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ORIGINAL RESEARCH ARTICLE

A Transparent Universal Health Coverage Index with Decomposition by Socioeconomic Groups: Application in Asian and African Settings

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Abstract

Background Health and wellbeing as one of the Sustainable Development Goals requires all countries to achieve Universal Health Coverage (UHC). That is, all people must have access to healthcare when needed at an affordable price. While several indices were developed recently to assess UHC status, these indices appeared to be difficult for practitioners to apply without statistical knowledge.

Objective This paper presents a transparent and step-by-step practical calculation method of such an index using Excel spreadsheets, applied to some Asian and African countries. We also decompose the contribution of socioeconomic groups to UHC index values.

Methods We utilized the well known UHC illustration (three-dimensional box, showing population coverage, service coverage and financial protection) to calculate the UHC index. We also broke down the index into socioeconomic groups. For validation, correlation coefficients between our index and other UHC indices were calculated and the relationship of our index with out-of-pocket (OOP) payments was estimated.

Results World Bank data from six Asian and 15 African countries on health-service coverage of people in five socioeconomic quintiles with financial protection were used to calculate our UHC index. Among the Asian countries, indices ranged between 26.0% (Nepal) and 58.7% (Kazakhstan), while in African countries indices ranged between 8.9% (Chad) and 55.3% (Namibia). Decomposition of the UHC index showed a higher contribution to the index by richer socioeconomic groups. The correlation coefficients between our estimated UHC index values and those of others ranged between 0.774 and 0.900. Our index reduced by 1.4% in response to a 1% increase in OOP payments.

Conclusions This spreadsheet approach for calculating the UHC index appeared to be useful, where the interrelation of UHC dimensions was easily observed. Decomposition of the index could be useful for policy-makers to identify the subpopulations and health services with need for further interventions towards UHC achievement.

Key Points for Decision Makers

This transparent Universal Health Coverage (UHC) index is easy to calculate using an Excel spreadsheet and with no need for advanced statistical knowledge. It can thus be useful for Ministries of Health and other relevant stakeholders in respective countries to monitor and assess the status of UHC, which is an important indicator of the journey towards sustainable development goals.

The index specifically quantifies the contribution of population coverage, service coverage and financial protection to the achieved UHC status of a country.

Decomposition of the UHC index shows how each socioeconomic group of a population contributes to the UHC status. This decomposition is useful to identify population groups at greater need for health interventions in order to achieve UHC.

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1 Introduction

Health and wellbeing as one of the Sustainable Development Goals (SDGs) requires achieving Universal Health Coverage (UHC), meaning that all people must have access to healthcare when needed, and at an affordable price [1]. In response to this UHC objective, several countries have developed monitoring and evaluation tools to measure their progress in achieving UHC [2, 3]. Such tools often include a large number of indicators, leading to difficulties in comparing the status of UHC across countries over different time periods [2]. Furthermore, even the same country can perform differently in different indicators over a given period. The benefit of having a composite index of UHC attainment thus becomes apparent. In recent years, several researchers have developed and validated such composite indices [4, 5]. Despite the usefulness of these indices, they too are methodologically challenging to apply in empirical analyses by UHC practitioners who do not have statistical knowledge, such as health service organizers (Governments, NGOs), stakeholders and policy-makers.

This study had three specific objectives: firstly, to develop a methodology for the calculation of a composite UHC index within an Excel spreadsheet; secondly, within the same spreadsheet, to decompose these index values into population groups; and thirdly, to validate the index. The relative advantage with this spreadsheet approach is that the contributions of UHC dimensions (population coverage, service coverage and financial protection) to the index are directly measurable and transparent to the audiences.

2 Methods

2.1 Concept of Universal Health Coverage (UHC)

A spreadsheet approach was undertaken to calculate the UHC index of a number of countries in Asia and Africa, using World Bank data and a formula, based upon the well known illustration depicting UHC (Fig. 1) [6]. The volume of the inner-box (actual health coverage) as a proportion of the outer-box (highest achievable health coverage) is expressed as a percentage, giving a UHC index ranging between 0 and 100%, with higher index values corresponding to better UHC achievement.

We describe below three dimensions of UHC, i.e. population coverage (length), service coverage (depth) and financial protection (height) of the UHC illustration.

2.1.1 Population Coverage

Striving for UHC is tied to the belief that all people in need, irrespective of their socioeconomic position, should be covered by all health services, whether they be promotive, preventive, curative, rehabilitative or palliative. A country's population can be divided into socioeconomic quintiles, based on an asset/wealth index [7]. Populations can be further classified into subgroups using other parameters, like geographic locations (urban, rural, suburban, hard-to-reach), gender, age (children, working-age people, elderly), and occupational attainment (blue- and white-collar workers). Since UHC promotes equal healthcare irrespective of socioeconomic status, in our index we give the same weight to all socioeconomic groups.

