



THE LONG-TERM IMPACTS AND COSTS OF EBOLA on the SIERRA LEONEAN HEALTH SECTOR

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EXECUTIVE SUMMARY

SIERRA LEONE WAS HEAVILY AFFECTED DURING THE 2014/15 OUTBREAK OF THE EBOLA VIRUS DISEASE (EVD). WITH RELATED COSTS A TOTAL OF 8,706 CASES AND 3,590 DEATHS RECORDED AS OF MARCH 2016, EVD HAD SUBSTANTIAL SHORT-TERM EFFECTS AND LONGER-TERM IMPACTS AT THE MICRO- AND MACRO-LEVEL.

To date, academic work dedicated to estimating the health-related costs of the EVD outbreak is limited. While the existing reports and academic studies provide valuable estimates of the overall macro-economic costs and sector-specific health costs relating to the EVD outbreak, they have focused on monetizing the short-term and medium-term cost of EVD, overlooking the long-term aspects that encompass future income and disability impairments. This study builds on the existing studies by developing a costing model with a longer-term perspective on the EVD outbreak and related cost incurred in the health sector. Furthermore, a broader scope with respect to indirect costs linked to the EVD is chosen, focusing on the consequences of (non-) treatment of other diseases as well. Besides drawing upon the results of previous research, this study accounts for and monetizes not only the impact of EVD itself, but also the impact of EVD on malaria, measles and HIV (These diseases were selected based on available data; in the case of measles, to serve as a proxy for other vaccine preventable diseases and malaria due to its high prevalence.), along with an overall decline in the quality and uptake of health services. In doing so, the study examines direct and indirect costs associated with the disease, estimating the costs that have already been incurred and projecting costs that are still to be incurred in the coming years.

METHODOLOGY

In order to estimate the incurred cost and future cost of EVD, a sector-specific macro-economic costing model was developed. The costing model estimates the cost of increased morbidity and mortality in the country due to EVD and the resulting non-treatment of other diseases. It covers the period of the next 15 years up to 2030. The impact is modelled based on various health indicators such as incidence and mortality of selected diseases, and an additional factor that models the general quality and uptake of health services in the country. With the help of the costing model, the impacts of EVD on the health sector are calculated. Several recovery scenarios are computed. The time-based recovery trajectory model assumes that the indicators require 5, 10, or 15 years to reduce back to the low and high baseline scenario, respectively. The two baseline scenarios model the future performance of health sector indicators, assuming



that no EVD occurred. The low baseline scenario assumes a pessimistic outlook, while the high baseline assumes optimistic outlook towards improved access, quality and uptake of health care, resulting in lower disease incidences and mortality rates. The study outlines the absolute cost, in million Sierra Leone Leones (SLL), of each recovery trajectory per baseline, per year, until 2030, as well as share of the forecast GDP. Moreover, the study presents the cumulative cost of all recovery trajectories in million SLL and as percentage of GDP, discounted to today's (2016) terms.

RESULTS

The study estimates the future costs of EVD on the Sierra Leonean health sector to range between 9.0 and 19.4 per cent of today's GDP. While the highest costs are incurred for a 15-year recovery trajectory, amounting to 15.5 and 19.4 per cent of today's GDP, respective of which baseline is chosen; the cost for a 10-year recovery are significantly lower, at 9.0 and 11.3 per cent of today's GDP respectively. An even shorter recovery trajectory of five years lowers the sectoral costs to 4.1 and 5.1 per cent of GDP. These findings emphasise the need to address the impact of EVD on the health sector in a timely manner, thereby lowering the future cost to be incurred.

Further supporting the call to immediate action, the costing model reveals that assuming a longer recovery period of 10- to 15-years, the majority of the cost of EVD on the health sector are yet to be incurred in the years to come. Hence, the effects and impacts of EVD on the health sector, through non-treatment of other diseases and an overall decrease in health service uptake and quality, are forecast to result in substantial costs in the future.

The costing model suggests that in future years, the costs directly incurred by EVD range from 8.3 to 10.2 per cent of the overall health sector cost. In contrast, the cost of HIV/AIDS and malaria are forecast to account for a maximum of 60 and 28 per cent of the overall cost respectively. Therefore, the impact of EVD on the overall health care system, rather than the cost of EVD itself, drives future costs to the health sector. .

CONCLUSIONS AND POLICY CONSIDERATIONS

Based on the results of the macro-level costing model discussed above, including the breakdown of costs according to health indicators included in the model and the potential of cost reductions for shorter recovery periods, different implications for future policy making and design of interventions arise. The analysis of different recovery scenarios and timeframes expounds that a timely response to the indirect impact of EVD on the health sector can significantly lower the future costs to be incurred. A comparison of the cumulative cost incurred over a 15-year recovery period and a 5-year period reveals that the cost of the latter are 5 to 6 percentage points lower, expressed in today's GDP. These findings support the need to respond to EVD-related impacts in a timely manner to avoid substantial costs in the future.

In conclusion, it is recommended that efforts and scarce resources be focused on efforts and scarce resources on an integrated response tackling the longer-term demand- and supply-side challenges experienced by the Sierra Leonean health sector that while exposed and aggravated through EVD, were already in existence before the outbreak. Thus, an EVD-response for the sector should focus on creating a more inclusive health care system, with increased service quality, access and uptake across the population. Finally, it should be taken into consideration that the timeliness of the response to these longer-term challenges in the sector is relevant, as a prompt response can significantly reduce the future cost of EVD.

INTRODUCTION

THE EBOLA VIRUS DISEASE (EVD) IS AN INFECTIOUS DISEASE WHICH HAS SEEN THE WIDEST AND DEADLIEST OUTBREAK SINCE ITS DISCOVERY IN 1976 DURING THE PERIOD, 2014 TO 2015. WHILE MOST COUNTRIES MANAGED TO CONTROL THE OUTBREAK IN TERMS OF INFECTIONS AND DEATHS, WEST AFRICAN COUNTRIES HAVE BEEN HEAVILY AFFECTED BY THE EPIDEMIC. IN GUINEA, LIBERIA, AND SIERRA LEONE, THE OUTBREAK WAS MASSIVE AND LONG LASTING, CLAIMING THE LIVES OF CHILDREN AND ADULTS. IN THESE THREE COUNTRIES, THE EPIDEMIC LED TO A MAJOR HEALTH CRISIS WHICH INEVITABLY DISRUPTED SOCIAL AND ECONOMIC LIFE FOR THE LONG-TERM.

Sierra Leone has been one of the countries most affected during the EVD crisis, with the disease exerting detrimental impact on the health care system and the population of the country. In addition to the confirmed 8706 cases and 3,590 deaths,¹ a significant portion of those surviving the disease suffered from post-EVD syndromes like musculoskeletal pain, headaches, and ocular and auditory problems. Moreover, EVD put tremendous pressure on an already fragile health care sector, which prior to the outbreak experienced critical shortages in both staff and crucial resources, such as basic equipment for service delivery and laboratory work. Importantly, as Sierra Leonean authorities rushed to contain the epidemic and treat the sick, critical resources were shifted away from monitoring, prevention and treatment of other health conditions. Against this backdrop, the EVD epidemic has resulted in significant health consequences on a nationwide scale and with it, mounting costs that threaten the country's economic outlook for years to come.

The aim of the study is to conduct a sectoral costing analysis of the EVD epidemic and its impact on Sierra Leone's health sector. In addition, the study aims to explore what interventions are needed to reduce the future cost of EVD and put the sector back on the developmental path of better access to health facilities, better quality of health care, and higher uptake of such care. The objective of this study is to identify and monetize the health-related effects of the EVD outbreak. In doing so, the study examines both direct and indirect costs associated with the disease such as the loss of income due to increased morbidity and mortality. Furthermore, the study simulates EVD's impact over the years to come,

¹ WHO Ebola Situation Report, as of 27 March, 2016



The aim of the study is to conduct a sectoral costing analysis of the EVD epidemic and its impact on Sierra Leone's health sector.

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and develops an estimate of cost to be incurred in the future in the health sector from the longer-term impact of EVD.

A brief background on existing information of EVD's impact on the health sector is provided, followed by a conceptual study framework to assess the impact and cost of EVD on the health sector. Subsequently, the qualitative and quantitative methodological concepts applied in the study are explained, including the approaches of *Disability-Averted Life Years (DALY)* and *the Value of a Statistical Life (VSLY)*. Thereafter, existing cost assessments of EVD in Sierra Leone are reviewed. Using the macro-level costing model developed for this study, the estimated cost EVD already incurred and projected to be incurred in the health sector are presented, as yearly costs and as a sum discounted back to today's terms, both in absolute numbers and as a percentage of the country's GDP. Finally, policy recommendations calling for imminent action to address the future cost of EVD in a timely manner are explored and a high-level fiscal and political space analysis is provided, examining factors of a fiscal and political nature that might facilitate and/or constitute a challenge to the realization of the proposed recommendations.

BACKGROUND

SEVERAL REPORTS AND ACADEMIC ARTICLES COVERING THE IMPACT OF EVD HAVE BEEN PUBLISHED BY THE WORLD BANK, THE WORLD HEALTH ORGANIZATION AND THE GOVERNMENT OF SIERRA LEONE SINCE THE OUTBREAK OF THE VIRUS.

The work conducted by these organizations and other entities, largely displays a gloomy outlook on the detrimental health-related effect of EVD in Sierra Leone. Besides the devastating impact of thousands of casualties and numerous survivors suffering from post-EVD syndromes, the epidemic brought havoc to an already fragile health care sector.² Firstly, the number of skilled personnel per 10,000 people declined from 17.2 prior to the outbreak to 3.4 during it, far below the recommended minimum of 25 per 10,000 people.³ By November 2015, the total EVD health personnel workforce of around 1,100 professionals had suffered from 302 infections and 221 deaths.^{4,5} In addition, the country recorded a 23 per cent drop in institutional delivery; a 39 per cent reduction in children receiving malaria treatment; and a 21 per cent drop in the amount of children obtaining basic immunization according to a study conducted in 2014.⁶ To make matters worse, the administrative burden caused by the epidemic led to a collapse in the country's monitoring and surveillance system, resulting in severe under-reporting of diseases other than EVD. However in 2015 CDC supported the Government of Sierra Leone (GoSL) to develop an Integrated Disease Surveillance and Response System, which has increased disease reporting from 35 to 96 per cent of health facilities reporting weekly data between 2015 and 2016. Given the disruption to immunization and monitoring efforts, along with the shortfall in institutional delivery, several studies and reports project a significant proliferation of diseases such as measles, HIV, and malaria, and detrimental reductions in the uptake of treatment of patients living with HIV.^{7,8,9}

² WHO, 2016, 2 March, Ebola Situation Report.

³ GoSL, 2015, National Ebola Recovery – Strategy for Sierra Leone, p. 6.

⁴ ACAPS, 2015, Ebola Needs Analysis Project: Sierra Leone Multi-Sector Needs Assessment, p. 18.

⁵ WHO, 2016, 4 November, Ebola Situation Report, p. 6.

⁶ GoSL, 2015, National Ebola Recovery – Strategy for Sierra Leone, p. 25.

⁷ Takahashi et al., 2015, Reduced vaccination and the risk of measles and other childhood infections post-Ebola, *Science*, 347 (6227), pp. 1240-1242.

⁸ Walker et al., 2015, Malaria morbidity and mortality in Ebola-affected countries caused by decreased health-care capacity, and the potential effect of mitigation strategies: a modelling analysis, *The Lancet. Infectious diseases*, 15 (7), pp. 825-832.

