Methods, Tools, and Data to Facilitate Development and Implementation of Essential Health Benefit Packages

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Abstract

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Essential Health Benefit Packages (EHBPs) are a key implementation strategy for achieving Universal Health Coverage (UHC). EHBP determines entitlement, reallocates resources, guides budgeting, influences service delivery, generates demand, and reduces service fees. Despite countries' interest in EHBP, the development of its implementation has been suboptimal. EHBPs are often criticized as aspirational rather than pragmatic. This has been attributed to 1) ad hoc and unsystematic prioritization, 2) High uncertainty in cost estimates, and 3) Lack of agreed-upon performance indicators. Through my dissertation, I aim to strengthen the effective implementation of EHBPs by utilizing innovative methods, tools, and data that bridge the gap between EHBPs development and implementation. For the first aim of the dissertation, I address the question of how policymakers choose which health interventions to implement when they face resource constraints. Second, I developed a model to assess the amount of funding governments would need to implement a comprehensive EHBP. Lastly, I address the question of how implementers in resource-limited settings monitor the implementation of EHBPs at a national scale.

For aim 1, I conducted a discrete choice experiment among 49 policymakers involved in developing Ethiopia's EHBP. The experiment used a four-attribute, forced-choice design. Vignettes presented two hypothetical alternative interventions, totaling 18 vignettes. The attributes specified for the two alternatives were (1) absolute reduction in mortality, (2) severity of disease targeted, (3) age group

targeted, and (4) absolute reduction in medical impoverishment. Based on 864 total observations, I estimated the average preference weights for each attribute using a random-parameter mixed logit model. I found that all four criteria were statistically significant and varied monotonically across different attribute levels, as expected. The conditional relative importance of each of the four attributes was 38.8% for the targeted age group, 27.8% for the absolute reduction in mortality, 19.1% for the reduction in medical impoverishment, and 14.2% for the severity of the disease targeted. These findings provide empirical preference weights that can be incorporated into multicriteria decision analysis, thereby enhancing the systematic and transparent development of EHBP in Ethiopia and similar resource-limited settings.

For aim 2, based on the Disease Control Priority Project (DCP 3) costing methodology, I developed a cost support model for EHBPs using Malawi as a case study. The model leveraged cost data and health system performance parameters to systematically estimate the total and incremental costs of EHBP implementation, mapping these costs by cost centers (delivery platforms and disease areas). The model utilizes the unit cost and Population in Need estimates collected through the structured review process. It uses estimates on health financing sources from the National Health Account and the Malawi health finance mapping exercise to map the cost distribution across cost centers. To demonstrate the model's utility, I estimated the projected cost of implementing Malawi's current Emergency Health Budget Plan (EHBP). The cost increases from $300 million in 2026 to $620 million under an adjusted coverage scenario (80% by 2050). The model presents a timely and non-resource-intensive starting point for countries to cost EHBPs. It provides a transparent and systematic approach to EHBP costing, enabling policymakers to align service packages with available fiscal space.

For aim 3, I developed a framework for utilizing health facility surveys and geospatial data to measure population coverage of a broader range of services and to demonstrate its application in Malawi. Using the data from the 2019 Harmonized Health Facility Assessment conducted in Malawi, I identified a list of 129 interventions recommended by the DCP 3 for inclusion in health benefits packages in low-resource countries. I conducted a structured literature search to develop an input-based composite indicator for each intervention and then assessed the readiness of each intervention in Malawi's 564 public healthcare facilities. I used high-resolution population estimates for Malawi from WorldPop 2020 Raster to conduct a service area analysis to translate these readiness statistics into informative input-adjusted coverage estimates for Malawi. This framework can be adapted for other types of facility surveys, interventions, and countries, facilitating the monitoring of EHBP implementation progress.

Most countries recognize UHC as a goal but have not taken concrete implementation steps to achieve it. Through providing a proof of concept for the quantification of decision makers' preferences, a cost support model that estimates the cost of EHBPs, and a flexible framework to assess health service coverage, the dissertation addresses three critical gaps and provides implementation research-oriented solutions to facilitate the support of the development and implementation of EHBPs. I hope that this work will provide starting points for researchers and public health policymakers interested in implementing EHBP and advancing UHC in resource-constrained settings.

Aim 1: How do policymakers prioritize interventions for health benefits packages? Insights from Ethiopia

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Introduction: When deciding which interventions to prioritize for health benefits packages, policymakers often need to balance multiple criteria and competing priorities. These include maximizing health outcomes, improving the distribution of health (i.e., equity), and providing financial risk protection. Little is known about how policymakers weigh these criteria, so we conducted a discrete choice experiment in Ethiopia to better understand local preferences.

Method: Our experiment was conducted among 49 policymakers involved in developing Ethiopia's health benefits package. The experiment used a four-attribute, forced-choice design. Vignettes presented two hypothetical alternative interventions, totaling 18 vignettes. The attributes specified for the two alternatives were (1) absolute reduction in mortality, (2) severity of disease targeted, (3) age group targeted, and (4) absolute reduction in medical impoverishment (assuming full public finance). We estimated the average preference weights for each attribute using a random-parameter mixed logit model and calculated the conditional relative importance of each attribute based on our estimates.

Results: Most respondents worked in the Ministry of Health or local insurance agency and were men. Based on 864 total observations, all four criteria were statistically significant and varied monotonically across different attribute levels, as expected. The conditional relative importance of each of the four attributes was 38.8% for the targeted age group, 27.8% for the absolute reduction in mortality, 19.1% for the reduction in medical impoverishment, and 14.2% for the severity of the disease targeted.

Discussion: We found that Ethiopian policymakers involved in EHBP development tend to prioritize interventions that target younger age groups, especially <5 years, and achieve substantial mortality reduction. Financial risk protection and disease severity were less critical, with implications for the design of insurance benefits. These findings provide empirical preference weights that can be incorporated into multicriteria decision analysis (MCDA), which can enhance systematic and transparent EHBP development in Ethiopia and similar resource-limited settings.

Introduction:

Achieving Universal Health Coverage (UHC) requires countries to navigate the complex interplay of maximizing health gains, promoting equity, ensuring financial protection, and achieving resource efficiency. Essential Health Benefits Packages (EHBPs) serve as a cornerstone policy in this endeavor, offering a structured framework to strengthen health systems while promoting equitable access to essential health services.[1–4] However, designing EHBPs involves difficult trade-offs between expanding the breadth of interventions, enhancing population coverage, and reducing financial burdens on households. Policymakers must reconcile these competing demands within the constraints of limited fiscal and administrative resources.[4–9]

While evidence-based prioritization is widely endorsed, no universal consensus exists on which interventions should be included in an EHBP or how they should be sequenced. The priority-setting process is often viewed as inconsistent and lacking a systematic approach.[10,11] While cost-effectiveness analyses dominate health prioritization, societal values such as equity and financial risk protection (FRP) can be explicitly incorporated to ensure fair and acceptable resource allocation decisions.[12,13] The relative contribution of interventions to health improvement, equity, and FRP varies across different settings, making prioritization inherently complex and context-specific.[14,15]

Beyond technical evidence, the priority decision-makers assign to different policy options are shaped by their values, attitudes, and perceptions of national priorities.[6,16,17] These beliefs are pivotal in determining which policy options are pursued and might lead to discrepancies between national health goals and resource allocation. Beyond costs-effectiveness, prevention of medical impoverishment and priority to the worse off are essential dimensions in setting health policy[12,18,19]. These considerations should ideally be reflected in economic evaluations beyond traditional metrics such as DALYs and QALYs. Verguet & Norheim (2022) emphasize the importance of evaluating health and financial risk protection outcomes, particularly for chronic diseases where financial burdens accumulate over time.[20] Similarly, Hendrix et al. (2023) argue that integrating financial risk protection considerations into economic evaluations can lead to more equitable prioritization of health interventions.[21]

Determining which interventions to implement is a critical decision-making challenge in resource-limited settings, where priorities compete for limited funding and capacity.[16] How governments select health interventions to include in EHBP can affect their uptake and the extent of population health gains.[14] Quantifying how policymakers' beliefs and values influence trade-offs in health policymaking is crucial for improving transparency and accountability in health prioritization. Despite the importance of transparent and evidence-informed health prioritization, limited research exists on how policymakers' preferences influence trade-offs in resource-limited settings, especially in low-income countries (LICs).

This study seeks to develop a structured approach to understanding the preferences of planners and policymakers in prioritizing health interventions within EHBPs in resource-constrained settings. Specifically, it aims to establish a proof-of-concept approach to empirically deriving weights for core priority-setting criteria. We developed this approach to enable its adaptation to other contexts, informing priority-setting processes that aim to balance multiple criteria against one another.

Methods:

The study employed a four-attribute, two-alternative, forced-choice discrete choice experiment (DCE) design. DCEs are a stated preference method used to quantify individual preferences by analyzing choices made in hypothetical scenarios.[22–25] DCEs assume that specific attributes can describe healthcare interventions and that individual valuations depend on the levels of these attributes.[24] In a typical DCE, participants are presented with vignettes (choice sets) containing two options defined by varying attribute levels. They are asked to select their preferred option, which allows the analyst to evaluate how

strongly the different attributes influence decision-making and to assess their relative importance in shaping individual preferences. DCEs compel respondents to weigh the trade-offs inherent in their choices; therefore, they are increasingly being applied to investigate societal and ethical perspectives on healthcare priority setting.[25–29] By requiring participants to select one option at the expense of others, DCEs ensure that the limitations of healthcare resources are explicitly considered.

Establishing attributes:

The selection of attributes (Table 1) was guided by the WHO declaration *"Making Fair Choices on the Path to Universal Health Coverage,"* which highlights UHC as the "ultimate expression of fairness in healthcare" and underscores the need for countries to set priorities that align with broader social goals.[18] Attributes were selected based on their relevance to the key dimensions of UHC: health maximization, equity, and financial risk protection. A structured literature review further refined these attributes, identifying seven studies that explored health intervention prioritization across diverse economic settings (high-, middle-, and low-income countries). Details of this review are provided in Appendix 1.

Each attribute was defined with a distinct and specific scope to avoid inter-attribute correlation and maintain their independence and mutual exclusivity. This ensured conceptual clarity, practical applicability, and integrity of the responses.[22,26] The number of attributes included in the survey was intentionally limited to reduce the cognitive burden and prevent reliance on simplified decision rules.[22,26] This design choice ensured meaningful engagement with the survey while balancing complexity and feasibility. The research team validated the attributes, ensuring their definitions were precise and comprehensible. This iterative refinement process ensured that the attributes were robust, accessible, and suitable for eliciting reliable data on healthcare priorities.

Table 1: Attributes, attribute definition, and levels

UHC dimension	Attribute	Definition	level
Maximizing health outcomes	Absolute reduction in mortality	The number of deaths averted in the target population if the intervention under consideration was selected.	1,000, 25,000, 50,000
Equity (fair distribution)	Severity of disease targeted	Healthy life expectancy without the intervention: the number of years expected to live without the intervention, where shorter durations reflect greater disease severity and urgency for intervention.	Least severe: 10 years; Medium Severity: 5years; Most severe: 1month (imminent death)
	Age group targeted	The age group targeted by the health intervention.	0-5 years old;6-15 years old; 16-59 years old; >60 years old
Fair contribution	Absolute reduction in medical impoverishment	The number of households (with one or more members affected by the disease) that avoid impoverishment or further impoverishment due to out-of-pocket expenditures for the targeted condition.	800; 18,000; 35,000

Experimental Design and Scenario Presentation:

The initial combination of attributes and their levels resulted in a full factorial design consisting of 108 scenarios, generated using the *AlgDesign* package in R. To reduce the cognitive burden on participants and ensure the choice tasks were manageable, a fractional factorial design comprising a subset of optimal scenarios was constructed using Federov exchange algorithm.[27] The final choice set was created by randomly selecting 18 scenarios without replacement to avoid potential bias. Eighteen choice sets were used to stay within the standard threshold for respondent engagement in DCEs, as presenting more can cause boredom and reduce the reliability of responses due to simplified decision-making.[22]We used an unlabeled DCE design presenting hypothetical interventions characterized by generic attributes such as age distribution of mortality, severity, and financial risk protection. These profiles were not tied to specific diseases but were designed to reflect patterns commonly observed across real-world health conditions, making the results broadly applicable to a wide range of interventions. This approach minimize the influence of pre-existing biases that respondents might have toward particular diseases or interventions relevant to their local context. Figure 1 provides an example choice set, where participants were required to select their preferred option between two hypothetical interventions.

Figure 1: Example of a choice set presented to the study participants

Choice set 1

Please add X to the box to choose one of the interventions below, considering that they have equal costs.

Intervention Attribute	Intervention 1	Intervention 2
Absolute reduction in mortality: number of deaths averted in the target population	50,000	1000
Severity of disease targeted: Health expectancy without the intervention	Medium severity: 5 years	Most severe: 1 month (imminent death)
Age group targeted: age group targeted by the health intervention.	> 60 years	0-5 years
Absolute reduction in medical impoverishment: number of households that avoid impoverishment due to out-of-pocket expenditure	18,000	18,000
	☐	☐

The questionnaire begins with a detailed explanation of the attributes and levels included in the study. Basic demographic information, such as respondent age and sex, in addition to professional affiliation, was also collected. The questionnaire was piloted with a small group of participants (n = 6) to identify and address any interpretation or face validity issues. The questionnaire was developed and administered in English, which is considered the working language in the Ministry of Health and its affiliated institutions.

Sample Size Calculations:

Sample size calculation for DCE studies in healthcare is complex, and the golden rule for sample size determination has yet to be agreed upon. The study used the rule of thumb proposed by Johnson and Orme to determine the minimum sample size for reliable statistical analysis of a DCE.[28]

$$N > 500c/(t \times a)$$

Where [c] is equal to the largest number of levels for any of the attributes, [t] is the number of choice tasks, and [a] is the number of alternatives. Accordingly, 56 respondents are required to allow informative interpretation of the results. However, a smaller number of participants is considered sufficient to determine the general relevance of the attributes in the analysis.[28]

Study Setting

The study focuses on Ethiopia's health system, which operates through a decentralized model that provides health services to around 120 million people. Governance is divided between national and regional levels: the Federal Ministry of Health provides policy direction and technical support, while Regional Health Bureaus oversee the management of health facilities within their jurisdictions. As part of Ethiopia's continued commitment to UHC, the Ethiopian Health Insurance Agency (EHIA) was established in 2010 to expand public health insurance in the country.

