A Sierra Leone-specific adult health intervention package with an emphasis on noncommunicable diseases and risk factors

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Abstract

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Background: Sierra Leone has one of the highest mortality rates in the world, and non-communicable diseases (NCDs) comprise 40% of all deaths. This study seeks to identify the most cost-effective NCD interventions in Sierra Leone to guide use of limited public resources and inform the country's pathway to Universal Health Coverage (UHC).

Methods: This study builds on recommendations from Disease Control Priorities (DCP) 3rd edition, which presented "model" lists of interventions, including for NCDs, that could provide good value for money in low- and middle-income countries. These interventions were applied to the Sierra Leonean context using country-level epidemiological, demographic, and cost data. Incremental cost effectiveness ratios (dollars per disability-adjusted life-year averted) were calculated, then population size, structure, and mortality rates from various causes were

projected from 2021-2030 under three different, sequentially expanding, sets of interventions based on the cost-effectiveness findings.

Results: All intersectoral policies were deemed to be cost-effective and highest priority for implementation. At a cost-effectiveness threshold of 0.5x per GDP per capita, seven of 14 clinical interventions were cost-effective. At a threshold of 1-3x, an additional six clinical interventions were cost-effective. Scale-up of (i) the intersectoral policies only, (ii) the intersectoral policies plus the seven most cost-effective clinical interventions, and (iii) all intersectoral policies and the 13 cost-effective clinical interventions at a rate of an additional 2.5% of the population per year could prevent 3,500, 4,500, and 5,000 premature deaths in the year 2025 and prevention of a significant number of total premature deaths accrued between 2023-2030. As a share of the current government health budget, the costs of scaling up these three sets of interventions about one sixth, one fourth, and one third, respectively.

Conclusion:

We can conclude that (1) there are multiple options for taking action on NCDs that fit within the health budget, and (2) a number of interventions for NCDs appear to be as cost-effective as interventions that are currently being implemented. Thus, this list of interventions merit special consideration as part of a future health benefits package that will be developed for SLeSHI.

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Introduction:

Sierra Leone is a low-income country and has one of the highest mortality and morbidity rates in the world, especially for children and pregnant women. The health system was further weakened by the Ebola outbreak in 2014. (1) The country faces a critical shortage of health workers and quality of care in health facilities remains suboptimal. (2) Sierra Leone launched a free healthcare initiative (FHCI) for all pregnant women and under-5 children in April 2010. The FHCI has also been providing malaria testing and treatment services free to the entire population since 2011. (2) The FHCI initiative had mixed results. It improved access to and utilization of MCH services, narrowing the inequity in antenatal and postnatal care visits but is insufficient in addressing wealth-related inequity for institutional deliveries (3). The initiative is currently a fully donor-dependent program and is unsustainable unless funded nationally. (4) The Sierra Leone GDP/ capita is 484.52 USD (2020) which is one of the lowest in the world. (5)

The total annual health spending in Sierra Leone is 10.84% of the total budget which is below the 15% threshold set by West African countries in the Abuja declaration in 2001. (6) International development assistance formed 9% of the country's Gross National Income in 2013. (7) The 2017 global Universal Health Coverage (UHC) monitoring report estimates that Sierra Leone had a service coverage index of 36% in 2015. The coverage index for UHC is presented on a numerical scale of 0-100 and measures a country's coverage for essential health services. In 2018, household out-of-pocket expenditure (OOP) contributed 64.6% to the national health expenditure and 10.42% of the population faces catastrophic out-of-pocket health expenditure. (8) The health system in Sierra Leone is divided into tertiary, secondary, and primary levels. The health system is made up of 1,411 public and private health facilities, which

includes 54 hospitals and 70 nursing and surgical clinics. The health facility density in the country stands at 1.8 facilities per 10,000 population. (8)

Universal Health Care (UHC) is a core tenet of the UN SDG3 and it focuses on ensuring everyone has access to quality, efficient, equitable and affordable healthcare through risk-pooling and cost-sharing. (9) Many lower- and middle-income countries (LMICs) however, have limited resources, high burdens of disease, and weak health systems to meet the needs of all. To provide health services and financial protection to the most vulnerable, countries with limited resources may choose a smaller set of the most cost-effective UHC services based on their financial resources by pursuing a "progressive universalism" approach. (10) (11)