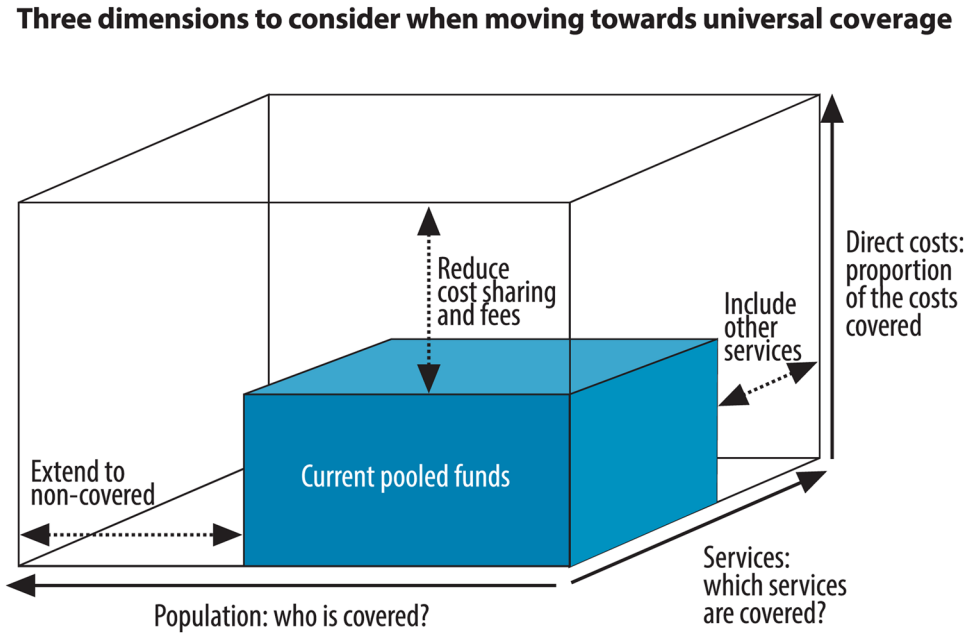


Fig. 1 Illustration of dimensions of universal health coverage. Source: http://journals.plos.org/plosmedicine/article/file?id=10.1371/journal.pmed.1001731&type=printable

2.1.2 Service Coverage

In principle, promotive, preventive, curative, rehabilitative and palliative health services should be available in order to achieve UHC in a given country. In practice, countries have different health priorities; many countries, for example, require priority services for malaria, HIV/AIDS and tuberculosis. However, some services are commonly found in all countries, including outpatient and inpatient services and immunization. Despite differences between countries, UHC places emphasis on the utilization of health services by people in need, rather than the availability of different services [5, 8].

2.1.3 Financial Risk Protection

Financial risk protection (FRP) means that payment for healthcare is not a barrier to utilizing health services and people do not beome poorer by paying for healthcare. An essential component of UHC is to ensure FRP for all people in need of health services—once again, irrespective of socioeconomic status. It is well documented that households affected by disease and illness often face 'catastrophic' health expenditure, becoming economically impoverished [9–11]. We measured the FRP situation in a country using the proxy of the proportion of households that did not face catastrophic health expenditure in utilizing healthcare. Like Wagstaff et al. [5, 8], we define a household as having experienced *catastrophic* health expenditure if their health expenditure in a given year is 25% or more of their total household consumption expenditure. Those with expenditure below 25% are therefore considered as being protected from financial risk while utilizing healthcare [5, 8].

2.2 Data and UHC Index Estimation

We used data from 21 countries to calculate the index of UHC and the impact of OOP payments on the UHC indices.

Calculation of the UHC index reflected "the proportion of defined health services actually utilized by people in five socioeconomic quintiles in comparison to full utilization of all these services by all people", which quantified the boxes in Fig. 1. The following equation was used for calculating UHC indices:[1]

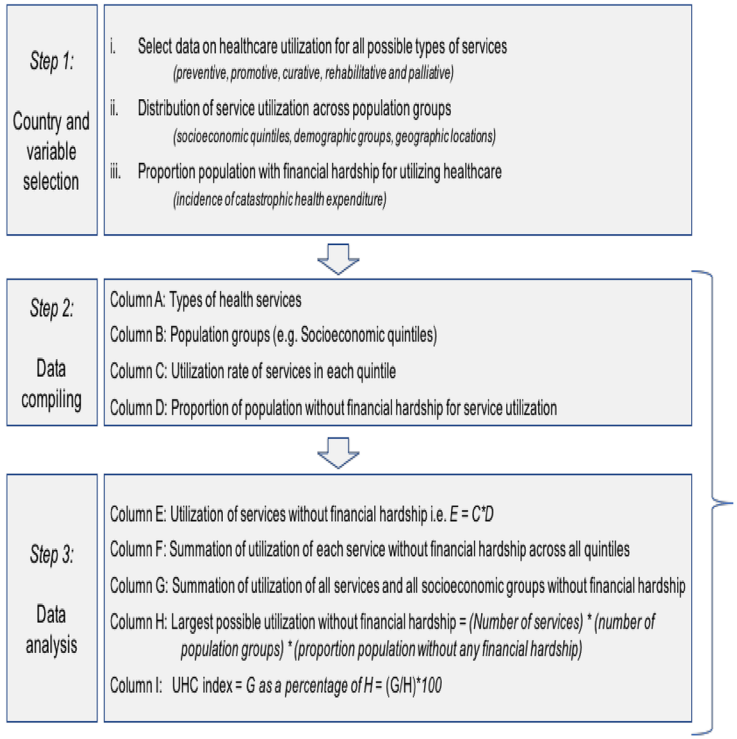
$$\begin{aligned}\text{UHC index} &= \text{Total volume of actual health service utilization by all people without facing financial hardship} \\ &\quad / \text{Total volume of potential health service utilization by all people without facing financial hardship} \\ &= \left(\begin{array}{r} \text{Length of service arm indicating actual utilization} \\ \times \text{Length of population arm who utilized the services} \\ \times \text{Length of financial risk protection arm indicating user without facing financial hardship} \end{array} \right) \\ &\quad / \left(\begin{array}{r} \text{Maximum achievable length of service arm} \\ \times \text{Maximum achievable length of population arm} \\ \times \text{Maximum achievable length of financial risk protection arm indicating no financial hardship} \end{array} \right) \ldots \end{aligned} \tag{1}$$