⁹ GoSL et al., 2014, The Economic and Social Impact of Ebola Virus Disease in Sierra Leone, p. 63.

Without question, the EVD outbreak has had a substantial impact on the institutions and population of Sierra Leone.

Moreover, there was a significant reduction in the number of households reporting a member giving birth at a clinic or hospital. During EVD only 28 per cent of women delivered at health facilities, compared to 71¹⁰ per cent in 2013. This rate bounced back to 64 per cent in January/February 2015, and reached 89 per cent in May 2015.¹¹ In turn, between May and September 2014, antenatal care visits dropped by 27 per cent nationwide.¹² Furthermore, health care uptake for serious health-related problems decreased from 80 per cent to 50 per cent, family planning visits by 90 per cent, and the number of people at risk resulting from serious unmet health needs was estimated at over 3.5 million.^{13,14} Overall, there was a 42 per cent reported drop in patients seeking non-EVD related care and, illuminatingly, a survey conducted in March 2015 showed that a full 72 per cent of respondents expressed fear of visiting health facilities.^{15,16} Without question, the EVD outbreak has had a substantial impact on the institutions and population of Sierra Leone. The conceptual study framework in the following section has been developed based on the background information outlined above.

¹⁰ Sierra Leone Demographic Health Survey 2013

¹¹ World Bank, GoSL, IPA, 2015, The Socio-Economic Impacts of Ebola in Sierra Leone – Results from a High Frequency Cell Phone Survey, Round 1; 2; 3; p. 19.

¹² CSIS/Strifel, 2015, How Did Ebola Impact Maternal and Child Health in Liberia and Sierra Leone? p. 12.

¹³ SPRING, 2015, Integration Nutrition and Agriculture Needs Assessment for Sierra Leone; After Fofanah 2015.

¹⁴ ACAPS, 2015, Ebola Needs Analysis Project: Sierra Leone Multi-Sector Needs Assessment, p. 21.

¹⁵ Ibid.

¹⁶ Ground Truth, 2015, Citizen's Views of the Ebola Response, p.2. Accessed on April 18, 2016 via: <http://nebula.wsimg.com/f61bc2e5601903bbb549a4e975f06bd8?AccessKeyId=4A3CCCF8E12ADC071A32&disposition=0&alloworigin=1>

2015
EVD Health personnel
workforce of around

1,100
professionals
suffered

302
infections

+

221
deaths

23%



institutional delivery

39%



children receiving malaria
treatment

21%



amount of children receiving
basic immunization

CONCEPTUAL FRAMEWORK

IN ORDER TO ASSESS THE COST OF EVD IN A STRUCTURED MANNER AND TO ACCOUNT FOR THE INTERLINKAGES AND INTERDEPENDENCIES OF COSTS, THE CONCEPTUAL FRAMEWORK FOR COSTING NEEDS TO BE CLEARLY DEFINED. GIVEN THAT THE COSTING EXERCISE GOES BEYOND THE IMMEDIATE OBSERVABLE COST, SUCH AS INCREASED COST IN THE HEALTH SECTOR TO TACKLE THE DISEASE, AND INCLUDES INDIRECT COSTS AND FUTURE COSTS RESULTING FROM THE EFFECTS OF EVD.

A schematic breakdown of costs into effects, outputs, outcomes and impacts indicators is developed, mapping out the scope of different types of costs incurred in the past and future. Table 1 below presents a holistic, non-exhaustive overview of the effects, outputs, outcomes and impacts of EVD on the health sector. While the effects are the immediate change resulting from the outbreak of EVD, outputs are considered the product of these effects. In turn, outcomes constitute a measurable change and objective indicator of these outputs. Finally, impacts refer to a broader effect, which can be conceptualized as the longer-term effect of an outcome.

EVD had, and continues to have, significant effects on the health sector in Sierra Leone, including deaths, suffering and trauma. In addition, EVD had an impact on the supply-side infrastructure of the health sector, decreasing the doctor-to-patient ratio and reducing the supply of hospital rooms and beds for treatment of other diseases. On the demand-side, effects such as fear of contamination and stigmatization of EVD-infected and potential vectors of the disease, including health workers, decreased the access to health services. Furthermore, the EVD outbreak had a negative effect on the prevention, detection/diagnosis and treatment of malaria, HIV and measles, among others.

On the demand-side, effects such as fear of contamination, and stigmatization of EVD-infected and potential vectors of the disease, including health workers, decreased the access to health services.

Table 1. *Conceptual framework for the health sector*

Effect	• Deaths of Sierra Leoneans due to EVD • Suffering of Sierra Leoneans affected by EVD • Trauma and other mental problems experienced • Doctor-to-patient ratio decreases, with health care staff being very vulnerable to infection^{17,18} • Many hospital rooms were used for quarantine – reducing the availability of rooms for other health problems • Hospitals no longer seen as treatment centres but rather sources of EVD infection¹⁹ • Fear of seeking health advice due to risk of contamination²⁰ • Reluctance to seek health services due to fears of contracting EVD and decreased trust in the medical staff • Stigmatization of people who contracted EVD, and potential vectors of the disease including health workers²¹ • Diagnosis and treatment of other diseases, such as malaria, HIV, and measles, decreased^{22,23} • Increase in foreign aid, with more material and supplies available • Heightened awareness-raising on importance of WASH to contain EVD and other diseases
Output	• Decrease in quality of health care • Reduced accessibility of health care • Decreased health care uptake
Outcome	• Increase in mortality rates • Increase in disability rates • Increase in morbidity
Impact	• Increase in Disability-Adjusted Life Years (DALYs) • Cost of DALYs expressed through the Value of a Statistical Life Year (VSLY)

Sources: Author's listed based on indicated sources.

¹⁷ GoSL, 2015, National Ebola Recovery – Strategy for Sierra Leone, p. 25.

¹⁸ CSIS/Strifel, 2015, How Did Ebola Impact Maternal and Child Health in Liberia and Sierra Leone? p. 16

¹⁹ UNDG, 2015, Socio-Economic Impact of Ebola Virus Disease in West African Countries, p. 54.

²⁰ Ground Truth, 2015, Citizen's Views of the Ebola Response, p. 2. Accessed on April 18, 2016 via: <http://nebula.wsimg.com/f61bc2e5601903bbb549a4e975f06bd8?AccessKeyId=4A3CCCF8E12ADC071A32&disposition=0&alloworigin=1>

²¹ Niang, C., 2015, The human factor. Bulletin of World Health Organization, 93 (2), pp. 72-73. Accessed on August 2, 2016 via: <http://www.who.int/bulletin/volumes/93/2/en/>

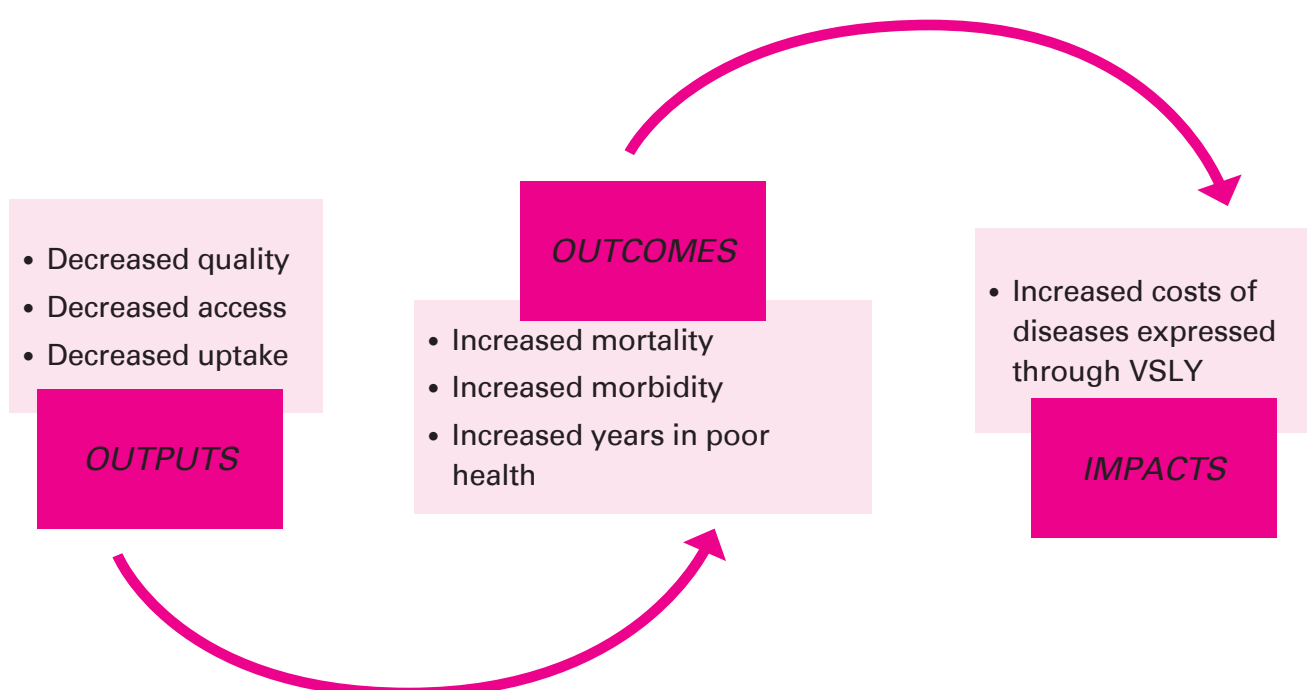
²² SPRING, 2015, Integration Nutrition and Agriculture Needs Assessment for Sierra Leone; After Fofanah 2015.

²³ ACAPS, 2015, Ebola Needs Analysis Project: Sierra Leone Multi-Sector Needs Assessment, p. 21.

These translate into the measurable outcomes of increased mortality rates, increased disability rates, and an increase in morbidity.

The multiple effects of EVD in Table 1 lead to decreased quality of health care, decreased accessibility and decreased uptake of health care, which in turn translates into the measurable outcomes of increased mortality, disability and morbidity. These outcomes are used to simulate the effects and outputs of EVD in the macro-level costing model. Based on the model, these measurable indicators are in the final step translated into impacts, determining the cost of EVD in the health sector, calculating the cost of increased years in poor health, disability rates, and premature deaths, expressed through a DALY and monetized through the VSLY. Below, *Figure 2* illustrates a simplified overview of the conceptual costing framework to arrive at the cost of EVD in the health sector, which is employed as a basis to develop the macro-level costing model, as described in detail in the following methodology section.

Figure 2. Overview of conceptual costing framework



METHODOLOGY

A MACRO-LEVEL COSTING MODEL, EMPLOYING METHODOLOGICAL CONCEPTS SUCH AS THE DALY APPROACH, SERVES AS A QUANTITATIVE APPROACH TO CALCULATE THE INDIRECT COST OF EVD, THAT HAVE BEEN INCURRED IN THE PAST, AND ARE TO BE INCURRED IN THE FUTURE. IN DOING SO, THE FOCUS LIES ON LONGER-TERM IMPACTS. THE QUANTITATIVE APPROACH IS COMPLEMENTED WITH A REVIEW OF SECONDARY DATA AND RELEVANT LITERATURE, AND STAKEHOLDER CONSULTATIONS, IN ORDER TO GATHER AND VALIDATE INFORMATION TO SUPPORT THE DEVELOPMENT OF THE COSTING MODEL. IN THE FOLLOWING SECTIONS, THE STRUCTURE OF THIS MODEL AND THE METHODOLOGICAL CONCEPTS EMPLOYED IN ESTIMATING THE COST OF EVD ARE FURTHER ELUCIDATED.

