Investing global, investing local: supporting value for money towards the health SDGs[1]

Technical Report

Department of Health Systems Governance and Financing

World Health Organization

Executive Summary.

WHO's proposed 13th General Program of Work (WHO GPW) for 2019-2023[2], aims at supporting the achievement of health SDGs country targets to progress towards UHC, health security and healthy lives. This document compiles the evidence on costs and benefits of projected overall investments at the country level to reach these targets. The document examines costs from a normative standpoint and measure benefits as lives saved, years of healthy life gained and some measure of economic gains.

This report uses a compilation of existing models and publications, with adjustments made as appropriate. The authors began by identifying the estimates of costs and benefits of scaling up interventions in the 2019-2023 timeframe, focusing on low- and middle-income countries (LMICs) where the global burden of disease is mainly concentrated and where progress towards universal health coverage (UHC) is required. Efforts were made to avoid double counting, and to exclude studies lacking the requisite methodological detail.

The costs presented are the sum of the financial costs of implementing interventions in a specific year, for each area, above what would be spent at established baseline levels. Each investment is associated with a health impact. Health benefits are thus measured as health outcomes only (expressed as lives saved), and not converted to monetary values. With regard to the investments needed to reach UHC, the health benefits are also expressed as healthy life years gained, and as a summary measure, increases in life expectancy.

This report also identifies the economic gains expected from the scale-up of interventions. Because the economic gains attributable to some investments in the 5 year period of the WHO GPW will continue to accrue beyond 2023, they are taken into account where published estimates existed. Investments leading to "cost savings" are presented as "cost offsets", but were not added to the other estimated gains.

The cost-benefit estimates for GPW target 1 (i.e. 1 billion more people benefitting from universal health coverage) draw on previous work undertaken by WHO as part of calculating a "health SDG Price Tag" that modelled the strengthening of health systems in 67 LMICs. Global targets for each

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disease area were compiled, and using the One Health Tool, the scale-up of health interventions was modelled, moving countries from current levels of service coverage towards previously identified sectoral or SDG targets. Estimation of the economic gains of investing in UHC were based on a revised version of the WHO tool for Economic Projections of Illness and Cost (EPIC), which estimates changes in rates of domestic GDP growth based on (1) the impact of health interventions on the size of the effective labor force, and (2) the impact of health expenditure, including on infrastructure and equipment, on physical capital accumulation, through changes in savings and investment. Headline numbers for the costs/benefits of investing in UHC over the 5 years of the WHO GPW are an expected 24.4 million total deaths averted and US$1.6 trillion of total economic gain for a total cost of US$1.1 trillion.

The cost/benefit estimates for GPW target 2 (i.e., 1 billion more people are better protected from health emergencies) were based on various sources, and examined the costs/benefits of investing in health emergency prevention, preparedness, and response. Key sources on the cost side included, inter alia, WHO's SDG Price Tag, calculations carried out by WHO's World Health Emergencies Programme for this report (estimated investment needs for prevention of health emergencies) and the R&D Blueprint (estimated needs for R&D for infectious hazard management). Country-specific calculations made by WHO's World Health Emergencies Programme for delivering a comprehensive package of services to targeted populations in fragile and conflict settings were also used, as were cost reports of previous WHO-led responses to acute public health events.

On the health benefit side, the focus is on lives saved as a result of interventions implemented during an outbreak response to prevent additional cases of specific disease. A priority at-risk population was identified and the impact of implementing preventative and curative interventions on these populations was modelled within countries and populations that have had health emergency response activities in the past. The authors also modelled the number of lives saved from the delivery of a basic package of services in selected fragile and conflict-affected countries.

The main economic benefit of investing in this area is determined to derive from prevention or reduction of the probability of a major pandemic, based on research by the National Academy of Medicine. Headline numbers for the costs/benefits of health emergency prevention, preparedness and response were 1.5 million deaths averted and total economic gains of US$240 billion, for a total cost of US$29 billion. Investment in this area will also mean that the responses will be better coordinated and outbreaks contained more quickly, resulting in a reduction in the global cost of responding to acute outbreaks. The effective implementation of preventative interventions such as emergency mass vaccination and targeted vector control, would also be expected to reduce treatment costs.

The cost/benefit estimates for target 3 (1 billion more people enjoy better health and well-being) addressed seven key areas reflecting the breadth of the target itself. This report draws on multiple information sources to develop their estimates. Headline numbers for the costs/benefits of target 3 were 3.8 million total deaths averted, short term economic gains ranging from US$177 billion to US$451 billion, with a further US$305 billion in longer-term benefits, for a total cost of US$94 billion. The specific areas considered that would have additional impacts and benefits from investing in health are listed below.

Improving Health Capital across the Life Course. Investments in creating UHC systems have far-reaching implications for the improvement of health capital across the life course. However, no additional investments for improving health capital, beyond those included under achieving Universal Health Coverage, were modelled.

Accelerating action on preventing noncommunicable diseases and promoting mental health. Many of the interventions aimed at preventing NCDs, such as cancers and cardiovascular disease, are included in the package of services modelled as part of scaling up towards UHC as calculated in the "health SDG Price Tag". This report also included on interventions designed to prevent Road Traffic Injuries (RTIs), which yield significant benefits both in terms of deaths averted and economic gain, for relatively small expenditures.

Accelerating elimination and eradication of high impact communicable diseases. Interventions aimed at combating communicable diseases constitute the core of the unfinished MDG agenda within UHC. As a result, all key interventions designed to combat the communicable diseases with the largest health burden are included in the modelling for scaling up towards the health SDGs and UHC.

Tackling antimicrobial resistance. Developing antimicrobial resistance (AMR) is expected to have a substantial negative impact on human lives and economic activity, if not addressed in the next 5 years. Drawing on research published by the World Bank, the authors identified estimates of the additional economic burden imposed by unchecked AMR, as well as cost estimates of the interventions needed to prevent, or mitigate the evolution of drug-resistant infections. A key part of battling AMR is human health system strengthening, an investment in which is already taken into account as part of scaling up towards UHC.

Tackling household air pollution. Air pollution is a risk factor for several disease conditions, on a par with other risk factors associated with NCDs. WHO estimates that 3.8 million people die every year from causes attributable to household air pollution (HAP). Relying on recent studies, including work by the World Bank on the economic burden of air pollution, the WHO IC authors generated estimates for the costs/benefits of investment in key interventions in this area, notably investments in clean cooking.

Water and Sanitation. For assessing the resource needs in countries in both water and sanitation, the authors included both health sector and non-health sector costs, to provide multi-sectoral estimates. For health impact, the authors examined the deaths averted by cause (including deaths averted in children above the age of 4 years) due to the increased coverage of WASH interventions. The economic gains of WASH interventions were estimated based on earlier research by the World Bank and WHO, and three direct effects on the economy were identified.

Climate Resilience. Global warming and resultant climate change is impacting weather patterns, which are in turn affecting the epidemiological profile of different parts of the world. While this section does not consider additional interventions aimed at combating climate change, and their costs and impacts, it adds a revision to the estimated deaths caused by diarrhoea out to 2023, and makes the point that investing in WASH interventions will yield health and economic gains, as well as cost offsets due to preventing diarrhoeal disease.

Table A1: Costs, impacts and benefits of Investing in Global Health

	Total Costs (2019-2023, Billions US$)	Health Benefits (Lives Saved, 2019-2023, Millions)	Expected Economic Gains(Accrued 2019-2023, Billions US$)	Long-term Expected Economic Gains (Accrued beyond 2023) *
1. Universal Health Coverage	$1134	24.4	$1616	**
2. World Health Emergencies	$29	1.5	$240	**
3. Healthier Populations				
a. Life course (ECD specifically)	***	***	***	$97
b. NCD`s (RTI specifically)	$0.8	0.4	$98	**
c. CD`s	***	***	***	**
d. AMR	$26	-	$79-$353	**
e. Environment				
i. Household Air pollution	$23	1.0	**	$32****
ii. WASH	$38	2.3	**	$148
iii. Climate resilience	$7	0.1	**	$27

Note: Adjusted numbers taken from their original sources, modified to meet minimum standards of comparability. Some double counting may remain.

* Gains presented here also come from models that do not account for the economy being able to absorb increases to the labour supply.

** Economic gains and cost offsets exist for investments in these areas, but estimates either do not exist, or use methods that are not consistent with the rest of the numbers presented in this table.

***Investments, impacts and benefits are found within the estimates for Universal Health Coverage

**** Economic gains from preventing household air pollution accrue from the first year of implementation, but are estimated as lifetime incomes, and as such, are benefits that accrue beyond 2023.

The various limitations of the exercise are set out in the last section, where several key issues are underlined.

