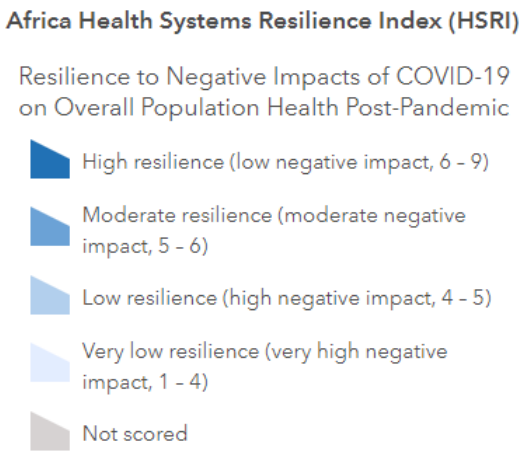
Introduction

The Health Systems Resilience Index (HSRI) was created with the following key question structured around State Department policymaker interests:

1. *How will Africa's health systems emerge following the changes brought on by the pandemic?*

2. *Which health systems were already being stressed to the max and the most vulnerable to being impacted by the effects of the pandemic?*

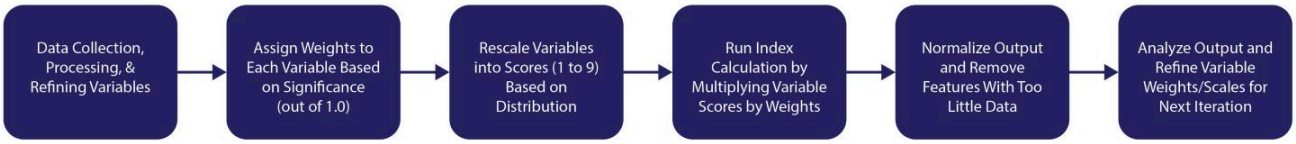
3. *What are the 5 most affected health systems in terms of resource strain and secondary impacts, such as increased non-COVID-19 deaths, post the COVID-19 pandemic?*



The Health Systems Resilience Index explores potential answers to these questions and paints a picture of the impact that the COVID-19 pandemic may have on the state of primary health care across the continent over the coming years. The index ranks countries on a scale of 1-9 with 9 being the highest score a country can receive and indicates there is little to no risk of negative COVID-19 Impact on overall societal health post pandemic.

Process

Weighted linear combination was then applied to the variables in each group to create the respective LBDI and HSRI.



Variables

With the key question in mind, we searched relevant research and reporting for variables to build the index around and quantify the details that would be used to rank each country's health system and vulnerability to the impacts of COVID-19.

variable in the main HSRI.

Local Burden of Disease Index (LBDI) variables:

- Prevalence of HIV
- Rate of Lower Respiratory Infection
- Malaria – Percent Population 5-14 y/o
- Prevalence of Diarrhea
- Prevalence of Under 5 mortality

Health Systems Resilience Index (HSRI) variables:

- Primary Health Care Expenditure as Percent of Current Health Expenditure
- Projected Decline of GDP per Capita Since 2019 (in USD)
- Primary Health Care Expenditure per Capita (in USD)
- Health Access and Quality Index (HAQ Index)
- HAQ Index – Difference Between Expected and Observed Values
- Percentage of the Population Living Below the Poverty Line
- Local Burden of Disease Index Value
- Number of Days Experiencing Epidemic Phase of Virus Spread

Local Burden of Disease Index (LBDI) variables:

Prevalence of HIV

The prevalence, given as a percent, of HIV among those age 15-49 in 2017. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/africa-hiv-prevalence-geospatial-estimates-2000-2017

Rate of Lower Respiratory Infection

The estimate of lower respiratory infection rate per 1,000 people among children under 5 in 2019. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/africa-under-5-lri-incidence-prevalence-mortality-geospatial-estimates-2000-2017

Malaria – Percent of Population 5-14 years

The estimate of the prevalence, given as a percent, of malaria among those ages 5-14 years in 2019. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/global-malaria-incidence-prevalence-mortality-geospatial-estimates-2000-2019

Prevalence of Diarrhea

The prevalence of Diarrhea among those under 5 y/o per 1,000 people in 2019. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/global-under-5-diarrhea-incidence-prevalence-mortality-geospatial-estimates-2000-2019

Prevalence of Under 5 Mortality

The prevalence of under 5 mortality as measured by child mortality probablity among those under 5 per 1000 live births in 2017. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/lmic-under5-mortality-rate-geospatial-estimates-2000-2017

Health Systems Resilience Index (HSRI) variables:

The amount the country spends (expenditure) on Primary Health Care as a percentage of the total Current Health Care Expenditure of the country. The data is from the World Health Organization (WHO) Global Health Expenditure Database. Website - https://apps.who.int/nha/database/ViewData/Indicators/en

Projected Decline of GDP per Capita Since 2019 (in USD)

The projected decline in GDP per capita from 2019 to 2020. This data is from The Institute for Security Studies (South Africa). Website - https://www.hss.de/news/detail/welche-auswirkungen-hat-corona-auf-afrika-news6361/

Primary Health Care Expenditure per Capita (in USD)

The amount of money (in USD) the country spends (expenditure) on primary health care funding per year, per capita. This data is from the World Health Organization (WHO) Global Health Expenditure Database. Website - https://apps.who.int/nha/database/ViewData/Indicators/en

Health Access and Quality Index (HAQ Index)

The Health Access and Quality (HAQ) Index is measured on a scale from 0 (worst) to 100 (best) based on death rates from 32 causes of death that could be avoided by timely and effective medical care (also known as 'amenable mortality'). This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/gbd-2015-healthcare-access-and-quality-index-1990-2015

HAQ Index – Difference Between Expected and Observed Values

The difference between the country's observed Health Access and Quality Index (HAQ) value and its Frontier Health Access and Quality Index value, defined as the maximum HAQ Index reached by a location as it relates to SDI. If a country or territory falls well below the frontier value given its level SDI, this finding suggests that greater gains in personal health care access and quality should be possible based on the country or territory's place on the development spectrum. This data is from the Institute for Health Metrics and Evaluation (IHME). Website - http://ghdx.healthdata.org/record/ihme-data/gbd-2015-healthcare-access-and-quality-index-1990-2015

Percentage of the Population Living Below the Poverty Line

The percentage of the total population estimated to be living below the poverty line. This data is from The World Bank. Website- https://povertydata.worldbank.org/poverty/home/

Local Burden of Disease Index Value

The score derived from the index created using the Local Burden of Disease Index meant to measure the prevalence of common disease in each country and potential burden/stress on existing health care systems notwithstanding the pandemic.