Macro-Level Costing Model

The macro-level costing model for the health sector covers the period of the next 15 years, estimating the cost of EVD until 2030. The time framework is divided into pre-EVD years, covering the years prior to the outbreak of 2008 to 2013, and post-EVD years, spanning all the years following 2016. The years 2014 to 2016 are thus considered the period in which EVD exerted a direct, and most destructive impact on the health sector in Sierra Leone. The impact is demonstrated based on various health indicators as observed in the model. These indicators include incidence and mortality of various diseases, and an additional factor that models the general quality of health services and the uptake in the country. As diseases, other than EVD, such as HIV, malaria and measles are included in the model, the selection of these disease to be part of the microsimulation were based on 1) incidence of the disease prior to Ebola for malaria; 2) measles as proxy for vaccine-preventable diseases; 3) HIV/AIDS based on evidence from observation reports during Ebola indicating that many of the people living positively with HIV absconded from treatment. Availability of data also played a critical role in determining the selection of these three diseases. The two factors of quality of health services and uptake that influences any epidemic was also considered in the simulation. It assumes that EVD not only had a negative impact on the health sector, but that the consecutive non-treatment of other diseases further aggravated this impact. Moreover, the model includes a factor reflecting overall changes in health service quality and uptake, which were negatively affected by EVD, and assumed to negatively impact the overall health and well-being of Sierra Leoneans. It is not feasible to model health service quality and uptake using the DALYs approach. The outlined indicators are included in the model based on evidence of non-treatment provided by UNDP (2015), Walker et al. (2015), Takashashi et al. (2015), and ACAPS (2015).

For the health sector, this implies that the incidence and mortality of diseases does not change significantly within the projected period, compared to their pre-EVD levels

The model is composed of two baseline scenarios, which model the future performance of health sector indicators, assuming that no EVD occurred. While one of these baseline scenarios provides a more pessimistic outlook, the other one assumes that the health sector indicators develop along a more positive path towards improved access, quality, and uptake of health care, resulting in lower disease incidences and mortality rates. In the next step, the impact of EVD on these baseline scenarios is simulated. Therefore, the performance of the health indicators is projected based on the impact EVD has shown to have on other diseases.

In the last step, the cost of EVD on the health sector is estimated by comparing the cost of diseases incurred in the baseline scenarios (constructed assuming that EVD never occurred) and the cost incurred in the EVD-adjusted baseline scenarios (this scenario also incorporates the shock the virus exerted on the health sector). The following sections further explore the construction of the baseline scenarios, the simulation of the EVD shock, and the computation of the cost arising from the latter.

CONSTRUCTION OF BASELINE

As a first step in developing the costing model, a baseline is constructed. This baseline is developed extrapolating past trends based on various sets of historical data. This data comprises economic data, population data, social data, and key indicators for the health sector. The latter includes data on the incidence and mortality of selected diseases that are assumed to have been impacted by the outbreak of EVD, and data on the health service quality and uptake. These indicators were chosen to reflect the key outcomes within the health sector resulting from the EVD outbreak. These are increased mortality rates, increased disability rates, and increased morbidity. As EVD not only impacted these indicators, but the non-treatment of other diseases as well, they are collected for EVD, HIV, malaria, and measles.

In a next step, the historical data is used as a basis for future projections of the indicators included in the model. After consultations with various stakeholders the future projections, produced for a period of 15 years, is presented in two different scenarios: a high scenario assuming full recovery back to the pre-EVD period, and a low scenario assuming a recovery with a slight change in health indicators. In the low scenario, a more conservative outlook over the next 15 years is provided, and only a slight change in indicator levels towards more positive developments will be incurred in the years to come. For the health sector, this implies that the incidence and mortality of diseases does not change significantly within the projected period, compared to their pre-EVD levels. In a more optimistic (high) scenario, it is assumed that the health indicators show more visible improvements over the next 15 years, assuming that the country would continue on a path to development of better access to health facilities, better quality of health care, and higher uptake of such care, as was the trend before the EVD outbreak.

The assumptions for the development of this more ambitious baseline are line with the Sustainable Development Goals (SDGs), which, among others, aim to end epidemics of AIDS, malaria and other communicable diseases by 2030,²⁴ and are grounded in the Agenda for Prosperity (A4P), developed by the Government of Sierra Leone. Among others, the A4P outlines activities to prevent and control the spread of communicable diseases, which include the scale-up and sustained treatment, and initiation of preventive and control measures for HIV/AIDS, malaria, and other communicable diseases.²⁵ The A4P also spells out the Government's ambitions to improve the access and quality of basic health care services for everyone, considered a key priority to move the country towards middle income status by 2035.

Box 1 below provides an overview of the assumptions employed in the modelling of baseline projections of the various health sector indicators included in the costing model.

1

MODELLING OF HEALTH SECTOR INDICATORS FOR THE BASELINE

Disease projections are based on historical data of morbidity and mortality cases for each of the diseases included. The data is retrieved from the WHO global disease burden databases. The next step is for this historical data to be utilized to produce future projections, until 2030, with the help of figures on disease and mortality rates as a share of the total population. For the low baseline scenario, it is assumed that a conservative change in the morbidity and mortality rates of diseases will occur over the coming 15 years, and the rate of change determined according to previously recorded changes. Contrary to this, high-scenario projections are grounded in the assumption that the disease indicators' future development will be guided along a more positive, accelerated path, with higher rates of changes, towards lower morbidity and mortality rates. These lower rates of morbidity and mortality are chosen based on the conservative scenario and how much change in the indicators is feasible, taking into account their historical performance.

Projections on the quality and overall uptake of health care services are computed employing available information on health service uptake in the country and a decrease in the doctor-to-patient ratio. According to the ACAPS EVD needs analysis (2015), about 80 per cent of the population accessed health services in cases of diseases in the years prior to the EVD outbreak, dropping to 42 per cent during the outbreak. For the purpose of the baseline projections, which provide future projections based on the assumption that EVD does not occur and disrupt the development of indicators in the health sector, it is assumed that the health care service uptake gradually increases over the next 20 years, to 85 per cent of the population for the low scenario, and 90 per cent for the high scenario.

SIMULATING THE IMPACT OF EVD

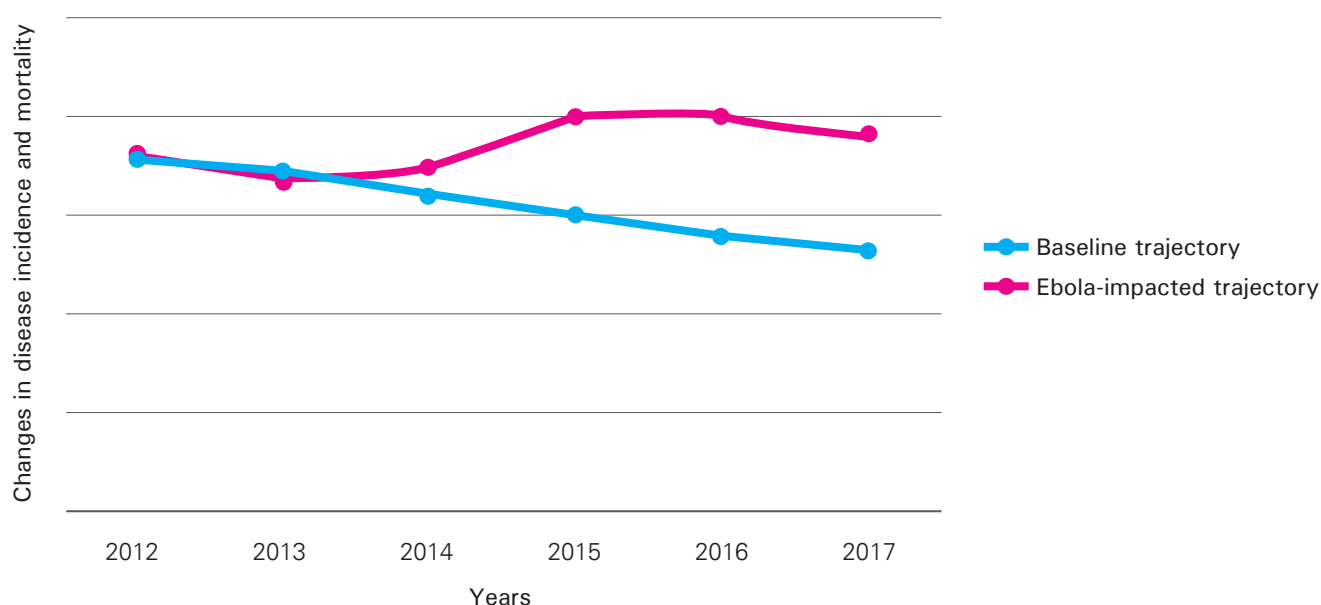
Once the baseline scenarios are constructed, the impact of EVD on these scenarios is simulated. In doing so, it is assumed that the virus exerted a shock on the health sector between 2014 and 2016, negatively impacting the prevention and treatment of other diseases in that period. The impact of EVD itself is included in the model as well, according to the disease incidence and mortality for the years 2014 to 2016. Moreover, a general worsening of the health sector conditions, expressed as a factor on an overall decrease of

²⁴ United Nations, 2015, SDGs – Goal 3: Ensure health lives and promote well-being for all at all ages. Accessed on August 2, 2016 via: <http://www.un.org/sustainabledevelopment/health/>

²⁵ GoSL, 2013, The Agenda for Prosperity – Road to Middle Income Status. Accessed on August 1, 2016 via: <http://www.sierra-leone.org/Agenda%20Prosperity.pdf>

health service quality and uptake, is included in the model. The baseline trajectory of disease incidences and mortality, versus the EVD-impacted trajectory of diseases, including the incidence and mortality of the virus itself, are exemplified in *Figure 3*, and the simulation of the impact is further elucidated in *Box 2*.

