Optimization in Universal Health Coverage Design in South Africa Considering both Health Outcomes and Health-Induced Poverty Outcomes

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Purpose

- Investing in health interventions to achieve universal health coverage (UHC), emphasized by the World Health Organization (WHO) in recent years, is a critical issue for policymakers, especially in low- and middle-income countries (LMICs)
- This study aims to identify the best set of interventions and corresponding funding percentages to enhance health benefits and financial risk protection of health benefit packages for each province in South Africa, constrained by the limited health budget and medical workforce

Data Sources

- **Intervention-specific information**: per-case health benefits (net DALYs) and per-case cost, from Tufts CEVR
- **Target population size**: obtained from (1) Disease burden from the 2016 demographic and health survey in South Africa (2) Population size estimates from Statistics South Africa
- **Health budget**: assume 50% of the budget reported in the National and provincial health budget from the National Treasury of South Africa can be allocated to health benefit packages
- **Medical workforce**: assume 20% of the medical workforces approximated for Uganda can be allocated to health benefit packages

Methods

- **Problem formulation**: a bi-objective mixed-integer linear programming model is defined with the following decision variables, and two objective functions, subject to budget and workforce constraints
- **Solving the model**: the model is solved via an iterative epsilon constraint approach that alternate between maximizing one objective while treating the other as a constraint
- **Heuristics baseline:** select intervention in the descending order of benefit-cost ratio until exceeding either budget or workforce cap

Parameters

N_{ij}: number of cases that need to receive intervention i at province j

B_i: benefit of intervention i (measured in Unit net DALYs averted) per case

Decision variables

p_{ij}: percentage of cost covered by the government

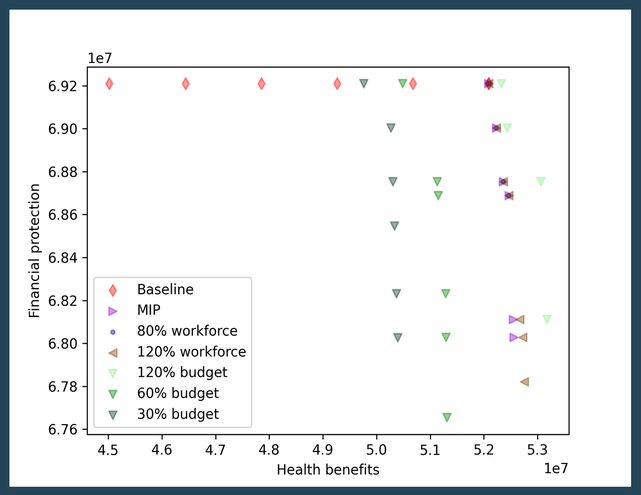
$$y_{ij} = \begin{cases} 0, & \text{if intervention } i \text{ leads to poverty at province } j \\ 1, & \text{otherwise} \end{cases}$$

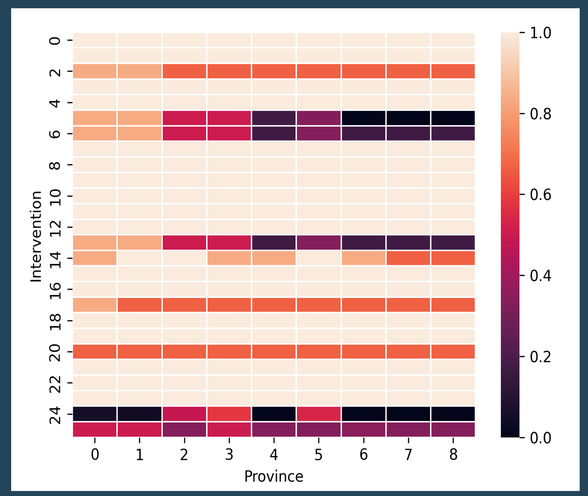
Objective functions

$$\max \sum_{i,j} B_i N_{ij} p_{ij}$$

$$\max \sum_{i,j} N_{ij} y_{ij}$$

Results





Implications

- **Competing objectives**: financial protection and health benefits are negatively correlated
- **Sensitivity analysis**: more/ less budget/ workforce leads to outward/ inward shifts of the Pareto curves
- **Better solution**: the bi-objective MIP discovers more solution compared to the heuristics baseline
- **Decision-making**: the Pareto curve provides all possible solutions and the heatmap illustrates the average coverage of each intervention at each province

Strengths

- **Consideration of medical workforce constraint**
- **Multi-criteria decision-making**: the proposed model simultaneously optimizes the interventions to be chosen and coverage of these interventions

Limitations

- Additional information is needed to determine the solution from the set
- Missing interdependencies between the authorities and the local preferences

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