Number of Days Experiencing Epidemic Phase of Virus Spread

The number of days each country has been in an epidemic phase of coronavirus spread. Epidemic phase (uncontrolled spread) is defined as: mean of recent new cases per day is over 33.334 and rate of active cases is over 2.0 per 100,000. These phases are assigned by ESRI based on the Covid-19 data from Johns Hopkins University. This data is from the Urban Observatory by ESRI (using data from Johns Hopkins Center for Systems Science and Engineering). Website - https://state-hiu.maps.arcgis.com/home/item.html?id=a5c38e516ab343cca68a256d7c13f9ee

Data Engineering, Rescaling, and Weighting

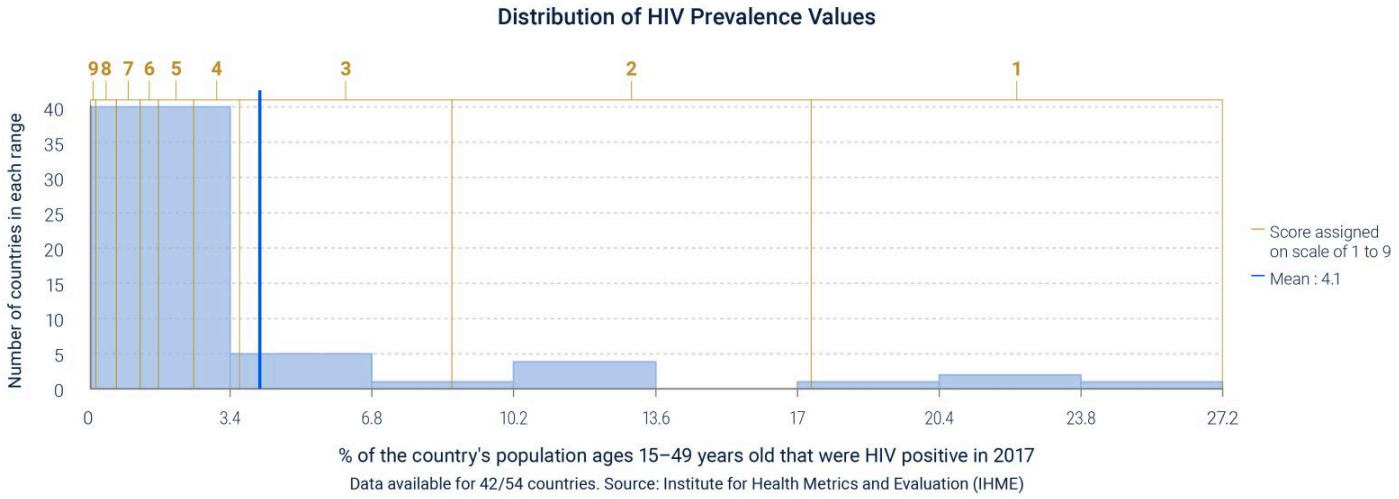
Variables were rescaled from original values to ensure a properly weighted model. Details on the scaling methods for each index are included below for each variable. Additionally, variables were each weighed according to the analysts' assessment on how important the variable is to the key question the index is trying to answer. A relative weighting scheme was used for this iteration.

LBDI Weights:

All variables were given the same weight as to not prioritize a single disease when determining overall local burden of disease values for each country.

Weight: 20

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating the lowest prevalence of HIV and 9 indicating the highest prevalence of HIV.

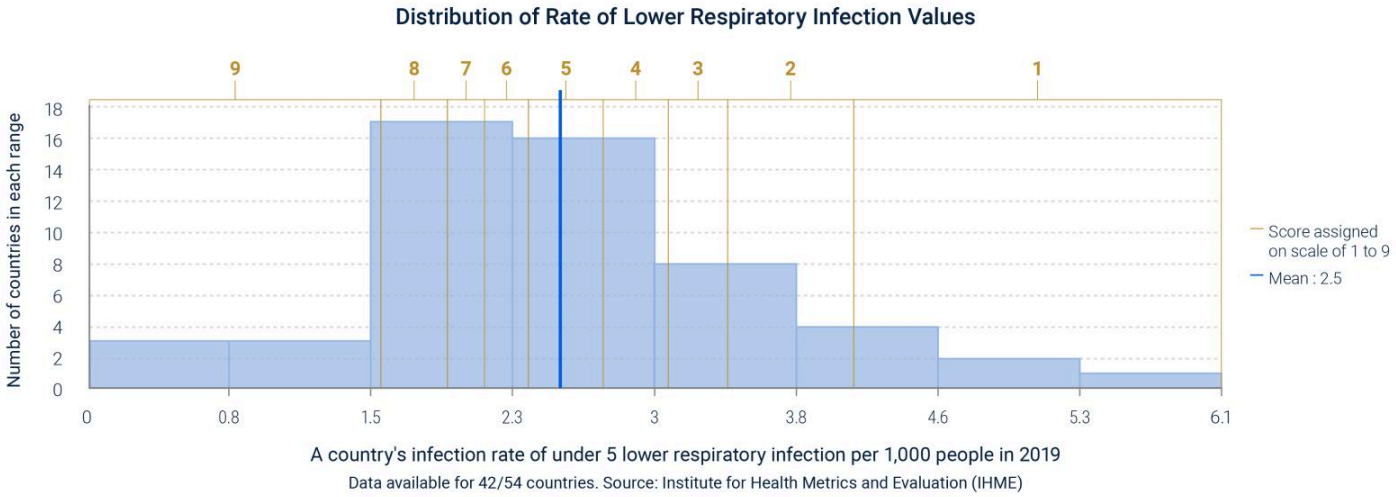


Rate of Lower Respiratory Infection

Negative of Positive Variable: Negative

Weight: 20

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating the lowest rate of lower respiratory infection and 9 indicating the highest rate of lower respiratory infection.

