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ASSESSMENT PAPER

*Benefits and Costs of the Health Targets
for the Post-2015 Development Agenda*

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Post-2015 Consensus

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HIGHLIGHTS

Objectives

- Develop a plausible estimate for a benefit-to-cost ratio (BCR) for a global reduction of 40% of all-cause deaths before age 70 years by 2030
- Comment on the health-related proposed Sustainable Development Goal and sub-goals, particularly where they are likely to be poor in terms of BCR (and relate to the overall goal of reducing mortality by 40% by 2030)

Summary

- We quantify the BCR for a new proposed over-arching health goal that is achievable and quantitatively measurable: avoidance of 40% of the premature deaths (deaths before age 70) in each country.
 - Sub-goals include: (i) avoid 2/3 of child and maternal deaths; (ii) avoid 2/3 of TB, HIV and malaria deaths; (iii) avoid 1/3 of premature deaths from non-communicable diseases; and (iv) avoid 1/3 of remaining causes at ages 5-69 years.
- The overarching goal has a population weighted BCR of 9 to 1 in low-income and lower-middle income countries combined when each Disability Adjusted Life Year (DALY) was valued at \$5000. Sensitivity analyses suggest that these favourable ratios persist even with higher costs but, are sensitive to fluctuations in the valuation of the benefits.
- In the year 2030, a 40% reduction in premature deaths before age 70 in low-income and lower middle-income countries would avoid 3.5 million and 7.2 million deaths, respectively or 2.2 million and 4.5 million, respectively if compared to 2030 United Nations projected totals (with cumulative reductions over a 20-year period being 22 million and 45 million, respectively).
- We also identified BCRs for interventions proposed in the Open Working Group health related SDGs and related these to specific goals for 2035 established for the Lancet Commission on Investing in Health proposed goals. These confirm specific high-priority interventions already well described as being highly cost-beneficial (such as immunization, subsidies for effective malaria treatment, tobacco taxation, and reproductive health

services). These specific interventions can be delivered as priorities within an overall commitment to reduce premature deaths by 40% by 2030.

- The 40% reduction in premature deaths goal is adaptable to low, middle and high-income countries, inclusive across ages and diseases and is consistent with targets currently in development. Moreover, these BCRs allow individual countries to customize their intervention approach based on their demographic and health profile.

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Introduction

A variety of development priorities have been proposed for 2030 as “Sustainable Development Goals (SDG)” to replace the highly-influential 2015 Millennium Development Goals (MDG). These proposed goals cover a wide range of development objectives, including SDG number 3 (SDG3), “Ensure healthy lives and promote well-being for all at all ages”. Within the overarching health goal, many sub-goals have been proposed, some of which are realistic and others that are not (Norheim et al. 2014). Common frameworks to evaluate these disparate goals are required by national governments and global agencies.

One proposed method to evaluate goals is benefit-cost analyses (BCAs), expressed as some monetary value of the benefits divided by the costs (or benefit-cost ratios or BCR) of achieving these benefits (Lomborg 2013). A favourable benefit cost ratio, that is, a BCR greater than one, for an assessed intervention indicates that it is socially beneficial compared to the next best use of the same resources. A ranking of interventions by the size of their BCRs allows the prioritization of interventions according to the relative benefits they provide to society. However, high coverage of individual interventions are seldom achieved without an extensive delivery system comprising community outreach of services, first referral and specialty hospitals, as well as supportive services for quality, patient safety, monitoring and evaluation and other services (Jha and Laxminarayan 2009). Moreover, some interventions (such as immunization) reduce deaths beyond the specific diseases they cover, by for example increasing the nutritional standing of children. The impact of increased access through universal health care is also not easily quantified through BCA. Therefore traditional BCA, applied to individual interventions, fails to fully capture the cumulative and synergistic benefits or costs of implementation within a health system, and in tandem with other health-promoting activities.

Thus, overall goals of reducing child and adult mortality are required as an overarching framework target. However, it should also be emphasized that within this framework, careful consideration be given to the specific sub-population needs for each major age group (0-4, 5-49 and 50-69 years), as they differ in disease patterns.

In this paper, we attempt to provide a BCR for an overall encompassing outcome of reducing premature mortality in low-income and lower-middle income countries by 40% by 2030 (40x30).