For calculating the indices, we used data available from the Health Equity and Financial Protection (HEFP) datasheets provided by The World Bank [7]. These datasheets provide information on healthcare service utilization, key health outcome indicators, health financing sources, the incidence of catastrophic health expenditure, and impoverishment due to out-of-pocket (OOP) health payments, disaggregated into socioeconomic groups in low- and middle-income countries (LMICs). The World Bank extracted this information from the Demographic and Health Surveys, World Health Surveys, Multiple Indicator Cluster Surveys, Living Standards and Measurement Surveys, and other available surveys of the LMICs [7]. During extraction, a common set of health indicators was used for all the LMICs. We therefore had the opportunity to employ these data for analysing the UHC status of 21 countries. However, data on service indicators related to rehabilitative and palliative care were unavailable in the countries under investigation [7].

[1] Mathematical expression for technical readers:

$$\text{UHC Index} = \left\{ \left(\sum_i \sum_j U_j^i \times FR_j^i \right) \div \left(\sum_i \sum_j FU \times NFR \right) \right\} \times 100$$

U_j^i is the Utilization rate of health service i in socioeconomic quintile j, FR_j^i is the proportion of population (range between 0 and 1) who faced financial risk (hardship) for utilizing any health service, FU is the full utilization of health service i in the socioeconomic quintile j and NFR is the no financial risk faced by any people (value 1).



(A) Types of health services	(B) Population group (e.g. socioeconomic quintiles)	(C) Utilization rate of services in each quintile (cm)	(D) Proportion of population without financial hardship (cm)	(E) Utilization of services without financial hardship [E = C X D] (sqr cm)	(F) Summation of utilization of each service without financial hardship across all quintiles (cubic cm)	(G) Summation of utilization of all services and all population groups without financial hardship (cubic cm)	(H) Largest possible utilization without financial hardship = Number of population groups X number of services X proportion population without any financial hardship (cubic cm)	(I) UHC index
Immunization	Q1	0.539	1.000	0.539	3.55	14.06	6 services X 5 population groups X 1.000 assuming no financial hardship = 30.0	(14.06/30.0X 100) = 46.9%
	Q2	0.724	1.000	0.724				
	Q3	0.742	1.000	0.742				
	Q4	0.735	1.000	0.735				
	Q5	0.807	1.000	0.807				
Skilled antenatal care (4 visits)	Q1	0.559	0.912	0.510	3.34			
	Q2	0.632	0.912	0.576				
	Q3	0.675	0.912	0.616				
	Q4	0.849	0.912	0.774				
	Q5	0.942	0.912	0.859				
Treatment of diarrhea	Q1	0.429	0.912	0.391	2.22			
	Q2	0.452	0.912	0.412				
	Q3	0.490	0.912	0.447				
	Q4	0.478	0.912	0.436				
	Q5	0.588	0.912	0.536				
Medical treatment of ARI	Q1	0.316	0.912	0.288	2.20			
	Q2	0.402	0.912	0.367				
	Q3	0.472	0.912	0.430				
	Q4	0.508	0.912	0.463				
	Q5	0.713	0.912	0.650				
Skilled birth attendance	Q1	0.205	0.912	0.187	2.38			
	Q2	0.314	0.912	0.286				
	Q3	0.438	0.912	0.399				
	Q4	0.727	0.912	0.663				
	Q5	0.924	0.912	0.843				
Inpatient (12 months)	Q1	0.054	0.912	0.049	0.38			
	Q2	0.070	0.912	0.064				
	Q3	0.080	0.912	0.073				
	Q4	0.109	0.912	0.099				
	Q5	0.103	0.912	0.094				

Fig. 2 Step-by-step calculation of the Universal Health Coverage (UHC) index of Ghana

Table 1 Absolute and relative contribution of each socioeconomic quintile to the Universal Health Coverage (UHC) index—example from Ghana

(A) UHC index	(B) Socioeconomic quintile	(C) UHC index value excluding respective quintile (values imported from corresponding sheet)	(D) Absolute contribution (A–C)	(E) Relative contribution $(D/A) \times 100$
0.469	Q1	0.403	0.065	14.0%
	Q2	0.388	0.081	17.3%
	Q3	0.378	0.090	19.3%
	Q4	0.363	0.106	22.6%
	Q5	0.342	0.126	26.9%

2.3 Step-by-Step Calculation of the UHC Index

We assessed the volume of the inner- and outer-box of the UHC illustration (Fig. 1) for calculating the UHC index values using Eq. 1. The outer-box captured the volume indicated by the maximum possible achievable volume, meaning that all the population in all socioeconomic quintiles utilized all health services without any financial hardship. We assumed that a socioeconomic quintile could achieve a maximum of 1.00 cm for 1.00 health service where all people (100% or 1.00) utilized such a service without any financial hardship. This implied that the maximum achievable volume of the outer-box would cover five quintiles for six health services with full financial protection for all people, i.e. length 5.00 cm × depth 6.00 cm × height 1.00 cm = 30.0 cm^3. The inner-box, on the other hand, captured the actual length achieved for all health services by the proportion of the population who had full financial protection. For instance, if a population actually achieved 3.0 cm on all socioeconomic quintiles for 6.00 health services with full financial protection for 90% of the people, the inner-box would capture a total volume of 16.2 cm^3 (length 3.00 cm × depth 6.00 cm × height 0.90 cm). The UHC index would then reflect the share of the inner-box as a percentage of the outer-box (length 5.00 cm × depth 6.00 cm × height 1.00 cm). We followed a step-by-step approach for calculating the index using real-life data from a number of Asian and African low- and middle-income countries. Below we describe, with the help of Fig. 2, step by step how we calculated the UHC index value for Ghana.