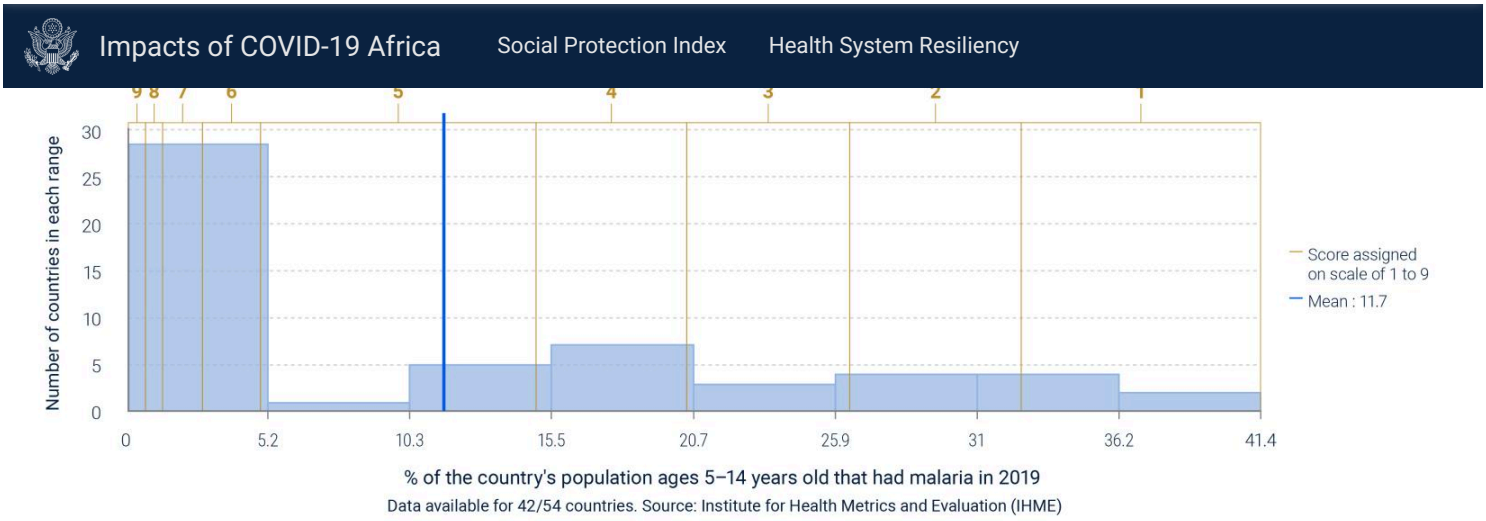


Malaria – Percent of Population 5-14 years

Negative of Positive Variable: Negative

Weight: 20

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating the lowest percent of malaria infected individuals and 9 indicating the highest percent of malaria infected individuals.

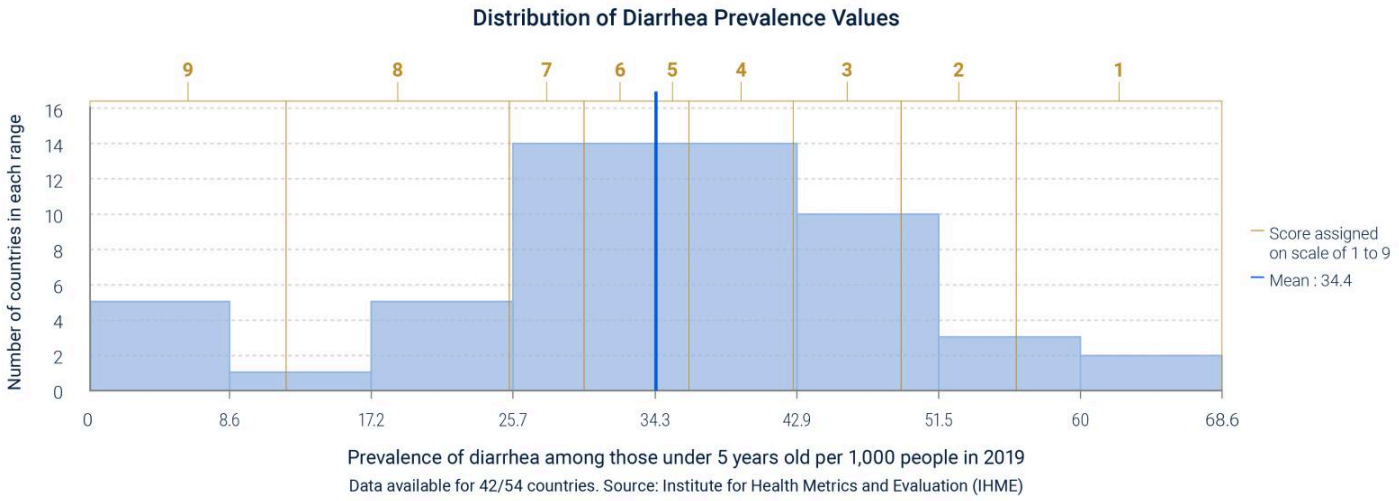


Prevalence of Diarrhea

Negative or Positive Variable: Negative

Weight: 20

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating lowest prevalence of diarrhea and 9 indicating the highest prevalence of diarrhea.