This method quantifies the value of an approach characterized by a broad-based expansion of health care resources for services and interventions rather than an incremental intervention-by-intervention approach. We propose this outcome as a new sub goal of SDG3 (Norheim et al. 2014). Additionally, important especially for low-income and lower-middle-income countries we try to indicate the affordability of achieving this goal by estimating its cost per capita. A secondary objective of this paper is to identify interventions that contribute positively to a reduction in premature mortality within the framework of the SGD3 sub goals and frame these within the context of the overall goal to reduce premature mortality.

By focussing on mortality we do not mean to deny the importance of the sub goals to reduce disability and suffering, such as that aimed at improving mental health or palliative care. However, the burden of disability and suffering as captured in the disability-adjusted life year (DALY), the main outcome metric for economic evaluations in low- and middle-income countries (LMICs), is relatively smaller than mortality (Jha 2014), especially in lower-income countries (Murray et al. 2012). Because most causes of premature mortality are highly correlated with those of disability, a reduction in the former will result in a reduction of the latter. However, the benefits of healthy years gained takes into account (albeit crudely) the ratio of disability to mortality.

Death in old age is not avoidable, but death prior to old age is avoidable (Doll 1994). Our focus on deaths before age 70 is not at the exclusion of strategies to reduce deaths at older ages. Rather, the main interventions relevant to reducing adult mortality can also be made available at older ages, and reducing premature deaths and disability prior to old age (such as from diabetes or smoking-related disease) can make the time period between onset of disease and death in older age shorter and less painful (the so called “compression of morbidity” in old age, by reducing key risk factors and deaths in middle age; Mathers et al. 2014)).

Methodology

Section One

In this section we describe the method for estimating the BCR for the 40% reduction of premature mortality in low and lower-middle income countries. We draw upon the methodology of previous work of the Copenhagen Consensus process and base the potential avoidance of premature mortality on that estimated recently (Norheim et al. 2014).

Premature mortality is defined as dying before the age of 70, the current global average life-span. We focus on a 40% reduction in premature mortality as proposed recently (Norheim et al. 2014). The focus of this analyses is on 0.9 billion people living in 34 low-income countries (GNI per capita <\$1045 in 2013 as defined by the World Bank) and 2.6 billion people living in 50 lower middle-income countries (GNI per capita \$1046 to \$4125 in 2013). The United Nations (UN) Population Division estimates that population will rise to 1.2 billion and 3.1 billion, respectively in these two regions by 2030 (UNPD 2012). Where relevant we also discuss all low and middle-income countries. We define BCR as the a benefit-to-cost ratio, with the benefit as deaths or DALYs¹ averted by the 40% reduction in premature mortality and the cost as the incremental healthcare expenditures required to achieve the reduction.

To determine an over-arching, achievable and quantitative goal that is more inclusive across ages and diseases, we conducted an analysis of the trends in mortality from 1970 to present as well as the current projections to 2030. We used the UN Population Division historical life tables (UNPD 2012); these cover each five-year time period from 1950 to 2010, with medium-fertility projections for 2010–15. For every fifth year from 1970 to 2010, we estimated the death rates in it by averaging the age-specific risks in the 5-year periods before and after it (so our 1970 rates describe risks in 1965–75); this method reduces year-to-year changes in mortality changes. From the historical life tables, we extracted for particular calendar years the risks in the age ranges 0-4, 5-49, or 50-69 years. The risk is the probability that someone who had survived to the start of an age range would die in it.

Cause-specific mortality rates for 2000 and 2010 for the world as a whole and for each World Bank income groupings were from the WHO Global Health Observatory (WHO 2014). Application of these 2000 and 2010 rates to the UNPD medium-fertility projection of the 2030 population yielded two numbers of deaths, comparison of which gave the change (% per decade); this is also the change in the death rate from 2000 to 2010, if standardised to the projected 2030 population being analysed.

¹ DALYs are a summary measure involving mortality change and a valuation of disability change that can be considered to have been generated by calibration against mortality change. DALYs generate a measure of the disease burden resulting from premature mortality by integrating a discounted, potentially age-weighted, disability-adjusted stream of life years from the age of incidence of the condition to infinity using a survival curve based on the otherwise expected age of death. The formulation within the family of DALYs previously used to empirically assess the global burden of disease specifies a constant discount rate of 3 percent per year and an age- weighting function that gives low weight to a year lived in early childhood and older ages and greater weight to middle ages. Current methods for estimating burdens of disease do not incorporate age-weighting (Murray et al. 2012).