Figure 3. *Simulating the impact of EVD*



2

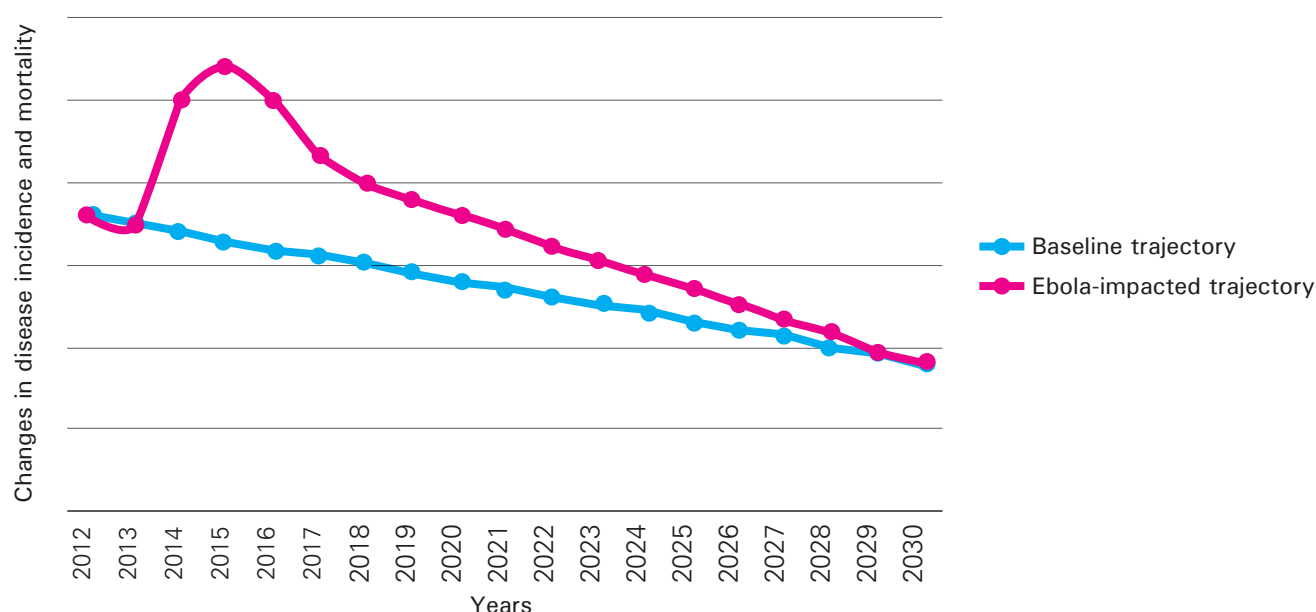
SIMULATING THE IMPACT OF EVD ON THE HEALTH SECTOR

Disease indicators for the EVD-affected years 2014 to 2016, are mainly based on estimates derived from past trends and evidence established on the course of disease cases and mortality during emergencies. Since data collection on other diseases came to a halt with the onset of EVD in 2014, the latest available data for most diseases stems from 2013/14. With figures for disease and mortality cases available for malaria and measles for 2014, projections for 2015 and 2016 are based on their respective trends, showing an increase in morbidity and mortality for both diseases. Furthermore, research from Wolfson et al. (2009) is used to generate estimates on measles mortality rates, indicating that mortality tends to increase to 5 per cent of all disease cases in emergency and disaster situations. In contrast, no data is available for HIV morbidity and mortality from 2014 onwards, which is why the impact of EVD is modelled with the help of established evidence, such as the reduction in malaria treatment by 88 per cent during the EVD-outbreak (Walker et al.). Based on this information, the disease incidence and mortality data is modelled to increase over the course of the outbreak. For EVD itself, situation reports from various agencies are used to retrieve disease and mortality numbers for the years 2014 and 2015, and latest available data for 2016.

Quality and uptake of health care services are modelled based on a reduction in service uptake by 42 per cent during the outbreak, and a simultaneous decrease in the doctor-to-patient ratio and heightened fear of consulting health personnel, as recorded by ACAPS (2015).

This follows a simulation of the future performance of these indicators in the post-EVD period. Although it is assumed that the direct shock exerted by EVD is limited to the period 2014 to 2016, the increased disease incidences and mortality are carried through into the following years and only gradually reduce back to pre-EVD levels thereafter. The model simulates a time-based recovery of the different health indicators, assuming that indicators have recovered to the high/low baseline trajectory levels over three different timeframes: 5, 10, and 15 years. This approach is taken in order to present a bandwidth of recovery trajectories, and consequently a bandwidth of costs. Figure 4 presents a simplified illustration of the modelling and the recovery trajectories. While the blue line represents the baseline trajectory, assuming no EVD had occurred, the orange line signifies the EVD-impacted trajectory with EVD's impact peaking during 2014 to 2016, and the recovery trajectory commencing in the following years. By the end of the period, here a 15-year timeframe is chosen, both the baseline and the EVD-impacted trajectories, align again.

Figure 4. *Simplified recovery model, 15-year recovery period*



It is assumed that the pace of change in indicators is higher for the high baseline, which has a lower end for indicators in 2030, compared to the low baseline, where a slower pace of change in the indicators' recovery is sufficient to reduce to the baseline within the chosen timeframe. Furthermore, the costs of EVD are expected to be higher for the high baseline scenario than for the low baseline scenario. Consequently, it is expected that the costs of EVD differ according to the timeframe chosen, where a shorter timeframe for recovery can significantly lower the cost. Box 3 further explores how health indicators are modelled for the recovery trajectory.

MODELLING OF HEALTH INDICATORS FOR THE RECOVERY TRAJECTORY

The different **disease recovery trajectories** are modelled back to the original low and high baselines, assuming a time-based recovery, lasting for 5, 10, and 15 years respectively. A maximum of 15 years is chosen as a period deemed sufficient to provide enough time for the health indicators to model back towards the original baseline. Nevertheless, shorter recovery trajectories of five and ten years are provided for the time-based recovery model, to offer a range of estimates on the future cost of EVD, stressing the need to tackle issues in a timely manner in order to reduce the costs. Within the period chosen for recovery, the indicators are modelled back to the baseline scenario in an exponential manner, so that at the end of the recovery period all indicators align with the respective baseline chosen, where all timeframes are modelled on the low and high baseline.

The recovery trajectory of the **health care services quality and uptake**, moving back towards the original trajectory of the low and high baseline respectively, is modelled to last five years, assuming that the factors initially leading to a reduction in uptake, mainly shortage of health personnel, closure of health units, and stigmatization, can be addressed within this period of time. This timeline is also chosen given the existing focus on stabilizing the health system in Sierra Leone with significant support from international organizations and donors. Therefore, after five years of recovery, the health service uptake is expected to follow the path prescribed in the low/high baseline, according to the scenario.

ESTIMATING THE COST OF EVD

The cost arising out of higher mortality and disability rates, and decreased health service quality and uptake, are monetized using the concepts DALY and the VSLY, as described below.

DISABILITY-AVERTED LIFE YEAR

DALY is widely used as a measurement to estimate the burden of disease, by estimating the cost of the overall disease burden resulting from poor health, disability, or premature death. Essentially, the measure aggregates the combined loss of health at population level into a single value by encompassing premature death signified as years of lost life (YLL) together with non-fatal health complications expressed as years lived with disability (YLD).^{26,27} The DALY measurement estimated number of years lost due to reasons of poor health, disability, or premature death. It follows:

$$DALY = YLL + YLD$$

where YLL corresponds to the number of mortalities (N) multiplied by the standard life expectancy at the age at which the death resulting from the disease takes place (LE), the result is:

$$YLL = N * L$$

²⁶ Haagsma et al., 2015, The Global Burden of Injury: Incidence, Mortality, Disability-Adjusted-Life Years and Time Trends from the Global Burden of Disease study 2013, The Lancet, p. 1 f.

²⁷ Solamon et al., 2015, Disability Weights for the Global Burden of Disease 2013, p. 712.

In turn, YLD is estimated on a population basis by multiplying the incidence of disability cases (I) with the average duration time of the disease (disability) (L) and a disability weight factor which mirrors the severity of a specific disease along a scale from zero (perfect health) to one (death).²⁸ Correspondingly, the basic formula equals the following:

$$YLD = I * DW * L$$

In addition, factors such as time and age can be estimated differently and have varying discounting rates which further complicate any applied formula.²⁹

This study adopts a model from the WHO³⁰ for its calculation of YLLs, YLDs, and DALYs, which is based on the formulas outlined above. Accordingly, each of the diseases of interest to this study – EVD, HIV, malaria, and measles – is assigned values for key variables required for the calculation. Disability weights, are drawn from the WHO definitions.³¹ Since no estimates on such a weight exist for EVD yet, for the purpose of this study, the disability weight value is equalized with the weight of Dengue haemorrhagic fever, given the close similarity of the affliction to an infectious and severe disease with acute episodes. Moreover, figures on the age at death, to estimate the standard life expectancy at the time of death due to disease, proved difficult to access and figures are therefore assigned based on an average of disease mortality risks among different age groups. *Table 2* presents an overview of the average standard life expectancy at time of death due to the disease, average duration of disease, and the disability weight per disease – all of which are key variables in the calculation of YLLs, YLDs, and finally DALYs.

Table 2. Overview of input variables per disease

DISEASE	STANDARD LIFE EXPECTANCY AT DEATH (LE)	AVERAGE DURATION TIME OF DISEASE (L)	DISABILITY WEIGHT (DW)
<i>EVD</i>	36.7	2 weeks	0.545
<i>HIV/AIDS</i>	29.9	10 years	0.300
<i>Malaria</i>	40.0	2 weeks	0.184
<i>Measles</i>	50.9	2 weeks	0.152

Source: Author's illustration based on WHO (n.d.), Gunda et al. (2016), Scot et al. (2016).

²⁸ Ibid.

²⁹ Prüss-Üstün A, et al., 2003, Introduction and methods: assessing the environmental burden of disease at national and local levels. Geneva, World Health Organization. (WHO Environmental Burden of Disease Series, No. 1), p. 27 ff.

³⁰ WHO, n.d., National Burden of Disease Supplementary Files – DALY calculation template. Accessed on April 2, 2016 via: http://www.who.int/healthinfo/global_burden_disease/tools_national/en/

³¹ WHO, n.d., National Burden of Disease Supplementary Files – Disability weights. Accessed on April 2, 2016 via: http://www.who.int/healthinfo/global_burden_disease/tools_national/en/

VALUE OF A STATISTICAL LIFE

In order to put a monetized value on the burden associated with the aforementioned diseases, this study follows previous work in equating one DALY with the VSLY.^{32,33,34} Given that data on a VSLY estimate for Sierra Leone, or Sub-Saharan Africa is scarce, this study assumes that a country's VSLY ranges between 2 to 4 times the per capita gross national income (GNI), depending on the level of the country's economic development.³⁵ Given that Sierra Leone is categorised as a low-income country, the lower estimate is used in this study, taking twice the GNI per capita as a VSLY.³⁶ Finally, the per capita GNI is presented using the purchasing power parity method, given its superiority in accounting for differences in relative price levels compared to the Atlas method, and is subsequently converted into SLL.³⁷

DATA SOURCES

Finally, the quantitative data used in the costing model are extracted from a wide array of sources, including data retrieved from WHO, World Bank, UNAIDS, and the Institute for Health Metrics and Evaluation which runs and administers the WHO global burden of disease database. To the extent possible, and to ensure a higher degree of validity, confirmed cases of diseases, instead of probable and suspected ones, are utilized in the costing model. As these numbers are consistently lower than the latter two categories, the cost estimates developed in the framework of this study are most likely on the conservative side. Additionally, for the overall economic and demographic projections underlying the model, data is retrieved from the population division of UNDESA, the World Economic Outlook (2015) provided by the IMF, and the World Bank.

LIMITATIONS OF COSTING MODEL

Various challenges are encountered in developing a costing model and projecting the recovery trajectory and expected cost over a long period, based on complexly interdependent and intertwined impacts. Despite the breadth of indicators included in the model, tackling disease mortality, morbidity and overall health care service quality and uptake, the model is limited in the extent to which it can wholly account for forces that impact the recovery trajectory of the Sierra Leonean health sector in the aftermath of the EVD outbreak. As an example, given the uncertainty about the involvement and form of support from donors and international organisations to be provided in the years to come, this factor is not included in the model, although increased support would likely speed

³² Kotagel et al., 2014, Health and Economic Benefits of Improved Injury Prevention and Trauma Care Worldwide, p. 4.

³³ Alkire et al., 2012, Obstructed Labour and Caesarean Delivery: The Cost and Benefit of Surgical Intervention, Appendix.

³⁴ Warf et al., 2011, Costs and Benefits of Neurosurgical Intervention for Infant Hydrocephalus in Sub-Saharan Africa, p. 520.

³⁵ Jamison, D., Jha, P., and Bloom, D., 2008, The Challenge of Diseases, p. 27.