It is pointed out that the estimates presented are only the first results of modelling the economic impacts of global health investment. For example, while the estimates of economic benefits of UHC focuses on the quantity of labour supply, as identified by deaths averted, it does not focus on the quality of the labour supply, which is affected by morbidity and labour productivity. Incorporating this second component into such an estimate would increase the resulting economic gains substantially, being particularly relevant for the impacts of scaling up to combat and prevent NCDs.

Another key point raised is the fact that while investments made between 2019 and 2023 may have a direct impact on saving lives, benefits may not be seen until later. This is the case for interventions that focus on the young, whose impact on the labor force and the economy are only seen at least a decade later. These benefits are not included for any area. In addition, preventative interventions also have benefits that appear many years later, in contributing to lower costs of complex treatment. The cost offsets of investing in such interventions have not been estimated for every investment area of the IC, but are present in every investment with a preventative or efficiency-focused aim.

Finally, the aim of the document was to identify the financial value of investing in health and saving lives. This can be controversial for a number of reasons, notable among them being the assumption that the lives of children, older people, and those not part of the market economy have no value. This is certainly not the case, as health has an *intrinsic* value and investing in health should be undertaken for the benefit of all. In line with this, no economic value is assigned to human life, and the expected number of lives to be saved is expressed separately from the economic gains of investing in global health.

I.   Background:

WHO's proposed 13th General Program of Work for 2019-2023 (WHO GPW[3]) aims to ensure that an additional 1 billion people benefit from universal health coverage (UHC), 1 billion more people are better protected from health emergencies, and 1 billion more people enjoy better health and well-being by 2023. This report proposes to estimate country resources required to achieve the "triple billion" targets, and the health and economic benefits such investments would generate. This document explains the approach taken to estimate the costs and benefits of the projected investments at the country level that WHO estimates will have substantial impacts in saving human lives.

II.   Overall methodological framework

This analysis of the costs and benefits of both health sector and intersectoral components that impact human health is a synthetic compilation of existing models and publications, which were modified in line with the framework presented below.

Previous research has often identified the total resource needs for a certain issue[4], or reported benefit-cost ratios of the returns generated by investing in a certain area. Rather than simply combining such previous estimates to provide a picture of the returns from investing in health overall, we identified estimates of costs and benefits of scaling up interventions in the 2019-2023 time-frame, demonstrating how countries would progress from current levels towards the "triple billion" targets.

Studies often report costs and benefits as yearly averages, rather than projecting what a gradual achievement of targets would look like. Realistically, implementation would have to be gradual, and existing modelled estimates were therefore adjusted to reflect this.

As the criterion for inclusion used is investments supporting the achievement of the "triple billion" targets, we focused on the costs/benefits of investments in low- and middle-income countries where the global burden of disease is mainly concentrated[5], and where UHC is yet to be achieved[6].

The scope of areas included in this analysis reflects the scope of the published studies that estimated both costs *and* benefits, or where costs and benefits were presented and estimated in separate publications, but were based on the same set of interventions and assumptions around implementation, often by the same set of researchers and authors. Failing this, different publications with a consistent set of data inputs were used with some adjustments.

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[3] http://www.who.int/about/what-we-do/gpw-thirteen-consultation/en/
[4] Such research fails to identify resources needs for scale up towards targets, presenting no estimate of current levels of attainment, a pre-requisite for identifying additional resource requirements.
[5] The burden of disease of certain areas can be considerable in High Income Countries, which reflects an underestimate of the costs, and benefits presented here, but reflect the greater role and impact WHO plays in Low and Middle Income countries.
[6] According to the OECD (OECD, (2016), Universal Health Coverage and Health Outcomes: Final Report for the G7 Health Ministerial meeting, Kobe, Japan, 11-12 September 2016), with the exception of the USA, all OECD countries have achieved UHC.

The "triple billion" targets of the WHO`s General Program of Work

The World Health Organization secretariat, in setting out its vision for the next five years, drafted the 13th GPW with specific goals it will strive to help the world achieve. The most of ambitious of these are the "triple one - billion" targets, which are:

- Achieving universal health coverage – 1 billion more people benefitting from universal health coverage
- Addressing health emergencies – 1 billion more people better protected from health emergencies
- Promoting healthier populations – 1 billion more people enjoying better health and well-being

Different interventions are needed to reach these targets, as among other things, the delivery of a package of health services is necessary for the first, emergence management operation centers are necessary for the second, and improved water and sanitation are necessary for the third.

Because investments in certain interventions may figure in several different published estimates of costs and benefits, resulting in double counting[7], we were careful to exclude double counting where possible[8]. Finally, no estimates of costs and benefits related to certain areas which are key to achieving the triple billion targets were included if no published numbers were available,, or where studies did not provide sufficient methodological detail to allow us to identify the possible presence of double counting, the method of estimation of costs, health impacts or economic benefits, or the type of economic benefit being considered.

Costs

This section discusses the way in which we estimate the quantity of resources needed to achieve the "triple billion" targets, or area-specific targets, such as the Sustainable Development Goal (SDG) targets for Malaria or air pollution. Each area included in this analysis presumes the provision of a series of key interventions, or activities that are implemented over time. To cost these activities, we first identified the baseline level of implementation and then calculated the costs that were additional to that baseline.

Each intervention has a series of inputs, with specific prices, which are multiplied by the quantities that are needed to reach pre-set targets. For this study, only market-traded inputs, such as costs of employing additional human resources, and purchasing equipment, diagnostic tests and medicines, and building infrastructure are included. All capital costs are accounted for in the cost projections, taking a financial perspective, regardless of payer or financing model, and considering the year that they were modelled as being built or purchased during 2019-2023 (i.e., no annualization of capital

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[7] For instance, strengthening the health system is the key component within reaching UHC, but it is also cited as a main cost in meeting global health security needs, as well as investment needs for preventing Antimicrobial Resistance.

[8] As the modelling of resource-needs towards UHC (from Stenberg, et al (2017).Financing transformative health systems towards achievement of the health Sustainable Development Goals: a model for projected resource needs in 67 low-income and middle-income countries - The Lancet Global Health. Lancet Global Health 2017; 5(9): e875-87)was a comprehensive, integrated model of costs and impacts, its costs and impacts were presented as close to its original results as possible; thus costs and impacts that could be considered in this area as well as another, such as intersectoral communicable disease investments, were counted within UHC, if not easily extractable.

investment)[9]. The costs presented here are therefore the sum of the financial costs of implementing interventions in a specific year, for each area, above what exists under current, baseline levels. All costs are expressed in 2010-2016 US$.

Health Impacts

Each investment considered has an associated measure of impact, in terms of preventing premature mortality[10]. Two alternate scenarios are projected: one in which coverage is maintained at the baseline level; and another in which coverage is scaled up, as described in the costing methodology. The difference between the two represents the estimated health benefit. These health benefits are measured as health outcomes only (expressed as lives saved), and not converted to monetary values. With regards to the investments needed to reach UHC, the impacts are also expressed as healthy life years gained, and as the increase in life expectancy as a summary measure[11].

Potential Economic Benefits and Gains

This analysis also sets out the economic gains expected to accrue from the scale-up of interventions. We limit ourselves to including market-valued benefits which would accrue to the economies of the countries in which the interventions are implemented between 2019 and 2023. These represent estimates from macroeconomic models that assess the impact of interventions on countries` economic activity (e.g., GDP). Details for these can be found under each area's description of benefits considered.

Economic gains attributable to investments in the 5 year period considered can continue to accrue over a longer time period. Where published estimates allowed for their estimation, they were taken into account, but these are presented separately, and should be added to the other estimated gains with caution, as they rely on different, and non-comparable estimation methods[12].

Furthermore, several investments can be said to lead to "cost savings", whereby investments would lead to lower future spending in many areas, particularly within the health sector, relative to expenditure levels that would be expected if the current situation were to continue unchanged. These are presented as "cost offsets", but do not reflect an impact on the market economy in the

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[9] A large part of the health system costs are *investment costs* in that they provide benefits beyond the time frame considered here; e.g. health infrastructure (20-30 years), vehicles (5-10 years), and equipment have a lifespan that go beyond 2023 and will continue to support services into the following decade.

[10] The measurement of health impact depends on the availability of established disease models. For some, the costs are included, but the complete health impact may not be included. For example, life-saving surgery like appendectomies (other than caesarean sections), can be made possible by the building of hospitals and producing health providers, but the health impact is not measured. At the other end, the treatment of lower back pain, a common cause of disability and loss of income, is not captured either.

[11] Estimates of healthy life years gained or increase in life expectancy were only available from the interventions linked to UHC. If such estimates of health impact were to be identifiable for the investments in the other areas, these would have also been presented.

[12] These estimates follow both (1) an unconstrained economic model, that does not consider how the economy will adjust to increased amounts (or quality) of labor, and (2) a contemporary estimate of their value resulting from current salary levels and expected future years of labor, neither of which will reflect reality in the future.

same manner as the two other types of economic benefits mentioned previously. This is not to say these should be overlooked, but they should not be added to the other estimated gains.