There has been a significant demographic, economic and epidemiological shift in recent years leading to NCDs causing the highest morbidity and mortality worldwide. In 2017, the proportion of DALYs and deaths attributed to non-communicable diseases (NCDs) in Sierra Leone was 40%, and the proportion of deaths attributed to NCD and injuries has increased significantly in the last 20 years. (12) There were 259,728 cases and 177 deaths for NCDs across primary and hospital levels in all Districts in 2018. (13) The National STEPS survey for the prevalence of risk factors for NCDs, conducted in November 2009, indicates that the majority (99%) of the population is exposed to at least one risk factor, such as tobacco smoke, consumption of less than 5 servings of fruits and/or vegetables on average per day, low level of physical activity, overweight, or raised blood pressure. (14)

Sierra Leone intends to pilot a Sierra Leone Social Health Insurance Scheme (SLeSHI) by 2025 which will use a sustainable funding pool to cover vulnerable populations not already covered by the FHCI. (4) After the Ebola outbreak, the country developed a Basic Package of Essential Health Services (BPEHS) plan 2015-2020 and a Health Sector Recovery Plan 2015-2020. However, the BHEHS did not consider NCD interventions fully. (4) An NCD health intervention package will help the Ministry of Health and Sanitation guide policies and could be integrated into SLeSHI as part of the move towards UHC. It will help to create a full-national Sierra Leone-specific health intervention plan for UHC.

A non-communicable diseases (NCD) cost-benefit package for Sierra Leone can help to identify the highest priority NCD services and the best use of limited public resources (health gains per dollar spent). It can help us make an explicit statement of what health services are guaranteed to be available and affordable and guide the United Nations (UN) Sustainable Development Goal (SDG) 3 Universal Health Care agenda in LMICs.

This study will build on the Disease Control Priorities (DCP) project's ongoing effort to systematically assess value for money (cost-effectiveness) of interventions that would address the major sources of disease burden in LMICs. DCP recommendations are meant to be used as a guide or starting point for doing local priority setting and planning. DCP, 3rd edition presented "model" lists of health interventions that could provide good value for money in LMICs across all areas of health, from HIV to injuries to NCDs. The DCP 3 developed a model benefits package referred to as "essential UHC" (EUHC) and identified a subset of interventions termed the "highest-priority package" (HPP). The HPP are selected based on the following criteria:

1. They provide good value for money
2. They are feasible to implement in low- and middle-income countries
3. They address a significant disease burden

There is a need to develop and sustain country-specific health benefits packages by doing local priority setting and assessing resources for the health sector from the public, private, and donor sources. (9)

Methodology:

This study builds on DCP3's modeling of the costs and mortality consequences of a model health benefits package. Candidate burden of NCDs, their effect sizes, linking interventions and standard costs for Sierra Leone will be identified from DCP3. Other data sources used include:

4. Countrywide Mortality Surveillance for Action (COMSA)
5. National Census data- Statistics Sierra Leone
6. The Demographic and Health Surveys (DHS) Surveys
7. Ministry of Health and Sanitation policy, strategy, and action plan documents

Identifying essential interventions: The first part involves identifying the candidate NCD interventions. DCP organized a series of essential intervention packages containing model intervention lists that were organized around health topics or professional communities (e.g., maternal health, CVD, cancer). For this study, we obtained our long list of interventions for this paper from DCP3 that address NCD mortalities. (15) These interventions were selected based on

systematic reviews of economic evaluations, epidemiological data, clinical effectiveness studies, and expert judgment. The interventions will be applied to the Sierra Leone context by doing a comparative cost-effectiveness analyses of these interventions using local costs and epidemiological data. The full list of DCP3 NCD interventions used in this study are provided in Appendix A.

