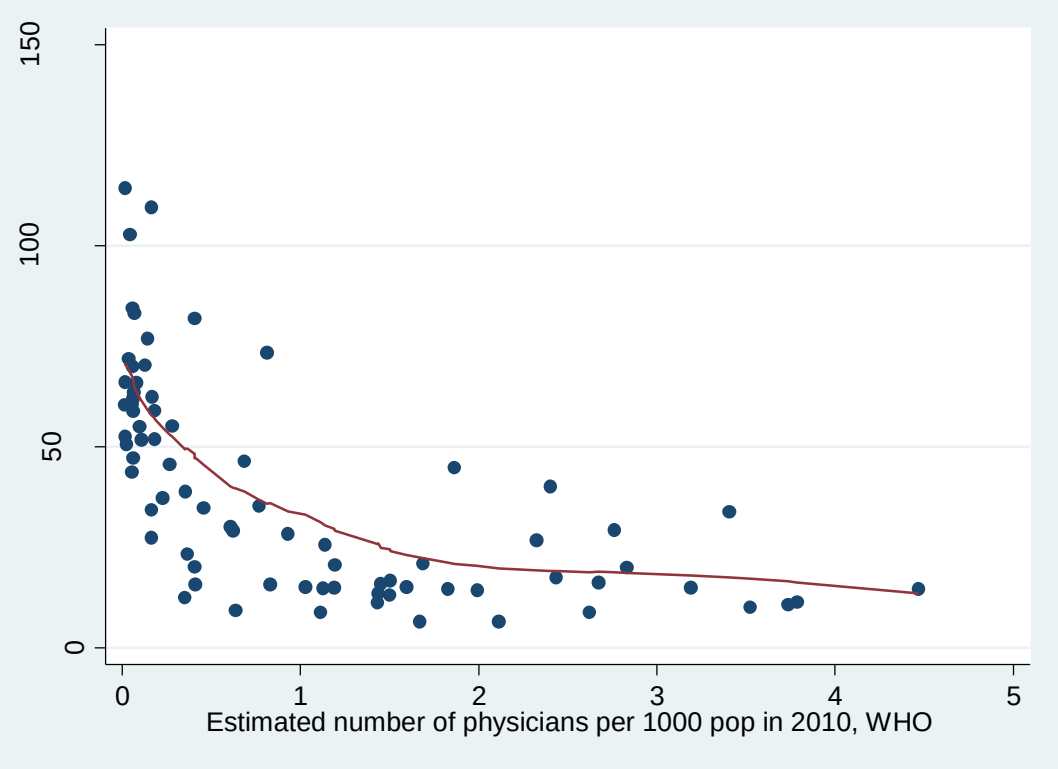
well as malaria prevention relatively straightforward; in terms of the actual material cost, the entire antenatal care package is unlikely to cost more than US$ 10 per child, even when staff time is taken into account. In terms of total cost, this is a relatively small amount: with an estimated 120 Million births per year in developing countries, the total annual cost would be less than US$ 1.5 billion per year globally.

Things are more complicated and costly for safe deliveries and post-natal care: deliveries in a safe environment and the management of birth complications (including Kangaroo mother care which appears to be mostly effective if delivered at health facilities) require not only decent secondary health care infrastructure, but also a constant stock of medical supplies and a sufficient number of trained staff available around the clock, all of which remain scarce in many settings.

Given these health system challenges, generating cost estimates is complicated, and published cost estimates for delivering such interventions vary widely. On one hand, one may want to only account for the direct and additional marginal cost generated by the outlined set of essential interventions (facility use time, medical staff time, input cost etc); this "marginal cost' approach was taken in the most recent Lancet neonatal series (Bhutta, Das et al. 2014), and resulted in an estimate of US$ 5.65 billion per year for the 75 countries with the highest burden of child mortality. Estimates get substantially higher when the cost of building additional capacity is taken into account; two recent papers using different costing tools find total annual cost estimates of US$ 9.2 and US$ 10.9 billion, respectively (Guttmacher Institute 2009, Bhutta, Yakoob et al. 2011).