What goes into a Estimating the Benefits of Investing in Health

The resulting economic benefits, and returns on investment, presented as part of this analysis may seem quite low. Other publications that have attempted to estimate the returns to investing in global health, in particular the Lancet Commission on Investing in Health[1], have used a different methodology, referred to as the "full-income" approach, that presents both the market-valued effect of health investments on national incomes plus an economic valuation of the health impact, in this case lives saved, that are a result of these investments[1]. Other approaches have further expanded this to include the value of other positive things that investing in health can bring, which are not market valued, such as equity (economic, gender, regional), financial risk protection, environmental benefits, educational benefits, or social role benefits, as well as people`s lives and time when not in the formal labor market. Furthermore, our approach serves to highlight the market-valued outcomes, which are often overlooked in most economic evaluations of investing in health, while avoiding any confusion of interpreting the overall economic benefits, and return-on-investment ratios, that may have otherwise represented not just the expected changes to national incomes, but changes in broader human welfare.

It is worth noting that the costs and benefits reported for the WHO GPW focus on those that fall within the left side of the table below, while the value of better health, represented in the right side of the table, is only presented in natural units and are not included in the ROI. Many other attempts to quantify the economic benefits of investing in health use "shadow prices", such as VSLs or VSLYs, to value non-market-traded outcomes such as direct health benefits; typically, moreover, such analyses do not value the market-traded outcomes of health interventions such as increased economic output.

Comparison of main ROI methodologies	
Economic growth and national income (GDP)	Value of reduced mortality risk to individuals
• Measures real money, income and wages	• Measures the intrinsic value of health in monetary terms
• Based on macroeconomic ("economy-wide") models of market-valued output	• Based on microeconomic ("individual") models of people's preferences for health versus other goods
• Attributes a monetary value only to market-traded-outcomes (e.g. goods and services, savings and investment)	• Attributes a monetary value only to non-market-traded outcomes (e.g. health itself)
• Does not include **non-market-traded** outcomes	• Does not include **market-traded** outcomes
• These models use national-level datasets (=>accepted scientific practice)	• These models use a single global value of "VSL", adjusted with widely different methodologies (=>scientific controversy)
• Input data available for all countries from recognized international sources	• Input data on VSL available only for a few rich countries

Researchers and theorists (Arrow KJ, Dasgupta P, Goulder LH, Mumford KJ, Oleson K. *Sustainability and the measurement of wealth*, National Bureau of Economic Research Working Paper 16599, Cambridge, MA, USA, 2010; Arrow KJ, Dasgupta P, Goulder LH, Mumford KJ, Oleson K. Sustainability and the measurement of wealth: further reflections, *Environment and Development Economics* 18: 504–516, 2013.) have found that when using shadow-pricing techniques such as VSL or VSLY for health capital, the value of health swamps in magnitude all other forms of capital relevant for sustainable development. This explains why the typical ROI health has such a high value: this is only an equivalent way of saying, but in different words, that the relative value of health in people's preferences is very high. Valuing the "full income" of health in monetary terms therefore adds very little information beyond what is already known when health benefits are counted in natural units, and in addition risks, by the fact of aggregating all benefits in a common monetary unit, to confuse the value of market-traded outcomes with non-market traded ones. It is important, therefore, not to compare the ROIs in analyses that exclude non-market traded outcomes, such as in assessing the benefits of investments needed to implement the WHO`s GPW (left side of the table) with ROIs reported elsewhere (right side of the table); to do so would be to compare apples with oranges.

In addition, our focus is on the period between 2019-2023, such that the estimation of benefits for most areas, such as those arising from investments towards Universal Health Care, are limited to those occurring in this limited time period, even if many investments, particularly those improving child health, can be expected to yield economic benefits in the long-term. Furthermore, while certain areas have estimates of "cost-offsets", or health spending that can be expected to be foregone due to forward-looking investments, such as spending on preventative services, these have not been calculated for most areas, including the investment needs towards Universal Health Care, and neither these nor the long-term benefits measured before are summed together with the short-term benefits presented initially, which make the results lower than other publications that do combine these.

III.   Incremental Costs, Impacts and Benefits of reaching the "triple billion" targets

A.   Universal Health Coverage: 1 billion more people benefitting from UHC

i.   Costs and health impacts: Estimates for increasing access to Universal Health Coverage draw on previous work undertaken by WHO which estimated the resources required by countries in order to advance towards the health-related SDGs.[13] A phased strengthening of health systems was modelled for 67 low- and middle-income countries (95% of the LMIC population), whereby the capacity to deliver priority health services was projected as increasing over time and across

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[13] Stenberg, et al (2017). Financing transformative health systems towards achievement of the health Sustainable Development Goals: a model for projected resource needs in 67 low-income and middle-income countries - The Lancet Global Health. Lancet Global Health 2017; 5(9): e875-87. Available at: http://www.thelancet.com/journals/lancet/article/PIIS2214-109X(17)30263-2/fulltext?elsca1=tlxpr

settings through a patient-centred, primary health care-oriented service delivery model. Global targets for each disease area were compiled, and using the One Health tool[14] the scale-up of health interventions was modelled, moving countries from current levels of service coverage towards previously identified sectoral or SDG targets. Assumptions around the speed of scale-up, based on contextual factors, such as economic development and political stability, were taken into account.[15] Health benefits were estimated by country and year, and in addition to calculating premature deaths averted, there are also estimations of the additional healthy life years expected from scaling up investments in UHC, as well as an estimate of the increase in life expectancy at birth as a result of the premature deaths that are averted[16].

ii. Economic benefits: Estimation of the economic gains of investing in UHC were based on a revised version of the WHO tool for Economic Projections of Illness and Cost (EPIC). EPIC was originally developed at WHO to estimate the economic impact of non-communicable diseases, and results using EPIC were published[17]. A newly revised EPIC estimates changes in rates of domestic GDP growth based on two channels: the impact on the labour force resulting from health interventions, and the impact of health expenditure, including on infrastructure and equipment, on physical capital accumulation, through changes in savings and investment[18]. These are all short-term benefits that should be expected to be seen in measures such as GDP during the five year period.

Table 1. Costs, Impacts and Benefits of UHC, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2014)	161	216	226	258	273	1,134
Health impacts (deaths averted, millions)	3.2	4.1	5.0	5.9	6.8	25.1
Economic gains ($US Billions, 2014)	290	306	323	340	357	1,616

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[14] http://www.who.int/choice/onehealthtool/en/

[15] For further details, refer to the Resource Needs for obtaining the Health SDG'S Technical Report, World Health Organization, 2018.

[16] For further details, see Annex 1.

[17] Bloom D.E., Cafiero E.T., Jané-Llopis E., Abrahams-Gessel S., Bloom L.R., Fathima S., Feigl A.B., Gaziano T., Mowafi M., Pandya A., Prettner K., Rosenberg L., Seligman B., Stein A., & Weinstein C. (2011). The Global Economic Burden of Non-communicable Diseases. Geneva: World Economic Forum. Available at: http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf

[18] For further details, see Annex 2.

Table 2. Additional Health Impacts of investments towards UHC[19]

	2019-2023
Healthy Life Years Gained (millions)	108
Increase in Life Expectancy (years)	1.74

Missing components: There are a few long-term benefits of UHC that are not considered here. For example, investments which can be considered "complete" by 2023, such as legislation, will continue to save lives after 2023 without any additional investment. There are also many investments included here, such as immunizations, which save the lives of children, which would benefit national economies *after* 2023, when these children enter the labour force. However, both of these post-2023 economic benefits are not included. In addition, several interventions that improve the health of older people, which are part of UHC, will have an impact on the supply of labor (and as such on the economy), by preventing relatives (generally girls) from having to withdraw from the labor force to take care of the sick. No estimates of the economic benefits of these at a LMIC or global level were identified. Furthermore, investments to strengthen health systems as modelled here, with a focus on patient-centered primary health care, would yield more health impact than can be estimated by the available disease models, while the health impact of investments in health infrastructure and human resources will extend beyond 2023. In addition, these PHC-focused investments will yield large cost offsets in avoided secondary and tertiary curative services in the future, but these have not been estimated.