Such age-standardised comparisons avoid issues of competing risks. A full explanation of the methods can be found in the article by Norheim and colleagues (2014).

To determine the BCR for the proposed over-arching goal (for low income and lower-middle income regions only), we converted deaths averted to averted DALYs using the World Health Organization (WHO)'s Global Health Estimates (for all cause death, by income level and for three broad age groups 0-4, 5-49 and 60-69). Conversion factors of 95 and 97 DALYs per child death at ages 0-4 years were used for low-income countries and lower-middle income countries, respectively. For deaths between ages 5-49 years, we used a conversion factor of 91 and 97; and for deaths between ages 50-69 years, we used a factor of 43 and 42, respectively. Rough estimates of the conversion factors were determined by taking the 2012 estimates for total 'All-cause death' values for that age group divided by the total all cause DALYs from the WHO (2014; Appendix A). We calculated the DALYs for each region over a twenty-year period (2010-2030) assuming they achieved the mortality projections estimated by the UNPD in 2030 (for a standardized 2030 population) as well as the DALYs assuming the regions achieved a higher premature mortality reduction articulated in the proposed goal (in the year 2030). For this analysis, the benefits were the difference between the DALYs averted by achieving a higher premature mortality reduction and the UNPD 2030 *status quo* medium projections. To convert the DALYs into a monetary value, we assumed each DALY was valued at 1) \$1000; 2) \$5000 or 3) by multiply the DALYs by two times the GDP per capita income in that region for that year (Jamison, Jha, et al. 2013). We applied a 3% and 5% discounting function to the stream of benefits achieved over the 20-year gradual increase in deaths/DALYs averted.

To determine the costs to achieve the goal, we estimated the incremental government health expenditures required to reduce premature mortality to the proposed level. WHO estimates (WHO 2014) that current public spending on health is about 2% of GDP in low income countries, and slightly lower for lower-middle income countries, but that a higher share of GDP to health (crudely at ~5%) would allow countries to achieve a "grand convergence" in health (Jamison, Summers, et al. 2013). We used this method as the majority of the funds required to achieve this goal would be derived from national health spending and it would be difficult to identify the full suite of interventions for each individual country or region and further estimate the cost to achieve a specific level of intervention coverage. In this paper, we assume that increases to government health expenditures will lead to higher access to basic health services such as promotion, prevention and treatment services. Section Two, however, does highlight highly cost-effective

interventions that could be explored given a country's particular context and epidemiological profile. A review of the benefits of expanded health coverage (via government health expenditure increases and universal health care) to population health outcomes can be found in the article by Moreno-Serra and Smith (2012).

We used the following cut-offs to all BCRs in this paper. A BCR of 15 or above was considered "excellent", a BCR between 5-15 was considered "good", a BCR between 1-5 was considered "fair", a BCR or less than 1 (or the target was internally inconsistent, poorly specified, or unrealistic) was considered "poor". To conduct a crude sensitivity analysis on the costs, we use an alternative study to estimate the expenditures required to reduce child and adult mortality to the proposed levels. In a country level panel data study, using instrumental variable specifications, Moreno-Serra and Smith (2015) show an estimated reduction of about 7.9 deaths of children under 5 years old per 1000 for a 10% increase in government health expenditures per capita; this reduction increases to about 12 deaths per 1000 when considering only low- and middle-income countries. For adults in low- and middle-income countries, they find a less dramatic impact at about 2.2 deaths averted per 1000 for the same 10% increase in government health expenditures. We linearly extrapolated the benefits of government funded health spending on child and adult mortality (by averaging the benefits across both sexes) according to their income level and calculated the required increase in health expenditures necessary to achieve higher target mortality goal from the UN 2030 mortality projected levels in the low-income and lower-middle income regions.

Section Two

Our second objective was to comment on the health-related proposed SDG3 and its sub-goals, particularly where they are likely to be poor in terms of BCR. We conducted a literature review to identify, where available, existing BCRs for the sub goals of the SDG3. Priority was given to benefit-cost ratios from previous Copenhagen Consensus exercises (Jamison, Jha, and Bloom 2008, Jamison et al. 2012, Jha et al. 2012), the Commission on Investing in Health (Jamison, Summers, et al. 2013), Global Burden of Disease (Lozano et al. 2012) and other large global health reviews. All of these papers build on the results of the second edition of "Disease Control Priorities" (DCP2), which engaged over 350 authors and estimated the cost-effectiveness of 315 interventions (Jamison et al. 2006). These papers examine nine key interventions in terms of their cost-effectiveness and the size of the disease burden they address (summarized in Table 4).