2.3.1 Step 1: Country and Variable Selection

We targeted countries in Asia and Africa that had data on the largest common number of health services. We found that six Asian and 15 African countries had data on six health services (with utilization rate by socioeconomic quintiles). The services were Immunization, Skilled antenatal care (four visits), Treatment of diarrhoea, Medical treatment of acute respiratory infection (ARI), Skilled birth attendance (SBA) and Inpatient care (in last 12 months). These services reflected the status of preventive and curative health services in each country. In principle, all types of health service (promotive, preventive, curative, rehabilitative and palliative) should be considered in the index calculation. Due to data service constraints, like missing data on promotive, rehabilitative and palliative care, as well as unavailability of data on the same health services across countries, we could not capture the complete scenario of UHC status. Our method, however, allows for the inclusion of as many health services as possible if data are available. Additionally, we were aware that there were inpatient services related to the treatment of diarrhoea, ARI, skilled birth attendance, etc. However, it was very likely that inpatient services included many other health conditions or diseases, for instance cancer, diabetes, cardiovascular diseases, injuries and so forth. Inclusion of inpatient services might thus be justifiable even if they might have overlapped with some services, like skilled birth attendance.

Keeping data limitation in mind, we put the emphasis on utilizing the available and comparable data from the Asian and African countries for calculating the UHC index and the validation of the index values. The HEFP datasheets from the World Bank provide data for the years 1993–2006. We used data on any health services available between 2002 and 2006 for this analysis. Since data on financial risk related to every single health service was not available, we applied financial risk for countries across all services, except immunization, which was often funded by the government and its development partners (such as GAVI Alliance).

2.3.2 Step 2: Data Compiling

In step 2, data were compiled in columns A–D which were later used for calculating the index. These four columns included health service types, population groups (socioeconomic quintiles), utilization rates of services and proportion of population without financial hardship, respectively. Column A indicated six types of health services and column B showed classification of the services into five socioeconomic

quintiles. Health service utilization rate of all six types across five socioeconomic quintiles were inserted in column C. For instance, 53.9% of the total population in the poorest quintile utilized immunization in Ghana. In column D, the proportion of the population who did not face any catastrophic expenditure due to specific healthcare utilization was inserted. For example, 100% of the population who utilized an immunization service did not face catastrophic expenditure, i.e. had financial protection. We applied 100% protection since immunization services in low- and middle-income countries were often funded by the government and an international development partner (such as GAVI alliance), and no OOP payment was required for such a service. For all other health services (such as skilled birth attendant, inpatient care), we applied the proportion of people with financial protection in general in the reported country. For instance, 8.8% of the population faced catastrophic expenditure in Ghana for any health services, meaning that 91.2% of the population had financial protection [7], which was inserted in column D.

2.3.3 Step 3: Data Analysis

Columns E–I were calculated in step 3. By multiplying columns C and D, we found the service utilization rate of people with financial protection. While 20.5% of the poorest people in Ghana utilized a SBA service (in column C), 18.7% utilized this service without facing any catastrophic expenditure (column E). Column F summed up the total arm length for each health service. For instance, the total volume attributable to immunization was 3.55 cm^3 out of a maximum possible of 5.00 cm^3. Volumes for each service were calculated accordingly. Column G then summed up the total volume of all six services, accounting for 14.06 cm^3. Column H showed the maximum possible achievable volume by multiplying the number of services across all socioeconomic quintiles with full financial protection of the whole population, i.e. 6.00 cm × 5.00 cm × 1.00 cm =30.00 cm^3. Finally, the UHC index was calculated in column I, applying Eq. 1, i.e. (G/H) × 100 or (14.06 / 30.00) × 100 = 46.9%. The step-by-step calculation of UHC index is available in an Excel spreadsheet (Electronic Supplementary Material, Excel sheet 1).

2.4 Decomposition of UHC Index by Population Groups, with an Example

In any country, each socioeconomic quintile contributes to the UHC index values in connection with their healthcare utilization. Table 1 presents the method of decomposition of the UHC index using Ghana as a case study. In Ghana, the UHC index was 0.469 (or 46.9%) (column A). The socioeconomic quintiles were indicated in column B. When we put a utilization rate of '0' in the poorest quintile across all six health services, the UHC index reduced to 0.403 (column C). The absolute contribution of the socioeconomic quintile was thus 0.469–0.403 or 0.065 (column D). In the same way, the absolute contributions of the second, third, fourth and fifth quintiles were calculated to be 0.081, 0.090, 0.106 and 0.126, respectively. The relative contribution was calculated by dividing the absolute contribution of each quintile by the total UHC index value multiplied by 100 in column E. The poorest quintile's relative contribution was thus calculated as (0.065/0.469) × 100 or 14.0%. Similarly, we found the relative contributions of the second, third, fourth and fifth quintiles to be 17.3%, 19.3%, 22.6% and 26.9%, respectively.