³⁶ World Bank, n.d., Data – Sierra Leone. Accessed on April 12, 2016 via: www.data.worldbank.org/country/sierra-leone

³⁷ Kotagel et al., 2014, Health and Economic Benefits of Improved Injury Prevention and Trauma Care Worldwide, p. 3.

up the recovery trajectory. Additionally, potential productivity gains in the health sector remain unaccounted for in the recovery trajectory. Increased productivity, brought about by improved equipment and enhanced training and education of health personnel for instance, is expected to accelerate the recovery trajectory.

The accuracy at which the forces impacting the recovery trajectory, such as the recovery of health care service uptake, can be determined, is narrow. Even though the future projections of such forces are based on historical data and validated assumptions, such as the time needed for retraining of health professionals and reopening of health units, predicting the actual recovery path is challenging. Consequently, the model should be seen as a simplification of reality, utilizing cogent assumptions to project the trajectory of included indicators, and not accounting for all forces potentially impacting the recovery of the health sector.

Increased productivity, brought about by improved equipment and enhanced training and education of health personnel for instance, is expected to accelerate the recovery trajectory.



EXISTING COST ESTIMATES

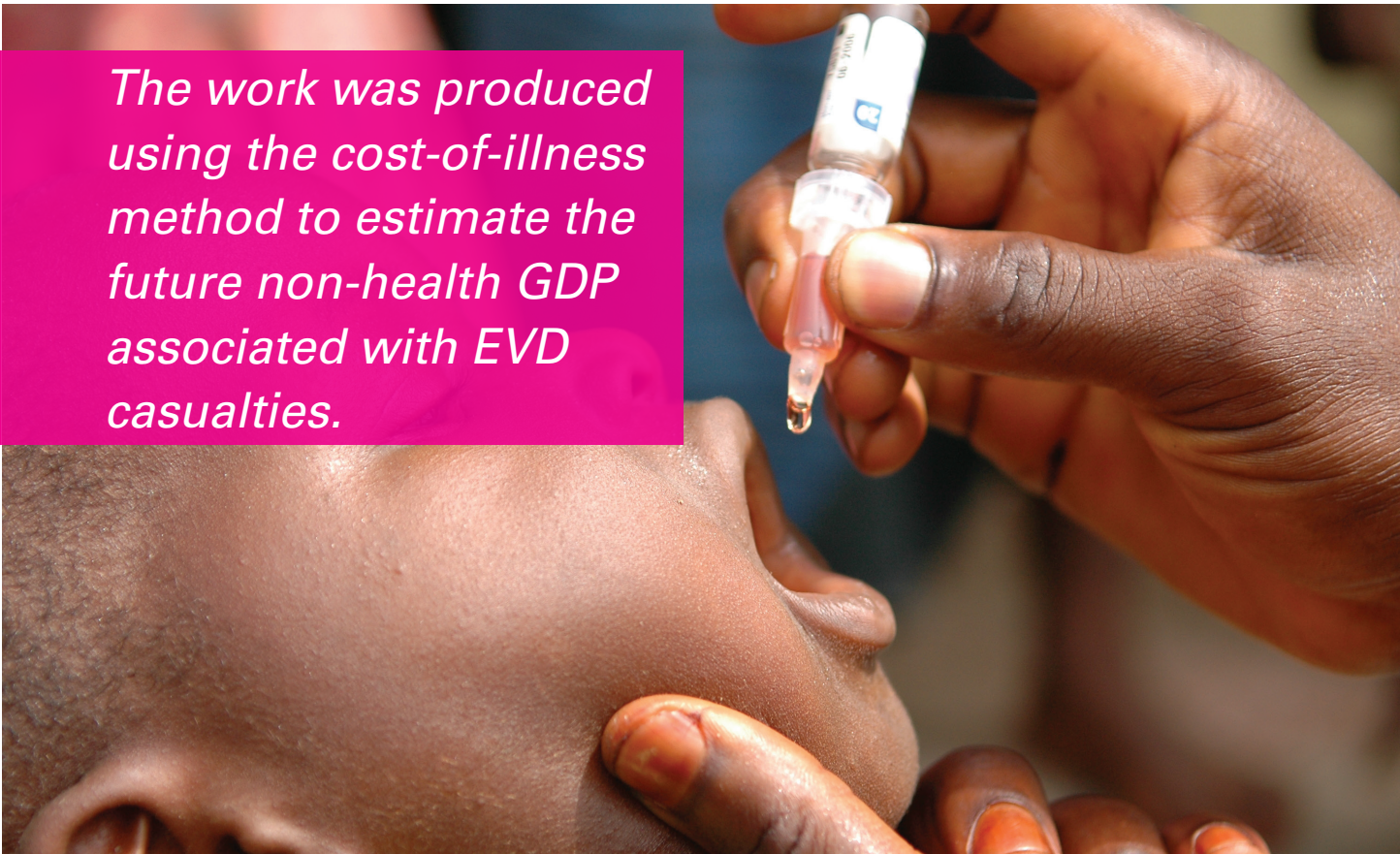
TO DATE, THE AMOUNT OF ACADEMIC WORK DEDICATED TO ESTIMATING THE HEALTH-RELATED COSTS OF THE EVD OUTBREAK IS LIMITED. ONE IDENTIFIED STUDY WAS CONDUCTED BY BARTSCH ET AL. (2015), AND FOCUSSES ON ESTIMATING THE DIRECT AND SOCIETAL COSTS ASSOCIATED WITH AN EVD CASE IN GUINEA, LIBERIA, AND SIERRA LEONE. BY ACCOUNTING FOR COSTS RELATING TO TREATMENT, EQUIPMENT, PERSONNEL, AND FUTURE PRODUCTIVITY LOSSES, THE AUTHORS ESTIMATE THAT THE AVERAGE COST FOR AN EVD CASE RANGES FROM USD 480 TO 18,929, DEPENDING ON SEVERITY AND OUTCOME. WITH RESPECT TO SIERRA LEONE, THIS AMOUNTS TO AN ESTIMATED TOTAL COST OF USD 30.5 TO 33.5 MILLION. BUT WHILE THE STUDY DELIVERS A MUCH-NEEDED EARLY COST ASSESSMENT OF THE EVD OUTBREAK, IT DOES NOT INCLUDE THE ECONOMIC IMPACT AND COST OF OTHER NON-TREATED DISEASES, SUCH AS MALARIA AND MEASLES.

Another study by Kirigia et al. (2015) sought to estimate the indirect costs linked to EVD deaths in West Africa using the cost-of-illness method to estimate the future non-health GDP associated with EVD casualties. The average non-health GDP loss linked to EVD deaths and infections in Sierra Leone was estimated at USD 14,633, and totalled USD 57.8 million economic loss for the country. As with the abovementioned study, this work does not take into consideration indirect costs such as losses in productivity resulting from morbidity prior to premature death and intangible costs linked to grief, pain, and stress associated with EVD. In addition, it does not include the increase in morbidity and mortality from other diseases and health conditions resulting from the massive strain caused by EVD on a country's health care system.³⁸

In a similar vein, macro-economic cost estimates of EVD produced by various development partners, including UN agencies and the World Bank, focus on the short and medium term of EVD's impacts. The United Nations Development Group (UNDG) for instance estimates the macro-economic cost of EVD in Sierra Leone in the medium term (2014 to 2017) to amount to annual losses of 6 to 8 per cent of GDP, for the low and high scenarios respectively. These numbers are arrived at by building a macro-economic model, capturing direct, indirect, and deferred indirect effects at the aggregate level.³⁹ The model assumes that direct costs

³⁸ Kirigia, Masiye & Akweongo, 2015, Indirect Costs Associated With Deaths From the Ebola Virus Disease in West Africa, *Infectious Diseases of Poverty*, 4 (1), p. 45.

³⁹ UNDG, 2015, Socio-Economic Impact of Ebola Virus Disease in West African Countries – A call for national and regional containment, recovery and prevention. Accessed on July 26, 2016 via: <http://www.africa.undp.org/content/dam/rba/docs/Reports/ebola-west-africa.pdf>



The work was produced using the cost-of-illness method to estimate the future non-health GDP associated with EVD casualties.

constitute mainly increased medical expenditure at the household level, indirect costs consist of a reduction in productivity, and deferred indirect costs are the costs the household has to pay in the absence of external aid. Similarly, the World Bank estimated the economic costs of EVD, expressed as lost income in GDP, to amount to a loss of 2 per cent for 2015 in Sierra Leone.⁴⁰ While these studies provide valuable insights into the macro-economic costs of EVD, the current study aims to provide estimates of EVD, specific to the health-sector.

Taken together, the existing reports and academic studies provide estimates of the overall macro-economic costs and sector-specific health costs relating to the EVD outbreak, but have focused on monetizing the short-term and medium-term cost of EVD, overlooking the long-term aspect that encompasses future income and disability impairments. The current study aims to build on the existing studies by developing a costing model with a longer-term perspective of the EVD outbreak and the related costs incurred in the health sector. Furthermore, a broader scope with respect to indirect costs linked to EVD is chosen, focussing on the (non-) treatment of other diseases. Besides drawing upon the results of previous research, this study accounts for, and monetizes the side-effects of EVD on malaria, measles, and HIV, as well as the direct impact of EVD itself, and on an overall decline in the quality and uptake of health services. In the following analysis, costs of EVD, estimated using a costing model which builds on the DALY and VSLY approaches to provide comprehensive and standardized estimations, are presented.

⁴⁰ World Bank, 2015, The Economic Impact of Ebola on Sub-Saharan Africa: Updated Estimates for 2015. Accessed on July 26, 2016 via: http://www.preventionweb.net/files/42039_wbebola.pdf

COSTS OF EVD IN THE HEALTH SECTOR

WITH THE HELP OF THIS COSTING MODEL, THE IMPACT OF EVD ON THE HEALTH SECTOR, AND THE ASSOCIATED COSTS, ARE CALCULATED. BASED ON TWO BASELINES, LOW AND HIGH, AND THE DIFFERENT TIMEFRAMES MODELLED, SEVERAL RECOVERY SCENARIOS ARE COMPUTED, RESULTING IN DIFFERING COSTS, AS ELUCIDATED BELOW.