The benefit-cost methodology used for most of the health interventions builds on the analysis framework in the Copenhagen Consensus 2008 Challenge Paper on disease control (Jamison, Jha, and Bloom 2008)). The basic approach to cost-benefit analysis used by the above-mentioned Copenhagen Consensus papers was to start with the cost-effectiveness (CE) results from the extensive comparative analyses reported in DCP2 (Jamison et al. 2006, Laxminarayan, Chow, and Shahid-Salles 2006). These results are expressed as the cost of buying a DALY.

The DCP2 experience shows that there is a broad range of reasonable estimates of the cost-effectiveness of most interventions. This results partly from (often highly) incomplete information and uncertainty. It results also, and even more importantly, from the responsiveness of the cost-effectiveness function to variations in prices, in the scale of the intervention (and of its substitutes and complements), and in the epidemiological environment specific to the country in which the study is set. Most CE studies have limited generalizability and caution is advised in extrapolating results to other jurisdictions and countries.

Given these often broad ranges in CE ratios, and hence in BC ratios, it makes little sense to conclude with precise estimates or with attempts to quantify statistical uncertainty around the point estimates. Rather we have identified major opportunities for investment in interventions that address a large disease burden highly cost effectively (Table 4). Even valuing DALYs at a conservative \$1,000 the benefit to cost ratios associated with investing in these opportunities is enormously high. Overall this suggests that the conclusions in our Table 4 are conservative.

Results

Table 1 presents the overall reduction of 40% in premature death by 2030 over 2010 death rates by ages 0-4, 5-49 and 50-69 and major disease globally and stratified by low-income and lower-middle-income countries, as well as the 2030 deaths at ages 0-69 years compared to 2030 UNPD baseline projections. The broad target translates to reductions of: 2/3 of child and maternal deaths; 2/3 of TB, HIV and malaria deaths; 1/3 of premature deaths from non-communicable diseases; and 1/3 among remaining causes. These goals are broadly consistent with goals proposed by the Commission on Investing in Health (Jamison, Summers, et al. 2013), the World Health Organization's call for a 25% reduction in selected NCDs by 2025 (WHO 2011). Importantly, many of the specific interventions calculated for earlier rounds of the Copenhagen Consensus are subsumed within these age and disease-specific goals. Note that while death rates fell about 24% and 16% from 2000 to 2010 in low-income and lower middle-income countries, there is no

certainty that these rates of progress will continue. In early childhood, the proportion of neonatal deaths (in the first month of life) is rising as deaths at ages 1-59 months fall faster, and such neonatal deaths are more difficult to reduce (Jamison, Summers, et al. 2013). Similarly, the effects of smoking are increasing among adults, so that smoking attributable deaths are falling less than deaths from other causes (Jha and Peto, 2014). However, to be conservative, we make our calculations against the 2030 UN foreword projections.

Table 1. Premature deaths in 2030 (millions): unaltered and targeted reductions, by age, specific disease and World Bank income groupings

	Low-income				Lower-middle-income				World					
	age 0-49		age 50-69		age 0-49		age 50-69		age 0-4		age 5-49		age 50-69	
	unaltered	targeted reduction	unaltered	targeted reduction	unaltered	targeted reduction	unaltered	targeted reduction	unaltered	targeted reduction	unaltered	targeted reduction	unaltered	targeted reduction
Neonatal or maternal*	1.01	0.68	--	--	1.63	1.09	--	--	2.5	--	0.3	0.2	--	--
HIV*	0.83	0.55	0.09	0.06	0.64	0.43	0.12	0.08	0.1	--	1.5	1.0	0.3	0.2
TB and malaria*	0.52	0.34	0.17	0.12	0.56	0.37	0.41	0.28	0.5	--	0.5	0.3	0.7	0.4
Other communicable**	1.87	0.62	0.38	0.13	2.31	0.77	0.88	0.29	2.8	--	1.9	0.6	1.6	0.5
Non-communicable**	1.04	0.34	1.55	0.52	2.61	0.87	6.69	2.23	0.9	--	4.9	1.6	17.5	5.8
Fatal injuries**	0.95	0.32	0.20	0.07	1.62	0.54	0.63	0.21	0.4	--	3.3	1.1	1.6	0.5
All deaths	6.21	2.86	2.40	0.89	9.37	4.07	8.74	3.08	7.2	4.8	12.4	4.9	21.7	7.5
All deaths at 0-69 years compared to 2010 rates			8.62	3.74			18.11	7.15			19.5	9.7	41.3	17.3
All deaths at 0-69 years compared to 2030 UNPD projections			7.58	2.18			16.29	4.52					NA	NA