Study Population and Data Collection

The study targeted technical experts in the development of Ethiopia's EHBP, including representatives from the Federal Ministry of Health, Regional Health Bureaus, the Ethiopian Public Health Institute, the Ethiopian Health Insurance Service, and academia. With input from the national team, a list of 60 potential participants was compiled. Data collection occurred in June 2024 across two rounds. The list also included representatives of development partners who worked closely with the Ministry team during the development of the EHBP. An in-person workshop was held at the Ethiopian Ministry of Health for the first round, while an online version of the survey was provided for those unable to attend. Of the 60 identified participants, 49 completed the study, resulting in an 87.5% response rate. The data were collected through a cross-sectional survey, with 48 participants valid for analysis.

Data analysis:

All attributes were recorded as categorical variables, and a detailed description of these attributes is provided in Table 1. The dataset consists of discrete choice data, characterized by within-subject variation and correlation introduced by each participant responding to multiple choices. The response variable is a binary indicator of whether an alternative is chosen. We employed a random-parameters mixed logit regression model to account for the hierarchical structure of the data and the correlation within responses. This approach captures heterogeneity in individual preferences by allowing attribute coefficients to vary randomly. The utility (U_{ij}) for respondent *i*, choosing alternative j in a choice set is modeled as:

$$U_{ij} = \sum_k \beta_{ik} X_{jk} + \epsilon_{ij}$$

Where:

- $\mathbf{U_{ij}}$: Utility of alternative j for respondent i,
- $\boldsymbol{\beta_{ik}}$**:** Preference weight for attribute level k of respondent i,
- $\boldsymbol{X_{jk}}$**:** Attribute level k of alternative j,
- $\boldsymbol{\varepsilon_{ij}}$**:** Error term, assumed to follow an extreme value distribution and are independently and identically distributed.

Dummy-coded variables were used to represent the attribute levels, providing measures of their relative desirability or importance by determining how much utility increases (or decreases) relative to the reference level of that attribute.[25,29] The conditional relative importance of each attribute was calculated as the difference between the preference weights of its most and least preferred levels,

expressed as a percentage of the total importance across all attributes.[30] This provided a comparative measure of each attribute's contribution to decision-making.

A baseline scenario was defined and compared to a counterfactual scenario to demonstrate how changes in attribute level influence the probability of choosing an alternative. The population-level likelihood of selecting the counterfactual over the baseline was estimated using the Monte Carlo method via simulation. This approach allows for robust prediction intervals and highlights the impact of varying attribute levels on decision-making.

Data Availability statement:

The de-identified data and R analysis codes we used are available in a public GitHub: https://github.com/salia25/DCE-policymakers-prioritize-interventions- for replication purposes.

Ethical considerations

This study received ethical approval from the University of Washington's Institutional Review Board and the Ethiopian Public Health Institute's Institutional Review Board. We obtained written informed consent from all interviewees before data collection.

Funding Statement

The study was not funded, but the data collection process was supported by the travel of the Thomas Francis, Jr. Global Health Fellowship Endowed Fund from the Department of Global Health at the University of Washington.

Results

Table 2 highlights the characteristics of the participants included in the analysis. The majority are from the Ministry of Health and related institutions.

Table 2: Participant characteristics

		Respondent (N=49)	
		n	%
Affiliations	Ministry of Health	29	59%
	Ethiopian Public Health Institute	3	6%
	Health Insurance Service	12	24%
	Universities	3	6%
	International Development Partners	2	4%
Age		38 (27-53)	
Gender	Male	81.6%	
	Females	18.4%	

Table 3 presents the average preference weights for each variable (i.e., attribute level) included in the model. Compared to the reference level for each attribute, the levels of the other attributes were all highly statistically significant. Additionally, the magnitude of the preference weights (coefficients) compared to the reference category is intuitive; for example, compared to averting 1000 deaths, policymakers prefer averting 25,000 deaths, but they prefer averting 50,000 deaths even more, all else equal. Finally, the magnitude of the preference weights for the target age group and mortality reduction is the largest, especially for the most extreme attribute level, indicating a stronger preference for these attributes compared to others.

Table 3: Estimates of coefficients in the MNL model, their 95% CIs, and overall significances:

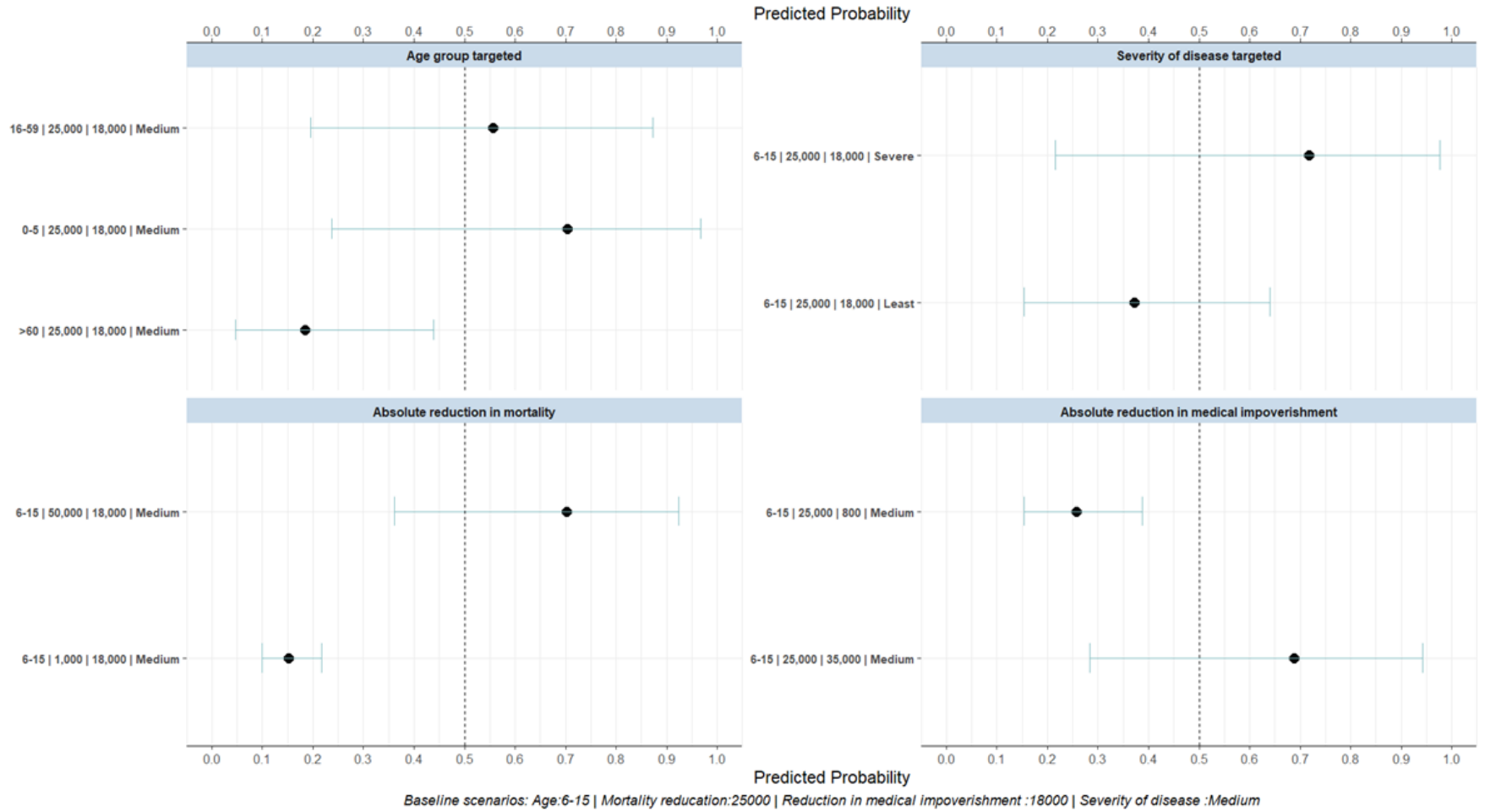
Attribute	Attribute levels	Average preference weights	Confidence interval	P value
Absolute reduction in mortality	1,000 deaths averted	Ref		
	25,000 deaths averted	1.745***	1.25 -2.25	< 0.001
	50,000 deaths averted	2.743***	2.08 -3.40	< 0.001
Severity of disease targeted	Least severe	Ref		
	Moderate	0.545*	0.06- 1.04	< 0.001
	Severe	1.74***	1.25 - 2.23	
Age group targeted	>60	Ref		< 0.05
	16-59	1.907***	1.37 -2.45	< 0.001
	6-15	1.633***	0.83 -2.43	
	0-5	2.726***	2.14 - 3.32	
Absolute reduction in medical impoverishment	800 households avoid impoverishment	Ref		
	18000 households avoid impoverishment	1.069***	0.49 – 1.66	< 0.001
	35000 households avoid impoverishment	2.015***	1.53 – 2.51	< 0.001

Ref: reference Group

Predicted Probabilities Across Alternative Scenarios

Figure 2 illustrates the predicted probabilities and 95% prediction intervals for nine alternative intervention scenarios across the four attributes analyzed. The dashed vertical line at 0.5 represents the threshold for equal likelihood, facilitating comparisons across the scenarios. Shifting the age group targeted by the intervention from less than 5 to >60 years reduces the likelihood of the intervention being prioritized by more than 50%. Shifting the absolute reduction in medical impoverishment from 35,000 households to 800 households decreases the likelihood by around 40%.

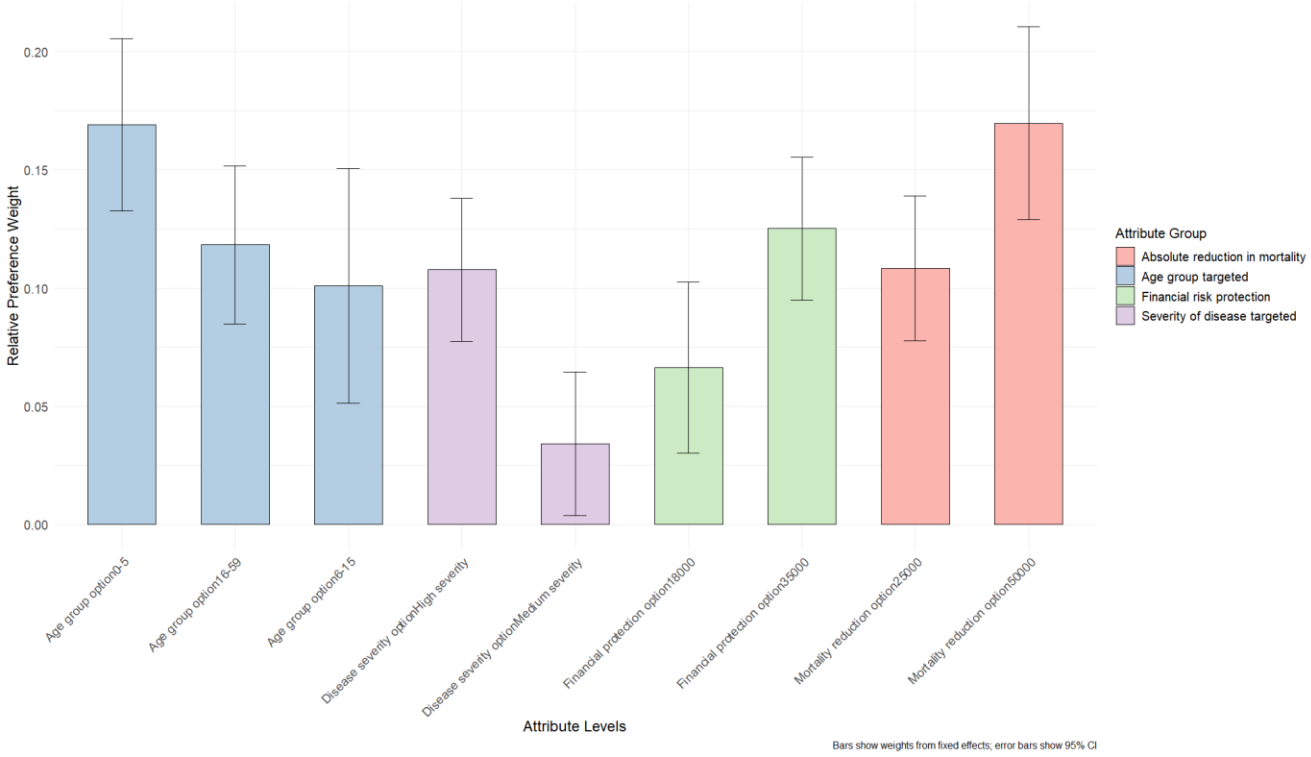
Figure 2: Attribute choice probabilities:



Relative preference weights and Conditional Relative Importance of Attributes

Figure 3 illustrates the **Relative preference weights** that quantify how much importance respondents assign to different levels of an attribute when making choices. Although averting 50,000 deaths is the most preferred individual intervention level, Age Group consistently ranks high across all levels, demonstrating it is a comparative influence on the overall participant choice. To discern the difference in influence across the four attributes included in the analysis, we calculated the Conditional Relative Importance of Attributes. The target age group is the most influential attribute in the model, accounting for approximately 38.8% of the conditional relative importance. Absolute mortality reduction is the second most influential attribute, contributing 27.8% to the conditional relative importance. Absolute reduction in medical impoverishment and severity of disease targeted contributed 19.1% and 14.2%, respectively, to the conditional relative importance.