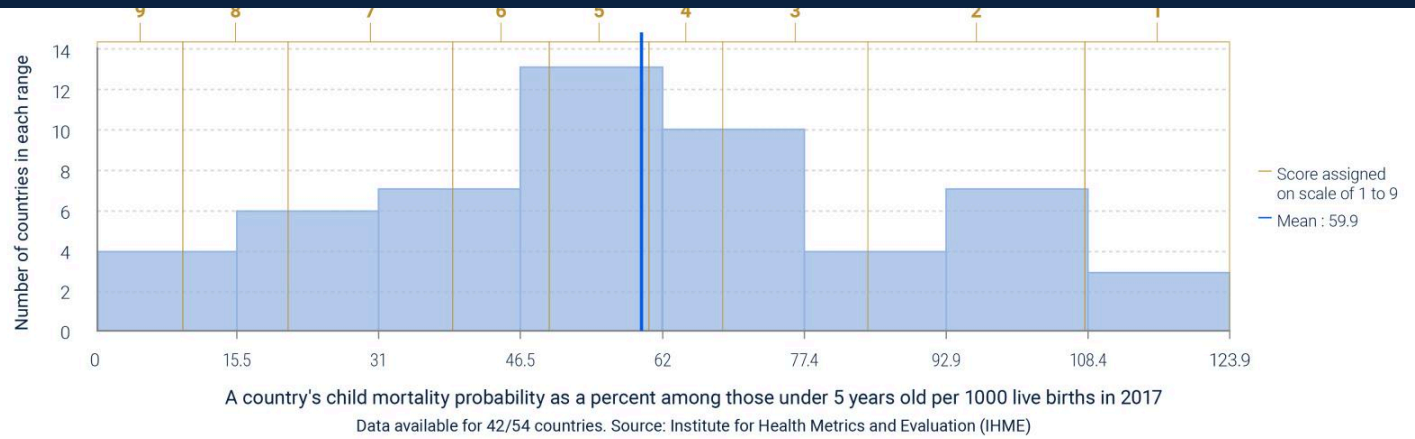


Prevalence of Under 5 Mortality

Negative or Positive Variable: Negative

Weight: 20

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating lowest prevalence of under 5 mortality and 9 indicating the highest prevalence of under 5 mortality.



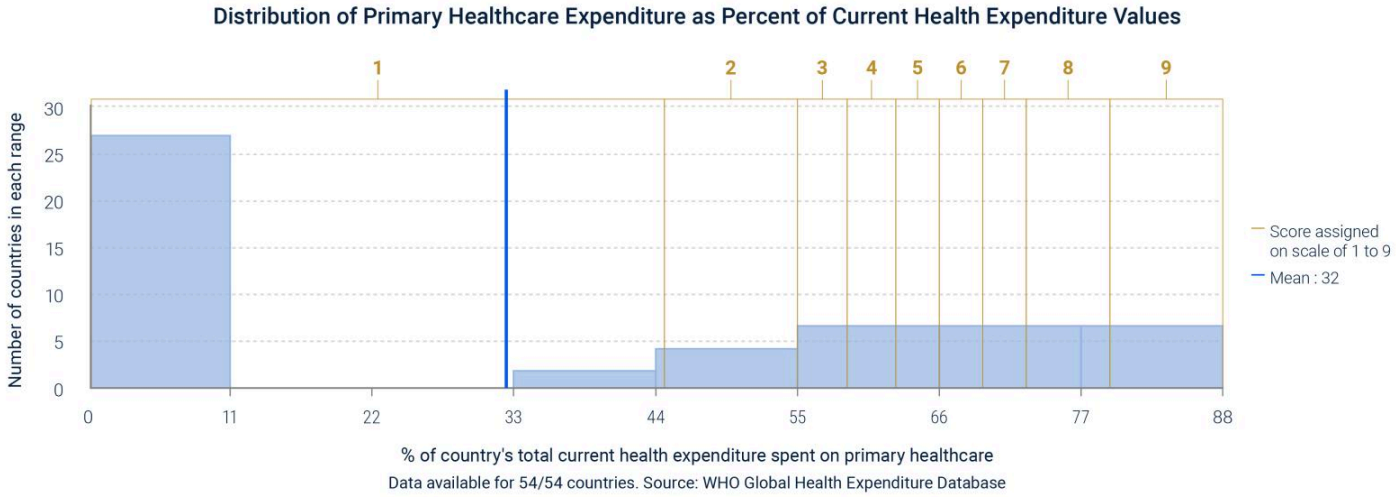
HSRI Weights:

Primary Health Care Expenditure as Percent of Current Health Expenditure

Negative or Positive Variable: Positive

Weight: 18 - This variable got the highest value because countries that have small portions of their budget going towards primary health care are likely to have larger primary health issues with budget realignments, due to declines in GDPs (below). Past responses to epidemics seen on the continent all saw issues with above normal fatalities due to more common ailments in the years post the epidemic.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating the highest percent of current health expenditure being spent by the government on primary health care and 9 indicating the lowest percent of current health expenditure being spent by the government on primary health care.

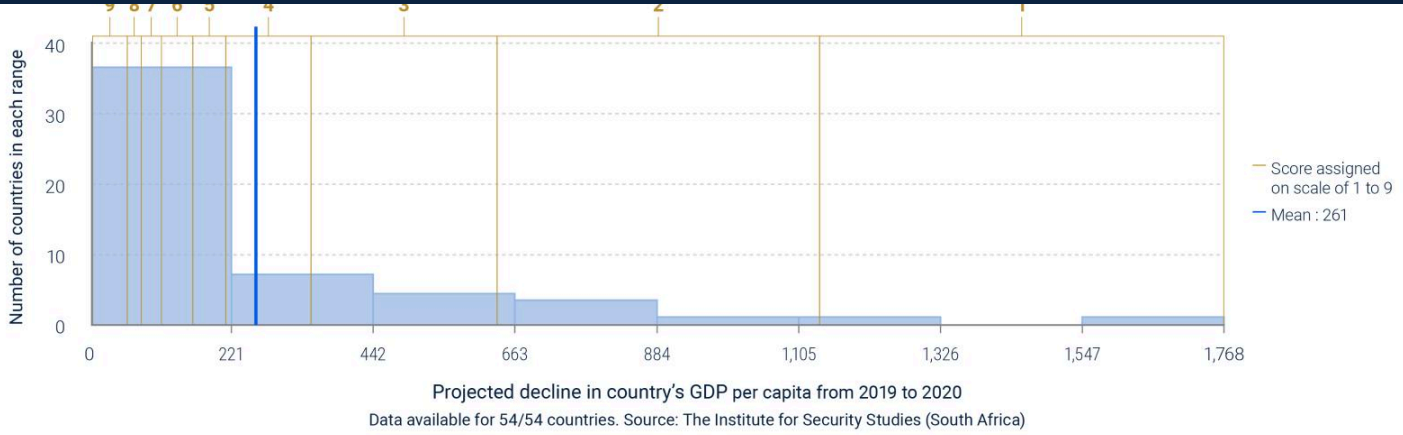


Projected Decline of GDP per Capita Since 2019 (in USD)

Negative or Positive Variable: Negative

Weight: 18 - For the reasons mentioned above, I think the health systems that will be double hit hard by a combination of health stresses and budgetary cuts are those that spend less on primary health care and have large reductions in their GDP, forcing budget cuts.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks – 1 indicating lowest projected decline in GDP per capita from 2019 to 2020 and 9 indicating the highest projected decline in GDP per capita from 2019 to 2020.