Notes: Unaltered=deaths at unaltered 2010 rates. Targeted reduction=deaths avoided through targeted reduction. Targeted reductions not estimated for world population age 0-4 by disease grouping.

*Conditions for which there is a targeted reduction of two-thirds; ** conditions for which there is a targeted reduction of one-third

Table 2 summarizes the calculations required to determine the BCR for achieving a 40% reduction in premature death. In low-income countries, a 40% reduction in premature death (achieved through a 66% reduction in child mortality, and 33% reduction for the ages 5-49 and 50-69 years) would avert an additional 2.2 million deaths in the year 2030 or 195 million DALYs compared to UN projections for 2030. For lower middle-income countries, the comparable total averted is 4.5 million deaths and 360 million DALYs. Over the two decades leading up to 2030, the cumulative averted deaths would be 21.8 million and 45.3 million in low-income and lower-middle income countries, respectively.

Table 2: Benefit-to-cost ratio for overarching goal: avoiding 40% reduction in premature death

	Low-income countries (Population of 1.2 billion in 2030)	Lower-middle income countries (Population of 3.1 billion in 2030)
Costs*		
GDP per capita (in 2010)	\$572	\$1599
GDP growth per capita	3.7%	5.3%
Increase in government health expenditures (by 2030)	\$42 million	\$402 million
Total costs over 20 years	\$434 million	\$4.3 billion
Benefits**		
Additional deaths and DALYs averted from 0-4 (in 2030)	0.9 million deaths 86 million DALYs	0.9 million deaths 89 million DALYs
Additional deaths and DALYs averted from 5-49 (in 2030)	1.1 million deaths 102 million DALYS	2.2 million deaths 201 million DALYs
Additional deaths and DALYS averted from 50-69(in 2030)	0.16 million deaths 7 million DALYS	1.5 million deaths 62 million DALYs
Total Monetary Value of DALYs in 2030 (where 1 DALY = \$1000)	\$195 billion	\$3.6 trillion
Total Monetary Value of DALYs in 20 years (where 1 DALY = \$5000)	\$973 billion	\$18 trillion
Cumulative deaths averted from 2001-2030	21.76 million	45.25 million
Benefit to Cost Ratio		
BCR @ \$1000/DALY with 3% or 5% discounting	4.5	0.8
BCR @ \$5000/DALY with 3% or 5% discounting	22.3	4.2

Population weighted average BCR @\$1000/DALY = 1.9 to 1

Population weighted average BCR @\$5000/DALY = 9.3 to 1

*Calculated to be an increase from 2 to 5% of GDP per capita over 20 year period

**Calculated by taking the difference between UN death projections to 2030 and a 40% reduction in 2010 death rates (standardized to the 2030 population distribution)

For these income groups, it is estimated that an additional \$34 and \$128 in government health expenditures per capita would be required to achieve these mortality reductions, respectively. At a

value of \$5000 per DALY, this suggests a benefit to cost ratio of approximately 22 to 1 for low-income countries and 4 to 1 for lower middle-income countries or a population-weighted overall BCR of 9 to 1. (An aggregate total BCR would be slightly lower at 6 to 1).