Figure 3: Relative Preference Weights



Discussion:

This study examined the preferences of Ethiopian health policymakers involved in EHBP development regarding the prioritization of interventions for inclusion in the EHBP. Using a DCE, we assessed how decision-makers balance health maximization, equitable health distribution, and FRP when allocating limited resources. Our findings indicate that age group and mortality reduction are the most influential factors in intervention prioritization, while FRP and disease severity, although significant, play a comparatively minor role. The study finds policymakers prefer 0-5 over other age groups given the same number of deaths averted, same disease severity, and same financial protection afforded. By prioritizing younger populations, policymakers diverge from a strict cost-effectiveness-based prioritization model, which typically allocates resources toward the most cost-effective interventions, regardless of age.[31]

Our study findings are mostly consistent with previous research. Jehu-Appiah et al. (2008) in Ghana and Milman et al. (2012) in five countries found a consistent preference for younger populations, confirming our findings except for Cuba.[11,32] Similarly, studies from Iran and South Korea reported a lower preference for the older population in resource allocation decisions.[33,34] Our study has shown that although FRP is a contributing factor in Ethiopian policymakers' decision-making, it plays a comparatively minor role. This aligns with findings from Ghana and a multi-county DCE, which reported a similar pattern in the influence of FRP, indicating that it continues to play a role in decision-making but ranks behind age and mortality attributes.[11,32] The 2019 revision of the EHBP incorporated FRP as one of seven criteria for prioritizing interventions.[35] However, the extent to which FRP influenced the final selection of prioritized interventions remains unclear. Our study revealed that disease severity is the least influential attribute in prioritizing intervention. This finding aligns with the results from Jehu-Appiah et al. (2008) in Ghana and Milman et al. (2012) .[11,32.] Contrary to a qualitative study from Tanzania, which found that disease severity was considered the most crucial factor in prioritization.[36]

Our study provides quantitative preference weights for key priority-setting criteria that can inform multicriteria decision analysis (MCDA) exercises in low-income countries. For instance, Lofgren et al. designed a mathematical optimization model to balance gains in health and financial risk protection (FRP) across candidate interventions in the Ethiopian context.[37] Their study identified Pareto-optimal solutions, demonstrating that increasing emphasis on one objective (e.g., maximizing health outcomes) required trade-offs in another (e.g., FRP), depending on the weights assigned to these priorities.[37] The weights derived from our study offer empirical data that could enhance such models by providing objective and context-specific inputs for FRP and mortality reduction. Similarly, Jehu-Appiah et al. in Ghana utilized DCE-derived weights to refine the country's third Five-Year Program of Work (2007–2011).[11] By incorporating these weights into an MCDA framework, they quantified the trade-offs between efficiency and equity. They provided actionable rankings of interventions based on their relative contributions to these competing priorities. These examples highlight the utility of integrating DCE results into policy optimization tools, and our study adds to this evidence base by offering robust preference estimates to guide resource allocation and prioritization in Ethiopia's Essential Health Benefits Package (EHBP).

Limitations:

This study has several limitations. While the sample included the majority of stakeholders identified in the sampling frame, it may not fully reflect all actors involved in Ethiopia's EHBP development, particularly from subnational or diverse institutional backgrounds. The attributes were based on literature and expert input but were not systematically validated for local relevance. Although all attributes were statistically significant, other important factors may have been missed. Future studies should consider a broader range of decision-making criteria.

To reduce the cognitive burden of the DCE, we have limited the number of attributes analyzed because as the number of attributes in a DCE increases, so does the number of choice sets. As the number of choice sets increases so does the likelihood that participants will resort to simple decision-making rather than fully considering the trade-offs between attributes.[38] Despite our efforts to recruit a representative sample, this study included 49 participants, which is slightly below the recommended 56 participants. The relatively small sample size likely contributed to wider prediction intervals in the choice probability calculations. However, a smaller number of participants is considered sufficient to determine the general relevance of the attributes.[28]

This study provides empirical evidence on the preferences of Ethiopian policymakers for prioritizing interventions in the EHBP. The findings emphasize a strong preference for interventions targeting children under five and have high absolute mortality reduction, while FRP and disease severity played comparatively smaller roles. Our study quantifies these trade-offs in EHBP prioritization and contributes to a more transparent and evidence-based process for setting priorities. The preference estimates generated can inform future revisions to the EHBP and be integrated into MCDA models to enhance the selection of systematic interventions. Future research should explore additional contextual factors, such as regional disparities and health system capacity, to further refine Ethiopia's approach to priority setting.

Aim 2: Essential Health Benefits Packages: A Costing Model to Support Universal Health Coverage

Authors: Sali Ahmed, Yanfang Su, David Watkins

Background: Choosing health interventions and defining entitlement to be publicly funded is a critical step toward Universal Health Coverage (UHC). Yet, Essential Health Benefits Packages (EHBP) are often criticized as aspirational rather than pragmatic. Costing EHBPs is essential to ensure financial feasibility and facilitate their adoption at a national scale, yet it is resource-intensive and time-consuming. Further data quality issues and limited cost experience at the country level lead to high uncertainty in cost estimates, which limits the EHBP's role in guiding sustainable financing and budgeting decisions.

Objectives: I aim to develop a cost support model for EHBPs using Malawi as a case study. The model seeks to leverage cost data and health system performance parameters to systematically estimate the total and incremental costs of EHBP implementation and map the costs by health centers, including delivery platforms and disease areas.

Methods: The analysis is embedded within the FairChoices policy support tool, designed to facilitate the cost-effectiveness analysis of a broad set of health interventions that serve as the basis for developing EHBPs. The model utilizes the unit cost and Population in Need estimates collected through the Systematic review process. It uses estimates on health financing sources from the National Health Account and the Malawi health finance mapping exercise to calculate costs for implementing a selected EHBP and map its distribution across cost centers.

Discussion: To demonstrate the model's utility, I used Malawi's EHBP. The projected cost of implementing the package increases from a baseline of $300 million in 2026 to $620 million under an adjusted coverage scenario (80% by 2050). Assuming Development assistance will remain constant, the government's share of the EHBP financing will rise from 24% at baseline to 62% by 2050. Out-of-pocket contribution to the package remains at 4%

Conclusion: The model presents a timely and non-resource-intensive starting point for countries to cost EHBPs. It utilizes a Standardized, transparent costing approach and can enhance the comparability and policy relevance of EHBP costing in limited resource settings. This cost support model provides a transparent and systematic approach to EHBP costing, enabling policymakers to align service packages with available fiscal space.

Introduction:

Public health policymakers responsible for drafting, developing, and implementing health policies, programs, and strategies to achieve Universal Health Coverage (UHC) are often required to make urgent and consequential decisions that shape national health system responses. Consensus on a comprehensive list of affordable health interventions within the given fiscal space can establish guarantees for service access, promote health equity, and protect against financial risk.[4] Developing Essential Health Benefits Packages (EHBPs) is a key policy tool for advancing UHC and strengthening the health system.[1–3] However, policymakers often face significant evidence gaps as they attempt to determine which health services should be made available to the entire population, under what conditions, and in what sequence.[14,39]

Developing EHBPs is complex and involves a series of trade-offs, as Public health policymakers need to weigh opposing priorities and criteria to establish an explicit package.[4] Decision-makers must determine whether to expand the number of priority Evidence-Based Interventions (EBIs) included, extend the coverage of the existing package, or reduce existing service co-payments.[5–9] Interventions may rank differently regarding health improvement or financial risk protection attributes; accordingly, prioritizing interventions on the pathway to UHC will likely involve weighing competing objectives.[14] Including cost considerations in the development and review process of EHBP can help estimate total resource needs, inform service inclusion decisions at the margin, and ensure that the adopted packages are implementable rather than merely aspirational.[40] Gaps between policy development and financial planning impact the Ministries of Health's (MOH) ability to present coherent budget demands and mobilize funds for EHBP implementation.[40,41]

Many countries have developed EHPB, yet the extent of the implementation of such packages remains limited.[1,4,42] A comprehensive assessment of EHBPs across 45 countries reveals that many packages lack specificity and tend to be more aspirational than pragmatic.[2] In certain instances, the per capita cost of implementing an EHBP surpasses public and total health expenditures (THE). In Ethiopia, the per capita cost for EHBP implementation is $40, compared to a THE of $33, with a significant portion financed through OOP.[43] In Afghanistan, inadequate financing for the EHBP was characterized by under-coverage in the designated health interventions, poor quality of care, and unaffordable OOP costs.[44] Moreover, when costing exercises yield unrealistically high budget requirements, they can stall political momentum by implying the need for immediate and unsustainable increases in public spending.[45]

The World Bank (WB) recommends that countries invest in accurate sources of essential data for EHBP, including costing, budget impact, and fiscal space analysis.[40] It also emphasizes the importance of adequate cost analysis to determine the resources needed for EHBP implementation and ensure that the services included match the budget envelope for delivering the package.[40] Many countries have included costing as part of the EHBP process. However, costing exercise results are not integrated into the planning and budgeting processes, hindering the effective implementation of the adapted packages.[46] Improving confidence in results is essential to ensure the policy relevance of costing exercises conducted as part of EHBP design and foster effective use in decision-making.[46] A review of five LLMICs' EHBPs costing experience noted that countries faced difficulties conducting costing exercises, such as insufficient quality data and inadequate costing skills and expertise.[40,46] Many countries perceived the tools to facilitate the costing exercise as time-consuming and labor-intensive.[46] The WB emphasizes that developing a sustainable approach to costing should account for resources and capacity available at the country level.[40]

This study aims to leverage cost data, health system performance parameters, and modeling to develop a cost support model that can systematically map the costs of EHBPs based on a broad range of proven cost-effective interventions. Using Malawi as a case study, the model will provide Public health policymakers with a macro-level budget estimate for selected EHBPs and help them evaluate the policy

trade-offs associated with prioritizing different EBIs. Specifically, the study addresses the following questions:

I. How much would governments need to implement an EHBP?
II. How is the cost distributed among the revenue collection entities (governments, Development Assistance for Health (DAH), and households)?
III. What are the main cost centers in the EHBP, disaggregated by:
    a. implementation platform (primary, secondary, tertiary)
    b. disease area

The model provides a systematic and timely approach to quantifying resources required for EHBP implementation and incorporates distributional insights across financing agents and cost centers. It highlights the implications for out-of-pocket (OOP) spending, ensuring that financial risk protection is considered during decision-making.

Methods:

Model orientation: The model is embedded within the FairChoices tool, a policy instrument developed to support public health policymakers in designing and revising EHBPs. FairChoices employs standardized epidemiological and health economic methodologies to inform evidence-based decision-making as part of a broader initiative on priority setting for UHC. The project is a collaborative effort involving a multidisciplinary team with expertise in three core areas: costing, health impact assessment, and demographic modeling.

As the lead contributor for cost data inputs, I am responsible for updating the cost data used by the FairChoices model. I reviewed and collected data regarding the average annual unit cost and the population in need (PIN) for each intervention. This includes conducting systematic literature reviews to validate and update existing cost data and identify additional estimates to ensure a comprehensive and accurate representation of the full range of interventions included in the tool.

As a starting point, FairChoices relied on unit cost estimates from systematic reviews conducted by the Disease Control Program (DCP3) in 2017. Building on the DCP review process, which adhered to a standard protocol for systematic reviews, I updated the unit cost data by systematically searching databases such as Medline, Embase, and Cochrane. I followed a search strategy that relied on search terms specific to diseases, cost-effectiveness analysis, economic evaluations, low-income countries (LICs), and middle-income countries (MICs). For a limited number of interventions without previously published cost estimates, I developed unit cost estimates using a "bottom-up" costing approach, which involved making assumptions about personnel, equipment, drugs, and consumables. I used the criteria listed below to guide the final selection of cost estimates:

1. Alignment between the intervention being costed in the study and the intervention recommended by FairChoices
2. Quality of evidence and the robustness of the costing methodology.
3. Studies originating from low- or lower-middle-income countries were given preference over studies in high-income countries.

All selected unit costs, underlying assumptions, and references are documented in an evidence brief. The FairChoices review team then validates the brief to ensure methodological consistency and rigor. Additionally, I contribute to refining cost codes, drawing from the DCP model and lessons learned from previous iterations of the FairChoices tool to ensure methodological rigor and consistency. thorough

Data sources and model parameters: The model draws upon diverse data sources to inform its analyses. a) Cost inputs from the FairChoices Tool estimate the normative, recurrent overall budget required for implementing specific EHBPs. b) Health Service Coverage Estimates. c) National Health Account (NHA) for Malawi 2020 and Round 5 of Malawi's Health Sector Resource Mapping: These sources provide insights into the distribution of financing sources for health interventions, including an estimate of cross-cutting or health system markup, facilitating the estimation of their respective shares. Based on these data sources, I developed a master database to catalog health interventions under analysis, detailing their unit costs, PIN, financing sources, delivery platforms, and average baseline coverage.

Data analysis: The analysis will follow two approaches: 1) Cost modeling to estimate the total and incremental cost of a specific EHBP and map the cost by revenue collection entities, and 2) Descriptive analysis to summarize the distribution of EHBP cost delivery platform and disease area.

Cost model (specific objectives 1 and 2): The model is adapted from Watkins and colleagues' model that uses annual cost estimates based on unit cost defined per population or per case treated for each specific intervention ($c_{i,lit}$) supplemented with markups to represent the health system cost (α) and health facility cost (β).[47] Unit cost estimates are combined with assessments of PIN and population coverage estimates to calculate intervention costs at a population level, denoted as $C_{i,pop}$. In this context, w_i represents the proportion of the target population covered by intervention i, and p_i denotes the estimated number of individuals treated by intervention i. The unit cost is converted, and all expenses are adjusted to 2026 US dollars for specific countries.[47]

$$c_i = c_{i,lit} + \alpha_{\cdot i,lit} + \beta.\left(c_{i,lit} + \alpha_{\cdot i,lit}\right)$$

$$c_{i,\ddot{Y}} = \left(\gamma.c_{i,x}.S_y/S_x\right) + (1-\gamma).c_{i,x}$$

$$C_{i,pop} = \sum_{t=0}^{y}\sum_{i=1}^{n} c_{i,\ddot{Y}}.w_{i,t}.p_{i,t}$$

To estimate the projected costs over time, I utilize the impact and demographic model developed by the FairChoices team to account for the reduction in mortality rates and increased longevity resulting from scaling health coverage and the equivalent increase in healthcare needs due to the projected demographic changes.

I extend the application of the Watkins et al. cost model by incorporating assumptions about the share of financing sources, enabling estimation of how selecting an EHBP impacts the required national budget, DAH, and OOP, as detailed below. $C_{i,pop} = \sum_{t=0}^{y}\sum_{i=1}^{n} C_{i,pop,gov} + C_{i,pop,d} + C_{i,pop,oop}$

$$C_{i,pop} = \sum_{t=0}^{y}\sum_{i=1}^{n}\left(C_{i,pop} * \delta\right) + \left(C_{i,pop} * \emptyset\right) + \left(C_{i,pop} * \vartheta\right)$$

$$IC_{i,\mathrm{pop}} = \sum_{t=0}^{y}\sum_{i=1}^{n}\left[\left(C_{i,pop} * \delta\right) + \left(C_{i,pop} * \emptyset\right) + \left(C_{i,pop} * \vartheta\right)\right].[w_1 - w_0] \times p_i$$

Where $\emptyset$ is the OOP share a δ is the government share out of the total resource envelope for the health sector, and ϑ Is the donors' share out of the total resource envelope for the health sector? w_0 is baseline coverage and w_1 is the target population coverage. The model will allow estimating the incremental cost ($IC_{i,\mathrm{pop}}$of scale-up to implement a comprehensive package of EBIs by a financing source for a specific coverage target.

Descriptive analysis (specific objective 3)

I will use descriptive analysis to identify how the projected EHBP budget will be distributed to the different service delivery platforms and disease categories, depending on which EBIs are selected for inclusion in the EHBP.