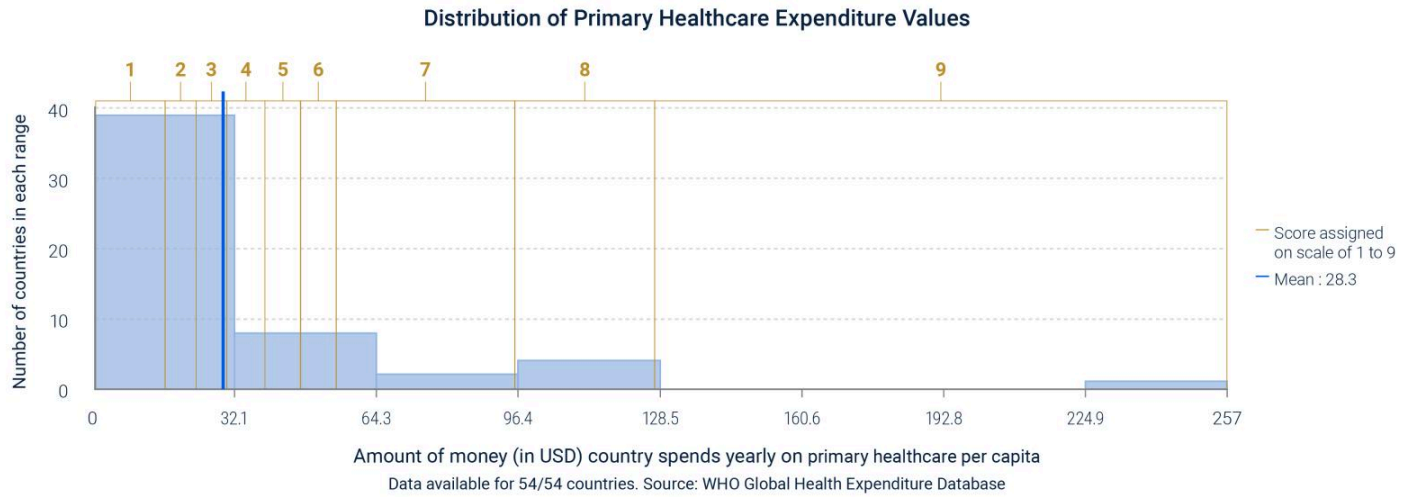


Primary Health Care Expenditure per Capita (in USD)

Negative or Positive Variable: Positive

Weight: 16 - This should serve as another way to look at the health/focus on the primary health care sector by the government and factors in population while the above data on primary health care does not. In addition, I checked and countries spending a larger percentage on their primary health care doesn't necessary equate to higher percentages per capita.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the highest amount spent by a country on primary health care expenditure per capita and 9 indicating the lowest amount spent on primary health care per capita.



Health Access and Quality Index (HAQ Index)

Negative or Positive Variable: Positive

Weight: 14 - This serves as a solid measure of Health Access and Quality in the Country and is an important measure of the overall health system and how accessible as well as useful it is for the population.

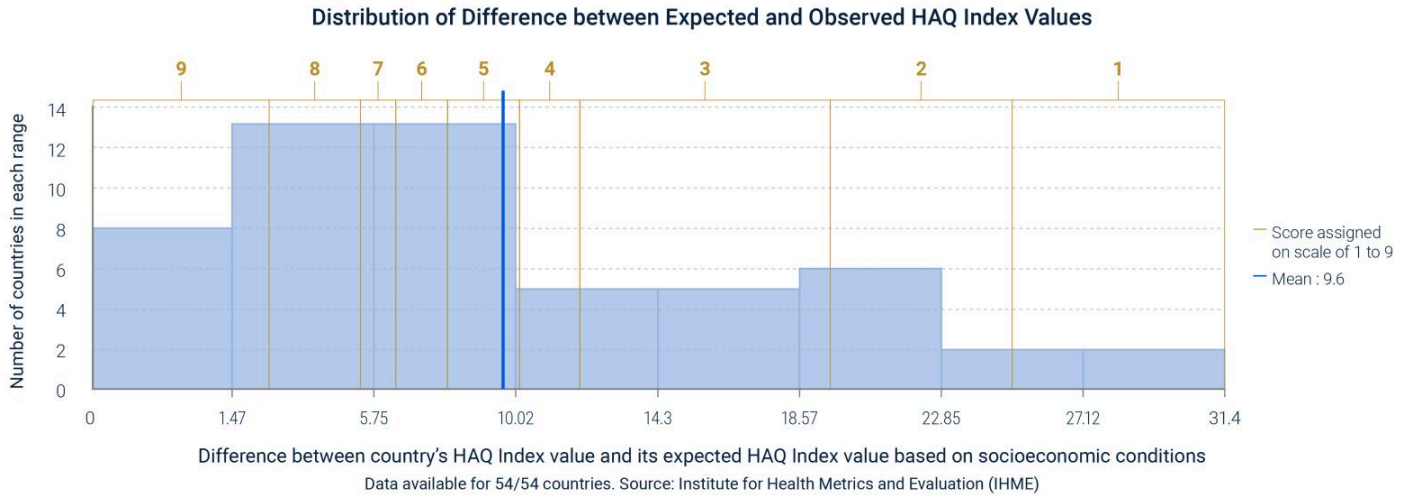
Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the highest health access and quality index values and 9 indicating the lowest health access and quality index values.