In practice, both approaches are unlikely to fully capture the investment required to achieve high coverage of essential services. In order to achieve comprehensive coverage of high-quality health services, most developing countries will not only have to increase their physical infrastructure, but will also have to improve the broader health system. This point is most obvious when it comes to physicians: most high-income countries have a physician density of 3 physicians per 1000 population or higher; in low and middle-income countries, the average current physician density is about 0.5 physicians per 1000 population. Figure 4 shows the cross-sectional relationship between physician density and infant mortality: no country with a physician density of one or more physicians per 1000 population has an infant mortality rate > 50. In fact, there are only three countries in this category globally who have an IMR > 30 (Azerbaijan, Tajikistan and Uzbekistan), all of which are in Central Asia. On the other hand, average IMR for developing countries with physician density of less than 0.5 was 63 deaths per 1000 in 2010.

Figure 4: Physician Density and Infant Mortality Rates in Low and Middle Income



Taking these figures, and assuming that each country needs an average of 1 physicians per 1000 population, the total need for new physicians is about 1.3 Million doctors today (not counting other staff). Assuming that doctors earn on average twice the national income per capita, the global annual salary cost would be US$7.7 billion, not counting the cost of training. Clearly this cost would generate benefits much greater than the reductions in neonatal mortality, and the same would be true for other staff as well improved infrastructure overall.

The critical question for costing is thus what proportion of the total additional investment and cost should be attributed to the neonatal health improvements. Average crude birth rates in developing countries are currently approximately 30 births per 1000, which means that under the ideal scenario of one doctor per 1000 population, each doctor would have to assist only about 30 births per year, which would clearly only take up a small amount of a physician's overall time allocation.

Similar arguments can be made for other health system improvements, such as improved supply chains, improved health information systems and improved governance. All of these factors will have to be shifted in order to achieve substantial reductions in neonatal mortality, but will, at the same time, obviously generate benefits well beyond the improvements in terms of child survival.

In the most comprehensive analysis to date, the Study Group for the Global Investment Framework for Women's and Children's Health made a major attempt to assess the total investment needed to comprehensively improve health systems for child and maternal

health (Stenberg, Axelson et al. 2014). Under the most ambitious scenario – including new infrastructure, health worker training, improved supply chains, improved information systems as well as financial incentives to increase demand for health services – the total estimated cost was US$ 678 billion, which translates to an annual cost of approximately US$ 30 billion over the 2013-2035 period. The total estimated cost under a slightly less comprehensive package - leaving out newly set up adolescent-friendly health services and demand side incentives such as conditional cash transfers for mothers - was US$ 428.2 billion in total, or US$ 17.3 billion per year over the 2013-2035 period.

Table 5: Estimated Cost of Scaling Up Essential Maternal and Neonatal Child Health Services

Author	Cost Estimate	Costing Assumptions
Bhutta (2014)	US$ 5.65 billion	Running cost only, including staff time, but no additional staffing or infrastructure (Lives Saved Tool-LiST)
Guttmacher Institute (2009)	US$ 9.2 billion	Running cost, capital cost plus overhead for management
Bhutta et al (2011)	US$ 10.9 billion	Running cost plus amortized facility cost (LiST, WHO CHOICE)
Stenberg et al (2014)	US$ 17.3-30bn	Running cost plus health system improvements including construction of health centers and hospitals. High cost scenario also includes interventions to increase demand for and utilization of essential health services.

Benefit-Cost Estimation

In order to estimate benefit-cost ratios for the proposed neonatal intervention package, we first compute the global benefits under two alternative benefit assumptions: a value of US$ 1000 per disease-adjusted life year (DALY), and a value of US$ 5000 per DALY. Based on the published literature, we assume that a comprehensive investment package could prevent 70% of neonatal deaths, which corresponds to 1.93 Million infant deaths prevented per year. Following WHO guidelines (WHO 2003), we assume that all surviving children will experience Japanese life expectancy[2]. At a discounting rate of 3% per year, this means 32.6 DALYs per life saved; at a discounting rate of 5%, each life saved yields an additional 20.8 DALYs.