Analytic Variables

1. **Normative total EHBP cost:** the financial cost required to deliver services of reasonable quality and efficiency within a specific EHBP in a country of interest.
2. **Incremental EHBP cost:** additional resources are required to scale up EHBP to a specific coverage target.
3. **Normative total EHBP cost by revenue collection entities:** the share of the financial cost borne by the primary revenue collection entities, namely the government, donors, and OOP expenditures.
4. **Normative total EHBP cost by platform:** The share of the EHBP financial cost attributed to each delivery platform within the health system. The platform represents the optimal level at which interventions can be delivered effectively and efficiently, whether at the community level, health center, district hospital, regional hospital, or referral hospital.[48]
5. **Normative total EHBP cost by disease area:** The share of the EHBP financial cost channeled to a specific disease category.

I adapted the Malawi Essential Health Package (EHPB) to demonstrate the model by mapping its interventions to the FairChoices taxonomy. Table 1present the interventions included in the analysis. A total of 40 clinical interventions from the EHPB were selected after mapping them to the FairChoices taxonomy. The community health package in the EHPB was excluded from the analysis. Additionally, one clinical intervention (deworming) and one public health intervention (Vitamin A supplementation) were not included, as they are not currently part of the Fair Choices interventions list. The final list of interventions was reviewed and refined in collaboration with country team members to ensure accuracy and relevance.

Table 1: List of interventions included in the analysis

Disease Group	**intervention**
Communicable diseases	BCG vaccine
	MMR vaccine
	Pentavalent vaccine (DPT-HepB-Hib)
	Pneumococcal vaccine
	Polio vaccine
	Rotavirus vaccine
	Management of drug susceptible extrapulmonary TB
	Management of drug susceptible pulmonary TB
	TB preventive therapy (Isoniazide) for high risk people (e.g. PLHIV)
	Treatment of Human African trypanosomiasis
	Treatment of acute diarrhea in adults
	Treatment of acute diarrhea in children
	Treatment of acute lower respiratory infections, adults
	Treatment of acute lower respiratory infections, children

Growth, development and aging	Treatment of acute malnutrition
Noncommunicable diseases and mental health	Basic management of epilepsy
	Dental care
	Human Papilloma virus (HPV) immunization
	Longitudinal management of diabetes mellitus type 1
	Longitudinal management of diabetes mellitus type 2
	Management of depression
	Management of psychotic disorders
	Primary prevention with absolute CVD risk
	Screening and treatment of pre-invasive cervical cancer
Reproductive and sexual health	Antenatal care
	Care for complications of abortion
	Condoms - Family planning
	Contraceptive pills, patches or rings
	Early care for newborn
	Early detection and treatment of neonatal sepsis and pneumonia
	Injectables - Family planning
	LARC methods
	Male or Female Sterilization
	Management of maternal sepsis
	Management of postpartum haemorrhage
	Safe delivery
Violence and injury	Management of burns
	Management of lower extremity injuries
	Management of upper extremity fractures
	Management of wounds (excluding burns)

Results:

The results present the projected budget impact of implementing the selected EHBP in Malawi from 2026 to 2050, comparing two scenarios: the baseline, which maintains current coverage levels, and the adjusted scenario, which scales coverage to 80% per UHC targets. Table 2 summarizes the projected costs in selected years. Under the baseline scenario, total EHBP costs will increase from $300 million in 2026 to $490 million by 2050. In contrast, the adjusted scenario, reflecting expanded coverage, shows a sharper cost rise, from $300 million to $620 million over the same period. Table 2 also includes incremental cost estimates associated with scaling up coverage and per capita costs, which rise modestly under the adjusted scenario, reflecting the higher resource needs of achieving 80% population coverage. The table also demonstrates the cost per capita moving from 13 USD for the baseline scenario to 18 USD for the adjusted coverage scenario.

Table 2: Budget Impact Analysis:

Category	**2026**	**2030**	**2035**	**2040**	**2045**	**2050**
Baseline Cost ($ million)	300	330	370	410	450	490

Adjusted cost ($ million)	300	350	410	470	540	620
Incremental cost ($ million)	3	17	38	64	95	130
Baseline Cost Per Capita ($)	13	13	13	13	13	13
Adjusted Cost Per Capita ($)	13	14	15	16	17	18

Figure 1 illustrates the projected allocation of the EHBP budget across key financing sources. Under the adjusted scenario, the government's share of total costs increases substantially, from 24% to 62%, reflecting greater domestic responsibility in financing expanded coverage. In contrast, the share of DAH declines from 63% to 29%. OOP expenditure remains relatively low across both scenarios, reinforcing the EHBP's contribution to financial risk protection.

Figure 1: Distribution of the total budget cost by financing source:

budget_share_horozintal.html

Figure 2 demonstrates the distribution of the share of the EHBP cost across platforms, comparing the baseline to the adjusted scenario, emphasizing that the package remains centered on primary health care.

Figure 2: Total budget distribution by platform

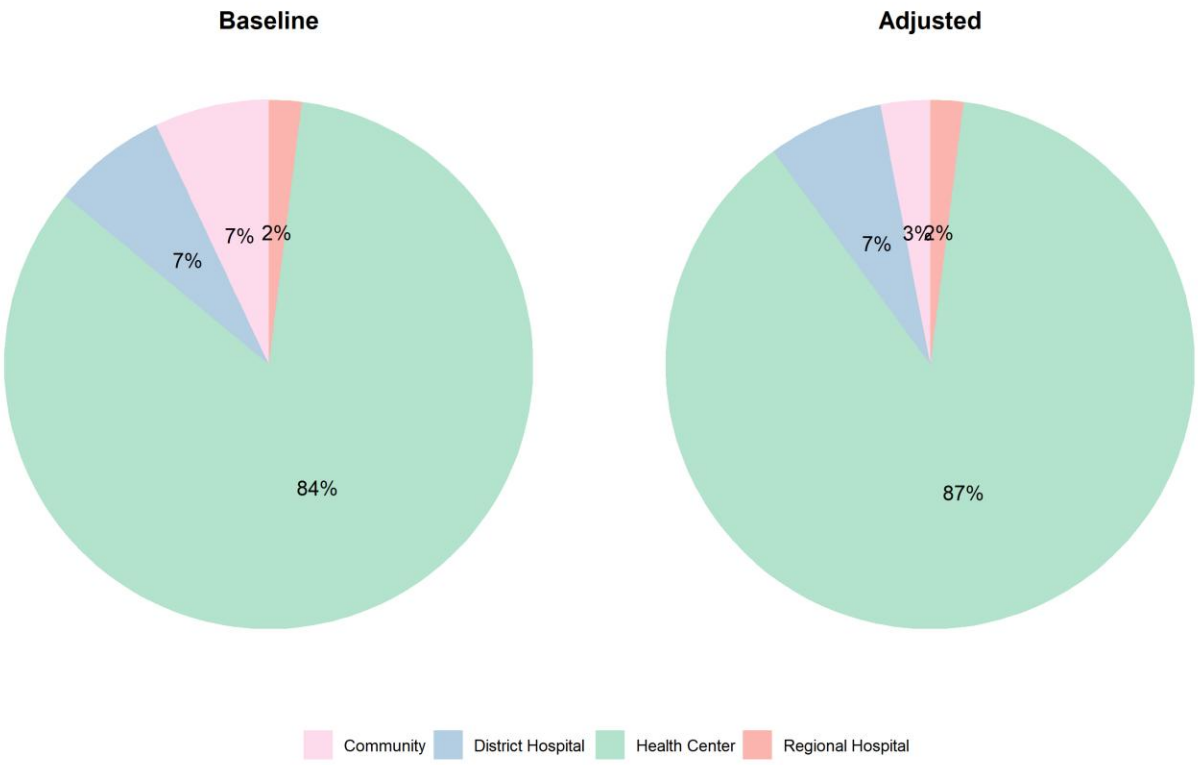
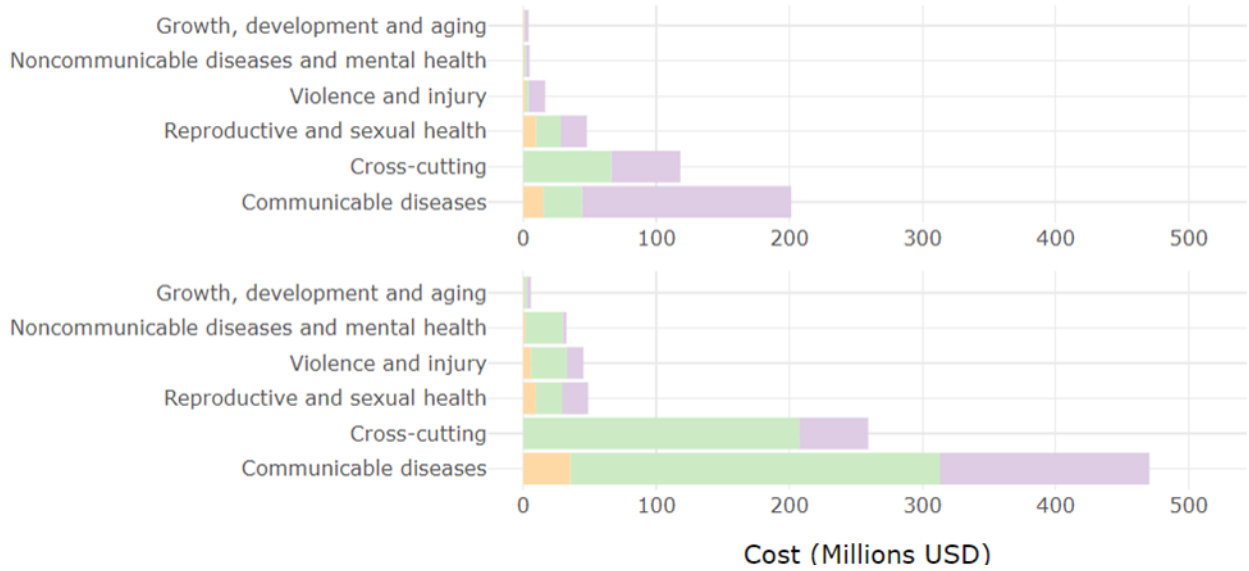


Figure 3 compares the distribution of EHBP costs and financing sources' shares across disease groups under baseline and adjusted coverage scenarios. Communicable diseases remain the most resource-intensive category in both scenarios. While noncommunicable diseases (NCDs) represent a smaller package share, the 9 included NCD interventions show a noticeable increase in cost under the adjusted scenario. In contrast, reproductive and sexual health services exhibit relatively stable cost levels across both scenarios, indicating limited change in resource requirements due to high baseline coverage.

Figure 3: Total budget distribution by disease group

budget_comparison_plot.html



Discussion:

This study contributes to the limited but growing body of research on country-specific costing of EHBPs in low- and lower-middle-income countries (LLMICs). While previous studies, such as Watkins et al. (2020), have provided global-level estimates representing an average cost of $79 per capita in LICs and $130 in LMICs for implementing a package of 218 high-priority services, this analysis advances the literature by generating detailed, country-specific estimates using Malawi as a case study. [47] The MOH Malawi has estimated that implementing the EHBP with 45-65% coverage in 2021 will cost 290 million USD for medicines and supplies.[49] Our model presents comparable estimates directly relevant to country-specific health finance planning and provides policymakers with an evidence base to inform budget negotiations, prioritize interventions, and develop feasible pathways to UHC.

By leveraging and extending the FairChoices tool, this study bridges the gap between evidence generation and strategic health planning. The model enables the disaggregation of EHBP costs by financing sources (government, donors, and OOP), delivery platforms, and disease areas, providing transparency and actionable insights for aligning health investments with national priorities and available fiscal space. This level of granularity is essential for identifying trade-offs in intervention scale-up and facilitating cross-sectoral dialogue on resource allocation.

Applying the model to the Malawi EHBP offers important insights. First, the projected increase in the government's share of EHBP financing under expanded coverage highlights the need for enhanced domestic resource mobilization, particularly with uncertainty in DAH. Second, consistently low levels of OOP spending across scenarios demonstrate the EHBP's potential to strengthen FRP, representing a key UHC dimension. Third, the analysis confirms that the EHBP remains focused on PHC, aligning with the global consensus that PHC forms the foundation of UHC. Finally, while communicable diseases continue to dominate EHBP costs, the rising resource demands associated with the NCD interventions included in the package reflect a growing need to focus on expanding financing for chronic diseases as Malawi's demographic and epidemiological profile continues to evolve. The nuanced analysis of cost centers moves beyond estimating aggregate funding gaps and instead serves as a tool to inform critical policy decisions. This approach enables a more meaningful shift from determining the cost of implementing an EHBP to assessing how existing resources can be strategically allocated to advance progress toward UHC.[45]

Further, the costing support model addresses critical methodological gaps identified in recent reviews. Jeet et al. (2021) noted that although costing exercises are increasingly common, the lack of consistency in costing inputs and reporting can hinder cross-country comparability and policy uptake, and they stressed the need for standardizing EHBP costing. Capitalizing on the standardized costing assumptions drawn from FairChoices and national data sources addresses the heterogeneity observed across EHBP costing studies.

Limitations: This analysis has several limitations. First, the model does not account for potential economies of scale or scope, which may affect unit costs as coverage expands, particularly the cost of infrastructure and capital investments. Second, the costing relies on economic rather than financial cost estimates; while informative for understanding resource requirements, financial costs may be more appropriate for immediate fiscal planning and budgeting. Third, the model lacks granularity in estimating how recurring costs may change with scale-up, which may understate the actual cost of service expansion. Finally, although national data sources were used to inform financing shares and baseline coverage, uncertainties in data quality may introduce biases into the estimates.

Despite these limitations, the study demonstrates a replicable and transparent model that can improve the generalizability and harmonization of EHBP costing methods and strengthen the policy relevance of EHBP cost estimates in low-resource contexts. As countries continue to design and revise their EHBP, this model provides a structured, data-driven approach to ensure packages are grounded in economic reality, support evidence-informed decision-making, and facilitate alignment between service delivery priorities, fiscal constraints, and UHC commitments.

Aim 3: Measures to monitor the implementation of Essential Health Benefit Packages at a national scale.

Authors: Sali Ahmed, Yanfang Su, David Watkins, Yanjia Cao, Sun Jiashuo

Abstract

Introduction: Achieving universal health coverage (UHC) requires identifying who is covered and by which specific services. Therefore, monitoring improvements in the coverage of a wide range of services is essential for the effective implementation of UHC policies. Nevertheless, existing coverage indicators focus on a narrow range of high-impact services. This study aimed to develop a method for utilizing health facility surveys to measure population coverage of a broader range of services and to demonstrate its application in Malawi.