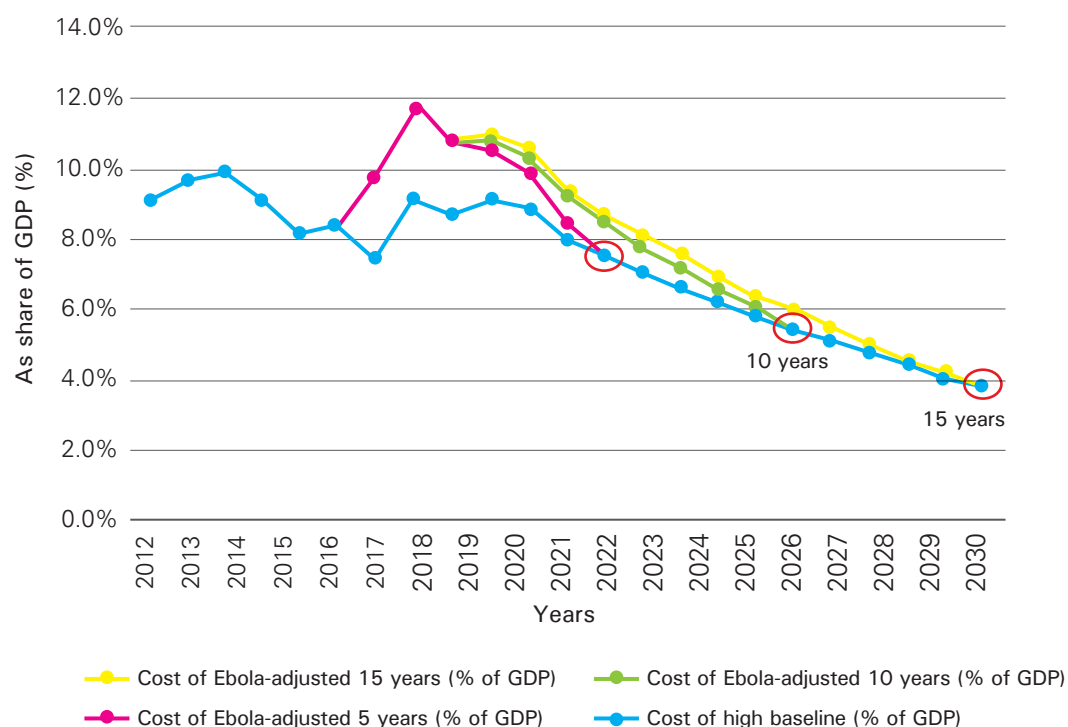
FUTURE COSTS OF EVD

The time-based recovery trajectory model assumes that the indicators require 5, 10, or 15 years to reduce back to the low and high baseline scenario respectively. *Figure 5* visualizes the trajectories of all three timeframes at hand on the high baseline scenario. The trajectories express the costs of the selected diseases, calculated using DALYs and the VSLY approach, as share of the country's GDP in the respective year. The baseline scenario (blue trajectory) signifies the costs of diseases assuming that no EVD-outbreak happened, while the three time-based trajectories illustrate the costs of the baseline adjusted for EVD, assuming that after 5, 10, and 15 years respectively, the EVD-adjusted trajectory aligns with the baseline, as pointed out by the circles.

The difference between the baseline and the respective recovery trajectories can be attributed to the outbreak of EVD, and represents the costs projected to be incurred due to EVD. While at the onset during 2014 and 2015, the difference between the baseline and recovery trajectories is most significant at approximately 2.5 per cent, the gap gradually decreases. The pace at which the gap reduces depends on the recovery timeframe chosen, with shorter timeframes reducing more rapidly as the recovery progresses at a faster pace.

The time-based recovery trajectory model assumes that the indicators require 5, 10, or 15 years to reduce back to the low and high baseline scenario respectively.

Figure 5. Baseline and time-based recovery trajectories, high baseline



While *Figure 5* illustrates recovery trajectories back to the high baseline, an almost similar picture would be painted for recovery paths towards the low baseline. However, given that the low baseline is modelled on more pessimistic assumptions for the future developments of disease morbidity and mortality, the baseline progresses at a less steep pace. It follows that

the recovery trajectories moving back to the low baseline are modelled at a slower pace of decline as well.

Figure 6 sets out the cost of EVD over a 15-year recovery period for the low and high baseline scenario. While the green and blue lines express the cost of EVD on the low and high baseline as percentage of the country's GDP, the bars show the absolute cost per year, expressed in million SLL. The distribution of cost throughout the recovery period is similar for both baselines, the cost of the high baseline scenario is always higher because of the increased investment required with an optimistic view of reduction in the indicators based on the *Poverty Reduction Strategy Paper (PRSP)* development trajectory.

The absolute cost decreases progressively at an accelerated pace from 2025 onwards. This can be explained by the expected exponentially-projected changes in the health sector indicators

The costs peak in 2014 and 2015, when EVD exerted a sizeable shock on the country's health system; it decreased in 2016 and continued to decrease over the following years. The dip in 2016 can be explained by the economic assumptions underlying the costing model and the methodology employed in deriving the cost. With the economy slowing down during the years of the EVD-outbreak, the costs of morbidity and mortality decrease, as the VSLY decreases in line with the GNI. From 2017 onwards, however, economic growth is projected to pick up again, resulting in an increased GNI and in turn heightened cost of a VSLY, and ultimately higher cost of diseases. Another factor playing into the sudden drop in cost in the year 2016 is the eradication of EVD in Sierra Leone, which significantly drives up costs in 2014 and 2015.

Figure 6. Cost of EVD on low and high baseline, 15 years

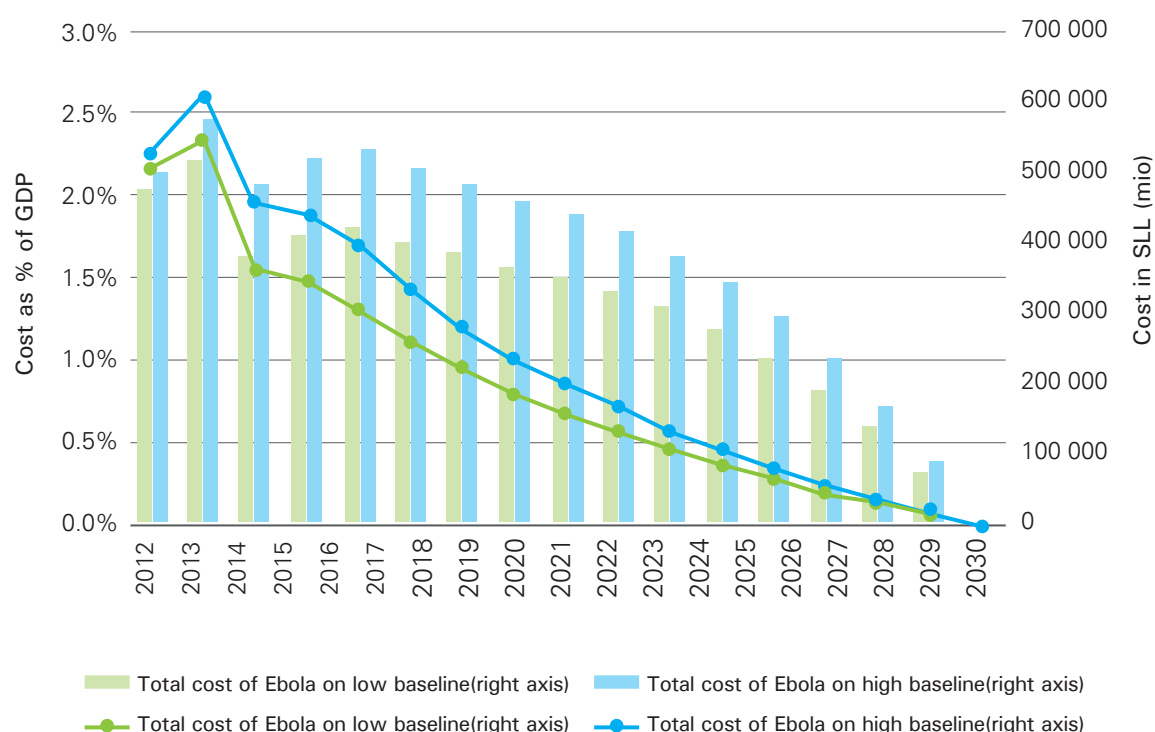


Figure 7 compares the costs of EVD incurred on the low and high baselines for different recovery timeframes, where the costs are demonstrated as share of GDP. The recovery trajectory follows a similar path for all timeframes and both baselines, however the steepness of recovery differs according to the timeframe, with shorter periods entailing a steeper trajectory. For both baseline scenarios, the costs incurred, expressed as share of GDP, are highest in 2015, at approximately 2.3 to 2.6 per cent of GDP, followed by a steep decline over the next years, gradually flattening the further recovery progresses. While the highest cost of EVD as share of GDP has already been incurred in the past two years, and is gradually reducing, significant costs are still expected to be incurred in the years following the outbreak.

Figure 7. Cost of EVD on low and high baseline for different recovery timeframes

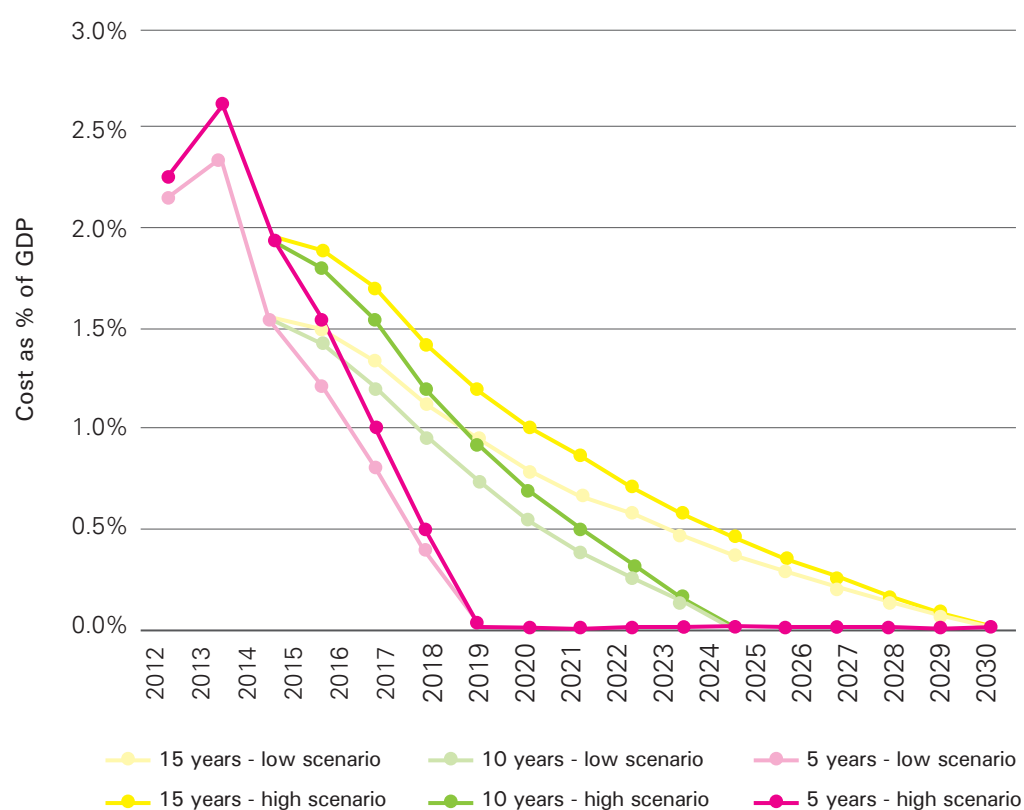


Table 3 summarizes the cost estimates for low and high baseline scenarios and the different recovery trajectories in million SLL (upper row), and as share of GDP of the respective year (lower row). While the costs of 2014 to 2015 and partially 2016 have already been incurred, the costs of the coming years are still to be incurred. The costs of EVD on the low baseline are less than the costs on the high baseline throughout the recovery period. This can be explained by the more ambitious endpoints of health indicators chosen for the high baseline, based on the overall assumption that the Sierra Leonean health sector will move back into a developmental track towards better quality of, access to and uptake of health care services in the future.