B. Health Security: 1 billion more people better protected from Health Emergencies

    i. Costs: The numbers presented on the costs for health emergencies draw upon various sources, and can be broken down into costs for prevention, preparedness, and response. For country-specific costs of preparedness, including costs of all-hazard preparedness and International Health Regulation (IHR) implementation, core capacities for emergency preparedness and disaster risk management, numbers were derived from the WHO's SDG price tag (Stenberg et al, 2017). Estimates for investment needs for prevention of health emergencies come from calculations carried out by WHO's World Health Emergencies Programme for this report. Estimated needs for research and development (R&D) for infectious hazard management were based on the infectious hazard R&D Blueprint[20], while country cost estimates were estimated for scaling up the implementation of prevention strategies for cholera, yellow fever, and meningitis. Investment needs in this area also include country-specific calculations made by WHO's World Health Emergencies Programme for delivering a comprehensive package of services to targeted populations in fragile and conflict settings. Finally, we also include an estimate of the

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[19] These results include the health impacts from WASH on populations of 0-4 years of age, scaling up health services in conflict and fragile countries, as well as the unadjusted impact of UHC interventions on conditions affected by air pollution. While this represents an overestimate of the health impacts of UHC, these indicators could not be estimated taking into account these adjustments, or for the other areas considered here, which would then yield a greater number of healthy life years gained and increases in life expectancy.

[20] http://www.who.int/blueprint/en/

additional resources needed for effective and coordinated response to acute public health emergencies, based on cost reports of previous WHO-led responses.

ii. Health impact: The health impact of this component includes the lives saved as a result of interventions implemented during an outbreak response to prevent additional cases of yellow fever, cholera, and meningitis, as well as treatment of cases as they arise. A priority population that is at risk of outbreaks was identified using the most recent burden of disease for these diseases[21]. Assuming that similar numbers of cases of these diseases would occur without World Health Emergencies Programme intervention, the impact of implementing preventative and curative interventions on these populations was modelled, within countries and populations that had health emergency response activities in the past. In addition, we also model a number of lives saved from the delivery of a package of services in selected fragile and conflict-affected countries. This is estimated as being equivalent to the impacts of scale-up of public health interventions, as modelled in the Stenberg et al. paper, for the target countries and populations considered. This was adjusted upward by 50%, as the delivery of health services will focus on at-risk populations that will have higher prevalence of disease than national averages, as well as much lower initial coverage level of services. In addition, with a coordinated effort, the modelled scale-up of service delivery is faster than that assumed in the Stenberg et al. paper, with its slow, back-loaded scale-up curves for these types of countries[22].

iii. Economic benefits: The main economic effect of these investments comes from preventing health emergencies, and minimizing their impact when they do occur.

In particular, these investments would have the impact of preventing, or drastically reducing, the probability of a major pandemic. Earlier research[23], cited in major publications[24], has estimated the expected economic losses of pandemics. Since pandemics are not expected to occur every year, the impact of pandemics of various sizes occurring over the next century has been

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[21] Ali M, Nelson AR, Lopez AL, Sack DA (2015) Updated Global Burden of Cholera in Endemic Countries. PLoSNegl Trop Dis 9(6): e0003832. Available at https://doi.org/10.1371/journal.pntd.0003832

[22] A proportional amount of costs for each target country of the estimates from the Stenberg et al paper were subtracted from the estimated costs for reaching UHC. The countries considered can be found in Annex A, and for countries not included in the analysis for resource needs towards the health SDG`s and UHC, the health impacts of similar countries were used as proxies, relative to the size of the target populations in the countries not found in the Stenberg et al sample.

[23] National Academy of Medicine. 2016. *The Neglected Dimension of Global Security: A Framework to Counter Infectious Disease Crises*. Washington, DC: The National Academies Press. Available at: https://doi.org/10.17226/21891

[24] World Bank. 2017. *From panic and neglect to investing in health security: financing pandemic preparedness at a national level*. Washington, D.C.: World Bank Group. Available at: http://www.worldbank.org/en/topic/pandemics/publication/from-panic-neglect-to-investing-in-health-security-financing-pandemic-preparedness-at-a-national-level

estimated, with an annualized expected shock to the global economy falling in the vicinity of $60 billion a year[25].

Table 3: Costs, Impacts and Benefits of investing in Health Emergencies, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2014)	2.9	3.6	6.0	7.6	8.8	28.9
Health impacts (deaths averted, millions)	0.2	0.2	0.3	0.4	0.4	1.5
Economic gains ($US Billions, 2015)	36	42	48	54	60	240

The investments related to preparedness and response will also mean that the response to acute outbreaks will be better coordinated and contain these outbreaks more quickly than has been the case in the past. This will mean that the global cost of responding to acute outbreaks will be reduced. Similarly, the effective implementation of preventative interventions to reduce the number of cases of cholera, yellow fever and meningitis, such as emergency mass vaccination and targeted vector control, would mean a reduced need for resources to treat these diseases. These cost offsets are presented below.

Table 4: Cost offsets due to additional investments in health emergency prevention and preparedness, US$ Billions, 2016

	2019	2020	2021	2022	2023	Total
Shorter Outbreak due to rapid response	0.7	0.7	0.8	0.8	0.9	3.7
Reduced need for Treatment Interventions	0.2	0.4	0.7	0.9	1.1	3.3

C.   Healthier Populations: 1 billion more people enjoying better health and well-being

i.   *Improving Health Capital across the Life Course*

The investments considered as part of UHC, as modelled in the Stenberg et al. paper, are considered to be comprehensive insofar as generating the improvement of health capital across the life course, and as such no additional investments not covered in UHC were included here. It is important to note that key interventions

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[25] These estimates are the outputs of a generalized equilibrium model, which estimated the effect of an external shock, in this case pandemics of different size, on various inputs to the economy, including labor supply and productivity, trade and international travel. This expected shock is in line with a baseline scenario where no additional investments are carried out, and where investments here prevent these effects. This estimate is a global estimate, and does not focus only on LMICs, but which is a valid consideration given that a pandemic that may start in a developing country will also impact the economies of high income countries.

within UHC focus on improving health capital, were considered, and by preventing disease and death in the large working-age populations in low and middle income countries, scaling up to UHC helps these countries take advantage of the benefits of the demographic dividend, and see substantial economic benefits from these investments. However, our estimate of the economic gains related to UHC focus on those that accrue in the period 2019-2023, and we did not attempt to capture the positive impact on wages and incomes from investments that benefit children, such as immunizations, even if these will represent key lives being saved when those children become working adults and those countries go through the demographic transition. However, we were able to identify estimated benefits that go beyond 2023 from investments in early childhood development, whose health-related costs were included in UHC. Based on work by Fink et al.[26], we identified an estimate of the economic burden of growth faltering, calculated as global lifetime foregone earnings of the children affected. Many of the interventions modelled as being scaled up as part of UHC will combat growth faltering. Taking stunting as a proxy for growth faltering, we identified expected reductions in stunting from the modelled impacts of UHC that we then used to create estimates of the lifetime earnings effects of early childhood development interventions, as related to its impacts on schooling, and, subsequently, labour productivity and higher lifetime earnings. While these economic gains are estimated for each yearly cohort of children who can be expected to not be stunted, they will only accrue once children enter the labour force. As such they are presented as long-term benefits[27].

Table 5: Economic gains from investments in Early-Childhood Development, 2019-2023

	2019	2020	2021	2022	2023	Total
Long term Economic Gains ($US Billions, 2010)	12.4	17.7	19.5	23.0	24.8	97.4

ii. *Accelerating action on preventing noncommunicable diseases and promoting mental health*

Many interventions aimed at preventing noncommunicable diseases, such as cancers, cardiovascular disease, lung diseases and others, were included in the package of services modelled as part of scaling up towards UHC, as calculated in the SDG price tag. One area that was not included in previous work was interventions

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[26] Günther Fink, Evan Peet, Goodarz Danaei, Kathryn Andrews, Dana Charles McCoy, Christopher R Sudfeld, Mary C Smith Fawzi, Majid Ezzati, Wafaie W Fawzi. *Schooling and wage income losses due to early-childhood growth faltering in developing countries: national, regional, and global estimates.* The American Journal of Clinical Nutrition, Volume 104, Issue 1, 1 July 2016, Pages 104–112. Available at: https://doi.org/10.3945/ajcn.115.123968

[27] In addition, these estimates do not come from a constrained macroeconomic model, and make the assumption that the respective economies of children who are not stunted, due to investments in ECD, are able to fully absorb this additionally skilled labor.

designed to prevent Road Traffic Injuries (RTIs), where in collaborating with the NVI department of the WHO, we were able to put together estimates of costs, health impacts and benefits. The period 2011-2020 was declared a "Decade of Action for Road Safety" in 2010, launching a Global Plan of Action, which estimated the global cost of 5 pillars of interventions for reducing road traffic injuries and deaths[28]. Detailed work remains to be done to identify how many lives could be saved through the implementation of these interventions, but published estimates indicate that 30% of RTIs could be prevented by a 5% cut in average speeds[29]. Implementing such speed management in LMICs requires establishing comprehensive road safety systems, but appears to be a reasonable goal for LMICs by 2030. Additional, non-speed focused interventions, will also have an impact.