For costing, we take the most recent comprehensive supply side cost estimate of US$ 17.3 billion as our main estimate, and show alternative (more optimistic) estimates using a cost number of US$ 10.9 billion (running cost and infrastructure only).

[2] Assuming lower life expectancies changes the overall numbers only marginally due to the relatively high discounting rates applied to future years. At 3% discounting, the net present value of a life year at age 60 (which infants would experience in 60 years from today) is only 17% of the value of a life year today; at 5% discounting, the net present value of a life year at age 60 is only 5.3%. Accordingly, the total DALYs gained from one infant life saved change by less than 10% if Japanese survival rates are replaced with survival rates from a typical developing country today..

Table 6 summarizes the main results for our benefit-cost analysis. With the more commonly used discounting rate of 3% and an average benefit of US$ 5000 per life year saved (which seems the more reasonable assumption given that the average GDP per capita in low and middle income countries today is US$ 4500), our calculations yield an estimated benefit-cost ratio of 18.2 with the more conservative cost estimate of US$ 17.3 billion. With a more conservative discounting rate of 5% per year, the benefit-cost ratio declines to 11.7; with a more optimistic cost estimate of US$ 10.9 billion per year and 3% discounting, the benefit-cost ratio increases to 28.9. Under all scenarios, benefit-cost ratios are positive and returns to investment high.

Table 6: Benefit-Cost Ratios for a Comprehensive Intervention Package to Reduce Neonatal Mortality by 70%

		3% Discounting			5% Discounting		
Assumptions		Benefit	Cost	B-C	Benefit	Cost	B-C
Cost	Benefit	(US$ billions)		Ratio	(US$ billions)		Ratio
Low	low	63.1	10.9	5.8	40.3	10.9	3.7
Low	high	315.4	10.9	28.9	201.7	10.9	18.5
High	low	63.1	17.3	3.6	40.3	17.3	2.3
High	high	315.4	17.3	18.2	201.7	17.3	11.7

Notes: All numbers reflect total benefits and costs per year. Total benefits are based on all surviving neonates experiencing typical high-income country life expectancies. Total cost includes all costs directly attributable to pre-, peri- and postnatal health services required to achieve the improvements in neonatal survival. For further details on costing, see Stenberg et al (2014).

Discussion

As of 2013, neonatal mortality accounts for more than 40% of total under-5 mortality globally. The results presented in this paper suggest that large improvements in neonatal mortality are possible, and that the required health interventions are likely to be highly cost-effective. Achieving these improvements will however be challenging, since neonatal risk factors and neonatal mortality are harder to prevent than most other causes of under-5 mortality, and major progress for neonatal mortality will likely only be possible if health services (and the health system more generally) are substantially improved. Improved perinatal health services require better infrastructure, more and better trained staff, better supply chains and better information systems. All of these improvements are possible, but will require major financial investment. The most recent cost estimates suggest that an additional US$ 17-30 billion per year will be needed to reduce neonatal mortality by 70%. This level of investment likely goes well beyond the financial and institutional capacities of many of the poorest countries, and definitely also goes beyond the scope and budget of international institutions like the Global Fund; major shifts in global health financing will likely be needed if ambitious targets are to be reached for neonatal mortality within the next 15 years.

In terms of the overall mortality targets to be defined as part of the new development goals, a global target of 20 per 1000 seems reasonable for infant as well as for under-5 mortality. However, a uniform and absolute mortality target of 20 as proposed by the HLPEP seems neither very attractive nor practical; any fixed target would be very difficult (if not impossible) to achieve for many of the poorest countries, and essentially not pose any challenge for the more advanced middle income nations. Aiming at smaller differences in health outcomes across income quintiles is clearly also a worthy target; these income-specific targets should not be kept constant across countries, but rather be defined relative to current conditions such that all countries face goals which are challenging but feasible with sufficient national efforts as well as adequate international support.