Methods: We identified a list of 129 interventions recommended by the Disease Control Priorities Project for inclusion in health benefits packages in low-resource countries. We reviewed available data from the 2019 Harmonized Health Facility Assessment conducted in Malawi and then conducted a systematic literature search to develop an input-based composite indicator for each intervention. We then assessed the readiness of each intervention in Malawi's 564 public healthcare facilities. We used high-resolution population estimates for Malawi from WorldPop 2020 Raster. We employed service area analysis to translate these availability statistics into coverage estimates. We assessed input-adjusted coverage for specific services within 5 km and 25 km catchment areas for primary and secondary care services, respectively.

Results: We found major differences in coverage estimates across interventions. Routine childhood immunization had the highest average coverage, with over 50% of the population living within a 5 km radius of a facility ready to provide the six vaccines. Treatment of acute childhood illnesses (15 interventions) had an average coverage of around 30%. Still, individual intervention coverage ranged from 10% for the treatment of severe malnutrition to 60% for the treatment of uncomplicated malaria. Approximately 12% and 16% of the population lived within a 5 km radius of a health facility ready to provide basic surgical services and basic cardiovascular and respiratory care. Less than 10% of the population lived within a 25 km radius of a health facility ready to provide enhanced cardiovascular and respiratory care.

Discussion: We translated facility survey data on service availability into geospatially-informed estimates of service coverage. We found considerable variations in coverage across interventions in Malawi. Our approach can be adapted for other types of facility surveys, other interventions and other countries, facilitating monitoring of progress towards universal health coverage.

Introduction:

Many countries have adopted Essential Health Benefits Packages (EHPB) as a policy tool to optimize limited resources and achieve universal health coverage (UHC), yet their implementation remains limited.[1,4,42] To effectively achieve UHC, it is essential to identify who is covered and by which specific services.[50] The availability of reliable and high-quality health information is crucial for evidence-informed policy development and effective implementation.[51–55]

Weak national health information systems hinder tracking EHBP implementation.[56] Consequently, countries and global health partners often rely on household surveys like Demographic and Health Surveys and Multiple Indicator Cluster Surveys, which focus on basic, high-value services for children, reproductive-age women, and some infectious diseases. While valuable for advocacy and global benchmarking, these surveys are less useful for country-level planning and lack the breadth necessary to evaluate EHBP implementation comprehensively.[57–60] Further, these surveys do not account for geographical accessibility, which can limit the number of patients who can utilize services.[61] Many studies use geographic proximity to healthcare facilities as a proxy for coverage; however, this does not guarantee service availability if the facilities are not ready to provide care.[62]

The lack of reliable coverage data further hinders UCH efforts. Researchers and policymakers are often compelled to use proxy indicators and expert opinions to inform policy decisions, thereby increasing uncertainty in quantifying and allocating investments needed to achieve UHC.[63] Leveraging existing datasets to estimate coverage for a broad set of health services is critical, especially for health systems with limited resources to expand health information infrastructure.[64]

Malawi has adopted EHBP for over twenty years, but limited resources and a lack of enforcement challenge its implementation.[65] According to the Health Sector Strategic Plan II, in 2016, 75% of Malawi's population lived within 8 kilometers of a primary healthcare facility, which is considered covered.[66] Although a health facility's geographical presence is necessary for health access, it does not necessarily mean receiving care.[67,68] For example, 55.6 % of women aged 15-49 considered distance a significant barrier to healthcare access.[69] Phiri et al. (2023) estimated that 62% of households in the Zomba district could walk 60 minutes to the health facility.[70]

Health services coverage is vital to achieving UHC, and it should be characterized periodically to support evidence-informed policies and practices, including EHBP planning and implementation.[71] The extent of coverage of supply-side determinants is critical for identifying national and subnational priorities. The Effective Coverage Think Tank states that different data sources, including service contact, inputs, interventions, quality of care, and user adherence, must be combined to assess effective coverage optimally and identifies that health facility assessments are suitable for estimating input-adjusted coverage.[72] Our study aims to develop measures to monitor the national adoption and implementation of a broad number of health interventions that serve as the basis of EHBP across countries. It combines facility readiness assessment and spatial analysis to assess input-adjusted coverage. More specifically, the study aims to:

I. Explore the possible set of EBI tracked by the Harmonized Health Facility Survey (HHFA)

II. Develop specific composite service readiness indicators based on the required basic inputs.
III. Assess health service coverage in Malawi by synthesizing data from the 2019 HHFA survey and spatial distribution of population estimates.

Methods:

Study setting: Malawi's health care system operates through public, private for-profit (PFP), and private not-for-profit (PNFP) facilities. Public healthcare providers, including government and Christian Health Association of Malawi (CHAM) facilities, provide universal access without requiring point-of-care payments.[66] PFP and PNFP facilities collectively represent 11% of all healthcare institutions and cater to a smaller population segment.[70,73] The healthcare system is organized into three tiers: primary care is provided in health centers and rural community hospitals (RCHs), district hospitals (DHs) are the first referral level, and central hospitals (CHs) offer advanced and specialized medical services.[66]

Data sources: The study utilized multiple sources to ensure a comprehensive assessment of input-adjusted population coverage. The list of interventions included in the analysis was derived from recommendations by the Disease Control Priorities Project.[74] These interventions span major health areas including infectious diseases, surgical care, and mental health and were recommended for EHBP based on value for money, feasibility, and relevance in low- and middle-income countries. The original Disease Control Priorities contained 218 interventions and have been further standardized and aggregated through an additional literature review and experience working with practitioners in several countries. We mapped the interventions to the HHFA core questionnaire questions created in 2018 to determine which interventions are captured by the survey.[75]

We used a structured review process to define composite indicators based on the basic input (medicines, diagnostics, human resources, and basic infrastructure) required to provide care for each intervention, using sources like the Service Availability and Readiness Assessment (SARA) reference manual, Malawi Standard Treatment Guidelines (MSTG), disease-specific WHO guidelines, and peer-reviewed articles. Appendix 2 details the list of interventions included in the analysis, the inputs selected to be included as part of the composite indicator, and the sources used to define each indicator. We used the 2019 Malawi HHFA Data to assess healthcare facilities' service-specific readiness.

Population and sample: The 2019 HHFA in Malawi covered all health facilities in Malawi. The analysis focused on 564 publicly financed health centers and hospitals, owned by the government and CHAM, that are functional, have qualified staff to provide outpatient services, and have sufficient data on outpatient services.[76] The analysis excluded PFP and PNFP facilities.

Operational definitions:

The study's definition of service readiness employed builds on the definition proposed by Ahmed et al., which uses a low minimum to estimate the proportion of ready facilities based on the functionality of essential equipment and supplies required for delivering specific health services.[77] This study extended the approach by including whether each facility possessed the fundamental infrastructure necessary to provide health services, including access to electricity, a clean water supply, and human resources relevant to each intervention.

The definition of input-adjusted coverage we use builds on Tanahashi's Health Service Coverage and Utilization Framework[68] and the Effective Coverage Think Tank's[72] standardized cascade for measuring effective coverage. Input-adjusted coverage is defined as the percentage of the population for whom the inputs required to provide the services are available.

Data Management and Analysis

Phase 1: Mapping Interventions to Survey Data

Mapping the HHFA- Core Module with the Disease Control Priorities interventions list we categorized the interventions into three distinct groups: (1) interventions with multiple inputs comprehensively covered by the HHFA, (2) interventions for which only the availability of medicines is assessed, and (3) interventions that cannot be evaluated due to the absence of relevant questions in the HHFA dataset.

Phase 2: Developing Composite Indicators

We developed composite indicators for each intervention to assess facility readiness, incorporating key inputs such as infrastructure, human resources, diagnostics, and essential medicines. These indicators were further classified based on their quality, reflecting the extent to which they comprehensively captured the necessary readiness elements (Appendix 2). Additionally, the list of interventions was mapped to Malawi's EHBP[78] to align the analysis with the planned level of service availability across Malawi's health system.

Phase 3: Facility Readiness Assessment

We classified interventions into three groups: 1) Basic primary care that should be available at health center but might be available higher-level facilities (RCHs, DHs, CHs), 2) Enhanced primary care that should be available at RCH may be available at higher level facilities 3) Secondary care that should be available in DHs but can be available at CHs. Restricting readiness estimation to the lowest health system level expected to provide service ensures that readiness is not overestimated and accounts for the fact that Gate-keeping is not strictly enforced in Malawi.[66] We calculated intervention readiness as:

$$Intervention\ Readiness = \frac{Intervention\ Readiness = \sum_{r=1}^{i_{1-n}} Facilaities}{Total\ number\ of\ fcailaities\ \ that\ should\ provide\ the\ service}$$

Phase 4: Population Coverage Analysis

We conducted a service area analysis (SAA) to estimate the proportion of the population who come into contact with a health service ready to provide care. SAA delineates the service and maps the geographical boundaries within which the population resides or is expected to travel to access the service.[79,80] We utilized the WorldPop 2020 Population Raster dataset to calculate health service coverage, which provides high-resolution population estimates per 1 km grid cell for Malawi (open source). and followed these steps:

1. **Creation of Catchment Areas:** We adopted a nuanced approach to catchment area determination, emphasizing the importance of considering the type of health service rather than solely relying on the classification of health facilities. A 5 km catchment area was delineated around all health facilities included in the analysis to assess the coverage of primary care services. We assume that the population should be able to access primary care within 5 km (2 hours walking distance), from any facility ready to provide care. Furthermore, we employed catchment area definitions that are well-accepted internationally and employed as health service planning standards by many ministries of health, especially in Sub-Saharan Africa. The WHO accepts that a 5 km radius is associated with the capacity and access component of the UHC and is used as part of the UHC Service Coverage Index (SCI) and overall UHC scores assessment.[81] Mitikie KA et all 2020 defined accessibility of institutional delivery service as the availability of a health facility providing delivery service within 2 hour's distance by walking or with in a 5 km radius and Ashiagbor G et al 2020 used a 5 km radius to assess geographic accessibility to health care in the Ashanti Region of Ghana.[82,83]
   To assess the coverage of secondary care health services, a 25 km catchment area was established around secondary and tertiary hospitals.[84] Specialized services offered at central hospitals were excluded, as the HHFA survey questions did not assess them. Chen X and Jia P (2019) state that catchment areas represent the acceptable distance that populations are willing to travel.[85]
2. **Dissolving and summing population in the Catchment Areas:** Overlapping catchments can lead to double-counting the population in the overlapped zones. Therefore, the catchment area around ready facilities was dissolved to develop a precise estimate of the total population covered and avoid double-counting.
3. **Coverage Estimation:** The percentage of the population covered for each condition was computed as follows:

$$\text{Input adjusted } population\ coverge\ (\%): \frac{P_{dissolved}}{P_{total}}$$

$P_{dissolved}$ is the total population residing within the merged (dissolved) catchment area of all ready facilities.
P_{total} is the total population of Malawi.

Results:

For the analysis, we mapped 280 interventions to the input availability and readiness questions in the HHFA 2018 core questionnaire. Of these, we assessed readiness and input-adjusted coverage for 129 health interventions. Most of these interventions are usually provided at health centers and rural community hospitals. Table 1 summarizes the number of health interventions included in the analysis by health service level, catchment area, and composite indicator data.

Table 1: Number of health interventions and facilities included in the analysis

Health facility level			Interventions	Evaluated based on multiple components of care (n= 113)	Evaluated based on the availability of medicines only (n=16)
	Catchment area (km, radius)	n			
All health facilities	5	564	Basic primary care	57	3
All Hospitals (Rural Community Hospital, District Hospital, Central Hospital)	5	93	Enhanced primary care	36	9
District Hospital, Central Hospital	25	52	Secondary care	22	4

Coverage by service categories:

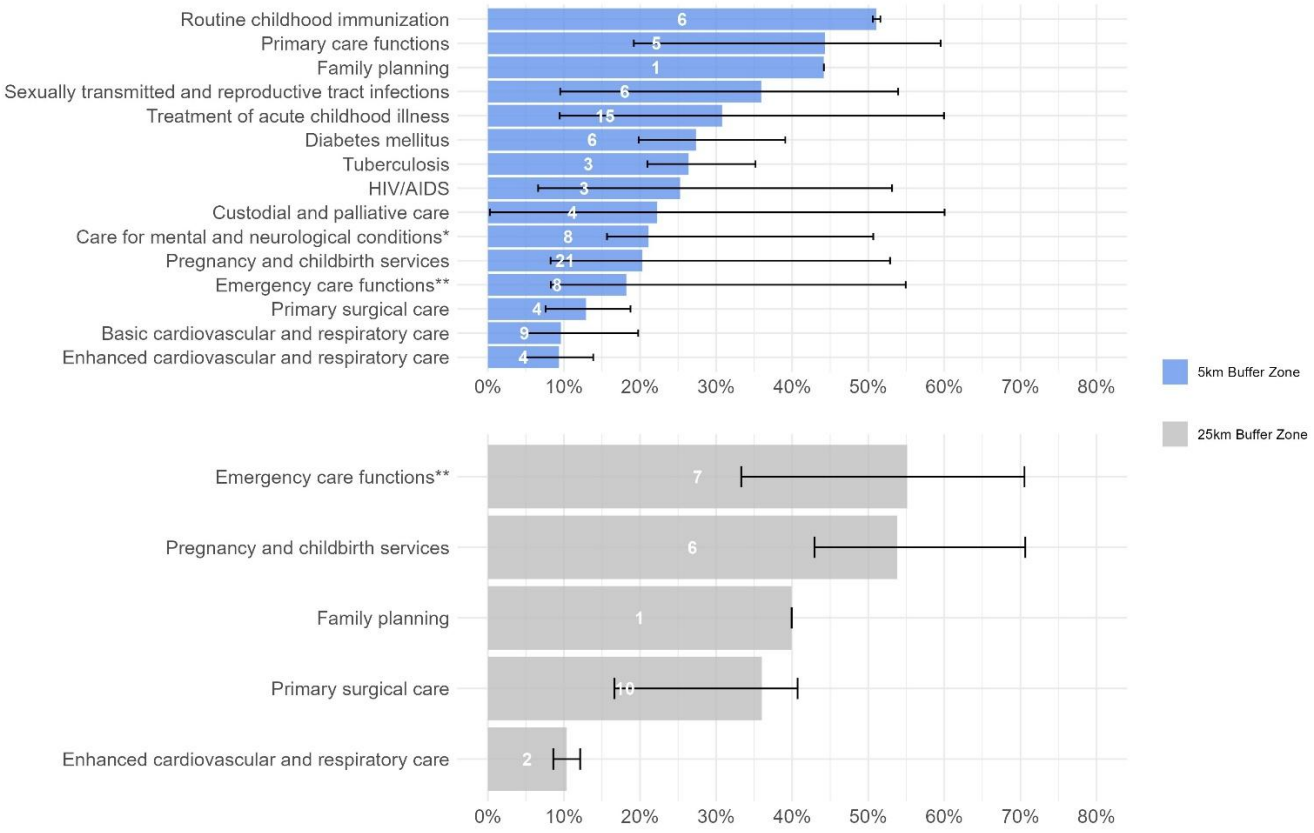
Figure 1 presents the average input-adjusted coverage for the 129 interventions grouped into 13 service categories. The service categories were adapted based on the program module defined by the Lancet commission paper "Global health 2050: the path to halving premature death by mid-century", which grouped interventions by program area with related policies and financing arrangements.[86] Pregnancy and childbirth category involve the highest number of individual interventions (21), whereas family planning services include only one intervention. The interventions used to define each service category are included in Appendix 2. Among PHC services, routine childhood vaccination (6 vaccine types) demonstrates the highest average input-adjusted coverage, with over 50% of the population residing within 5 km of a facility ready to provide these services. Primary care function (Basic Fever Evaluation, treatment of diarrheal diseases, typhoid and paratyphoid, acute lower respiratory infections, and supportive care for acute hepatitis A, for adults) and family planning (around 45%).