Recent research, estimating the economic benefits of investing in road safety, identifies "the economic loss associated with every year of inaction where LMICs fail to move beyond their status quo performance on road safety"[30]. The research focuses on the impacts of morbidity and mortality of road traffic injuries on the labour force. These impacts are shown to cascade through many other productive sectors of the economy, ultimately affecting GDP.

Following the scenario developed in this paper, which targets implementation of all platforms of road safety in the SDG era, we identified the expected economic impacts related to reducing RTI deaths by 37.5% by 2030 which equates to an expected drop in RTI deaths of 15.6% by 2023. Such reductions were shown to have a substantial positive effect on the economy, as seen below.

Table 6: Costs, Impacts and Benefits of investing in Road Traffic Safety, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2014)	0.11	0.14	0.16	0.18	0.21	0.8
Health Impacts (deaths averted, Millions)	0.04	0.07	0.11	0.14	0.18	0.53
Economic Gains ($US Billions, 2014)	6.5	13.0	19.5	26.0	32.9	97.9

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[28] WHO (2010). *Global Plan for the Decade of Action for Road Safety, 2011-2020.* Geneva, Switzerland. Available at: http://www.who.int/roadsafety/decade_of_action/plan/plan_english.pdf. Values inflated to 2016 US$. It is noted that authors were unable to provide the details of this cost estimate, and comparing to similar types of investments mobilized, on a per capita basis, by the Bloomberg Road Safety Program (that yielded a health impact of less than 20,000 lives saved over 5 years in 6 countries), the resources required to implement the interventions that will yield such substantial health impacts will likely be much larger than the costs presented in the table.

[29] Save LIVES - A road safety technical package. Geneva: World Health Organization; 2017. Available at: http://www.who.int/violence_injury_prevention/publications/road_traffic/save-lives-package/en/

[30] World Bank, 2017. The High Toll of Traffic Injuries: Unacceptable and Preventable. Washington, DC: World Bank: Available at: http://www.worldbank.org/en/programs/global-road-safety-facility/publication/the-high-toll-of-traffic-injuries-unacceptable-and-preventable

iii. Accelerating elimination and eradication of high impact communicable diseases

Interventions aimed at combating communicable diseases constitute the core of the unfinished MDG agenda within UHC. As a result, all key interventions designed to combat the communicable diseases with the largest health burden are included in the modelling for scaling up towards the health SDGs and UHC[31].

iv. Tackling antimicrobial resistance

Developing antimicrobial resistance (AMR) is an urgent threat to global health, and is expected to have a substantial negative impact on human lives and economic activity, if not addressed in the next 5 years. Based on recent research by the World Bank[32], and in cooperation with the AMR department of the WHO, we identified estimates of the additional health and economic burden imposed by unchecked AMR, as well as cost estimates of the interventions needed to prevent, or mitigate the evolution of drug-resistant infections. A key part of battling AMR is human health system strengthening, investment in which is already taken into account as part of scaling up towards UHC.

The costs included here, outlined in the recent World Bank research, cover the active management at the country level of the "antimicrobial commons", such as infection prevention and control interventions, and antimicrobial stewardship, and global interventions, such as the promotion of new antimicrobials, development of shared standards and interoperable systems, and global public awareness campaigns[33]. Investments are also needed to support a "One Health" approach, which looks at the human-animal interface, and involves the strengthening of veterinary and wildlife health systems to mitigate the impact of overuse and misuse of antibiotics in animals which can lead to resistance that spreads to human populations[34]. The total investment needs were identified, and scale-up for these investments was modelled as being front-loaded, given the urgency of strengthening interventions to combat AMR.

To estimate the economic benefits of preventing AMR, the recent World Bank report presents scenarios reflecting pathogen-drug pairs that will be affected by AMR in the immediate future, ranging from 5% of drug pairs as a most optimistic scenario, to all drug pairs as a most pessimistic scenario. We focus on these upper and lower bound

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[31] Resource needs and impacts for Hepatitis interventions were not part of the interventions covered in the modelling for scaling up health systems towards achieving the health SDG`s and UHC. Estimates of the resource needs and health impacts of a global plan to combat Hepatitis should be published in mid-2018.

[32] World Bank. 2017. *Drug-Resistant Infections: A Threat to Our Economic Future*. Washington, DC: World Bank. Available at http://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-future. Costs refer back to an earlier WB publication, (World Bank. 2012. *People, pathogens and our planet: the economics of one health*. Washington, DC: World Bank, available at: http://siteresources.worldbank.org/INTARD/Resources/PPP_Web.pdf).

[33] Original research and costing in O'Neill J., Tackling drug-resistant infections globally: Final report and recommendations. The review on antimicrobial resistance; London: HM Government and the Welcome Trust; 2016.) Available at https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf

[34] Original research and costing in World Bank. 2012. *People, pathogens and our planet: the economics of one health*. Washington, DC: World Bank.

scenarios here. The economic impact of AMR is modelled based on increases in morbidity and mortality of humans and livestock, which lead to reductions in the national effective labour supply, increases in health-care expenditures, and reductions in the supply of livestock. These shocks then cascade through all sectors of the economy and influence consumption, investment, and total output (GDP)[35]. The resulting benefits of investing in AMR prevention correspond to preventing and containing the effect of all AMR-affected drug-pairs in the low scenario, and preventing and containing half of all AMR-affected drug pairs in the high scenario (reflecting the difficulty of containing such widespread resistance)[36].

Table 7. Costs and Benefits of Investments in Antimicrobial Resistance, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2011)	3.4	4.3	5.1	6.1	6.9	25.8
Economic Gains ($US Billions, 2014)	2.1	1.8	12.1-45.6	27.8-112.1	35.0-192.6	79.2-353.3

v. *Health and the environment*

i. Household Air Pollution

Air pollution is a risk factor for several disease conditions, on a par with other risk factors associated with noncommunicable diseases (NCDs). WHO estimates[37] that 3.8 million people die every year from causes attributable to household air pollution (HAP). Changing the way people heat their homes and cook their food, by switching to cleaner fuels, and thereby drastically reducing levels of indoor or HAP has been shown to have a substantial positive impact on the incidence of HAP-attributable NCDs. Moving towards a goal of meeting 100% clean household energy, the International Energy Agency (IEA) estimated the cost, and health impacts, of making investments towards meeting this goal[38]. The World Bank and Institute for Health Metrics and Evaluation[39] have

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[35] This general equilibrium model is fully consistent, in that the shock of AMR leads to greater spending on health treatment, but this increase is fully offset by lower consumption and production of other goods and services.

[36] Authors could not find guidance to help identify what the prevention and containment capacity under a comprehensive AMR scenario would realistically be. WB research presented various levels of expected containment, but only in reference as showing that even without complete containment, the benefits would be expected to far outweigh the costs of the required investments.

[37] WHO (forthcoming), Household Air Pollution Burden of Disease, 2016.

[38] IEA. (2017). Energy Access Outlook 2017: From poverty to prosperity, 144. Available at: https://doi.org/10.1787/9789264285569-en. Yearly cost estimates shared by authors via personal communication. Estimates of health impacts were revised by technical staff at the Department of Public Health, Environmental & Social Determinants of Health, to reflect the lagged impact these interventions will have on increased incidence and relative risk of death from disease.

[39] World Bank and Institute for Health Metrics and Evaluation. 2016. The Cost of Air Pollution:

estimated the economic burden of air pollution, including HAP. In collaboration with the PHE department of the WHO, who provided the most recent estimate of the global burden of disease for household air pollution, we combined the IEA study and the updated WHO estimate of mortality attributable to estimate an updated reduction in the share of the health burden of HAP. Since interventions in UHC also prevent deaths attributable to air pollution, the health impacts of both investments in UHC and clean cooking were adjusted to prevent double counting[40]. Taking the resulting estimated deaths averted, this was combined with the results of the WB-IHME study to estimate the economic benefit of combating household air pollution, which are presented as prevented foregone lifetime earnings[41]. As seen below, investments in clean cooking will be key in preventing millions of deaths by 2023, with corresponding estimated foregone lifetime earnings if these deaths are not prevented.

Table 8. Costs, Impacts and Benefits from Investments in Household Air Pollution Prevention, 2019-2023.

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2016)	5.3	4.7	4.3	4.5	4.3	23.0
Health Impact (deaths averted, Millions)	0.04	0.12	0.20	0.28	0.36	1.0
Long-term Economic Gains ($US Billions, 2011)	1.2	4.0	6.6	9.1	11.5	32.4

ii. Water and Sanitation

While expanding access to basic water, sanitation and hygiene (WASH) requires investments that go beyond the health sector, the health SDG price tag[2] included the WASH health sector resource-needs for 67 countries. These estimates of the required investments draw upon a World Bank publication (2016)[42] with country-specific cost projections. In order to consider the

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Strengthening the Economic Case for Action. Washington, DC: World Bank. Available at: http://hdl.handle.net/10986/25013

[40] As competing risk factors, including household air pollution, affect the same diseases, the separately estimated attributable fractions of these risk factors in causing these diseases are adjusted to be consistent with the modelled scenario of scaling up both clean cooking and UHC investments.