Model development:

In order to carry out cost-effectiveness analyses from 2021 to 2030, the study must project the dynamics of the population and costs over these 10 years. The dynamics in local population per year will be measured using the demographic cohort component projection model (CCPM) which measures new population using the following formula:

New population= baseline population (for the preceding year) + change in population (birth – deaths + net migration)

The baseline age- and sex- specific mortalities will be calculated using disease specific mortalities as follows:

Baseline mortality for disease= total age- and sex- specific population x mortality rate of the disease

The mortality data was extracted from the World Health Organization (WHO) Global Health Estimates (GHE) and the population data was obtained from the United Nations (UN) World

Population Prospects (WPP). The comparator to the baseline statistics is a scenario in which coverage of the interventions studied in this study are scaled up at various levels. An increase in coverage will lead to reduction in mortality rates for a given population. The new mortality will be calculated using the following formula:

$$\textbf{New mortality} = \text{Baseline mortality} \times \frac{\text{effect size of intervention (increase access-baseline access)}}{1 - (\text{effect size of intervention} \times \text{baseline access})}$$

DCP3 costs of interventions were calculated by adding tradable cost to service costs. In addition, to these, for every intervention facility level cost (utilities, maintenance, administration, laboratory and pathology services, etc.) and "above facility" level costs (including supply chain, financing, governance and administration, and health information). The dynamics of each year's costs were also adjusted for inflation using methods described by Watkins et al. (16)

Disability Adjusted Life Years (DALYs) will be calculated using the standard and project life expectancies over the years considering a baseline increase in intervention coverage over the 10 years. I looked at the costs and consequences of instantaneously increasing coverage of each intervention by 10% and sustaining this through 2030. Then take the difference in costs and divide by the difference in DALYs to get a set of standardized cost-effectiveness ratios that can be directly compared across interventions.

The cost-effectiveness ratios for the intersectoral policies will not be reported since we only have healthcare sector costs, and these provide a very incomplete view.

DALYs= Years of life lost (YLL) + Years of life lived with disability (YLD)

Where YLLs are calculated as the number of deaths (n) multiplied by the country-specific remaining life expectancy at the age of death. Since the model I used in this study did not estimate dynamic changes in disease incidence and prevalence, I used a simple approach to calculating YLDs based on the ratio of age-standardized YLD rates to age-standardized YLL rates by cause of death, using data from the GBD 2019 study.

An incremental cost-effectiveness ratio (ICER) will be calculated using the following formula:

$$\text{ICER} = \frac{\text{cost of intervention at new access} - \text{cost of intervention at baseline access}}{\text{DALYs averted at new access} - \text{DALYs averted at baseline access}}$$

Figure 1 gives a visual illustration of the model structure and various data inputs