Table 3 outlines the results of other methods to determine the BCR of this goal, varying the monetary value of each DALY, and various health expenditures increments. In particular, we used Moreno-Serra and Smith’s study to determine the percentage increase in baseline government health expenditures to achieve our proposed goal; for low-income countries, this was determined to be a 235% increase from a 2% baseline (or 4.7% GDP) and for lower middle income countries, it was 325% (or 6.5% of GDP); these values very much approximate the 5% GDP devoted to health expenditures advocated by other global health researchers. For low-income countries, the BCR ranged from 4.5 to 1 to 25 to 1. While the range is large, even the lowest BCR ratio suggests a good return on investment. For lower middle-income countries, the BCR ranged from 1 to 1 to 5 to 1; which is fair to good rating, as we define above. Both income regions were highly influenced by the monetary value of the DALY and varied less to the different cost calculations. Notwithstanding the heterogeneity in the BCR across the two regions, taking a combined median BCR yielded a 5 to 1 ratio (across both income regions and averaged across all sensitivity analyses).

Table 3. Benefit to Cost Ratio Sensitivity Analysis using a variety of methods

Country income group	Option 1: Base scenario from 2 to 5% GDP, \$5000/DALY	Option 2: \$1000/DALY	Option 3: monetary value of 2xGDP/DALY	Option 4: increasing health expenditures according to Moreno-Serra & Smith, \$5000/DALY
Benefit to Cost Ratio				
Low-income	22 to 1	4.5	8 to 1	25 to 1
Lower middle-income	4 to 1	1 to 1	5 to 1	3 to 1
Combined	6 to 1	1 to 1	6 to 1	6 to 1

Table 4 summarizes the BCRs associated with the SDG goal 3 targets. In addition to the above classification of BCRs, we add an “uncertain” rating when the economic evidence was unclear or the policy response to reach the goal was uncertain. Table 4 also presents alternative targets based on the Commission on Investing in Health (CIH; Jamison, Summers, et al. 2013) or avoiding 40% of premature deaths in each country 2010-30 (Norheim et al. 2014) where applicable. The first two

SDG3 sub-goal targets were categorized by maternal and child health. Target 1, to reduce the global MMR to less than 70 per 100,000 live births by 2030, was rated “unrealistic”. Alternative targets proposed consist of a global MMR of 94 per 100,000 live births by the CIH or to avoid 2/3 of maternal deaths by 2030 as proposed by Norheim and colleagues (2014). Essential surgeries to address difficult childbirth, trauma, and other complications have a BCR of 10 and are therefore “good” interventions to focus on (Jamison et al. 2012). Target 2, to end preventable deaths of newborns and under-five children by 2030, was also assessed “unrealistic”. The CIH proposes an under-five mortality rate of 20 per 1,000 live births and a newborn mortality rate of 11 per 1,000 live births, while the Norheim paper proposes to avoid 2/3 of child deaths by 2030. Interventions aimed at childhood diseases and expanded immunization coverage have “excellent” BCR of 20 (Jamison et al. 2012).

Table 4: Benefit-to-cost ratio for proposed targets

Proposed Target	BCR	Rating
3.1 By 2030 reduce the global MMR to less than 70 per 100,000 live births		Unrealistic
Essential surgery to address difficult childbirth, trauma, and other conditions	10	Good
3.2 By 2030 end preventable deaths of newborns and under-five children		Unrealistic
Childhood diseases: expanded immunization coverage	20	Excellent
3.3 By 2030 end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases		Unrealistic
HIV: "combination prevention"	12	Good
TB: appropriate case finding and treatment, including dealing with MDR TB	15	Excellent
Malaria: subsidy for appropriate treatment via Affordable Medicines Facility-malaria	35	Excellent
3.4 By 2030 reduce by one-third pre-mature mortality from NCDs through prevention and treatment and promote mental health and wellbeing		Uncertain
Cancer, heart disease, other: tobacco taxation	40	Excellent
Heart attacks: acute management with low-cost drugs	25	Excellent
Heart disease, strokes: salt reduction	20	Excellent
Hepatitis B immunization	10	Good
Heart attacks and strokes: secondary prevention with 3-4 drugs in a "generic risk pill"	4	Fair

3.5 Strengthen prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	NI	Uncertain
3.6 By 2020 halve global deaths and injuries from road traffic accidents	NI	Fair
Combined intervention strategy that simultaneously enforces speed limits, drink-driving laws, and motorcycle helmet use	NI	
3.7 By 2030 ensure universal access to sexual and reproductive health care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes	NI	Excellent
Providing adequate services for all 867 million women in developing countries who want to avoid a pregnancy in 2012	NI	Excellent
3.8 Achieve universal health coverage (UHC), including financial risk protection, access to quality essential health care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all	NI	Uncertain
3.9 By 2030 substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination	NI	Uncertain
3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate	NI	Uncertain, but likely to be Good to Excellent if tobacco taxation is central
3.b Support the research and development of vaccines and medicines	NI	Uncertain
3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce	NI	Uncertain
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.	NI	Uncertain

Note: NI= No information on CE or BCR is available.