[41] The modelled prevented foregone lifetime earnings will accrue from the first year that there are health impacts, but as these are estimated over a period that goes beyond 2023 they are presented as long-term benefits. Furthermore, these are not the result of macroeconomic modelling that takes into account the ability of economies to absorb additional supplies of labor.

[42] Hutton G and Varughese M (2016). The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene. World Bank and Water and Sanitation

multisectoral nature of Water and Sanitation, this analysis includes both health sector and non-health sector costs, as they are projected to increase over time in the 67-country sample used for the SDG price tag. The estimates include capital investments in water and sanitation infrastructure, as well as overall operation and management of the water supply and sanitation system. In terms of health impact, we examined the deaths averted by cause (including deaths averted in children aged 0-4 years) due to the increased coverage of WASH interventions (as included in the Stenberg paper)[43]. In order to capture deaths prevented in the population aged 5 years and above, in collaboration with the PHE department at WHO, we made a proportional adjustment of the health burden of diarrhoea (WHO, 2016 data, forthcoming) to incorporate deaths in all age groups. The adjustment was made on the assumption that deaths in young adults 4 years old and above would be impacted proportionally to the same extent as deaths in children under 4 years old from the modelled scale-up of WASH services.

The economic gains of these interventions were estimated based on research by the WHO[44] that identified a series of benefits stemming from implementing the same basic package of WASH interventions used for resource needs estimates above. WASH interventions were identified as having three direct effects on the economy: increased supplies and skill of labour due to not having to miss work to take care of sick children or being too sick to work or study; time saved due to avoiding travel and having to wait to collect water outside the home; and avoided foregone lifetime earnings due to mortality prevented by WASH. As these benefits were not easily separable, given the long-term nature of both economic benefits related to avoided foregone lifetime earnings and school absenteeism avoided, these benefits as a group are presented as also accruing beyond 2023[45].

Table 9. Costs, Impacts and Benefits of Water and Sanitation Investments, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2014)	5.8	6.7	8.0	8.5	8.9	37.8
Health Impact	0.3	0.4	0.5	0.5	0.6	2.3

Program. Available at http://documents.worldbank.org/curated/en/415441467988938343/pdf/103171-PUB-Box394556B-PUBLIC-EPI-K8543-ADD-SERIES.pdf

[43] It should be noted that the 67 SDG price tag countries account for 96-97% of total WASH deaths in LMICs, thus the predictions capture the bulk of the affected population.

[44] Hutton G. Global costs and benefits of drinking-water supply and sanitation interventions to reach the MDG target and universal coverage. Journal of Water and Health 2013;11(1):1-12. Available at: http://www.who.int/water_sanitation_health/publications/2012/globalcosts.pdf

[45] The research carried out to estimate the benefits of WASH interventions did not use a general equilibrium model, and presents benefits from increases to the labor supply with the assumption that all of these would be absorbed by national economies.

(deaths averted, Millions)						
Long-term Economic Gains ($US Billions, 2014)	22.7	26.2	31.2	33.1	34.5	148.1

There are also cost offsets estimated for investing in WASH interventions, such as fewer cases of diarrheal disease resulting in avoided costs of seeking and receiving treatment. These are presented below.

Table 10. Costs offsets due to Water and Sanitation Investments, 2019-2023

	2019	2020	2021	2022	2023	Total
Avoided costs to seek and receive treatment for diarrheal disease ($US Billions, 2014)	2.3	2.6	3.1	3.3	3.4	14.7

iii. Climate Resilience

Global warming and resultant climate change is impacting weather patterns, which are in turn affecting the epidemiological profile of different parts of the world. In addition, WHO research[46] estimates that because of climate change, populations in vulnerable areas, such as small island states, which currently rely on existing water and sanitation systems, will need new water and sanitation systems. Similarly, in the absence of major climate change mitigation, the burden of disease imposed by diarrhoea on these vulnerable populations is expected to increase in the coming decades.

While this section does not consider additional interventions aimed at combating climate change, and their costs and impacts[47], it adds a revision to the estimated deaths caused by diarrhoea out to 2023. Based on recent projections shared by the PHE department of WHO[48], there will be an estimated additional 7-9% diarrhoea-related deaths due to climate change between now and 2023. Applying the same country-specific population-based costs of applying WASH interventions to additional populations, these will yield a proportional number of lives saved, and economic gains, as well as cost offsets due to preventing diarrheal disease.

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[46] WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. http://www.who.int/globalchange/publications/quantitative-risk-assessment/en/
[47] We model the provision of a basic water and sanitation package to an additional population, preventing diarrhoea-related deaths, presented in the Water and Sanitation section earlier.
[48] Country-specific model developed in 2017, based on work for the 2014 publication above.

Table 11: Costs, Impacts, Benefits and cost offsets of Climate Resilience, 2019-2023

	2019	2020	2021	2022	2023	Total
Costs ($US Billions, 2014)	0.5	1.4	1.7	1.7	1.8	6.9
Health Impact (deaths averted, Millions)	0.02	0.02	0.03	0.04	0.04	0.15
Economic Gains ($US Billions, 2014)	1.8	5.4	6.4	6.5	7.0	27.0
Cost Offsets ($US Billions, 2014)	0.2	0.6	0.6	0.7	0.7	2.7

Missing components from "healthier populations":

There are other NCDs which tend to require intersectoral action to bring about behavioral change that were not included in the modelling of scaling up towards UHC, including the majority of cancers. Modelled estimates of the global resource-needs to prevent and treat these diseases, and the health impacts and economic benefits of the relevant interventions have yet to be identified.

Ambient or outdoor air pollution (AAP) is another important risk factor that contributes to many deaths worldwide. Published estimates exist of the global burden of disease related to AAP, what the health impacts of combating it would be, and what the economic burden of it is in terms of foregone lifetime earnings. However, it is still unclear what the costs of additional interventions to reduce AAP would be for LMICs, and as a result, costs, health impact and economic benefits for AAP are not included here. It is clear that climate change, due to AAP will impose heavy additional costs in the future if not enough is done to prevent its occurrence, or at best to mitigate its effects. None of these cost offsets are presented here, but they should not be overlooked in evaluating the justification for additional investments in AAP-focused interventions.

IV.   Overall Results

Table 12: Costs, Impacts and Benefits of Investing in Global Health, by Target and area

	Total Costs (2019-2023, Billions US$)	Health Impacts (Deaths Averted, 2019-2023, Millions)	Expected Economic Gains (Accrued 2019-2023, Billions US$)	Long-term Expected Economic Gains (Accrued beyond 2023) *	Cost Offsets
1. Universal Health Coverage	$1134	24.4	$1616	**	**
2. Health Emergencies	$29	1.5	$240	**	$7
3. Healthier Populations					
a. Life course (ECD specifically)	***	***	***	$97	**
b. NCD`s (RTI specifically)	$0.8	0.4	$98	**	$0.8
c. CD`s	***	***	***	**	***
d. AMR	$26	-	$79-$353	****	**
e. Environment					
i. Household air pollution	$23	1.0	**	$32****	**
ii. WASH	$38	2.3	**	$148	$38
iii. Climate resilience	$7	0.1	**	$27	$7

Note: Adjusted numbers taken from their original sources, modified to meet minimum standards of comparability. Some double counting may remain.

* Gains presented here also come from models that do not account for the economy being able to absorb increases to the labour supply.

** Economic gains and cost offsets exist for investments in these areas, but estimates either do not exist, or use methods that are not consistent with the rest of the numbers presented in this table.

*** Investments, impacts and benefits are found within the estimates for Universal Health Coverage

**** Economic gains from preventing household air pollution accrue from the first year of implementation, but are estimated as lifetime incomes, and as such, are benefits that accrue beyond 2023.

In addition, the above costs and benefits can be represented as return-on-investment ratios (ROIs), as presented below. However, it should be noted that these have been generated from different concepts and measurements of what can be considered an *economic benefit*. Therefore, these cannot be added up and should be compared with caution.

Table 13: Return on Investment Ratios (ROIs) of Areas of Investment

Component	Return-On-Investment Ratios (ROIs)
1. Universal Health Coverage	1.4
2. Health Emergencies	8.3
3. Healthier Populations	
a. Road Traffic Safety	120.9
b. AMR	2.9-13.0
c. Environment	
i. Household Air Pollution	1.5
ii. WASH	3.9
iii. Climate resilience	3.9

*Ratios above will differ from calculations taking the costs and benefits reported in table 12 above. This is because costs and benefits for certain areas are denominated in US$ of differing base years, and have been adjusted by U.S. price indices to be expressed in the same base year.