Table 3. Overview of cost estimates in million SLL and as percentage of GDP in given year

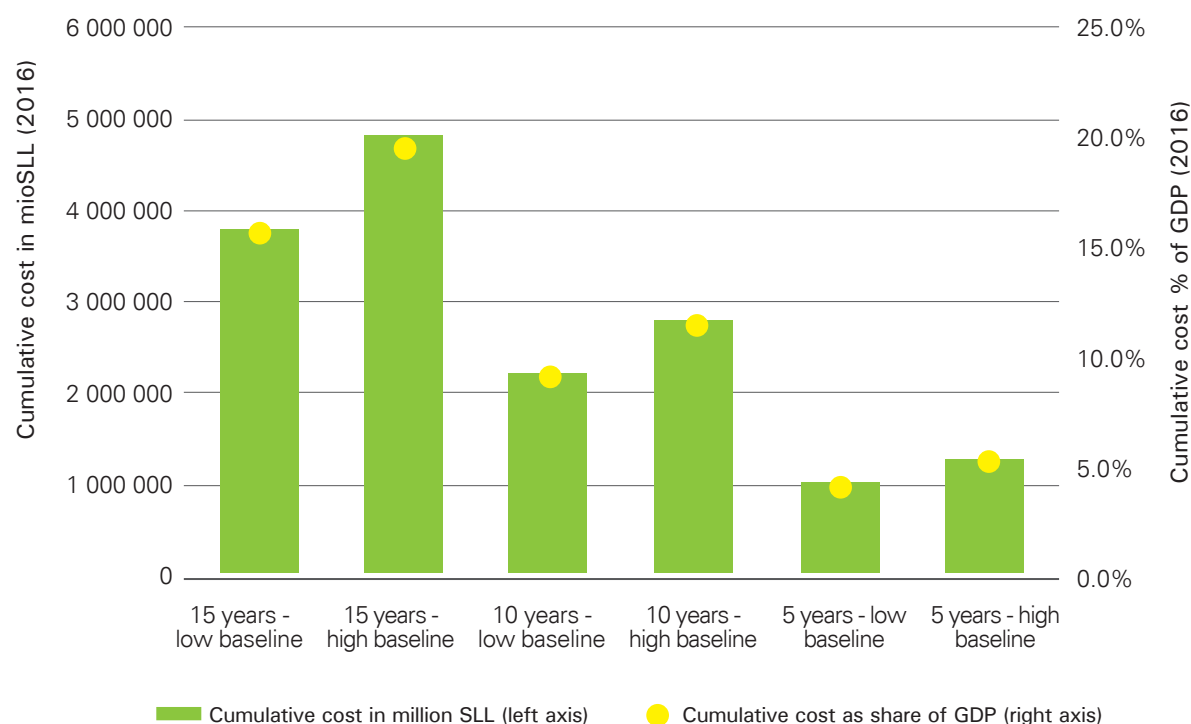
	2014	2016	2018	2020	2022	2024	2026	2028	2030
15-year recovery trajectory									
Low baseline	472,294	378,344	417,253	379,678	346,477	303,368	236,380	138,029	0
	2.1%	1.5%	1.3%	0.9%	0.7%	0.5%	0.3%	0.1%	0.0%
High baseline	494,935	479,758	527,735	480,081	436,455	377,892	290,916	167,676	0
	2.2%	1.9%	1.7%	1.2%	0.8%	0.6%	0.3%	0.2%	0.0%
10-year recovery trajectory									
Low baseline	472,294	378,344	380,360	296,168	200,198	77,627	0	0	0
	2.1%	1.5%	1.2%	0.7%	0.4%	0.1%	0.0%	0.0%	0.0%
High baseline	494,935	479,758	480,156	373,496	251,851	96,502	0	0	0
	2.2%	1.9%	1.5%	0.9%	0.5%	0.1%	0.0%	0.0%	0.0%
5-year recovery trajectory									
Low baseline	472,294	378,344	252,914	0	0	0	0	0	0
	2.1%	1.5%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
High baseline	494,935	479,758	316,044	0	0	0	0	0	0
	2.2%	1.9%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: Cost estimates based on author's calculations

In *Figure 8* the cumulative cost of all recovery trajectories is presented in million SLL and as percentage of GDP, discounted to today's terms⁴¹, underlining that a shorter recovery trajectory back to the baseline development, regardless of whether the lower or higher baseline is chosen, significantly reduces the future cost incurred. While the highest costs are incurred for a 15-year recovery trajectory, amounting to 15.5 and 19.4 per cent of today's GDP, irrespective of which baseline is chosen, the costs for a 10-year recovery are significantly lower at 9.0 and 11.3 per cent of today's GDP respectively. An even shorter recovery trajectory of 5 years lowers the sectoral costs to 4.1 and 5.1 per cent of GDP respectively, once more stressing the need to address the impacts of EVD on the health sector in a timely manner, thereby lowering the future costs.

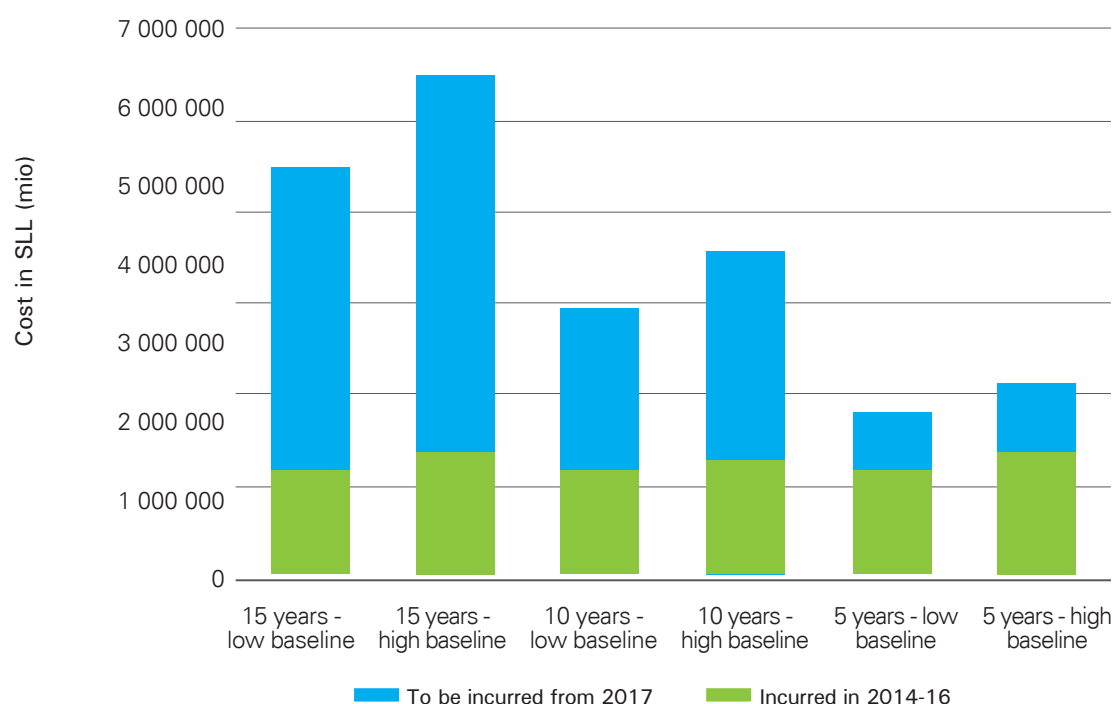
⁴¹ The future costs are discounted to today's terms in applying an interest rate of 10 per cent on the cost of each year to come. The sum of the costs is then expressed of the current year's (2016) GDP. An interest rate of 10 per cent is chosen based on the current rate and projections for the coming years.

Figure 8. Cumulative cost of EVD in different scenarios, expressed in today's (2016) terms



Lastly, *Figure 9* shows the distribution of total absolute cost in million SLL per scenario, according to past (2014-2016) and future (2017 onwards) costs. While the costs already incurred are the same for all low baseline and high baseline scenarios respectively, the future costs differ according to the recovery timeframe and baseline chosen, with high baseline scenarios across all timeframes incurring higher future costs. A comparison between the different recovery timeframes reveals that for both baseline scenarios under the 15- and 10-year recovery timeframe, the majority of costs are still to be incurred. In contrast, assuming a five-year recovery timeframe, most costs have already been incurred, with a smaller share to be incurred in the coming five years. These findings support the need to respond to EVD-related impacts in a timely manner to avoid substantial costs in the future.

Figure 9. Breakdown of total absolute costs per scenario into past and future costs



BREAKDOWN OF COSTS

Figure 9 represents the costs of each indicator as a percentage of the overall cost, distinguished according to the different time-based recovery trajectories based on the low and high baseline respectively. The stacked bars represent the cost of all health indicators for the year of 2015, when the sectoral costs incurred as percentage of GDP peaked. This year is also chosen as EVD is estimated to have exerted the biggest shock on the Sierra Leonean health system during that period, with thousands of EVD infections and deaths. Any later period would not have captured the impact of the disease itself, given that the country was declared EVD-free in March 2016.

For both scenarios, EVD and HIV account for the biggest share of the costs. EVD is estimated to account for 39.3 per cent of the costs for the different recovery trajectories modelled using the low baseline scenario, compared to 35.2 per cent using the high baselines scenario. This difference can be explained by the higher share of costs for other diseases in the latter scenarios, resulting from the higher cost of reducing the health indicators back to the high baseline, which is modelled using more ambitious assumptions in the future reduction of disease mortality and morbidity compared to the low baseline. Similarly, the lower cost share of the overall health care service uptake in the high baseline scenarios can be explained this way.

Given that the costs are determined based on the DALYs of the single diseases, the total cost is significantly driven by the development of EVD and HIV. This is because EVD and HIV have relatively high DALYs, due to their higher disability weights, mortality rates, and longer average disease duration in the case of HIV, whereas relatively low DALYs are recorded for malaria and measles. Finally, it should be taken into consideration that with the end of the EVD flare-up in 2016, the cost distribution is projected to change for the forthcoming years, with the costs being distributed among the diseases of HIV, malaria and measles, as well as decreased health service quality and uptake.