HAQ Index – Difference Between Expected and Observed Values

Negative or Positive Variable: Negative

Weight: 14 - I wanted to make this the same weight as the overall HAQ index, but this says something different about the health systems. This tells you vs countries at the same socioeconomic level, this country is this far below what would be expected, denoting not just a weaker health system, but one that is devoid of proper attention and resources given the opportunities/resources available. Larger values equal greater discrepancies and negative values (there were a couple) mean that they were above expectations and got higher values.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the lowest difference between the expected HAQ index value and the observed HAQ index value and 9 indicating the highest difference between the expected HAQ index value and the observed HAQ index value.

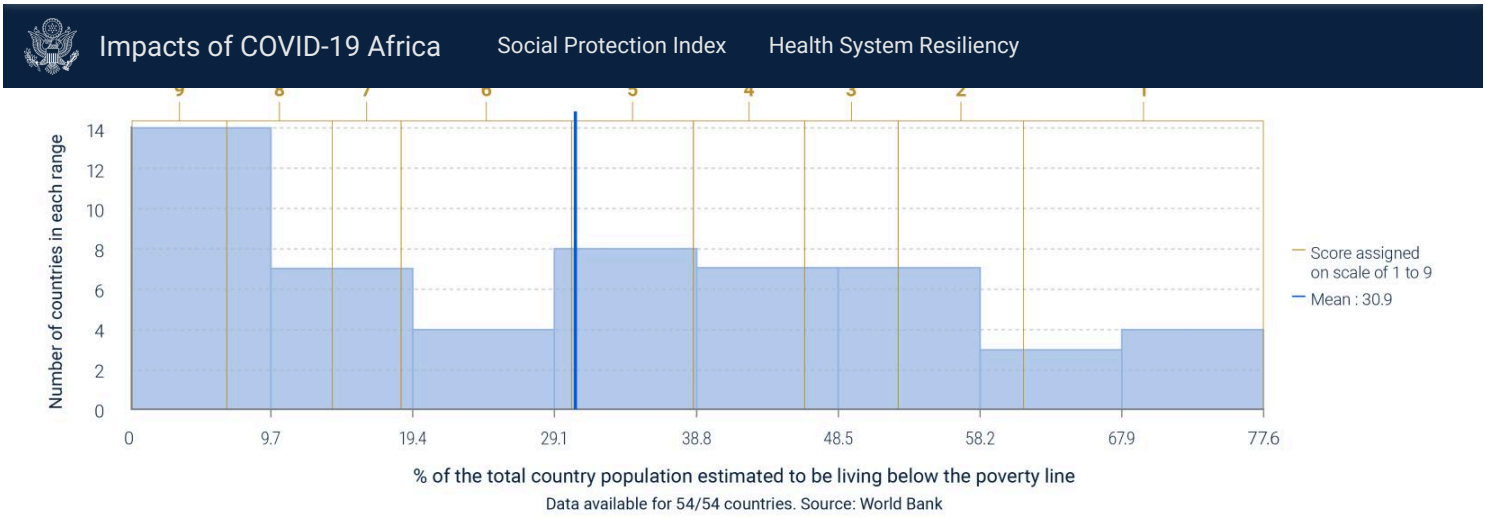


Percentage of the Population Living Below the Poverty Line

Negative or Positive Variable: Negative

Weight: 10 - People living in poverty are likely to feel the effects of the pandemic on their daily lives more than those that aren't. In addition, those living in poverty are likely to have worse general health as well as have the hardest time accessing health care. Therefore, when measuring future stresses/impacts on the health systems post the pandemic, it is important to keep in mind countries with higher levels of poverty.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the lowest percentage of the population living below the poverty line and 9 indicating the highest percentage of the population living below the poverty line.

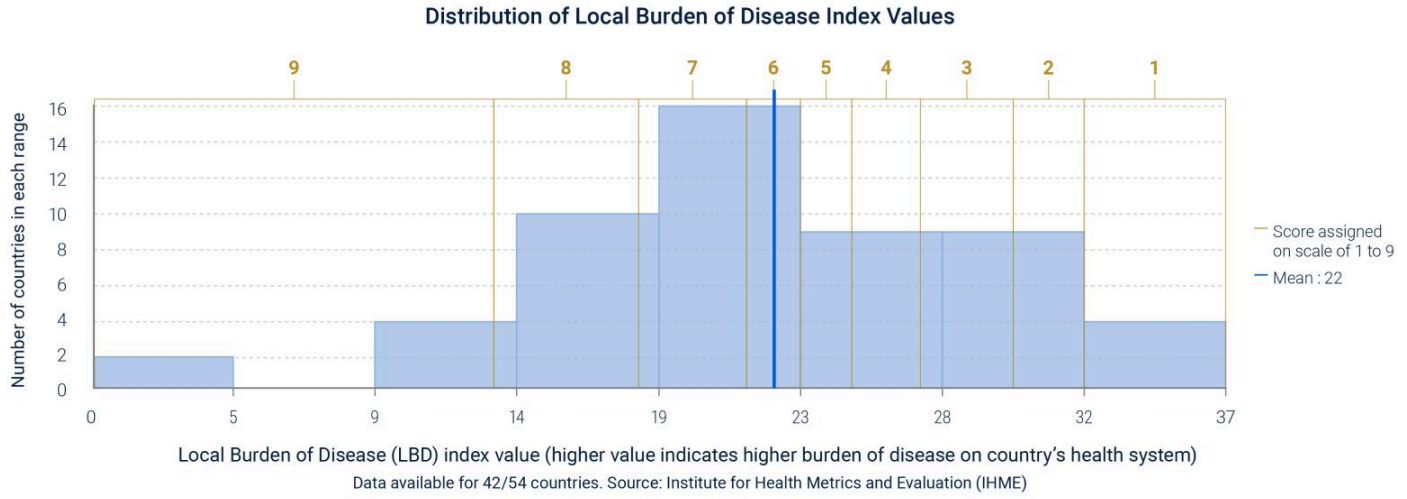


Local Burden of Disease Index Value

Negative or Positive Variable: Negative

Weight: 5 - This is the variable calculated from the sub-index. While important, it is less scientifically derived based on the other variables and was more of a proxy to help place a value on the overall health of a country's population by taking a look at the prevalence of some major diseases throughout the continent. This variable also serves to quantify stress on the health system as well with countries having larger burden's of disease placing more stress on the systems in place.

Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the lowest local burden of disease value and 9 indicating the highest local burden of disease index value.

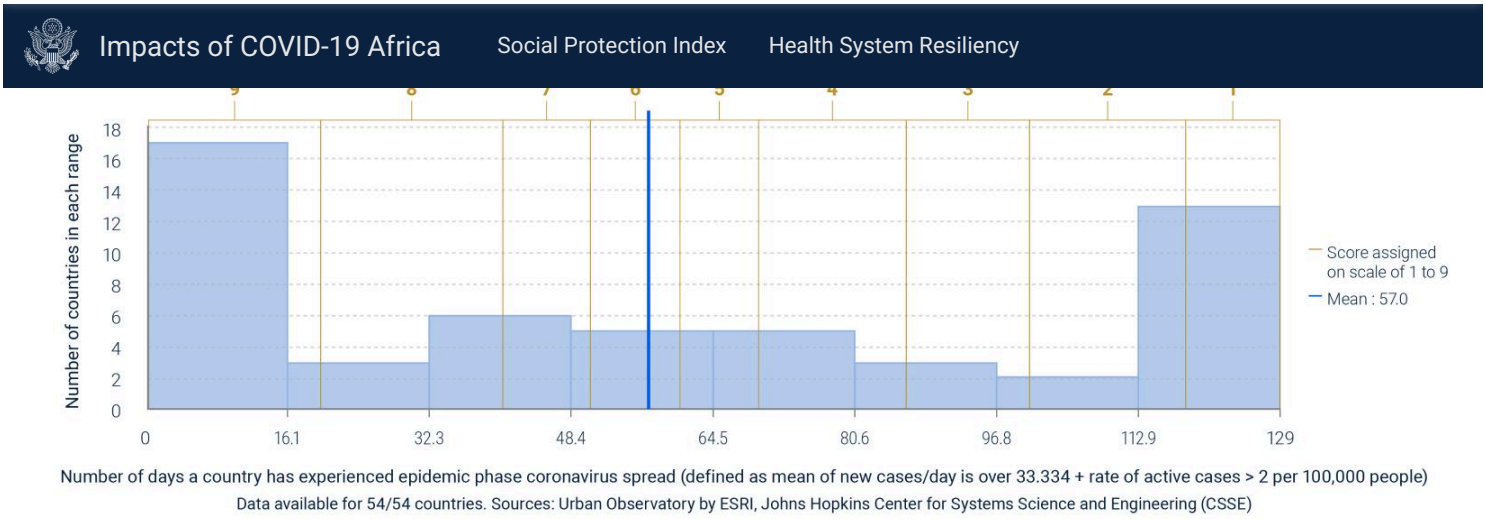


Number of Days Experiencing Epidemic Phase of Virus Spread

Negative or Positive Variable: Negative

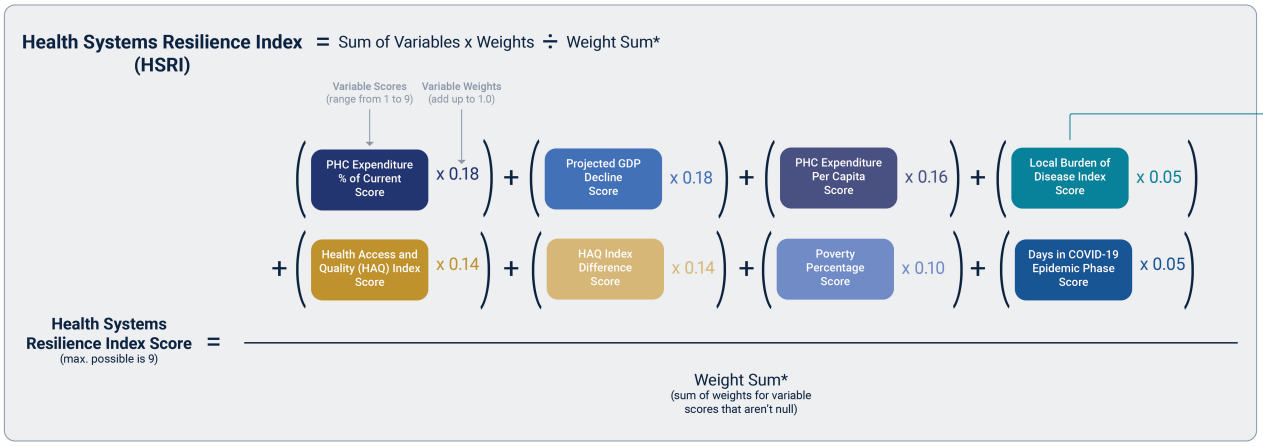
Weight: 5 – We wanted to quantify stress on the health system due to due to virus alone with the logic that countries experiencing the pandemic the worse were likely to have more stressed health systems, requiring more resource diversion, and therefore contributing to greater secondary health impacts. Originally, total COVID-19 case numbers were used, but these were substituted for counts of days each country was experiencing epidemic level spread. We felt this did a better job of quantifying the stress of the pandemic vs case numbers alone as they added a time component.

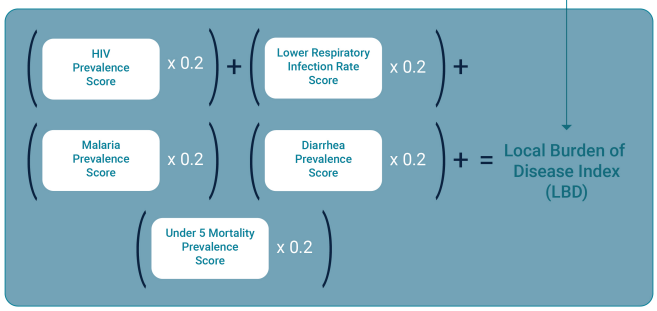
Rescaling Method: To score each variable, the values were reclassified into 9 different "scores", 1-9, based on natural breaks - 1 indicating the lowest number of days having experienced epidemic levels of COVID-19 virus spread and 9 indicating the highest number of days having experienced epidemic levels of COVID-19 virus spread.