V.   Overall Limitations

Unlike the work carried out as part of estimating the resources required to reach the health-sector SDGs, which consisted of epidemiologic modelling by a single team, consolidating the numbers was made by attempting to reconcile differences between studies that used different costing and benefit calculation methodologies and/or accounting frameworks, and to adjust them, however crudely.

The possibility of overlaps between the areas included above, both within costs and benefits, is an important limitation. Although every attempt has been made to minimize double counting, it cannot be ruled out completely. In addition, calculations of the economic impact on GDP were estimated for different areas over the same years using different specifications of macroeconomic models. It is likely that the combined impact will be different from a simple aggregation of the estimates from the different macroeconomic models. For this reason no grand total is provided in the table.

The set of countries included in "global" estimates are not always consistent across studies. While the SDG agenda is global in scope, the vast majority of additional investment needs for health are within LMICs. We made efforts to limit global estimates to publications that focused on such countries, and further focused on identifying costs, impacts and benefits on a consistent, smaller, LMIC sample. Nevertheless, while a more comprehensive analysis that would include all LMICs, as well as high-income countries would provide a more correct estimate of resource needs and health impacts and benefits of meeting the county-level targets of the WHO`S GPW, we believe we capture the vast majority of the relevant investment needs, and benefits, by focusing on these 67 countries[49].

Estimates of costs and economic benefits are not always calculated or presented for the same reference year, the years ranging between 2011 and 2017. As these were values reported in aggregate, it was not possible to correctly represent these in a single base year, adjusting for country-specific rates of inflation and price changes across this 6 year time-span.

Initially, this document sought to consider only studies that examined the effects on overall national income as economic benefits, in order to directly draw a parallel between the investments presented and the more tangible, immediate effects these will have on national incomes. However, in order to avoid being overly conservative in

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[49] For instance, 96-97% of deaths preventable by WASH interventions in LMICs are found in the 67 country sample set used.

estimating the benefits of investing in health, other types of economic benefits were subsequently included.

First, for components such as health emergencies and AMR, published research pointed to the possibility of large external shocks related to these areas, and proposed investments that would prevent, or mitigate the impact of these shocks. To estimate the impact of preventing or mitigating the effects of a pandemic, for example, the cited research modelled the likelihood of a series of pandemics of differing sizes over the next century, and annualized the expected economic losses in GDP terms for a given year. However, these benefits represent the value of investments that will help avoid losses, rather than bring about gains.

Second, it is important to note that the analysis is not always based on the assumption of immediate returns. Thus, while investments made between 2019 and 2023 may have a direct impact on the economy, this may not be seen until later. Research referenced above identified effects of some investments, such as investing in early childhood development, which will only accrue when the young children who benefit from these interventions enter the labour force. No such estimates have been made regarding the long-term economic impact of many other investments considered above, including key interventions such as immunizations. In particular, many investments that are part of UHC that bring about decreases in infant and child mortality would represent key steps of many developing countries` movement through the demographic transition and the forthcoming demographic dividend that would bring substantial economic benefits, particularly in low income countries. All of these points reflect a general underestimation of the long-term benefits of investing in health.

The estimates for the economic benefits accruing from the scaling up of health services in support of the health SDGs and UHC are only initial results of modelling the economic impacts of investments in global health. For example, while one component of the benefits estimated focuses on the quantity of labour supply, as identified by deaths averted, it does not focus on the quality of the labour supply, which is affected by morbidity and labour productivity. Incorporating this second component into such an estimate would increase the resulting economic gains substantially, being particularly relevant for the impacts of scaling up to combat and prevent NCDs.

Also, it is important to note that several of the investments considered above are in interventions that have preventative aims, seeking to deal with a disease, risk factor or global condition in the present, in order to avoid a much larger, and more expensive, response in the future. The cost offsets of investing in such interventions should not be overlooked, and while these have not been estimated for every area presented, they are present in every investment with a preventative or efficiency-focused aim. Nevertheless, these do not reflect a change in national incomes from these investments, and without a generalized equilibrium model that identifies the alternative impacts of redistributing these resources, such as for AMR, they cannot be considered to be addable with the two types of economic gains presented above.

Nevertheless, we do not report an economic value of saving lives or reducing morbidity, as would be covered in a full-income approach to economic benefits, nor do we consider the economic value of other non market-valued benefits, such as greater equity, financial risk protection, environmental quality, educational attainment, or improvement in family and social roles, as well as additional days or years of healthy life, even when not in formal employment. While estimates of social benefits, or the "full-income approach do exist for certain areas we have considered, such estimates have not yet been calculated for investing in expanding health systems and services towards Universal Health Coverage, the largest component of our analysis. In addition, in economic analyses of health, market-valued benefits are often overlooked, and when both market–valued and non-market valued benefits are calculated, it is tempting to combine and present them as one overall benefit or as part of one overall return-on-investment ratio, which becomes a more complex number to understand and interpret, in comparison to a benefit-cost ratio or return-on-investment ratio that only compares costs with expected effects on GDP.

Furthermore, it is worth taking into account that costs, impacts and benefits are reported for the entire sample of countries, and that the ROI`s above provide a general picture of returns to investments in these areas. At the country level, the health impact and economic benefits to investing in these areas will be different, depending on factors such as the epidemiological and demographic profile of the country. In addition, unlike published estimates of the benefits of investing in certain areas, our framework models the scaling up of investments in all of these areas, correcting results to avoid double-counting. If countries chose to, or cannot scale up in all of these areas simultaneously, the expected returns-on-investment would approach the results in these published estimates, while subsequent investments would likely have lower impacts and benefits, from some health impacts and benefits having already been captured by the earlier investments.

Finally, the aim of this document is only to identify the economic value of investing in health and saving lives. There are a few ways in which this may seem either incomplete or too limiting. For example, unlike other cost-benefit analyses of health, our approach does not assign a monetary value to each life that is saved. However, it does impose an instrumental valuation of human life, by assuming that the lives of the children, older people and all those not part of the formal workforce have no value. This is certainly not the case, as health has an *intrinsic* value and investing in health should be undertaken for the benefit of all, taking equity and human rights into account. Our approach to quantifying economic benefits, however, only considers that which is given a value by the market, which unfortunately leaves out these groups.

There would be substantial value in further work that systematically attempted to model the investment needs and health and economic benefits of a single set of countries, using a consistent accounting framework, set of modelling parameters, and inputs. This would be strengthened by considering the more comprehensive ways in which investing

in health results in economic benefits, and provide a closer to a complete picture of the financial justification for investing in saving and improving people's lives.

ANNEX 1: Health Impacts of UHC: Beyond averting premature deaths

For the analysis of the impacts of investments in strengthening health systems towards the health SDG`s and UHC, additional summary measures of health, primarily life expectancy (LE) and healthy life years were estimated. Using OneHealth Tool (OHT) projections, including Spectrum impact modules (AIM, GOALS, LIST, DemProj, FamPlan, NCD), which produced estimates on changes to population and deaths by age, taking into account coverage of interventions to prevent or treat various diseases, we were able to estimate changes in life expectancy. The Spectrum model tracks the population by single age as people are born, grow older, and die, and produces outputs on modelled deaths by age. We used these outputs to adjust/construct standard life tables[50] to estimate life expectancy at birth, and drawing upon GBD 2010 disability weights by region,[51] to calculate the healthy life years gained due to the scale up of interventions considered.

We calculated life expectancy for three scenarios[52]: life expectancy at birth in 2015, the base year of our analysis; life expectancy at birth in 2023 based on projecting current intervention implementation without additional investment; and life expectancy at birth in 2023 projecting the health impacts of increased investments. Comparing the life expectancy at birth under the scenario with additional investments to the projected life expectancy at birth in 2023 with a constant coverage scenario allowed us to estimate the LE gained through the scale-up of the interventions, whilst implicitly taking into account the background projected increase in LE built-into the UN population projections.

The 2023 projected life expectancy at birth within the scale-up scenarios includes the impact of scaling up care in HIV/AIDS, maternal and child health, and a set of non-communicable diseases (cardiovascular disease, diabetes, asthma, COPD), epilepsy, and mental, neurological, and substance abuse disorders, as modelled through the OHT. Additional data available for cancers modelled using the International Agency for Research on Cancers GloboCan database[53], TB[54] and NTDs[55] were available from models with the same underlying methodology which we were able to incorporate into the calculations. We additionally explicitly show the impact of avoiding stillbirths on life expectancy increases. Intrapartum and Antepartum stillbirths are counted differently to avoided deaths following a live birth. A body of literature suggests that sentience begins at 28 weeks gestation, and as such we included avoided stillbirths in calculations of health impacts[56]. Although sentience exists, there appears to be consensus that each stillbirth avoided should not be valued the same as neonatal death following live birth[57]. Thus, each intrapartum stillbirth avoided is weighted at 75% of a neonatal death and each antepartum stillbirth avoided is weighted at 25% of a neonatal death.