The figure also represents variability in the input-adjusted coverage with each service category. Apart from immunization, notable variation among the individual interventions within each service category. For example, treatment of acute childhood illnesses (15 interventions) had an average coverage of around 30%, but the interventions within this category showed variation (between 10% and 58% coverage for treatment of severe malnutrition compared to treatment of uncomplicated malaria).

The average input-adjusted coverage of secondary-level health care services assessed within a 25 km radius of DH and CH was around 55% for Pregnancy and childcare services, and Emergency care functions, which included interventions such as the management of burns and resuscitation with advanced life support measures. Input-adjusted coverage for cardiovascular and respiratory care was low

for both basic care provided at the primary level and enhanced care provided at rural hospitals and higher-level facilities.

Figure 1: Average coverage by service level and coverage catchment area (CA) :-



Note: Numbers in the bar represent the number of interventions in each service group.
** Intervention assessed based on availability of medicines only.

Table 2: Input adjusted coverage assessment by intervention- Attached HTML table

Table 2 presents detailed facility readiness and input-adjusted coverage for 129 health interventions, emphasizing the levels at which readiness was assessed and the catchment area used to determine coverage. Among basic PHC interventions, those with adequately composed indicators for meaningful readiness assessment demonstrated varying scores. For example, the treatment of uncomplicated malaria achieved the highest input-adjusted coverage, 58% of the population living within a 5 km radius of a ready facility. Other PHC interventions with a 50% input-adjusted coverage included the management of trichomoniasis, HIV treatment, and the six routine childhood vaccinations. In contrast, interventions addressing chronic respiratory diseases, such as routine longitudinal management of chronic asthma and COPD, had the lowest input-adjusted coverage, around 10 -15%.

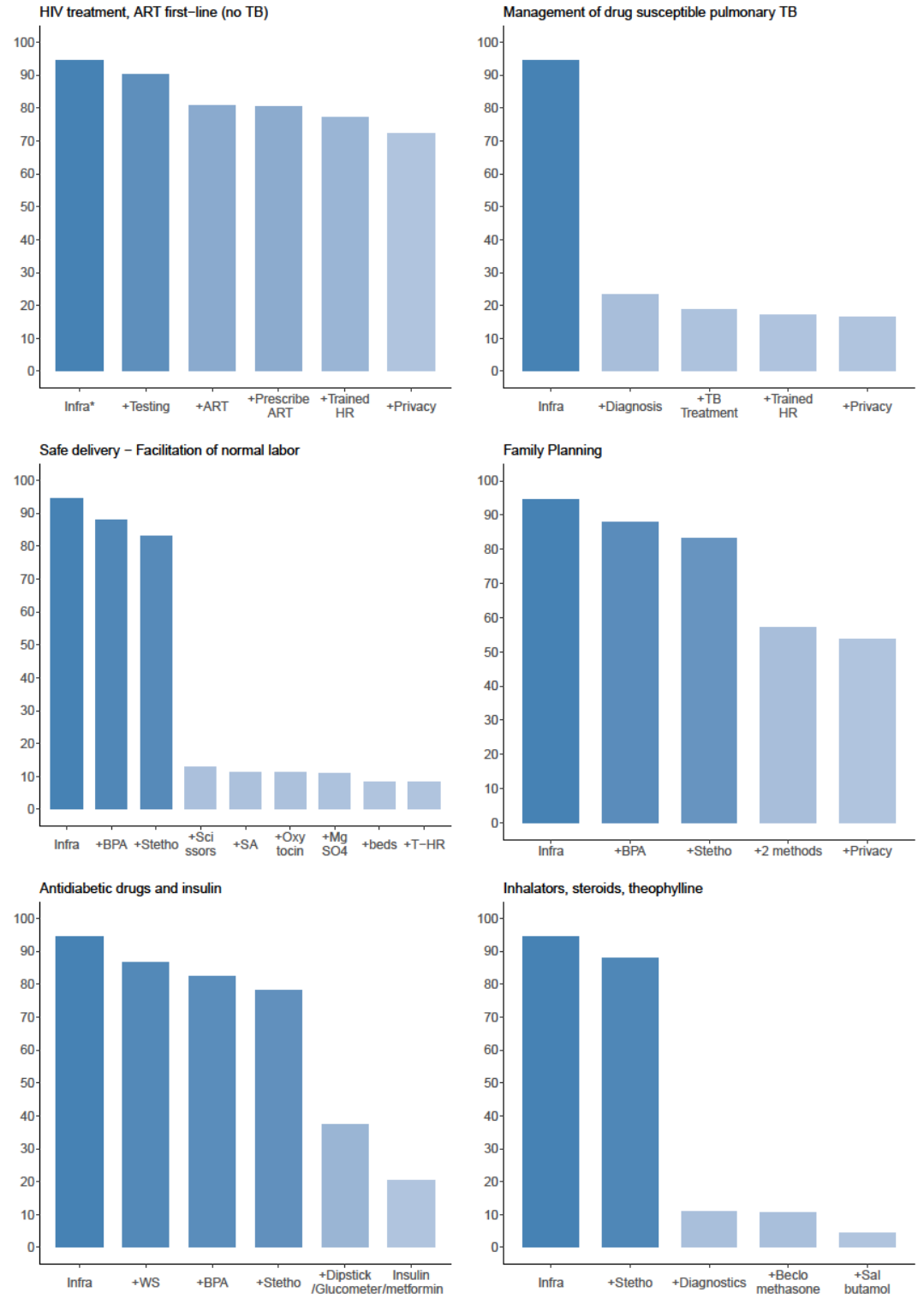
The input-adjusted coverage for PHC interventions requiring more advanced clinical skills, assessed starting at the RCH level, for example, the management of complicated malaria among children, was 18%. Input adjusted coverage for secondary prevention of ischemic heart disease and Longitudinal management of heart failure was around 5%. Around 13% of the population lived within 5 km of facilities ready to provide stabilization and referral of severe cases of asthma and COPD. In comparison, only 5% lived within 5 km of a facility ready to manage those severe cases.

For interventions requiring district hospital-level care, 70% of the population lived within 25 km of a facility ready to provide management of post-abortion complications (e.g., sepsis and lacerations). However, input-adjusted coverage for cardiovascular disease interventions, such as the treatment of acute coronary syndromes and acute heart failure, was around 12% and 8.6%, respectively. Input-adjusted coverage for surgical interventions ranged from 17% to 40% of the population living within a 25 km radius of a facility equipped to perform these procedures.

Readiness bottleneck analysis:

The analysis identified supply-side inputs contributing to low readiness and coverage scores across various health interventions. Figure 2 illustrates readiness cascades, how the least available component of care drives the indicator variable for each intervention. The most significant drop in Safe delivery readiness occurs due to the low availability of surgical scissors. In the management of type two diabetes, two readiness drops are noticeable: first, when diagnostic tests are added, and second, when medication is added. Appendix 3 included bottleneck analysis for the 129 interventions included in the study.

Figure 2: Readiness percentage by composite indicator component for selected interventions:



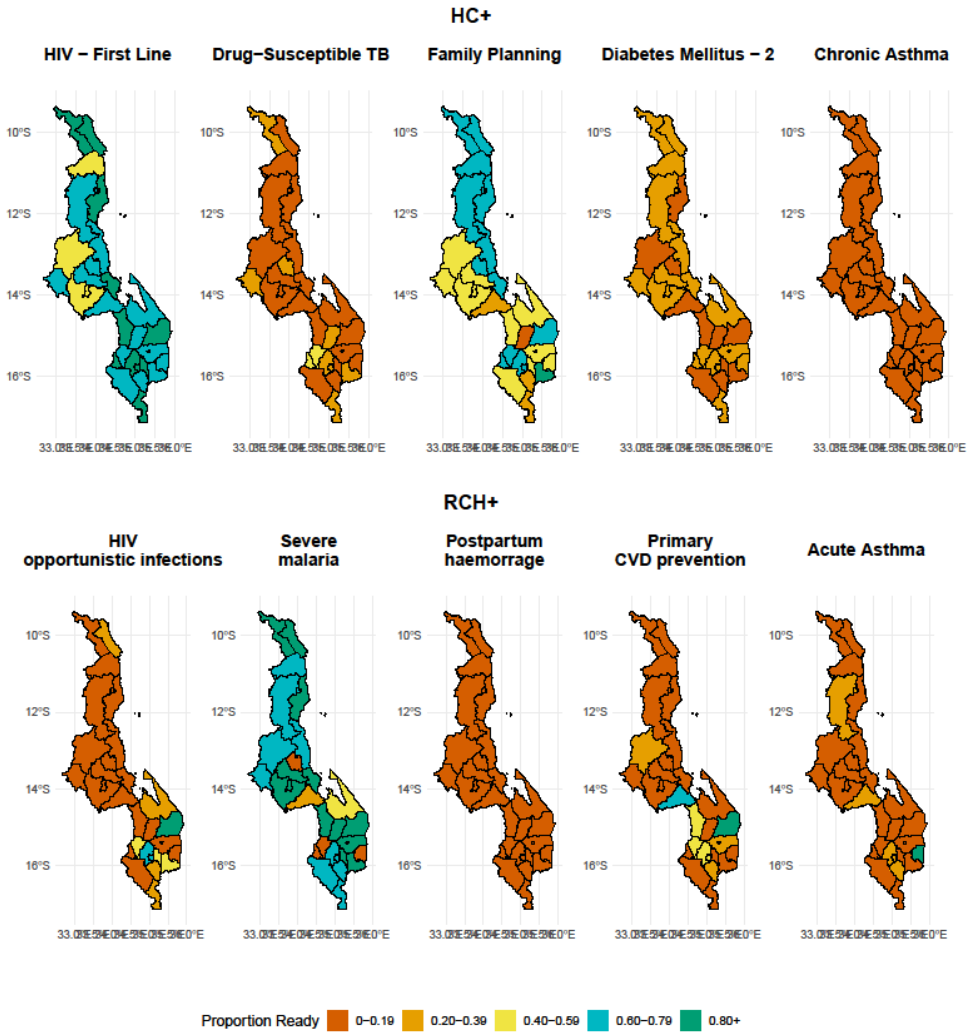
Note: Infra: infrastructure, BPA: Blood Pressure Apparatus, Stetho: Stethoscope, SA: Suction Apparatus, T-HR: Trained Human Resources

Readiness variation across districts:

Figure 3 highlights geographical variations in readiness for selected PHC services. Readiness for first-line HIV treatment was generally high across districts. Three districts, Lilongwe, Mchinji, and Rumphi, have lower readiness levels in the 40–59% range. The readiness for managing drug-susceptible TB is comparatively lower, with most districts below 20%. For family planning services, the readiness of facilities in the northern region is above 80% compared to 40 to 59% in the central region. Facility readiness for diabetes management varies between 20-39% and <20% across districts in the three regions, while readiness for managing chronic asthma is uniformly below 20%.

The readiness of hospitals for managing HIV-associated opportunistic infections is below 20% in most districts, apart from Neno and Machinga, and districts in the southern region have a readiness of 60 to 79% and >80%, respectively. Readiness for managing postpartum hemorrhage is below 20% for all districts. CVD primary prevention demonstrates higher readiness in some districts in the southern and central regions. Appendix 4 includes service readiness by district map for all interventions analyzed.

Figure 3: Facility readiness comparison across selected primary healthcare services across districts:



HC+: Basic PHC services assessed across all health facilities. RCH+: Enhanced PHC services are assessed starting at rural and community hospitals.

Discussion:

This study presents a comprehensive analysis of health facility readiness and input-adjusted coverage for a wide range of essential health interventions in Malawi. The findings highlight significant variations in readiness and coverage across service categories, facility levels, and geographical locations, offering critical insights into the implementation efforts of UHC policies and plans in Malawi. We used equal-weight composite indicators of essential health service inputs to assess health facility readiness based on 2019 Malawi HHFA data. We evaluated the adequacy of data points in the HHFA survey that can provide information on these essential service inputs and documented the comparative adequacy of each indicator. We developed readiness cascades for each intervention to ensure transparency of the composite indicators and identify bottleneck inputs, which provide critical insights into the infrastructure, equipment, and human resource gaps undermining service readiness and hence coverage. We created a hierarchical catchment and used SAA, a robust method for determining input-adjusted coverage in Malawi.

Key Findings and Implications

Our analysis revealed high readiness and coverage for routine childhood vaccinations, HIV/AIDS, and malaria management, which reflect the prioritization of these services in national health policies and international donors' support. For example, malaria management readiness was 84%, an improvement over previous estimates using 2013-2014 Service Provision Assessment (SPA) data, which reported readiness at 25%.[87] Despite methodological differences, this progress indicates focused investments in infrastructure, diagnostics, and medicines for these high-priority interventions.

Conversely, readiness for NCDs and surgical care remains low. For example, readiness for cardiovascular disease management at district hospitals was less than 15%, with only 8.6% of the population living within 25 km of a facility capable of providing care for acute heart failure. This disparity reflects critical imbalances in health service prioritization. It highlights the urgent need for targeted investments in under-resourced areas of care, especially with the shifting burden of disease in Malawi, as NCDs are starting to become a leading cause of mortality and morbidity in the country.