2.5 Excel Spreadsheet with Ghana as Country Case: UHC Index Calculation and Decomposition Step by Step

The Electronic Supplementary Material contains seven Excel sheets. Excel sheet 1 shows step-by-step calculation of the UHC index. For calculating the decomposition of the index, we used Excel sheets 2–7. In sheets 2–6, the health service utilization rates in socioeconomic quintiles (Q1–Q5) were assumed to be '0' (one quintile at a time in each sheet). In sheet 7, the UHC value in total was calculated (column A). Column B represented the socioeconomic quintiles and UHC values assuming '0' in each quintile was captured in column C. Column D calculated the absolute contribution (A–C) and column E captured the relative contribution ($D/A \times 100$) of the socioeconomic quintiles.

The absolute contributions of the socioeconomic quintiles to the UHC index were later used for calculating the concentration index, which is reported in Table 3 using a method applied by Yao [12].

2.6 UHC Index Validation

For index validation, we calculated the correlation coefficients between our index values and those of other authors who estimated the UHC index or index of universal health service coverage. We estimated the effects of OOP payments on UHC achievement for further validation by employing data from the World Bank [13]. Data for explanatory variables were OOP payments expressed as a percentage of total health expenditure, GDP per capita, gender (proportion female), the proportion of elderly people in the population and the population of the country.

Since the values of UHC indices ranged between 0% and 100%, we transformed them into the logit function, which is the inverse of the logistic transform. When the function's variable represents a probability p, the logit function gives the log-odds, that is, the logarithm of the odds $p/(1-p)$. We predicted the log-odds with OOP payments as a share of

Table 2 Universal Health Coverage (UHC) and health expenditure in some Asian and African countries

Region	Country	UHC index (%)	GDP per capita[a,c]	Total health expenditure per capita[a,c]	Public health expenditure[b,c]	Out-of-pocket health expenditure[b,c]
Asia	Bangladesh	32.0	1832	41.43	39.11	58.12
	India	34.1	2922	109.69	24.51	68.48
	Kazakhstan	58.7	14,259	446.41	57.75	41.65
	Nepal	26.0	1633	79.15	29.63	57.56
	Pakistan	36.6	3770	97.69	24.75	62.52
	The Philippines	52.2	4564	133.33	39.98	48.38
Africa	Burkina Faso	27.0	1167	60.23	49.53	47.26
	Chad	8.9	1423	63.28	37.84	57.38
	Comoros	33.5	1473	47.65	49.27	50.73
	Cote D'Ivoire	29.4	2737	120.57	26.95	55.59
	Ethiopia	13.2	683	25.97	55.92	35.11
	Ghana	46.9	2442	117.71	58.05	26.99
	Kenya	36.9	2176	83.82	42.22	45.10
	Malawi	46.6	823	36.18	65.36	13.21
	Mali	27.8	1711	75.07	45.78	53.92
	Morocco	40.7	5164	227.18	28.89	58.19
	Namibia	55.3	6815	393.59	52.20	3.78
	Congo Rep	33.2	4634	103.63	55.48	44.01
	Senegal	31.6	2015	92.42	45.17	47.44
	Zambia	53.1	2350	143.82	51.73	23.56
	Zimbabwe	54.0	1893	105.23	44.47	31.38

[a]Constant 2011 in international

[b]As a percentage of the total health expenditure

[c]Average over the period 2002–2006

total health expenditure in each country. Equation 2 below was used in this estimation.

$$\text{Logit}\{p|(1-p)\} = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \varepsilon \ldots \quad (2)$$

where p denotes the probability of incurring a specific UHC index, α a constant, x_1 the OOP payments are expressed as a percentage of total health expenditure, $x_2$logged GDP per capita, x_3, x_4, x_5 denote demographic structure and $\varepsilon$is the error term.

3 Results

Based on available data, we calculated the UHC indices for six Asian and 15 African countries (Table 2). Among the reported Asian countries, Kazakhstan achieved the highest UHC index value (58.7%), followed by the Philippines (52.2%). Nepal achieved the lowest index value (26.0%). The average UHC index value in Asian countries was 39.9%, with Kazakhstan and the Philippines achieving a higher value than this average. In Nepal, the best utilization of healthcare was observed for immunization (54.2% and 82.8% in the poorest and richest quintiles, respectively), while all other services were utilized at a lower rate. For instance, medical treatment of ARI and inpatient care was utilized by only 38.0% and 7.5%, respectively, of the population in the richest quintile. It should be noticed that the country-specific health service utilization data are presented in the supplemenatary material 2.

Among the 15 African countries we considered, the highest UHC index was observed in Namibia (55.3%), followed by Zimbabwe (54.0%). The average index value among the African countries was 35.9%, with seven countries achieving higher than this average. The lowest index in Africa was observed in Chad (8.9%); other countries with low indices were Ethiopia (13.2%), Burkina Faso (27.0%) and Mali (27.8%).