In summary, all the evidence presented in this paper suggests that large further reductions in neonatal as well as child mortality are possible and should be targeted by the new development goals. Compared to other areas like diarrhea, malaria or HIV, achieving improvements in neonatal mortality will have a much larger impact on the total under-5 mortality burden, but will also require more fundamental changes in health systems, and, accordingly, require substantially more resources. All available evidence suggests that the returns to investing these resources would be large; major changes in global health financing may however be necessary if these benefits are to be reaped within the coming 15 years.

References

Bhutta, Z. A., J. K. Das, R. Bahl, J. E. Lawn, R. A. Salam, V. K. Paul, M. J. Sankar, H. Blencowe, A. Rizvi, V. B. Chou and N. Walker (2014). "Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost?" The Lancet 384(9940): 347-370.

Bhutta, Z. A., M. Y. Yakoob, J. E. Lawn, A. Rizvi, I. K. Friberg, E. Weissman, E. Buchmann and R. L. Goldenberg (2011). "Stillbirths: what difference can we make and at what cost?" Lancet 377(9776): 1523-1538.

Bloom, D. E., D. Canning and G. Fink (2009). "Disease and Development Revisited." NBER Working Paper 15137.

Feenstra, R. C., R. Inklaar and M. P. Timmer (2013). The Next Generation of the Penn World Table".

Guttmacher Institute (2009). Facts on investing in family planning and maternal and newborn health. Guttmacher Institute. http://www.guttmacher.org/pubs/AddingItUp2009.pdf.

Haidong Wang, Chelsea A Liddell, Matthew M Coates, Meghan D Mooney, Carly E Levitz, Austin E Schumacher, Henry Apfel, e. al and C. J. L. Murray (2014). "Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013." Lancet Forthcoming.

Open Working Group (2014). Open Working Group proposal for Sustainable Development Goals. http://sustainabledevelopment.un.org/focussdgs.html. Accessed 2 November 2014., United Nations Division for Sustainable Development, Department of Economic and Social Affairs.

Preston, S. H. (1975). "The changing relation between mortality and level of economic development." Population Studies 29(2): 231–248.

Soares, R. R. (2005). "Mortality Reductions, Education Attainment, and Fertility Choice." American Economic Review 95(3): 580-601.

Stenberg, K., H. Axelson, P. Sheehan, I. Anderson, A. M. Gulmezoglu, M. Temmerman, E. Mason, H. S. Friedman, Z. A. Bhutta, J. E. Lawn, K. Sweeny, J. Tulloch, P. Hansen, M. Chopra, A. Gupta, J. P. Vogel, M. Ostergren, B. Rasmussen, C. Levin, C. Boyle, S. Kuruvilla, M. Koblinsky, N. Walker, A. de Francisco, N. Novcic, C. Presern, D. Jamison and F. Bustreo (2014). "Advancing social and economic development by investing in women's and children's health: a new Global Investment Framework." Lancet 383(9925): 1333-1354.

UN Inter-agency Group for Child Mortality Estimation (2014). Levels & Trends in Child Mortality Report 2014. Estimates Developed by the Online, UN.

UN Inter-agency Group for Child Mortality Estimation (IGME) (2014). Child Mortality Estimates. http://www.childmortality.org/, UN.

United Nations (2014). A New Global Partnership: Eradicate Poverty and Transform Economies through Sustainable Development. New York. http://www.post2015hlp.org/wp-content/uploads/2013/05/UN-Report.pdf, United Nations;.