Our study found that 41% of health facilities in Malawi were ready to provide early detection and treatment for neonatal sepsis and pneumonia. Similarly, Penzias et al. (2023) reported that 50% of neonatal units implementing the Newborn Essential Solutions and Technologies (NEST360) initiative in Malawi met service readiness criteria.[88] While our study uses composite indicators, Penzias et al. (2023) applied two alternative scoring frameworks. Despite the differences in the number and level of facilities assessed, both studies reveal persistent gaps in neonatal care readiness.

Methodological Innovations and Comparisons

Unlike studies that use a broad service readiness index to assess general facility capacity, our study adopted an intervention-specific approach. For example, while Leslie et al. (2017) provided an overall service readiness index for each facility based on a fixed set of WHO indicators,[89] we evaluated readiness in terms of a facility's capacity to deliver targeted interventions. This approach integrates

relevant factors such as the availability of specific medicines and trained personnel, ensuring that readiness assessments are directly aligned with service delivery needs and provide a more precise measure of how facility-level readiness translates into population-level service coverage.

Current health service coverage estimation literature is increasingly utilizing geospatial mapping. Safura AH et al. (2021) used SAA to evaluate health service coverage and access in North Jakarta.[90] Amoah Nuamah J et al. (2023) used SAA to identify the number of communities outside the WHO-recommended 5 km distance to access health facilities.[91] Shaba HA et al. 2023 used SAA to assess the distribution of healthcare facilities in Nigeria, Plateau State.[92] This study advances the methodology for evaluating health service coverage by combining facility readiness and spatial analyses. The hierarchical catchment area methodology used here is particularly innovative, as it allows for service-specific coverage assessments tailored to different facility levels and intervention types.

Our analysis highlights that even if people live close to a facility, they may not have access to all the services they need, especially for neglected conditions like NCDs. Previous studies have not examined variations in coverage across interventions within the same facility, which is where this study adds value. For example, McBride and Moucheraud (2022) reported that most households in Malawi live within 5 km of a health facility offering comprehensive primary care services.[93] Their definition of "comprehensive" services was based on facilities providing more than the median percentage of required services for their level (primary or secondary), as assessed by SPA survey data. However, this definition did not incorporate measures of facility readiness, likely overestimating the accurate coverage of health services.

Based on DHS surveys, crude coverage rates (percent of patients needing treatment who received it within a specified time frame), have also been used to assess health service coverage. My findings align with and extend those of Wang et al. (2019), who assessed effective coverage by combining crude coverage (percentage of facility-based deliveries in the two years preceding the survey) with facility readiness. Their study demonstrated that although Malawi achieved 93% crude coverage for facility deliveries, effective coverage was only 66% after accounting for readiness gaps.[94] These findings emphasize the importance of integrating readiness and quality measures into coverage assessments. Yet we note that crude coverage rates mask patients' hardships accessing geographically remote health facilities.

Our method enhances the application of health facility surveys by incorporating geospatial mapping to generate credible estimates of health service coverage. These estimates are not merely descriptive of health system performance but serve as valuable insights for policy analysis and decision-making. For example, the intervention-specific indicators we generate are more readily mapped to EHBP contents and can be used to monitor implementation of specific EHBP components more accurately than assessing service coverage in the aggregate. Aggregate service coverage assessment masks coverage variation in service components and is often driven by high performance in HIV and child health. This may mask service-specific gaps. This methodological advancement addresses the limitations of current practices, which often rely on proxy estimates and expert opinions to fill in gaps in coverage data, thereby reducing uncertainty and improving the accuracy of health policy planning.

Strength:

The HHFA provides a robust framework for evaluating health facility readiness and input-adjusted coverage across various health interventions. It is an essential tool for advancing UHC implementation

efforts. Although input-adjusted coverage only partially reflects elements of the broader definition of effective coverage, it represents an advancement in the current coverage estimation methods that is less resource-intensive than attempting to estimate effective coverage for a broad list of interventions. This study utilized the HHFA to assess 129 interventions that included most of the interventions outlined in Malawi's EHBP. A key strength of the HHFA lies in the feasibility of integration with geospatial population data, enabling input-adjusted coverage calculations that offer nuanced insights into the relationship between service readiness and geographical health facility coverage. The level of disaggregation of information can inform local planning efforts and allow targeting of investment and available budgets toward high-priority interventions. Furthermore, the flexibility of the composite indicators approach will enable tailoring them to reflect locally relevant inputs, ensuring alignment with national health priorities and contextual needs. Further, the same composite indicator method can be applied to additional interventions based on local context.

Limitations:

While the HHFA provides a robust framework for readiness assessment, its primary focus on PHC limits the quality of secondary and tertiary care readiness indicators. For example, readiness assessments for cancer care are limited. The comprehensiveness of readiness indicators varies across interventions and could introduce bias. Interventions assessed by using simplified indicators, such as the availability of medicines, often yield inflated readiness scores. For instance, readiness for intermittent malaria prevention during infancy, assessed using a basic indicator (availability of sulfadoxine-pyrimethamine and basic infrastructure), achieved a high readiness score of 89%. In contrast, readiness for intermittent malaria prevention during pregnancy, which includes more comprehensive indicators (e.g., whether antenatal care providers received training in IPTp within the past two years), was considerably lower at 37%.

Another critical limitation is that the analysis did not include direct measures of service provider availability, which is a fundamental component of facility readiness. The exclusion of such measures may lead to overestimations of facility readiness, particularly in under-resourced areas where workforce shortages significantly constrain service delivery. Including provider-related metrics, such as staff availability, would improve the reliability of readiness assessments and enhance their applicability to real-world health system challenges. Further, our analysis is likely underestimating coverage for interventions delivered through outreach activities, such as vaccination services.

This study highlights that the HHFA can provide nuanced and comprehensive data on input-adjusted coverage, making it a valuable tool for guiding the development and implementation of EHBPs in Malawi and other countries. By identifying key supply-side bottlenecks, the findings provide policymakers with actionable insights to optimize resource allocation and enhance health system performance. Expanding the scope of the survey to include targeted questions for NCDs and advanced care would significantly enhance HHFA utility and substantially improve the comprehensiveness and precision of readiness estimates. Future research should examine the potential of utilizing the HHFA quality module to go beyond input-adjusted coverage to assess quality-adjusted coverage, which can further close the gap in

effective coverage assessment. Further exploring more advanced geospatial mapping to produce nuanced coverage estimates by specific gender and by district can also be explored.

References:

1. Alwan A, Siddiqi S, Safi M, et al. Addressing the UHC Challenge Using the Disease Control Priorities 3 Approach: Lessons Learned and an Overview of the Pakistan Experience. *Int J Health Policy Manag*. 2023;12:8003. doi:10.34172/ijhpm.2023.8003

2. Shekh Mohamed I, Hepburn JS, Ekman B, Sundewall J. Inclusion of Essential Universal Health Coverage Services in Essential Packages of Health Services: A Review of 45 Low- and Lower- Middle Income Countries. *Health Syst Reform*. 2022;8(1):e2006587. doi:10.1080/23288604.2021.2006587

3. Danforth K, Ahmad AM, Blanchet K, et al. Monitoring and evaluating the implementation of essential packages of health services. *BMJ Glob Health*. 2023;8(Suppl 1):e010726. doi:10.1136/bmjgh-2022-010726

4. Norheim OF, Watkins DA. The Role of HTA for Essential Health Benefit Package Design in Low or Middle-Income Countries. *Health Syst Reform*. 2023;9(3):2273051. doi:10.1080/23288604.2023.2273051

5. Darrudi A, Khoonsari MHK, Tajvar M. Challenges to Achieving Universal Health Coverage Throughout the World: A Systematic Review. *J Prev Med Pub Health*. 2022;55(2):125-133. doi:10.3961/jpmph.21.542

6. Lofgren KT, Watkins DA, Memirie ST, Salomon JA, Verguet S. Balancing health and financial protection in health benefit package design. *Health Econ*. 2021;30(12):3236-3247. doi:10.1002/hec.4434

7. Baltussen R, Jansen MP, Bijlmakers L, Tromp N, Yamin AE, Norheim OF. Progressive realisation of universal health coverage: what are the required processes and evidence? *BMJ Glob Health*. 2017;2(3):e000342. doi:10.1136/bmjgh-2017-000342

8. Jimba M, Fujimura MS. Shrink the universal health coverage cube. *The Lancet*. 2018;392(10164):2551. doi:10.1016/S0140-6736(18)32518-2

9. Universal health coverage (UHC). Accessed April 10, 2023. https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)

10. Baltussen R, Youngkong S, Paolucci F, Niessen L. Multi-criteria decision analysis to prioritize health interventions: Capitalizing on first experiences. *Health Policy*. 2010;96(3):262-264. doi:10.1016/j.healthpol.2010.01.009

11. Jehu-Appiah C, Baltussen R, Acquah C, et al. Balancing Equity and Efficiency in Health Priorities in Ghana: The Use of Multicriteria Decision Analysis. *Value Health*. 2008;11(7):1081-1087. doi:10.1111/j.1524-4733.2008.00392.x

12. Hendrix N, Bolongaita S, Villano D, Memirie ST, Tolla MT, Verguet S. Equitable Prioritization of Health Interventions by Incorporating Financial Risk Protection Weights Into Economic Evaluations. *Value Health*. 2023;26(3):411-417. doi:10.1016/j.jval.2022.09.007

13. Schwappach DLB. Resource allocation, social values and the QALY: a review of the debate and empirical evidence. *Health Expect Int J Public Particip Health Care Health Policy*. 2002;5(3):210-222. doi:10.1046/j.1369-6513.2002.00182.x

14. Verguet S, Olson ZD, Babigumira JB, et al. Health gains and financial risk protection afforded by public financing of selected interventions in Ethiopia: an extended cost-effectiveness analysis. *Lancet Glob Health*. 2015;3(5):e288-e296. doi:10.1016/S2214-109X(14)70346-8

15. Baltussen R, Niessen L. Priority setting of health interventions: the need for multi-criteria decision analysis. *Cost Eff Resour Alloc*. 2006;4(1):14. doi:10.1186/1478-7547-4-14

16. Farley K, Thompson C, Hanbury A, Chambers D. Exploring the feasibility of Conjoint Analysis as a tool for prioritizing innovations for implementation. *Implement Sci*. 2013;8(1):56. doi:10.1186/1748-5908-8-56

17. Drummond et al. MF. , Fouth Edition. Scribd. 2015. Accessed January 2, 2023. https://www.scribd.com/document/422116097/Drummond-Methods-for-the-Economic-Evaluation-of-Health-Care-Programmes-pdf

18. Chan M. Making Fair Choices on the Path to Universal Health Coverage. *Health Syst Reform*. 2016;2(1):5-7. doi:10.1080/23288604.2015.1111288

19. World Health Organization. *Making Fair Choices on the Path to Universal Health Coverage: Final Report of the WHO Consultative Group on Equity and Universal Health Coverage*. World Health Organization; 2014. Accessed March 2, 2025. https://iris.who.int/handle/10665/112671

20. Verguet S, Norheim OF. Estimating and Comparing Health and Financial Risk Protection Outcomes in Economic Evaluations. *Value Health*. 2022;25(2):238-246. doi:10.1016/j.jval.2021.08.004

21. Hendrix N, Bolongaita S, Villano D, Memirie ST, Tolla MT, Verguet S. Equitable Prioritization of Health Interventions by Incorporating Financial Risk Protection Weights Into Economic Evaluations. *Value Health*. 2023;26(3):411-417. doi:10.1016/j.jval.2022.09.007

22. Mangham LJ, Hanson K, McPake B. How to do (or not to do) … Designing a discrete choice experiment for application in a low-income country. *Health Policy Plan*. 2009;24(2):151-158. doi:10.1093/heapol/czn047

23. NonAsciiFileName0.pdf. Accessed June 30, 2023. https://documents1.worldbank.org/curated/en/586321468156869931/pdf/NonAsciiFileName0.pdf

24. Aizaki H, Nishimura K. Design and Analysis of Choice Experiments Using R: A Brief Introduction. *Agric Inf Res*. 2008;17(2):86-94. doi:10.3173/air.17.86

25. Bridges JFP, Hauber AB, Marshall D, et al. Conjoint Analysis Applications in Health—a Checklist: A Report of the ISPOR Good Research Practices for Conjoint Analysis Task Force. *Value Health*. 2011;14(4):403-413. doi:10.1016/j.jval.2010.11.013

26. van den Broek-Altenburg E, Atherly A. Using discrete choice experiments to measure preferences for hard to observe choice attributes to inform health policy decisions. *Health Econ Rev*. 2020;10(1):18. doi:10.1186/s13561-020-00276-x

27. Ralph. Design of Experiments – Optimal Designs | R-bloggers. November 29, 2009. Accessed January 26, 2023. https://www.r-bloggers.com/2009/11/design-of-experiments-%e2%80%93-optimal-designs/

28. Speckemeier C, Krabbe L, Schwenke S, Wasem J, Buchberger B, Neusser S. Discrete choice experiment to determine preferences of decision-makers in healthcare for different formats of rapid reviews. *Syst Rev*. 2021;10:121. doi:10.1186/s13643-021-01647-z

29. Hauber AB, González JM, Groothuis-Oudshoorn CGM, et al. Statistical Methods for the Analysis of Discrete Choice Experiments: A Report of the ISPOR Conjoint Analysis Good Research Practices Task Force. *Value Health*. 2016;19(4):300-315. doi:10.1016/j.jval.2016.04.004

30. Kandzari DE, Weber MA, Poulos C, et al. Patient Preferences for Pharmaceutical and Device-Based Treatments for Uncontrolled Hypertension: Discrete Choice Experiment. *Circ Cardiovasc Qual Outcomes*. 2023;16(1):e008997. doi:10.1161/CIRCOUTCOMES.122.008997

31. Schwappach DLB. Resource allocation, social values and the QALY: a review of the debate and empirical evidence. *Health Expect Int J Public Particip Health Care Health Policy*. 2002;5(3):210-222. doi:10.1046/j.1369-6513.2002.00182.x

32. Mirelman A, Mentzakis E, Kinter E, et al. Decision-Making Criteria among National Policymakers in Five Countries: A Discrete Choice Experiment Eliciting Relative Preferences for Equity and Efficiency. *Value Health*. 2012;15(3):534-539. doi:10.1016/j.jval.2012.04.001

33. Bae EY, Lim MK, Lee B, Bae G, Hong J. Public preferences in healthcare resource allocation: A discrete choice experiment in South Korea. *Health Policy*. 2023;138:104932. doi:10.1016/j.healthpol.2023.104932