In India, 20.3% of people who utilized healthcare faced financial hardship in terms of catastrophic health expenditure. It was further noticeable that India had the highest rate of OOP payments (68.5%) among all reported countries in Asia. We found that countries with a higher gross domestic product (GDP) per capita appeared to be more successful in

Table 3 Absolute and relative contribution of each socioeconomic quintile to Universal Health Coverage (UHC) index and inequality in contribution

Region	Country	UHC index (%)	Contribution of socioeconomic quintiles to UHC index						Concentration index
			Type	Q1	Q2	Q3	Q4	Q5	
Asia	Bangladesh	32.0	Absolute	0.044	0.055	0.060	0.070	0.092	0.141
			Relative	13.6%	17.0%	18.8%	21.8%	28.8%	
	India	34.1	Absolute	0.039	0.050	0.066	0.082	0.104	0.188
			Relative	11.6%	14.7%	19.4%	23.9%	30.4%	
	Kazakhstan	58.7	Absolute	0.109	0.116	0.119	0.122	0.121	0.021
			Relative	18.5%	19.7%	20.3%	20.9%	20.6%	
	Nepal	26.0	Absolute	0.037	0.040	0.048	0.052	0.083	0.161
			Relative	14.2%	15.5%	18.3%	20.1%	31.9%	
	Pakistan	36.6	Absolute	0.047	0.060	0.070	0.084	0.105	0.155
			Relative	12.7%	16.4%	19.2%	23.0%	28.8%	
	The Philippines	52.2	Absolute	0.072	0.094	0.110	0.117	0.129	0.106
			Relative	13.8%	18.0%	21.1%	22.5%	24.7%	
Africa	Burkina Faso	27.0	Absolute	0.035	0.039	0.048	0.053	0.095	0.198
			Relative	12.9%	14.6%	17.9%	19.6%	35.0%	
	Chad	8.9	Absolute	0.007	0.012	0.016	0.018	0.036	0.288
			Relative	7.9%	13.5%	17.6%	20.6%	40.4%	
	Comoros	33.5	Absolute	0.045	0.063	0.067	0.081	0.079	0.104
			Relative	13.3%	18.8%	20.1%	24.2%	23.6%	
	Cote D'Ivoire	29.4	Absolute	0.038	0.046	0.058	0.070	0.082	0.151
			Relative	12.9%	15.7%	19.8%	23.8%	27.8%	
	Ethiopia	13.2	Absolute	0.016	0.017	0.024	0.022	0.053	0.237
			Relative	12.3%	13.0%	18.0%	16.6%	40.1%	
	Ghana	46.9	Absolute	0.066	0.081	0.090	0.106	0.126	0.125
			Relative	14.0%	17.3%	19.3%	22.6%	26.9%	
	Kenya	36.9	Absolute	0.055	0.066	0.072	0.082	0.094	0.103
			Relative	14.9%	17.9%	19.4%	22.3%	25.5%	
	Malawi	46.6	Absolute	0.078	0.085	0.088	0.101	0.114	0.074
			Relative	16.8%	18.2%	19.0%	21.7%	24.4%	
	Mali	27.8	Absolute	0.083	0.085	0.087	0.096	0.128	0.085
			Relative	17.3%	17.7%	18.2%	20.1%	26.8%	
	Morocco	40.7	Absolute	0.052	0.067	0.083	0.097	0.108	0.138
			Relative	12.8%	16.5%	20.3%	23.9%	26.5%	
	Namibia	55.3	Absolute	0.091	0.103	0.111	0.119	0.129	0.066
			Relative	16.5%	18.6%	20.1%	21.6%	23.3%	
	Congo Rep	33.2	Absolute	0.052	0.062	0.069	0.072	0.077	0.073
			Relative	15.6%	18.6%	20.9%	21.8%	23.1%	
	Senegal	31.6	Absolute	0.043	0.047	0.059	0.080	0.088	0.156
			Relative	13.6%	14.7%	18.8%	25.1%	27.8%	
	Zambia	53.1	Absolute	0.087	0.093	0.099	0.123	0.131	0.089
			Relative	16.3%	17.5%	18.5%	23.1%	24.6%	
	Zimbabwe	54.0	Absolute	0.104	0.106	0.105	0.108	0.117	0.020
			Relative	19.2%	19.7%	19.5%	19.9%	21.7%	

achieving UHC. For instance, Kazakhstan and the Philippines had higher economic levels in Asia with US$14,259 and US$4,564 per capita (PPP adjusted), respectively. African countries showed a similar pattern, meaning that the countries with a higher economic level like Namibia (GDP per capita US$6,815 PPP) and Morocco (GDP per capita US$5,164 PPP) had higher UHC indices of 55.3% and 40.7%, respectively. However, we observed exceptions in some countries, for example Zimbabwe (GDP per capita

Table 4 Estimated effects of out-of-pocket payments on Universal Health Coverage (UHC) index[a] values

Variable	Model 1		Model 2	
	Odds ratio	95% CI	Odds ratio	95% CI
Out-of-pocket health expenditure[b]	0.986***	0.981; 0.992	0.985***	0.977; 0.993
GDP per capita[c]	1.382***	1.211; 1.577	1.336***	1.091; 1.636
Female population[d]			1.031	0.873; 1.217
Elderly population (65 years and above)[d]			1.025	0.886; 1.187
Total population[e]			1.043	0.958; 1.136
Constant	0.279**	0.096; 0.804	0.049	4.88e-06; 502.808
Number of observations	21		21	
Adjusted-R^2	0.707		0.692	
F value (probe > F)	25.14 (0.0000)		10.01 (0.0002)	
Mean VIF (max)	1.00 (1.00)		2.36 (3.09)	
Ramsey Reset F (Prob > F)	1.56 (0.241)		1.69 (0.221)	

**$p < 0.05$, ***$p < 0.01$

[a]Logit transformed

[b]Percent of total health expenditure

[c]Natural log

[d]As a percentage of the total population

[e]Natural log of the population in thousands

US$1,893 PPP) achieved a UHC index of 54.0%, i.e. the second largest among the African countries.