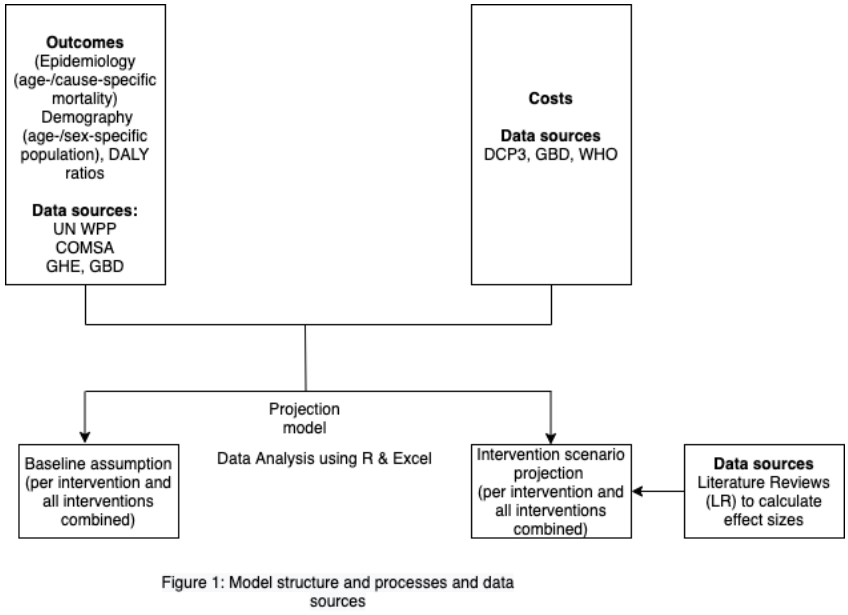

Figure 1: Model structure and processes and data sources

Figure 1 Model structure and data sources

An ICER (cost per DALY averted) / GDP percent value will be calculated to make comparisons with the cost-effectiveness threshold of health spending in Sierra Leone. Three intervention scenarios will be recommended in this study as described below. The first interventions list will consider intersectoral policies and interventions that meet the cost-effectiveness threshold value of up to 0.5 of GDP per capita as described by Claxton and colleagues (17). A second interventions list scenario will consider intersectoral policies and a more liberal cost-effectiveness threshold (1-3x GDP per capita) as informed by the WHO commission on macroeconomics and health (18). This will represent the upper bound of what is plausible. If the value of a DALY is no more than 3x GDP per capita, then any intervention costing >3x GDP per capita will be considered not cost-beneficial. A third intervention scenario will include all interventions. An NCD health package will be created using the most cost-effective interventions.

The analyses was done on R software and a cost-benefit package will be created using a two-step method; Step 1 involved doing a comparative cost-effectiveness analysis looking at the costs and DALYs averted for each intervention in isolation using a standardized 10% increase in coverage (2023-2030), vs. baseline Step 2 will involve selection of interventions that are the most cost-effective in the Sierra Leone context and model their joint costs and health impact during the latter SDG period, vs. baseline. The three intervention bundles are scale-up of (i) the intersectoral policies only, (ii) the intersectoral policies plus the seven most cost-effective clinical interventions, and (iii) all intersectoral policies and the 13 cost-effective clinical interventions at a rate of an additional 2.5% of the population per year.

Results:

1. **Comparative cost-effectiveness of candidate interventions for NCDs**

The preliminary results from table 1 below show that seven interventions and all intersectoral policies meet the current threshold for "cost-effective" as the ICER per GDP per capita percentage of these interventions is below 50%. The three cost-effective interventions include; Aspiring for suspected ACS, pulmonary rehabilitation, treatment of early-stage breast cancer, Heart failure chronic treatment, Heart failure acute treatment, CVD primary prevention and Medical management of ACS. The intersectoral policies have a very high impact and low implementation costs and are therefore are likely to be a top priority for the MOHS. The administrative costs for the intersectoral policies are scaled-up linearly from 2023 to 2025. Cost effectiveness is not calculated for these policies as we are only calculating the administrative costs of running the program. The other interventions do not make the cut under the current resource environment of the country. The full calculations on incremental costs, DALYs averted, ICER and ICER per GDP per capita percent is provided in Appendix B. The link code used for analysis in R is provided in Appendix C.

2. **Mortality gains that could be achieved by 3 different sets of interventions**

Figure 2 below is a line graph that projects the number of NCD deaths over time and compares baseline scenario (in red) with implementation of all interventions (purple), implementation of only intersectoral policies (in green) and implementation of the most cost-effective interventions (blue) at 2.5% higher coverage level than baseline.

The magnitude of mortality effect depends on:

1. The number of interventions included in the package and

2. The rate of intervention scale-up of that MOHS could achieve (we assume annual increase in population coverage of an additional 2.5% per year).

ICER/GDP/Capita x100	Intervention	
• 0.01%	Aspirin for suspected ACS	Alcohol excise taxes
• 7.4%	Pulmonary rehabilitation	Alcohol regulations
• 2.9%	Treatment of early-stage breast cancer	Tobacco excise taxes
• 9.2%	Heart failure chronic treatment	Smoking regulations
• 25.9%	Heart failure acute treatment	Salt reduction policies
• 27.7%	CVD primary prevention	
• 47.5%	Medical management of ACS	
• 51.8%	Asthma/COPD acute treatment	
• 68.6%	CVD secondary prevention	
• 84.4%	Treatment of early-stage colorectal cancer	
• 65.6%	Early-stage cervical cancer screening/treatment	
• 154.4%	Diabetes screening/treatment	
• 183.8%	Asthma/COPD chronic treatment	
• 389.6%	Management of acute ventilatory failure	