The quality as well as quantity of health impact is important. In addition to the life expectancy, the number of healthy life years gained due to this set of interventions was estimated in the OHT projection models where possible, and from additional sources for TB and NTD. Increases in healthy life years lived within the Spectrum impact models are calculated based on comparisons between continuation of the status quo, and implementation of interventions to prevent or treat diseases, resulting in more people alive and healthy, and reduced disability of the population. Across the 67 countries, a total gain of 108 million healthy life years

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[50] Life tables: http://www.who.int/healthinfo/statistics/LT_method.pdf?ua=1&ua=1. WHO methods and data sources for life tables 1990-2015 (Global Health Estimates Technical Paper WHO/HIS/IER/GHE/2016.8)

[51] For Disability weights, see Salomon et al. (2012).

[52] This analysis is intended as being indicative, as we ran projections for 18 countries representing 60% of the global burden of disease (2010) and 79% of the population of the 67-country set.

[53] http://globocan.iarc.fr/Default.aspx

[54] The Global Plan to End TB, 2016-2020

[55] Sake J. de Vlas , Wilma A. Stolk , Epke A. le Rutte , Jan A. C. Hontelez, Roel Bakker, David J. Blok, Rui Cai, Tanja A. J. Houweling, Margarete C. Kulik, Edeltraud J. Lenk, Marianne Luyendijk, Suzette M. Matthijsse, William K. Redekop, Concerted Efforts to Control or Eliminate Neglected Tropical Diseases: How Much Health Will Be Gained? PLOS Neglected Tropical Diseases.

[56] Quereshi, Z U (2015) ; Phillips and Millum, (2015).

[57] Jamison DT, Shahid-Salles SA, Jamison J, et al. (2006)

between 2019 and 2023. A calculation such as this is crucial for diseases for which treatment focusses on quality of life rather than cure. For example, mental, neurological and substance abuse disorders contribute only 3% of projected life expectancy gain, but 15% of the projected healthy life years gained.

ANNEX 2: The Economic Projections of Illness and Cost (EPIC) model

In this report we estimate the projected impact of investing in UHC on economic growth. The analysis was undertaken using the WHO tool for Economic Projections of Illness and Cost (EPIC). The EPIC model relates macroeconomic outcomes to direct and indirect impacts of the burden of disease (Bloom et al. 2011). EPIC considers two main channels through which the improvements in the health status of a country can impact its economy: through physical capital accumulation and through the size of the effective labour force.

EPIC uses an augmented Solow growth model with a Cobb-Douglas functional form that relates the contribution of these factors to production levels in a country:

$$Y_t = \gamma * A * K_t^{\alpha} * (H * L_t)^{1-\alpha}$$

where *Y* is national output, *A* is total factor productivity, *K* is physical capital, *H* is human capital, L labour force, γ scaling factor, and 0<α<1. To estimate the required parameters, the model is fit to time series GDP data.

Investing in UHC will contribute to reduced disease morbidity and associated mortality. A reduction in morbidity will improve the productivity of the labour force by reducing the number of work days lost. Associated savings in health care expenditure will contribute to increased capital accumulation. Finally, a decline in mortality will increase the size of the labour force.

Physical Capital

The model assumes that a constant fraction of output, s, is devoted to investment. The existing physical capital depreciates at the constant rate of δ_i. The evolution of physical capital, K, follows the equations below.

$$\dot{K}_{it} = s_i Y_{it} - \delta_i K_{t-1}$$

$$K_{it} = s_i Y_{it-1} + (1 - \delta_i)K_{t-1}$$

In the original Solow model, δ_i is constant across countries but in this model, each country has a different rate of depreciation. Saving rates are assumed to remain constant for the period of the projection.

Effective Labour, L

Labour force is defined as people within working age of 15-69 years who participate in the labour market in each country. The stock of the labour force is augmented with the education and experience factor. Education factor is reflected in Human Capital, H, which accounts for returns to education that augment the quality of the labour force. In the current version, Human Capital, H, is country specific and exogenously given. The quality of labour accumulated with experience is taken into consideration with the Cuddington factor for accumulated experiences.

Following the Cuddington and Hancock (1994), the skill augmented effective labour force is defined as

$$L_i = \sum_{p=15}^{69} \rho_p L_{pt}$$

L_i is the size of the augmented labor force for a country i, where L_{pt} is the number of workers of age p at time t in the country. ρ_p is the Cuddington factor for adjustment for experience. Cuddington and Hancock (1994) applied an experience factor to adjust the labour stock for workers' experience.

$$\rho_p = \rho_1 + \rho_2 (age_p - 15) - \rho_3 (age_p - 15)^2$$

age_p is age of worker p while it is set that and ρ_1=0.8, $\rho_2 = 0.02$, and $\rho_3 = - 0.0002$.

Total Factor Productivity, A

Mankiw, Romer, and Weil (1992) note that the level of technology, or Total Factor Productivity (TFP), A, reflects not just technology but resource endowment, climate, institutions, and so on. The initial level of technology, A_0 may therefore differ across countries. In the original Solow model, the initial TFP, A_0, is exogenously given to be the same for all countries. However, in this model, we relax the assumption and let different countries have a different initial (fitted) level of technology A.

Consequences of Health Intervention

Diseases have negative effects on capital accumulation, and size and productivity of labour force. Health interventions thus affect economic performance through two channels, accumulation of physical capital, K, and growth of labour force.

Impacts of Mortality on Labour

Illnesses causing deaths reduce the prospective size of labour force. The impacts of mortality caused by diseases are calculated as follows.

$$L_{it} = \sum_{p=15}^{69} \rho_p \left(L_{pt} + x_z z_{dpt} \right)$$

The labour force of a country i, L_i, is reduced by the number of lost lives due to respective diseases. The parameter z_{dpt} indicates the number of deaths lost from the disease d for the age p at time t. $\rho_p L_{pt}$ is the projected skill augmented labour force which differentiate the impacts of the diseases to different age groups. Health intervention will reduce the size of z_{dpt} so as to increase the total number of labour force, L_i, of the country. x is the objective percentage of decline in mortality in the disease d.

Impacts of Mortality and Morbidity on Labour

The impacts of mortality and morbidity due to diseases include the number of deaths and productivity loss due to the respective diseases. The size of labour force affected by mortality and morbidity is calculated as follows.

$$L_{it} = \sum_{p=15}^{69} \rho_p (L_{pt} + x_z z_{dpt})(1 + x_b b_{dpt})$$

With other parameters the same as in the equation of the mortality impacts above, b_{dpt} is the productivity loss due to disease d as percentage of lives lost in the population at time t for the age group p. As a result of averted mortality and morbidity through the health intervention, the number of deaths, z_{dpt}, and productivity loss of diseases, b_{dpt}, will be reduced, and subsequently the size of labour force, L_{it}, will increase.

Impacts of Cost of Treatment on Physical Capital Accumulation

Health intervention as a whole incurs the cost of intervention. Particularly, the burden of disease reduces the accumulated stock of physical capital because saving is diverted to medical expenditures. It is assumed that some portion of the total cost of treatment is funded from domestic saving, while the remainder is taken from consumption expenditures. The evolution of physical capital is given by:

$$K_{it} = s_i Y_{it-1} - r C_{it-1} + (1 - \delta_i) K_{it-1}$$

The domestic saving, $s_i Y_{it-1}$ is replaced by saving minus medical expenditures, $s_i Y_{it-1} - x C_{it-1}$, where C_{it} is cost of medical treatment for a country i at time t, and r is the proportion of the cost funded from savings. The fraction of output devoted to investment, s, is exogenous and constant for each country for the projection period.

Results

Exploratory analysis in a limited number of countries suggests that the greatest economic benefits of UHC (~4% increase in GDP) are realized in countries, mainly LMICs, with a high incidence of NCDs in working age populations. Other countries, mainly UMICs, including mega-countries with different age-specific patterns of incidence of NCDs, show smaller but still positive benefits (~0.25% GDP). Intermediate are countries, mainly LICs, that require large expenditures on child health that do not translate into significant labour-force gains on a 5-year time scale. In such countries the benefit of UHC is ~2% GDP. This is a very high return of investment in comparison to what was typically found in OECD countries. [3] Indirect inference based on the finding of a positive "Baumol effect" (i.e. wage inflation in the health sector) in OECD countries (Hartwig 2008, Hartwig 2011).

Extrapolating these results to the sample of 67 countries, the economic benefits of UHC show the following pattern:

- LICs, $53 billion in economic benefits (28 countries)

- LMICs, $1,196 billion in economic benefits (20 countries)

- UMICs, $366 billion in economic benefits (19 countries).

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