The second category within the SDG3 sub-goal health targets were disease specific. Target 3, to end the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases by 2030, was rated “unrealistic”. Alternative, more realistic targets consist of CIH’s proposal to reverse the spread of HIV/AIDS and reduce annual AIDS deaths to 3 per 100,000 persons in 2030; reverse the spread of TB and reduce TB deaths to 4 per 100,000 persons; and to reverse the spread of malaria and reduce annual malaria deaths by 95% from 2010 to 2030. Norheim and colleagues suggests avoiding 2/3 of TB, HIV, and malaria deaths by 2030 (Norheim et al. 2014). HIV “combination prevention” was found to

have a “good” BCR or 12 (Jamison, Jha, and Bloom 2008), whereas appropriate case finding and treatment of TB (including dealing with MDR TB) has a “excellent” BCR rating of 15, and subsidy for appropriate malaria treatment via a novel subsidy to reputable private providers has a “excellent” BCR rating of 35 (Jamison et al. 2012).

Category three consists of non-communicable diseases and injury. The fourth target, to reduce by one-third premature mortality from non-communicable diseases (NCDs) through prevention and treatment and promote mental health and wellbeing by 2030, was rated “uncertain” due to the lack of economic evidence. The paper by Norheim and colleagues proposes to avoid 1/3 of premature deaths from NCDs and 1.3 of those from the remaining causes at ages 5-69 years (other communicable diseases and injuries). The Copenhagen Consensus paper in 2012 on chronic diseases (Jha et al. 2012) found tobacco taxation to prevent cancer, heart disease, and other diseases has a “excellent” BCR of 40; acute management with low-cost drugs to reduce heart attacks has an excellent BCR of 25; and salt reduction to address heart disease and strokes also has an excellent BCR of 20. The same paper found Hepatitis B immunization to have a “good” BCR or 10 and secondary prevention with 3-4 drugs in a “generic risk pill” to reduce heart attacks and strokes has a “fair” BCR rating of 4. The fifth target, to strengthen prevention and treatment of substance abuse including narcotic drug abuse and harmful use of alcohol was also rated “uncertain” with low priority. The six, and final target within this category, to halve global deaths and injuries from road traffic accidents was decided to be “fair”. A mathematical modeling study in the BMJ on the cost effectiveness of strategies to combat road traffic injuries in sub-Saharan Africa and South East Asia (Chisholm et al. 2012) found that combining intervention strategies that simultaneously enforces speed limits, drink-driving laws, and motorcycle helmet use saves one DALY for a cost of \$Int1380.

The fourth category revolves around access. Target seven; to ensure universal access to sexual and reproductive health care services, including family planning information and education, and the integration of reproductive health into national strategies and programmes by 2030 was rated “excellent”. The CIH proposes in their report 50% coverage with modern family planning methods to reduce the global total fertility rate (TFR) to 2.2 by 2030. The Guttmacher Institute and UNFPA estimate that it costs \$30 to prevent each unintended pregnancy, making this target highly cost-effective (Singh et al. 2009). Target eight, to achieve universal health coverage, including financial risk protection, access to quality essential health care services, and access to safe, effective, quality and affordable essential medicines and vaccinations for all, though a excellent goal is rated “uncertain” due to the lack of cost-effective data. The CIH proposes a set of pro-poor pathways to

universal health coverage (progressive universalism) in their report, with similar proposals made earlier for India (Jha and Laxminarayan 2009).

Target nine, which we categorized as environmental hazards aims to substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination by 2030. This target was rated “uncertain” due to the lack of cost-effectiveness data we were able to find. Finally, targets 3.a, 3.b, 3.c, 3.d are concerned with improving health systems and policies and are therefore outside of the scope of this review. We ranked them “uncertain” due to the lack of available cost-effective data.