Table 1 List of interventions with ICER per GDP per capita

ACS=Acute Coronary Syndrome, CVD= Cardiovascular Disease, COPD=Chronic Obstructive Pulmonary Disease

The initial big impact on death rates is from implementation of intersectoral policies such as tobacco and alcohol control. NCD deaths still continue to increase in each scenario due to population aging and growth (age-specific death rates decrease). The goal here is to reduce the probability of death even if more people are getting exposed. So, in the intervention scale-up scenario, the curve will not go up as fast as it otherwise would have in the baseline scenario. The deaths averted is the area under the curves in each of these scenarios. The difference in the areas and baseline will be the number of deaths averted at 2.5% coverage levels. The scale-up of (i) the intersectoral policies only, (ii) the intersectoral policies plus the seven most cost-effective clinical interventions, and (iii) all intersectoral policies and the 13 cost-effective clinical interventions at a rate of an additional 2.5% of the population per year could prevent 3,500, 4,500, and 5,000 premature deaths in the year 2025 and prevention of a significant number of total premature deaths accrued between 2023-2030.

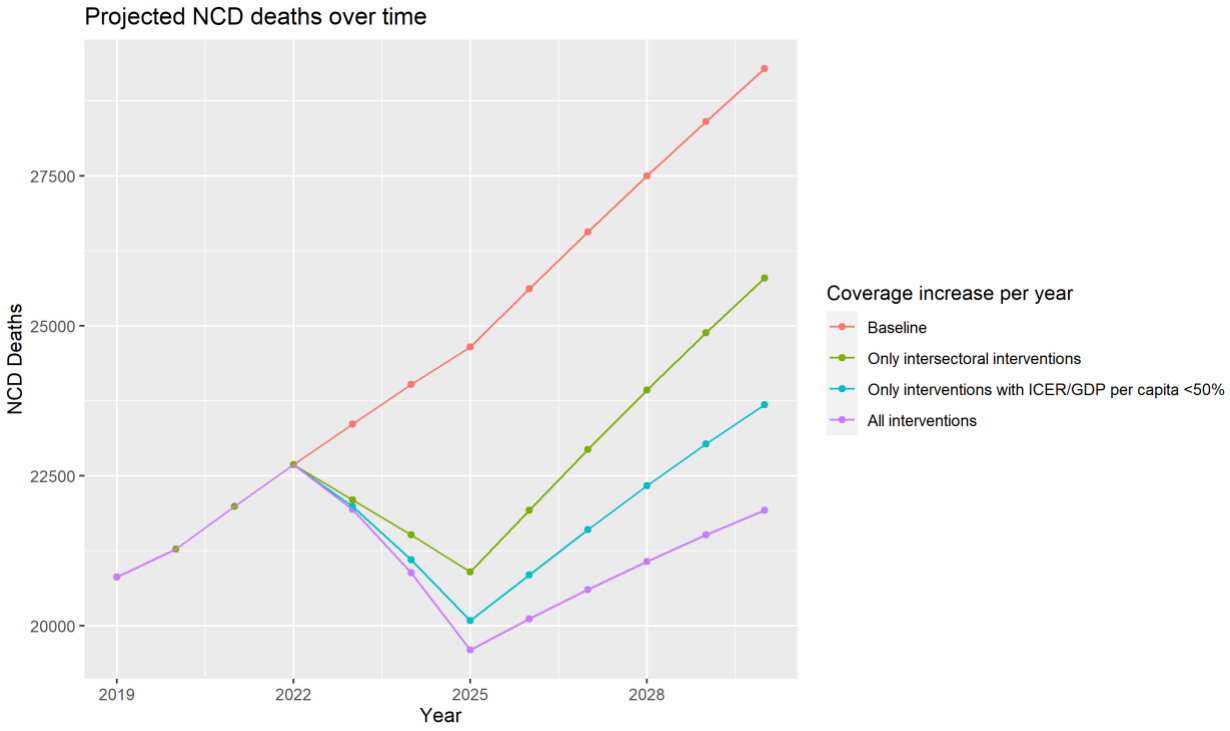

Figure 2 Projected NCD deaths over time

3. Implementation costs of 3 different sets of interventions

Figure 3 below shows the cost difference in values if all interventions versus the most cost-effective interventions versus intersectoral policies were scaleup to 2.5% coverage levels. The government health budget at 66 million USD currently (19) and by 2030 NCD costs for scaling up of all interventions by an additional 2.5% per year would be approximately one third of the total health budget (~25 million) if there is no additional increase in budget over this time period. The costs of scaling up the most cost-effective interventions will cost one fourth of the total health budget (~16.5 million) and the costs of implementing only intersectoral policies will cost about one sixth the total health budget if not additional increase in budget over this time.