Decomposition of the UHC index generally showed a higher contribution from richer socioeconomic groups than from poorer ones. The richest quintile (Q5) contributed more than 20% towards the index values across all countries (Table 3). The highest contributions of the richest quintile to UHC index values were observed in Asia in Nepal (31.9%) and in Africa in Ethiopia (40.1%), and reached concentration indices of 0.161 and 0.237, showing great inequality across socioeconomic groups. Both countries also scored a low UHC index: 26.0% in Nepal and 13.2% in Ethiopia.

The experience of countries with high UHC values was the opposite. Kazakhstan (UHC index 58.7%) and Namibia (UHC index 55.3%) with the largest of the UHC indices in Asia and Africa, respectively, had a much more equitable distribution of contribution to their UHC index across socioeconomic groups. The richest group in Kazakhstan contributed 20.6% and the poorest 18.5% to UHC index, giving a concentration index of 0.021, which showed much more equality in healthcare utilization across socioeconomic groups. A similar experience was observed in Namibia (concentration index = 0.066) and Zambia (concentration index = 0.089). Nevertheless, some countries with a high UHC index also showed great inequality. For instance, the Philippines and Ghana had UHC indices of 52.2% and 46.9%, respectively, but also experienced high concentration indices of 0.106 and 0.125, respectively. Overall, however, there was a strong and significant correlation (-0.7519, $p = 0.0001$) between a country's UHC index and their concentration index.

For validation of our UHC index, we estimated correlation coefficients between our index values and the index values estimated by other researchers [5, 14]. The correlation coefficients between our estimated UHC index values and Wagstaff's [5] and Hogan's [14] were 0.900 (p value 0.037) and 0.774 (p value 0.000), respectively. It should be noted here that we included five countries in common with Wagstaff and all 21 countries with Hogan. This implied that our spreadsheet approach to the UHC index calculation reflected the UHC status of the reported countries similarly. Further, we fitted two models for explaining UHC indices through the level of OOP payments (Table 4). In Model 1, we controlled for both economic level (GDP per capita) and population size of the countries, while Model 2 additionally controlled for variations in demographic structure, i.e. the proportion of females and elderly people in the total population. Both regression equations explained the models well, i.e. by 70.7% (Model 1) and 69.2% (Model 2). Neither significant multicollinearity nor misspecification was found in the estimations.

Both models showed a negative significant relationship between the share of OOP payments and the UHC index. Our estimation of the recommended model (Model 2), which controlled for both economic level and demographic variations, showed that a 1% increase in OOP healthcare payments reduced the UHC index values by 1.4 percentage points. These estimations supported our hypothesis that reliance on OOP payments for healthcare reduces the probability of achieving UHC.

4 Discussion

The composite UHC index presented quantified three dimensions of UHC, as other developed indices have [4, 5]. The presentation of the index in this paper provided a transparent relationship between the dimensions and their contribution to the index. We further decomposed the index into subpopulations (socioeconomic groups) by calculating the absolute and relative contribution of each socioeconomic group to the index value of each country under investigation. Using the same method of decomposition, we could also calculate the contribution of individual health services to the index, which was not shown in this paper.

Our calculated index values were strongly correlated with those of Wagstaff's [5] and Hogan's [14]. Further validation of our index was reflected in the estimated coefficient of OOP payments on UHC index values using Eq. 2. This econometric estimation (Model 2 in Table 4) found that a 1% increase in OOP payments reduced our UHC index by 1.4% when accounting for the economic level and demographic structure of the countries. This finding was in line with a generally acceptable negative relation between OOP payments and UHC achievement.

In this paper, decomposition of the index showed that, in general, health benefits are considerably concentrated on the richer segment of society and these inequalities were, in fact, more pronounced in counties with a lower UHC achievement. We found that a higher prevalence of OOP payments for healthcare within a country contributed to inequity, favouring the richer people, in line with previous studies of benefit incidence analysis of healthcare [15, 16]. In Bangladesh, both in- and outpatient care benefits through private providers had a concentration index of 0.237, while that through public providers was 0.044 [16]. Akazili and colleagues found concentration indices of outpatient care benefits of 0.1807 in private and 0.1166 in public facilities, where the inpatient care benefits showed concentration indices of 0.4086 in private and 0.0784 in public facilities [15]. Experience from both countries demonstrated that private healthcare benefits fostered inequalities in healthcare to a much greater extent. The UHC mission aims to guarantee need-based health coverage for all people irrespective of their socioeconomic position, but the current nature of health service provision through the private sector suggests this mission is far from being achieved.

While the other researchers used the geometric mean of health service tracers [5, 14] for calculating the index, we utilized a transparent step-by-step spreadsheet approach, which should be useful for potential users (such as health managers in Ministries and local government, international health observers) without a statistical background and research skills. It should be emphasized here that our spreadsheet approach can even be used for monitoring the service coverage status in local (subdistrict) and regional (province) areas, as well as in any health service catchment areas, by customising the spreadsheet to local conditions.