Figure 10. Cost of health indicators as share of total cost in 2015

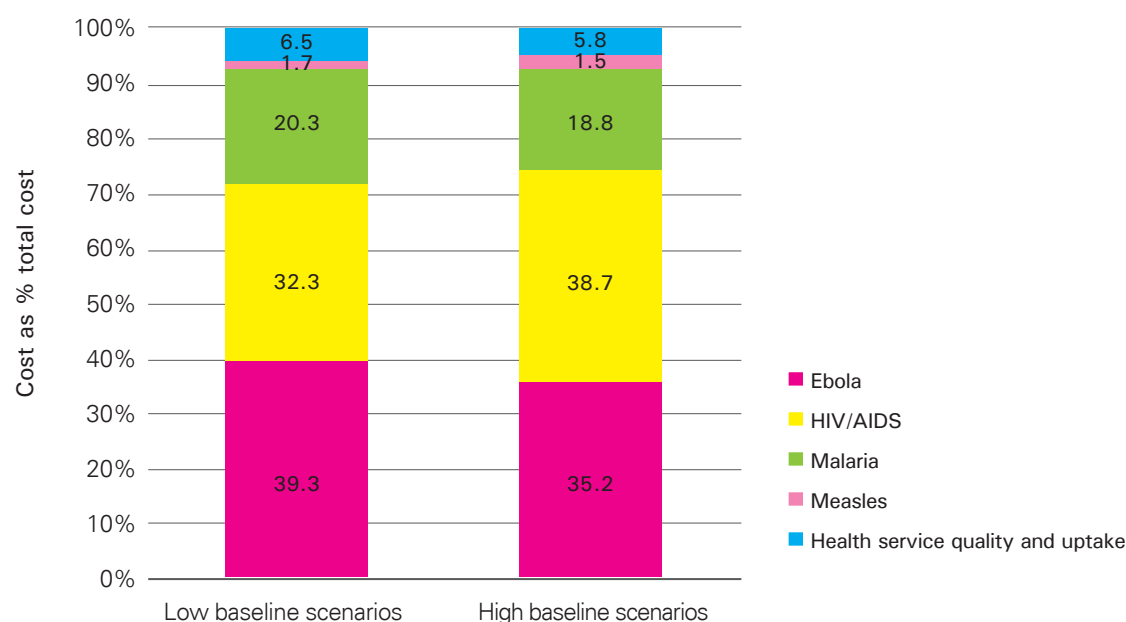
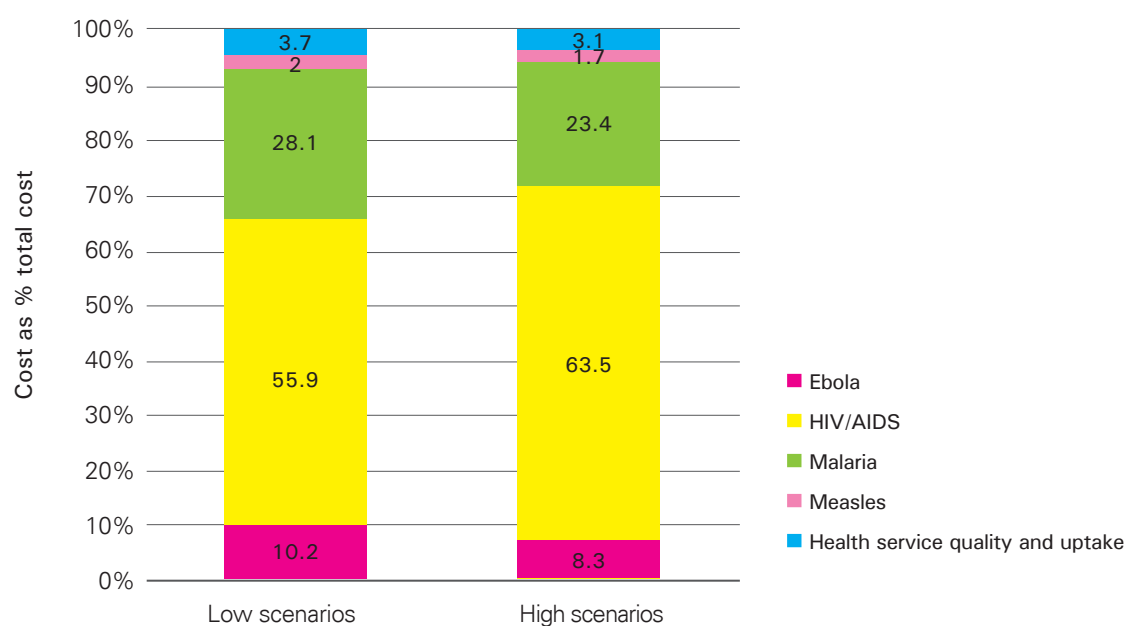


Figure 10 shows the cost distribution among the selected diseases as well as the factors of health service quality and uptake, as included in the study for the period from 2014 to 2030, based on low and high scenarios. The share of EVD decreases to 10.2 and 8.3 per cent of the overall cost in the low and high scenarios, respectively. However, in the long-term, the costs of HIV increase significantly, to 55.9 per cent in the low scenario and 63.5 per cent in the high scenario. The implications of the projected future costs of EVD and the breakdown of these costs for policy making are further discussed below.

Figure 11. Total cost of health indicators as share of total cost, 2014 to 2030



CONCLUSIONS AND RECOMMENDATIONS

BASED ON THE RESULTS OF THE MACRO-LEVEL COSTING MODEL DISCUSSED ABOVE, INCLUDING THE BREAKDOWN OF COSTS ACCORDING TO HEALTH INDICATORS INCLUDED IN THE MODEL AND THE POTENTIAL OF COST REDUCTIONS FOR SHORTER RECOVERY PERIODS, DIFFERENT IMPLICATIONS FOR FUTURE POLICY MAKING AND DESIGN OF INTERVENTIONS ARISE. IN THE FOLLOWING, VARIOUS CONSIDERATIONS ON THE COST-EFFECTIVENESS OF THE EVD-RESPONSE, ITS TIMELINESS, AND ITS INTEGRATION INTO THE LONGER-TERM FRAMEWORK OF THE DEVELOPMENT OF THE HEALTH SECTOR, ARE FURTHER ELABORATED UPON.

The results illustrate that a timely response to the indirect impacts of EVD on the health sector can significantly lower the future costs to be incurred. A comparison of the cumulative costs incurred over a 15-year versus a 5-year recovery period reveals that the cost of the latter are 5 to 6 percentage points lower, expressed as today's GDP. Therefore, improving quality, access, and uptake of health care services can significantly lower the future costs of EVD and accelerate the developmental path towards lower morbidity and mortality, and a concomitant reduction in years of bad health. This makes the case for investments today rather than tomorrow.

The outlined costs distribution suggests that, the focus should not only lie on the direct impact of EVD on its survivors, but also on the indirect impacts and costs arising out of the non-treatment of other diseases and a general decrease in the health quality and uptake. A response to the EVD-outbreak should therefore be integrated into a wider framework of policies and interventions to bring the country back on a developmental track towards better health quality, access, and uptake.

A short-term, EVD-centred response, where cash transfers and other forms of support are provided to EVD survivors and families of victims, is of great importance to mitigate the impact of EVD on those affected. However, the findings of this analysis suggest that from a cost-benefit perspective scarce health sector resources should be used to address the more structural weaknesses in the health care system that facilitated the rapid spread of the disease and that were further aggravated by EVD itself. In the long term, such spending would also result in a more inclusive, and more resilient, health care system.

However, the evaluation also found that over time, the momentum of improvements to the health care system and its accessibility was lost.

Requirements for such a health care system can be summarized into six building blocks, which enable a system to operate adequately and render it sustainable, regardless of the context the system is established in. These blocks include (i) effective, safe, and qualitative service delivery, generating demand at the same time; (ii) a well-trained health workforce; (iii) a well-functioning health information system; (iv) equitable access to essential medical products, vaccines, and technologies; (v) a solid health financing system; and (vi) leadership and governance responsible for the development of strategic policy frameworks.⁴² Combined, these building blocks can enhance access to, quality, and uptake of health care. For Sierra Leone, a combination of demand and supply recommendations is necessary to strengthen the selected building blocks.

From a demand-side perspective, longer-term policy options focused on increasing access to health care services for the whole population would feed into the building blocks of service delivery and financing. With only 1 per cent of all women aged 14 to 49 years, and 2.9 per cent of all men in the same age group being covered by health insurance as from 2013,⁴³ access to health care services is substantially restricted, rendering the health care system more prone to shocks and outbreaks. Policy interventions aiming at increasing health insurance coverage could come in manifold forms, including community-based health insurance schemes, subsidies, and/or reduced premiums for well-defined groups. One of such examples is the *Free Health Care Initiative* (FHCI), which was launched in 2010, and targets pregnant and breast-feeding women, and children under five. A recent evaluation of the FHCI reveals that the programme is having a positive impact on the lives of new and expectant mothers and their children. The FHCI was a clear contributor to increased coverage and greater equity of health care provision for the groups targeted by the programme.⁴⁴ However, the evaluation also found that over time, the momentum of improvements to the health care system and its accessibility was lost. This was further aggravated by the EVD crisis, which struck a major blow to coverage of essential services. Hence, it is recommended that policy refocus on strengthening initiatives to enhance access to health care as well as build them shock-responsive.

⁴² WHO, n.d., The WHO Health Systems Framework. Accessed on November 23, 2016 via: http://www.wpro.who.int/health_services/health_systems_framework/en/

⁴³ Republic of Sierra Leone et. al., 2013, Demographic and Health Survey, p. 49.

⁴⁴ Witter, S. et. al., 2016, The Sierra Leone Free Health Care Initiative (FHCI): Process and Effectiveness Review.

To build such shock-responsive systems, demand-side policy recommendations could be supported by supply-side interventions, to yield the intended outcomes and impacts. Supply-side challenges experienced by the Sierra Leonean health sector were exposed and intensified through EVD. Even before the outbreak, the country had only 136 doctors and slightly above 1,000 nurses,⁴⁵ meaning that Sierra Leone would have needed to increase its number of health workers 20 times to meet even a minimum threshold for an adequate health workforce.⁴⁶ Moreover, on average, facilities had only about 35 per cent of the required essential drugs in stock, and adding to the challenge, those medical products that reached health facilities were inefficiently used due to a lack of operational guidelines, training, and tools.⁴⁷

Hence, there is an urgent need to enhance supply-side conditions in order to ensure that the desired increase in uptake of services is met by an increase in quality of services. Therefore, firstly, there is an urgent need to train and adequately compensate health staff, thus guaranteeing personnel's availability, competency, responsiveness, and productivity.⁴⁸ In addition to a well-performing workforce, a well-functioning health information system is needed to ensure the production, analysis, dissemination, and use of reliable and timely health information by health workers and decision-makers at different levels of the health system, both on a regular basis and in emergencies.⁴⁹

While the EVD crisis has had devastating impact on the country; it has also brought positive forces and new opportunities. In the aftermath of the EVD-outbreak, Sierra Leone has invested in screening and triage processes, enabling 98 per cent of its peripheral health units to detect, prevent, and respond to outbreaks at an early stage. Moreover, the country has trained staff on infection and prevention control, further strengthening the capacities of health units.⁵⁰ Increased disease surveillance and response can also be instrumental in the reduction of child mortality and morbidity caused by malaria and measles, among others, which causes the death of approximately 26,000 children annually.⁵¹ Despite the progress made, it is recommended that further investment in these newly developed capacities and opportunities be made, to build and foster a resilient and responsive health care system, and increase the quality of health care services.

⁴⁵ WHO, 2010, Global Health Observatory data repository. Accessed on November 23, 2016 via: <http://apps.who.int/gho/data/node.main.A1443?lang=en&showonly=HWF>

⁴⁶ Gostin, L. O., 2014, Ebola: towards an International Health Systems Fund. Accessed on November 23, 2016 via: [http://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(14\)61345-3/fulltext?_eventId=login](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)61345-3/fulltext?_eventId=login)

⁴⁷ WHO, n.d., Analytical summary - Medical products, vaccines, infrastructures and equipment. Accessed on November 23, 2016 via: http://www.aho.afro.who.int/profiles_information/index.php/Sierra_Leone:Analytical_summary_-_Medical_products,_vaccines,_infrastructures_and_equipment

⁴⁸ WHO, 2007, Everybody's Business – Strengthening Health Systems to Improve Health Outcomes.

⁴⁹ WHO, 2007, Everybody's Business – Strengthening Health Systems to Improve Health Outcomes.

⁵⁰ CSIC/Strifel, 2015, How Did Ebola Impact Maternal and Child Health in Liberia and Sierra Leone, p. 18

⁵¹ WHO, 2016, From the ground up: rebuilding health systems in the wake of Ebola. Accessed on August 7, 2016 via: <http://www.who.int/features/2016/rebuilding-health-systems/en/>

In conclusion, it is recommended that focus is on efforts and scarce resources in an integrated response, tackling the longer-term demand- and supply-side challenges experienced by the Sierra Leonean health sector that were exposed and aggravated through EVD. Thus, an EVD response for the health sector should focus on creating a more inclusive health care system, with increased service quality, access and uptake across the population, rather than focusing on addressing the impacts of EVD alone. Moreover, following an integrated and longer-term approach in addressing impacts on the health sector would imply that scarce resources are utilized more effectively and justly, with a higher cost-benefit, short-term measures and interventions focused on EVD survivors and families of EVD victims may be considered while a longer-term perspective of improving health service delivery is put in view. Finally, it should be taken into consideration that the timeliness of the response to these longer-term challenges in the sector is relevant, the analysis showed clearly that the time to make these investments is now, as a prompt response can significantly reduce the future costs of EVD.

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