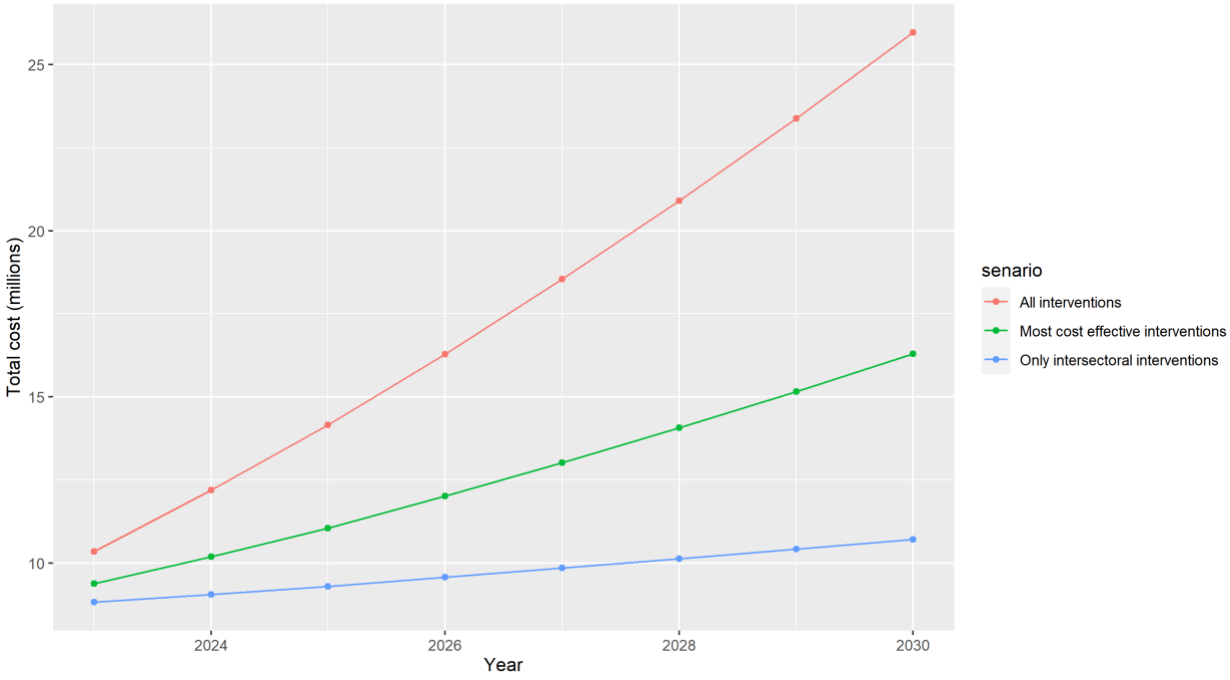

Figure 3 Costs per year in baseline vs top 5 interventions scaled to 2.5% coverage

Discussion:

Sierra Leone has limited resources for health and will need to ration NCD interventions based on the most cost-effective interventions. This analysis helps to identify which NCD interventions are high priority for SLeSHI. Substantial changes in NCD mortality can be achieved over a relatively short period of time by scaling up intervention coverage and controlling major risks like salt intake, smoking, and alcohol use. The NCD sub-package costs will likely be a reasonable but not unmanageable share of the total health budget (formal budget impact analysis to be done in future studies). SLeSHI does not implement intersectoral policies, but these are important complements to healthcare interventions which can reduce demand for healthcare over time by reducing disease incidence and case-fatality.