In principle, any number of possible service indicators and population strata, as well as the indicator of financial protection, can be accommodated in constructing the proposed index. Though we have placed an equal weight across all services and population groups, it is possible to assign different weights according to the priority of services and subpopulations in calculating the index. If the service utilization rates change over time in subpopulations in a way that the total length of coverage remains the same, our index value will not be sensitive to these changes while equal weights are applied. The index values will, however, be sensitive if different weights are applied for different services and in different population subgroups. Use of sex- and age-standardized service utilization rates might be more useful for comparing the index values across countries. In this initial phase of developing the index, we focused on actual values reflecting three dimensions of UHC (population coverage, service coverage and financial protection). Since we did not find any priority in specific health services and population groups for any global health policy for achieving UHC, we assumed the same weight across services and subpopulations. It is, however, technically simple to add weights in the analysis.

In a practical context, data on utilization of services like rehabilitative and palliative care are often missing in most of the low- and middle-income countries. However, we expect that through ongoing research into UHC, more data will be available in the near future that will be useful to calculate more robust UHC index values using this current method. We expect that more robust and frequent data on healthcare utilization and financial risk protection will be more useful to observe the UHC status of the countries and their progress over periods. We would also benefit from quantifying the effects of any changes in service utilization by any socioeconomic groups. It is also possible to classify the populations according to demographic characteristics (age group, male-female), residence (urban, rural, semi-urban, hard-to-reach area) etc. for observing the population coverage of healthcare. The countries will then be able to identify their under-developed areas of health services for future intervention for achieving universal health coverage.

5 Conclusion

A spreadsheet approach for calculating a UHC index worked well for our analyses, where the interrelation of UHC dimensions to the index values could easily be observed. Decomposition of the index into socioeconomic groups was useful

for identifying the target population for further intervention aimed at UHC. The index was validated by estimating the correlation coefficients with other relevant UHC indices and also by estimating the effect of OOP payments on our index values. The proposed UHC index is expected to be used by UHC practitioners without any advanced knowledge in statistics, and they can simply observe the efforts of their work towards UHC as the index is sensitive to any changes in health coverage by any subpopulations and for any health services in the country. This index can also be useful for observing affordable health service coverage in local and regional levels in any country.

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Compliance with Ethical Standards

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References

1. Kieny MP, Bekedam H, Dovlo D, Fitzgerald J, Habicht J, Harrison G, et al. Strengthening health systems for universal health coverage and sustainable development. Bull World Health Organ. 2017;95:537–9.
2. Huda T, Khan JAM, Ahsan KZ, Jamil K, El Arifeen S. Monitoring and evaluating progress towards Universal Health Coverage in Bangladesh. PLoS Med. 2014;11:e1001722.
3. Nyonator F, Ofosu A, Segbafah M, D'Almeida S. Monitoring and evaluating progress towards Universal Health Coverage in Ghana. PLoS Med. 2014;11:e1001691.
4. Prinja S, Gupta R, Bahuguna P, Sharma A, Kumar Aggarwal A, Phogat A, et al. A composite indicator to measure universal health care coverage in India: way forward for post-2015 health system performance monitoring framework. Health Policy Plan. England. 2017;32:43–56.
5. Wagstaff A, Dmytraczenko T, Almeida G, Buisman L, Hoang-Vu Eozenou P, Bredenkamp C, et al. Assessing Latin America's Progress Toward Achieving Universal Health Coverage. Health Aff. 2015;34:1704–12.
6. WHO. The world health report: health systems financing: the path to universal coverage. Geneva: World Health Organisation; 2010.
7. The World Bank. Health Equity and Financial Protection Datasheets. 2016. http://www.worldbank.org/en/topic/health/publication/health-equity-and-financial-protection-datasheets. Accessed 2 Apr 2016.
8. Wagstaff A, Cotlear D, Eozenou PHV, Buisman LR. Measuring progress towards universal health coverage: with an application to 24 developing countries. Oxford Rev Econ Policy. 2016;32:147–89.
9. Khan J, Ahmed S, Evans T. Catastrophic healthcare expenditure and poverty related to out-of-pocket payments for healthcare in Bangladesh—an estimation of financial risk protection of universal health coverage. Health Policy Plan. 2017;32(8):1102–10. https://doi.org/10.1093/heapol/czx048.
10. van Doorslaer E, O'Donnell O, Rannan-Eliya RP, Somanathan A, Adhikari SR, Garg CC, et al. Catastrophic payments for health care in Asia. Health Econ. 2007;16:1159–84.
11. Xu K, Evans DB, Carrin G, Aguilar-Rivera AM, Musgrove P, Evans T. Protecting households from catastrophic health spending. Health Aff (Millwood). 2007;26:972–83.
12. Yao S. On the decomposition of Gini coefficients by population class and income source: a spreadsheet approach and application. Appl Econ. 1999;31:49–64.
13. The World Bank. World Development Indicators [Internet]. Washington, DC: The World Bank; 2017. http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators.
14. Hogan DR, Stevens GA, Hosseinpoor AR, Boerma T. Monitoring universal health coverage within the sustainable development goals: development and baseline data for an index of essential health services. Lancet Glob Heal. 2018;6(2):e152–68. https://doi.org/10.1016/S2214-109X(17)30472-2.
15. Akazili J, Garshong B, Aikins M, Gyapong J, Di McIntyre D. Progressivity of health care financing and incidence of service benefits in Ghana. Health Policy Plan. 2012;27:i13–22.
16. Khan JAM, Ahmed S, MacLennan M, Sarker AR, Sultana M, Rahman H. Benefit incidence analysis of healthcare in Bangladesh—equity matters for universal health coverage. Health Policy Plan. 2017;32:359–65.

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