34. Jouyani Y, Hadiyan M, Salehi M, Souri A. Using discrete choice model to elicit preference for health-care priority setting. *J Educ Health Promot*. 2019;8:117. doi:10.4103/jehp.jehp_404_18

35. Eregata GT, Hailu A, Geletu ZA, et al. Revision of the Ethiopian Essential Health Service Package: An Explication of the Process and Methods Used. *Health Syst Reform*. 2020;6(1):e1829313. doi:10.1080/23288604.2020.1829313

36. Ottersen T, Mbilinyi D, Mæstad O, Norheim OF. Distribution matters: Equity considerations among health planners in Tanzania. *Health Policy*. 2008;85(2):218-227. doi:10.1016/j.healthpol.2007.07.012

37. Lofgren KT, Watkins DA, Memirie ST, Salomon JA, Verguet S. Balancing health and financial protection in health benefit package design. *Health Econ*. 2021;30(12):3236-3247. doi:10.1002/hec.4434

38. Johnson FR, Backhouse M. Eliciting stated preferences for health-technology adoption criteria using paired comparisons and recommendation judgments. *Value Health J Int Soc Pharmacoeconomics Outcomes Res*. 2006;9(5):303-311. doi:10.1111/j.1524-4733.2006.00119.x

39. whats-in-whats-out-designing-benefits-final.pdf. Accessed September 6, 2023. https://www.cgdev.org/sites/default/files/whats-in-whats-out-designing-benefits-final.pdf

40. World Bank. Making explicit choices on the path to UHC - the JLN Health Benefits Package Revision Guide.

41. Anderson I, Maliqi B, Axelson H, Ostergren M. How can health ministries present persuasive investment plans for women's, children's and adolescents' health? *Bull World Health Organ*. 2016;94(6):468-474. doi:10.2471/BLT.15.168419

42. Alwan A, Yamey G, Soucat A. Essential packages of health services in low-income and lower-middle-income countries: what have we learnt? *BMJ Glob Health*. 2023;8:e010724. doi:10.1136/bmjgh-2022-010724

43. Alwan A, Majdzadeh R, Yamey G, et al. Country readiness and prerequisites for successful design and transition to implementation of essential packages of health services: experience from six countries. *BMJ Glob Health*. 2023;8(Suppl 1):e010720. doi:10.1136/bmjgh-2022-010720

44. Saeed KMA, Osmani S, Collins D. Calculating the Cost and Financing Needs of the Basic Package of Health Services in Afghanistan: Methods, Experiences, and Results. *Glob Health Sci Pract*. 2022;10(4). doi:10.9745/GHSP-D-21-00658

45. Barber SL, O'Dougherty S, Vinyals Torres L, Tsilaajav T, Ong P. Other considerations than: how much will universal health coverage cost? *Bull World Health Organ*. 2020;98(2):95-99. doi:10.2471/BLT.19.238915

46. Gaudin S, Raza W, Skordis J, Soucat A, Stenberg K, Alwan A. Using costing to facilitate policy making towards Universal Health Coverage: findings and recommendations from country-level experiences. *BMJ Glob Health*. 2023;8(Suppl 1):e010735. doi:10.1136/bmjgh-2022-010735

47. Watkins DA, Qi J, Kawakatsu Y, Pickersgill SJ, Horton SE, Jamison DT. Resource requirements for essential universal health coverage: a modelling study based on findings from Disease Control Priorities, 3rd edition. *Lancet Glob Health*. 2020;8(6):e829-e839. doi:10.1016/S2214-109X(20)30121-2

48. Watkins DA, Jamison DT, Mills A, et al. Box 3.1, Defining Delivery Platforms for Essential UHC in DCP3: A Standardized Typology. November 27, 2017. Accessed April 9, 2025. https://www.ncbi.nlm.nih.gov/books/NBK525285/

49. Ministry of Health. Malawi- Health Sector Strategic Plan III 2023-2030 - Reforming for Universal Health Coverage.pdf. Published online 2022.

50. Measuring health coverage - OECD. Accessed July 16, 2023. https://www.oecd.org/els/health-systems/measuring-health-coverage.htm

51. Koumamba AP, Bisvigou UJ, Ngoungou EB, Diallo G. Health information systems in developing countries: case of African countries. *BMC Med Inform Decis Mak*. 2021;21(1):232. doi:10.1186/s12911-021-01597-5

52. Bosch-Capblanch X, Ronveaux O, Doyle V, Remedios V, Bchir A. Accuracy and quality of immunization information systems in forty-one low income countries. *Trop Med Int Health*. 2009;14(1):2-10. doi:10.1111/j.1365-3156.2008.02181.x

53. Harrison K, Rahimi N, Carolina Danovaro-Holliday M. Factors limiting data quality in the expanded programme on immunization in low and middle-income countries: A scoping review. *Vaccine*. 2020;38(30):4652-4663. doi:10.1016/j.vaccine.2020.02.091

54. Weltgesundheitsorganisation, ed. *Improving Data Quality: A Guide for Developing Countries*.; 2003.

55. Ndabarora E, Chipps JA, Uys L. Systematic review of health data quality management and best practices at community and district levels in LMIC. *Inf Dev*. 2014;30(2):103-120. doi:10.1177/0266666913477430

56. World Health Organization. Framework and standards for country health information systems. Published online Reprinted 2012 2008:63.

57. Indicators-for-Measuring-Universal-Health-Coverage-A-Five-Country-Analysis-DRAFT.pdf. Accessed July 9, 2023. https://www.hfgproject.org/wp-content/uploads/2015/02/Indicators-for-Measuring-Universal-Health-Coverage-A-Five-Country-Analysis-DRAFT.pdf

58. Boerma JT, Sommerfeltb AE. Demographic and health surveys (DHS): contributions and limitations. Published online 1993.

59. Kyu HH, Abate D, Abate KH, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*. 2018;392(10159):1859-1922. doi:10.1016/S0140-6736(18)32335-3

60. The DHS Program - Demographic and Health Survey (DHS). Accessed August 7, 2023. https://dhsprogram.com/Methodology/Survey-Types/DHS.cfm

61. Wigley AS, Tejedor-Garavito N, Alegana V, et al. Measuring the availability and geographical accessibility of maternal health services across sub-Saharan Africa. *BMC Med*. 2020;18(1):237. doi:10.1186/s12916-020-01707-6

62. Carter ED, Munos MK. Impact of imprecise household location on effective coverage estimates generated through linking household and health provider data by geographic proximity: a simulation study. *Int J Health Geogr*. 2021;20(1):38. doi:10.1186/s12942-021-00292-y

63. Watkins DA, Qi J, Kawakatsu Y, Pickersgill SJ, Horton SE, Jamison DT. Resource requirements for essential universal health coverage: a modelling study based on findings from Disease Control

Priorities, 3rd edition. *Lancet Glob Health*. 2020;8(6):e829-e839. doi:10.1016/S2214-109X(20)30121-2

64. Murray CJ, Frenk J. Health metrics and evaluation: strengthening the science. *The Lancet*. 2008;371(9619):1191-1199. doi:10.1016/S0140-6736(08)60526-7

65. Connolly E, Mohan S, Twea P, et al. Revision of Malawi's Health Benefits Package: A Critical Analysis of Policy Formulation and Implementation. *Value Health Reg Issues*. 2024;39:84-94. doi:10.1016/j.vhri.2023.10.007

66. Government of the Republic of Malawi. Health Sector Strategic Plan II (2017-2022): towards universal health coverage. Published online 2022. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://extranet.who.int/countryplanningcycles/sites/default/files/planning_cycle_repository/malawi/health_sector_strategic_plan_ii_030417_smt_dps.pdf

67. Florio P, Freire S, Melchiorri M. Estimating geographic access to healthcare facilities in Sub-Saharan Africa by Degree of Urbanisation. *Appl Geogr*. 2023;160:103118. doi:10.1016/j.apgeog.2023.103118

68. Tanahashi T. Health service coverage and its evaluation. *Bull World Health Organ*. 1978;56(2):295-303.

69. National Statistical Office and ICF. Malawi Demographic and Health Survey 2015-16. Published online 2017. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://dhsprogram.com/pubs/pdf/FR319/FR319.pdf

70. Phiri Y, Munthali KG. Primary Health Care Accessibility in Zomba, Malawi: A Spatial Modelling Approach. *Proc ICA*. 2023;5:1-7. doi:10.5194/ica-proc-5-16-2023

71. Moturi AK, Suiyanka L, Mumo E, Snow RW, Okiro EA, Macharia PM. Geographic accessibility to public and private health facilities in Kenya in 2021: An updated geocoded inventory and spatial analysis. *Front Public Health*. 2022;10:1002975. doi:10.3389/fpubh.2022.1002975

72. Marsh AD, Muzigaba M, Diaz T, et al. Effective coverage measurement in maternal, newborn, child, and adolescent health and nutrition: progress, future prospects, and implications for quality health systems. *Lancet Glob Health*. 2020;8(5):e730-e736. doi:10.1016/S2214-109X(20)30104-2

73. World Health Organization. Malawi: Country Cooperation Startegy at a glance. Published online 2018. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://iris.who.int/bitstream/handle/10665/136935/ccsbrief_mwi_en.pdf;jsessionid=6622A9B77AC48437784A63B1C127472E?sequence=1

74. Jamison DT, Alwan A, Mock CN, et al. Universal health coverage and intersectoral action for health: key messages from Disease Control Priorities, 3rd edition. *The Lancet*. 2018;391(10125):1108-1120. doi:10.1016/S0140-6736(17)32906-9

75. World Bank, pangapanga. HHFA questionnaire_combined_core. Published online 2028. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://documents1.worldbank.org/curated/en/917921611553493007/pdf/Survey-Identification-Information-Questionnaire-Description.pdf

76. Washington, D.C. : World Bank Group. Malawi - Harmonized Health Facility Assessment : 2018-2019 Report (Vol. 1 of 4) : Main Report (English). http://documents.worldbank.org/curated/en/417871611550272923

77. Ahmed S, Cao Y, Wang Z, et al. Service readiness for the management of non-communicable diseases in publicly financed facilities in Malawi: findings from the 2019 Harmonised Health Facility Assessment census survey. *BMJ Open*. 2024;14(1):e072511. doi:10.1136/bmjopen-2023-072511

78. GOVERNMENT OF THE REPUBLIC OF MALAWI. Health Sector Strategic Plan II 2017-2022. Published online 2017. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://extranet.who.int/countryplanningcycles/sites/default/files/planning_cycle_repository/malawi/health_sector_strategic_plan_ii_030417_smt_dps.pdf

79. Álvarez RG. Calculating Service Areas in ArcGIS. November 30, 2015. Accessed April 30, 2024. https://www.giscourse.com/calculating-service-areas-in-arcgis/

80. Service Area Analysis. Accessed April 30, 2024. https://reactjs.org/en/tutorial/Network/7-2ServiceAreaDia/

81. World Health Organization. Primary Health Care on the Road to Universal Health Coverage 2019 MONITORING REPORT. Published online 2019. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.who.int/docs/default-source/documents/2019-uhc-report.pdf

82. Mitikie KA, Wassie GT, Beyene MB. Institutional delivery services utilization and associated factors among mothers who gave birth in the last year in Mandura district, Northwest Ethiopia. *PLoS ONE*. 2020;15(12):e0243466. doi:10.1371/journal.pone.0243466

83. Ashiagbor G, Ofori-Asenso R, Forkuo EK, Agyei-Frimpong S. Measures of geographic accessibility to health care in the Ashanti Region of Ghana. *Sci Afr*. 2020;9:e00453. doi:10.1016/j.sciaf.2020.e00453

84. District Health Facilities - Guidelines for Development and Operation - WHO.pdf. Accessed December 11, 2023. http://www.frankshospitalworkshop.com/organisation/management_documents/District%20Health%20Facilities%20-%20Guidelines%20for%20Development%20and%20Operation%20-%20WHO.pdf

85. Chen X, Jia P. A comparative analysis of accessibility measures by the two-step floating catchment area (2SFCA) method. *Int J Geogr Inf Sci*. 2019;33(9):1739-1758. doi:10.1080/13658816.2019.1591415

86. Jamison DT, Summers LH, Chang AY, et al. Global health 2050: the path to halving premature death by mid-century. *The Lancet*. 2024;404(10462):1561-1614. doi:10.1016/S0140-6736(24)01439-9

87. Taylor C, Linn A, Wang W, Florey L, Moussa H. Examination of malaria service utilization and service provision: an analysis of DHS and SPA data from Malawi, Senegal, and Tanzania. *Malar J*. 2019;18(1):258. doi:10.1186/s12936-019-2892-x

88. Penzias RE, Bohne C, Gicheha E, et al. Quantifying health facility service readiness for small and sick newborn care: comparing standards-based and WHO level-2 + scoring for 64 hospitals implementing with NEST360 in Kenya, Malawi, Nigeria, and Tanzania. *BMC Pediatr*. 2024;23(2):656. doi:10.1186/s12887-024-04578-5

89. Leslie HH, Spiegelman D, Zhou X, Kruk ME. Service readiness of health facilities in Bangladesh, Haiti, Kenya, Malawi, Namibia, Nepal, Rwanda, Senegal, Uganda and the United Republic of Tanzania. *Bull World Health Organ*. 2017;95(11):738-748. doi:10.2471/BLT.17.191916

90. Safura AH, Andi STV, Rohmah NL, et al. Accessibility and suitability analysis of health facilities in Penjaringan Subdistrict, North Jakarta in 2021. *IOP Conf Ser Earth Environ Sci*. 2022;1039(1):012063. doi:10.1088/1755-1315/1039/1/012063

91. Amoah-Nuamah J, Agyemang-Duah W, Prosper Ninorb G, Gladstone Ekeme B. Analysis of Spatial Distribution of Health Care Facilities and its Effects on Access to Primary Healthcare in Rural Communities in Kpandai District, Ghana. *Cogent Public Health*. 2023;10(1):2183566. doi:10.1080/27707571.2023.2183566

92. Shaba HA, Omomoh E, Nannim S, et al. Cluster and Buffer Analysis of the Distribution of Healthcare Facilities in Plateau State. *Int J Med Sci Clin Res Stud*. 2023;03(10). doi:10.47191/ijmscrs/v3-i10-58

93. McBride K, Moucheraud C. Rural–Urban Differences: Using Finer Geographic Classifications to Reevaluate Distance and Choice of Health Services in Malawi. *Health Syst Reform*. 2022;8(1):e2051229. doi:10.1080/23288604.2022.2051229

94. Wang W, Mallick L, Allen C, Pullum T. Effective coverage of facility delivery in Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania. *PLOS ONE*. 2019;14(6):e0217853. doi:10.1371/journal.pone.0217853