Discussion

Our analyses suggests that an overarching goal of 40% reduction in premature mortality is cost-beneficial under a range of assumptions about the economic value of an extra disability adjusted life year and a range of costs required to achieve such gains. The overall BCRs for broader goals of mortality reduction of 40% are comparable in terms of BCR to some of the specific sub-constitutions, such as maternal delivery services. However, the reality is that most political and administrative decisions are seldom about a single intervention, but rather about adopting and supporting broad health system goals. The 40% reduction is also relatively easy to monitor, as global systems from the UNPD provide reasonable estimates of age-specific mortality for every country. However, expanded efforts to evaluate cause-specific mortality changes are required as most countries do not have adequate registration and medical certification of deaths (Jha 2014).

Our analysis has the advantage of introducing quantification to the target-setting process, based on rigorous analysis of mortality trends by age as well as by disease category. The proposed targets focus on premature mortality before age 70 and avoid more complex metrics that are much harder to measure and track over time, such as changes in DALYs similar composite measures.

For this study, we were unable to identify each specific intervention to achieve the 40% reduction however gave a general estimation of the level of incremental increase in government health expenditures required to achieve the proposed goal. Our estimated values draw largely from research by Moreno-Serra and Smith (2015) but others have also studied publicly funded health expenditures and concluded similar impacts on under-5 and maternal mortality (Wagstaff and Claeson 2004, Bokhari, Gai, and Gottret 2007, Bidani and Ravallion 1997). We did not attempt to do a full meta-analysis/systematic review on the subject but rather prioritized the general costing of

5% of GDP devoted to health expenditures as advocated by the Lancet Commission on Investing in Health (Jamison, Summers, et al. 2013). To conduct a sensitivity analysis regarding the 5% GDP costing, we used Moreno-Serra and Smith's analysis given its statistical rigour via the use of the most recent cross-country data from 1995 to 2008, an instrumental variable analysis, an allowance for differential impacts on low versus higher income countries, and the inclusion of both adult and child mortality as outcome variables. We note that the values we derived from the Moreno-Serra and Smith analysis yielded suggested increases of 4.7% and 6.5% of GDP devoted to health expenditures for low-income and lower-middle income regions, approximating the 5% suggested by others.

The level of increase in health expenditures remains to be a topic of research. Jamison and colleagues (2013) using WHO data (2014) estimate that current public spending on health is about 2% of GDP in low income countries, and slightly lower for lower-middle income countries, but the opportunity (as income grows) to devote a higher share of GDP to health exists—with some countries able to achieve a 4% allocation completely from domestic resources and others supplemented via development assistance for health. Alternatively, Evans and colleagues (2001) estimated that health system performance increased greatly with expenditure up to about \$100 per capita a year (in 2010 adjusted dollars). We were, nonetheless, unable to cost out the full suite of specific interventions required to achieve this goal for each country. We do provide a list of existing BCR and CERs that have been developed for well-researched interventions. This can be used to assist governments in determining highly cost effective interventions that would be achievable within their government budgets and appropriate for their population health context.

Technological progress of course can reduce the costs of these interventions and thereby also reduce the necessary public spending on health (Hum et al. 2012). Our previous research shows that the cost to save a child's life has fallen by half from 1970 to 2010, with the greatest decline achieved after 1990, coinciding with actions following the UN's World Summit for Children (Hum et al. 2012). Unfortunately the spread of HIV/AIDS, an increase in smoking consumption in LMIC and smaller political attention devoted to adult mortality (Jha and Peto, 2014). has allowed the costs to rise for older populations. Indeed, a goal of reducing premature mortality would not necessarily give preferential treatment by age or disease and could stimulate research that can reduce the adult mortality cost curve already achieved in children.

In sum, ambitious but feasible goals of reducing premature mortality before age 70 by 40% by 2030 worldwide are likely to be cost-beneficial.

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Appendix

Estimating the ratio of 'Disability Adjusted Life Years' (DALY) to total 'All-cause deaths', by age group, below age 70 years in the year 2012.

Income Group	Indicator	0 to 4 years	5 to 49 years	50 to 69 years
Low-income countries	Deaths	2,170,484	2,345,348	1,324,540
	DALYs	207,114,297	213,531,697	56,866,398
	Ratio	95	91	43
Lower middle income countries	Deaths	3,535,967	4,668,495	5,265,371
	DALYs	341,469,034	454,202,863	223,579,101
	Ratio	97	97	42

*Data is extracted from the WHO's Global Health Observatory Data (2014).

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