This study provides a starting point for doing a more detailed formal analysis that includes primary cost data collection. The analysis relies on extrapolation of cost estimates from international data sources COVID-19 pandemic has impacted feasibility of interventions, not clear whether 5% annual increase in coverage can be sustained right now. Regardless, this is probably the most efficient pathway to reduce mortality from NCDs post-COVID-19 in SL
All modelling studies use simplifying assumptions and include uncertain parameters; sensitivity analyses forthcoming.

In future, we plan to finalize projection model and budget impact analysis. We will be replacing the WHO GHE epidemiological data with COMSA data (verbal autopsies) and replace cost data with local data sources.

Conclusion:

Sierra Leone has limited resources for health and will need to prioritize the most cost-effective health interventions. We can conclude that (1) there are multiple options for taking action on NCDs that fit within the health budget, and (2) a number of interventions for NCDs appear to be as cost-effective as interventions that are currently being implemented. Thus, this list of interventions merit special consideration as part of a future health benefits package that will be developed for SLeSHI.

References:

1. Death rate, crude (per 1,000 people) - Sierra Leone | Data [Internet]. [cited 2021 Jun 24]. Available from: https://data.worldbank.org/indicator/SP.DYN.CDRT.IN?locations=SL

2. Ministry of Health and Sanitation. (2015, July). SIERRA LEONE BASIC PACKAGE OF ESSENTIAL HEALTH SERVICES 2015–2020. https://mohs2017.files.wordpress.com/2017/06/gosl_2015_basic-package-of-essential-health-services-2015-2020.pdf

3. Jalloh MB, Bah AJ, James PB, Sevalie S, Hann K, Shmueli A. Impact of the free healthcare initiative on wealth-related inequity in the utilization of maternal & child health services in Sierra Leone. BMC Health Serv Res. 2019 Jun 3;19(1):352.

4. Thompson F. Now it's free, how to pay for it? Sierra Leone's dilemma. Bull World Health Organ. 2010 Dec 1;88(12):883–4.

5. Sierra Leone | Data. (2021). World Bank. https://data.worldbank.org/country/SL

6. Public financing for health in Africa: 15% of an elephant is not 15%. (2020, November 3). Africa Renewal. https://www.un.org/africarenewal/magazine/october-2020/public-financing-health-africa-when-15-elephant-not-15-chicken

7. Tracking universal health coverage: 2017 global monitoring report [Internet]. World Bank. [cited 2021 Jun 24]. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/640121513095868125/Tracking-universal-health-coverage-2017-global-monitoring-report

8. Sierra Leone - AFRICA- P153064- Health Service Delivery and System Support Project - Procurement Plan [Internet]. World Bank. [cited 2021 Jun 24]. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/233321590518058365/Sierra-Leone-AFRICA-P153064-Health-Service-Delivery-and-System-Support-Project-Procurement-Plan

9. Watkins DA, Jamison DT, Mills A, Atun R, Danforth K, Glassman A, et al. Universal Health Coverage and Essential Packages of Care. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, et al., editors. Disease Control Priorities: Improving Health and Reducing Poverty [Internet]. 3rd ed. Washington (DC): The International Bank for

Reconstruction and Development / The World Bank; 2017 [cited 2021 Jun 24]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK525285/

10. Glassman A, Giedion U, Sakuma Y, Smith PC. Defining a Health Benefits Package: What Are the Necessary Processes? Health Syst Reform. 2016 Jan 2;2(1):39–50.

11. Jamison DT, Summers LH, Alleyne G, Arrow KJ, Berkley S, Binagwaho A, et al. Global health 2035: a world converging within a generation. The Lancet. 2013 Dec 7;382(9908):1898–955.

12. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017 - The Lancet [Internet]. [cited 2021 Jul 1]. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32279-7/fulltext

13. Ministry of Health and Sanitation. (2020, November). Sierra Leone Non-communicable Diseases and Injuries Poverty Commission: Findings and Recommendations. https://static1.squarespace.com/static/55d4de6de4b011a1673a40a6/t/5fc5571408845d09243c2da8/1606768405948/SL+Report+layout_FINAL.pdf

14. National Policy on Non-Communicable Diseases. Freetown, Sierra Leone: Ministry of Health and Sanitation. [Internet]. Ministry of Health and Sanitation; 2013. Available from: https://extranet.who.int/ncdccs/Data/SLE_B3_NCD%20POLICY%20.pdf

15. National Policy on Non-Communicable Diseases. Freetown, Sierra Leone: Ministry of Health and Sanitation. [Internet]. Ministry of Health and Sanitation; 2013. Available from: https://extranet.who.int/ncdccs/Data/SLE_B3_NCD%20POLICY%20.pdf

16. Watkins, D. A., Qi, J., Kawakatsu, Y., Pickersgill, S. J., Horton, S. E., & Jamison, D. T. (2020). Resource requirements for essential universal health coverage: a modelling study based on findings from Disease Control Priorities, 3rd edition. The Lancet Global Health, 8(6), e829–e839. https://doi.org/10.1016/s2214-109x(20)30121-2

17. Ochalek, J. M., Lomas, J., & Claxton, K. P. (2015). Cost per DALY averted thresholds for low- and middle-income countries: evidence from cross country data. (pp. 1-50). (CHE Research Paper; No. 122). Centre for Health Economics, University of York. http://www.york.ac.uk/media/che/documents/papers/researchpapers/CHERP122_cost_DALY_LMIC_threshold.pdf

18. World Health Organization. (2010, June). Exploring the thresholds of health expenditure for protection against financial risk. https://www.who.int/healthsystems/topics/financing/healthreport/19THE-thresv2.pdf

19. Domestic general government health expenditure per capita (current US$) | Data. (2021). World Bank. https://data.worldbank.org/indicator/SH.XPD.GHED.PC.CD

Appendices

Appendix A: List of DCP3 NCD Interventions

Community	**Health Center**	**District Hospital**	**Tertiary Hospital**	**Intersectoral Policies**
Pulmonary rehabilitation	CVD primary prevention	Medical management of ACS	PCI for ACS	Alcohol excise taxes
HBV immunization (all infants)	CVD secondary prevention	Heart failure acute treatment	Management of acute ventilatory failure	Alcohol regulations
HPV immunization (school-aged girls)	Aspirin for suspected ACS	Treatment of early-stage cervical cancer	Treatment of early-stage breast cancer	Tobacco excise taxes
	Heart failure chronic treatment	Asthma acute treatment	Treatment of early-stage colorectal cancer	Smoking regulations and IEC
	Cervical cancer screening	COPD acute treatment	Treatment of early-stage childhood cancers	Salt reduction policies
	Asthma/COPD chronic treatment			Trans fat bans
	Diabetes screening/treatment			Sugar-sweetened beverage excise taxes
	CKD screening/treatment			
	RHD primary prevention			
	RHD secondary prevention			

Appendix B: Cost effectiveness of NCD Interventions

Intervention name	Incremental cost	DALY's averted	Cost per DALY averted (ICER)	ICER/GDP/Capita
Pulmonary rehabilitation	27579.8	771.3	35.8	7.4%
Asthma/COPD chronic treatment	4028203.3	4522.8	890.6	180%
Diabetes screening/treatment	10689740.5	14288.6	748.1	150%
CVD primary prevention	7615574.1	56667.7	134.4	28%
Aspirin for suspected ACS	217.8	3710.9	0.1	0.012%
CVD secondary prevention	10598441.1	31881.6	332.4	69%
Heart failure chronic treatment	1409606.1	31558.8	44.7	9.2%
Medical management of ACS	2935687.3	12754.1	230.2	48%
Heart failure acute treatment	7567097.8	60269.7	125.6	26%
Early-stage cervical cancer screening/treatment	1634222.3	5143.8	317.7	66%
Asthma/COPD acute treatment	7055254.2	28131.5	250.8	52%
Management of acute ventilatory failure	451332.7	239.1	1887.6	390%
Treatment of early-stage breast cancer	19685.8	1418.8	13.9	2.9%
Treatment of early-stage colorectal cancer	141603.6	346.1	409.1	84%

Appendix C: The analysis code link

https://github.com/DCP-UW