WHO (2003). Making Choices in Health: WHO Guide to Cost-Effectiveness Analysis. Geneva, WH

Appendix Table 1: Neonatal Mortality by country

Rank	Country	Deaths	Rank	Country	Deaths	Rank	country	Deaths
1	India	706.6	41	South Sudan	12.2	81	Turkmenistan	2.4
2	Nigeria	247.3	42	Algeria	12.1	82	Lesotho	2.1
3	Pakistan	163.3	43	Senegal	12.1	83	UK	2.1
4	China	115.7	44	Burundi	11.4	84	The Gambia	2.0
5	Ethiopia	89.7	45	Morocco	10.7	85	Paraguay	1.9
6	DR Congo	87.2	46	Uzbekistan	10.7	86	Sri Lanka	1.7
7	Bangladesh	76.7	47	Zimbabwe	10.4	87	Jordan	1.7
8	Indonesia	69.5	48	Rwanda	9.2	88	Malaysia	1.7
9	Tanzania	44.0	49	Russia	8.0	89	Nicaragua	1.6
10	Uganda	39.9	50	Sierra Leone	7.9	90	France	1.5
11	Kenya	32.9	51	Benin	7.9	91	Germany	1.4
12	Afghanistan	32.1	52	Cambodia	7.7	92	Japan	1.4
13	Brazil	30.2	53	Togo	7.4	93	Palestine	1.4
14	Philippines	29.5	54	Colombia	6.7	94	Tunisia	1.4
15	Mali	28.5	55	Haiti	6.5	95	Italy	1.4
16	Mozambique	26.7	56	Peru	6.4	96	Poland	1.3
17	Cameroon	25.7	57	CAR	6.1	97	Gabon	1.2
18	CÃ´te d'Ivoire	25.7	58	Argentina	5.3	98	Canada	1.2
19	Sudan	25.1	59	Thailand	4.6	99	Mongolia	1.2
20	Chad	22.8	60	Tajikistan	4.6	100	Romania	1.1
21	Angola	22.6	61	Papua NGa	4.6	101	Spain	1.0
22	Ghana	21.5	62	Bolivia	4.6	102	Namibia	1.0
23	Niger	21.2	63	Laos	4.5	103	Libya	0.9
24	Egypt	20.3	64	Eritrea	4.5	104	South Korea	0.9
25	Burkina Faso	18.9	65	Guatemala	4.4	105	Chile	0.9
26	Mexico	18.5	66	Mauritania	4.3	106	Eq. Guinea	0.8
27	Burma	16.5	67	Syria	4.3	107	El Salvador	0.8
28	Malawi	16.1	68	Kazakhstan	4.0	108	Swaziland	0.8
29	South Africa	15.8	69	Venezuela	3.9	109	Botswana	0.7
30	Yemen	15.6	70	North Korea	3.8	110	Australia	0.7

31	USA	15.3	71	Liberia	3.8	111	Timor	0.7
32	Madagascar	15.2	72	Congo	3.6	112	Georgia	0.6
33	Iraq	15.0	73	Dom. Rep	3.6	113	Comoros	0.6
34	Iran	15.0	74	Saudi Arabia	3.4	114	Panama	0.6
35	Somalia	14.6	75	Azerbaijan	3.0	115	Djibouti	0.5
36	Guinea	14.2	76	Ecuador	3.0	116	Jamaica	0.5
37	Vietnam	13.6	77	Ukraine	2.8	117	United Arab	0.4
38	Zambia	13.0	78	Guinea- Bis.	2.5	118	Taiwan	0.4
39	Nepal	12.8	79	Kyrgyzstan	2.5	119	Lebanon	0.4
40	Turkey	12.3	80	Honduras	2.4	120	Netherlands	0.4
Colum	% of total	88%			9%			2%

Source: Bhutta et al for mortality estimates; own calculations.

This paper was written by Günther Fink, Professor of International Health Economics, Department of Global Health and Population at Harvard School of Public Health. The project brings together 60 teams of economists with NGOs, international agencies and businesses to identify the targets with the greatest benefit-to-cost ratio for the UN's post-2015 development goals.

For more information visit post2015consensus.com

COPENHAGEN CONSENSUS CENTER

Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on how much social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 100+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.