Number of days a country has experienced epidemic phase coronavirus spread (defined as mean of new cases/day is over 33.334 + rate of active cases > 2 per 100,000 people)
Data available for 54/54 countries. Sources: Urban Observatory by ESRI, Johns Hopkins Center for Systems Science and Engineering (CSSE)

Calculations for the HSRI Model



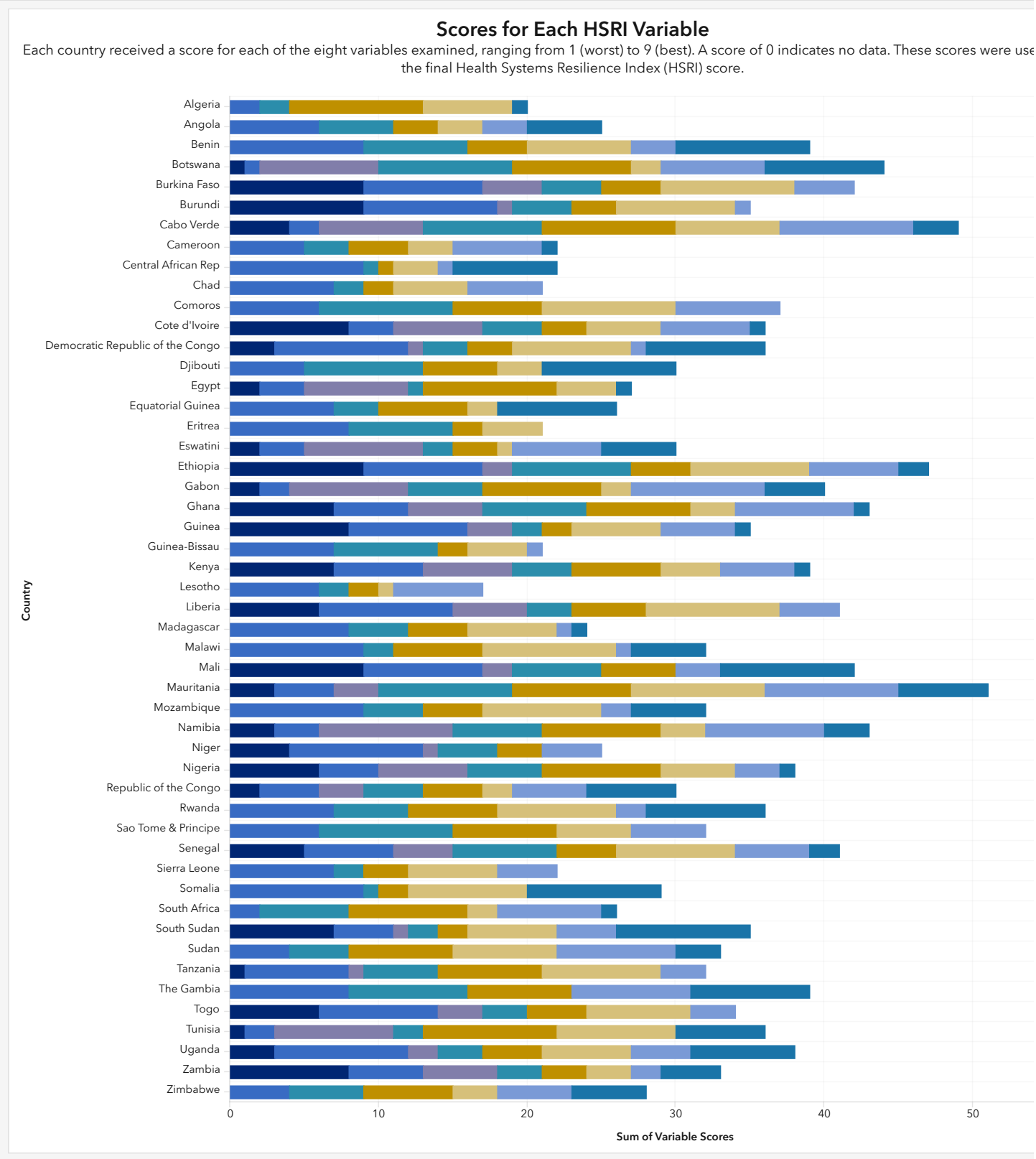


***Normalization of Data**

During previous iterations of the analysis, we identified a bias towards countries with more data available (fewer null values). To address this issue of some countries having higher SPI scores simply because they had data for 5/5 variables instead of 4/5, we developed an algorithm to normalize the data. This consisted of dividing the interim "Sum of Values x Weights" by the "Weight Sum", or the sum of weights for all variables that are not null.

For example, Mali had data available for 4/5 variables analyzed and was missing data for the Social Protection Coverage, which is weighted the highest in the index. Mali's "Sum of Variables x Weights" came out to be 1.85. Mali's "Weight Sum" was 0.65, which is equal to the sum of the weight for the four variables it did have values for (Social Protection Expenditure, Government Stringency, and Direct and Indirect Social Protection Measures), or 0.15 + 0.1 + 0.25 + 0.15. By dividing Mali's Sum of Variables x Weights, 1.85, by the Weight Sum, 0.65, we arrived at

Once a Weight Sum for each country was generated, any country with a Weight Sum of less than 0.5 was removed from the analysis, because it was deemed to have data available for less than half of the variables analyzed. The 4 countries with a Weight Sum of 0.5 or lower were Libya, Mauritius, Morocco, and Seychelles, so they appear under the category of "Not scored" on the map.



being based off of some indicators that were 2-3 years old.

2. Most of the variables used are from different time periods (mostly between 2016-2019). Ideally data would all be updated as of the same year.

3. As assumption was made that all of the variables being used to measure Local Burden of Disease are negative in value and have the same weight in terms of impact (are weighted the same).