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Resource Allocation Framework for Pandemic Risk and Surveillance: Version 1.0

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Abstract

This proposed Resource Allocation Framework may inform country-level allocation decisions by the Pandemic Fund for its first call for proposals supporting surveillance, laboratories, and human resources. This framework incorporates three measures of pandemic risk and one index of need for surveillance capacity for an overall allocation index. The measures of pandemic risk involve an absolute measure using estimated country mortality losses, a relative measure using estimated mortality losses normalized on a per person basis, and a measure of 'spark risk'. A country's absolute measure is scaled down based on its World Bank income group, by a factor that is scaled to average differentials in total health spending between World Bank income groups relative to low-income countries (LIC) (i.e., lower-middle income countries spend 4x as much per capita compared to LIC, upper-middle income countries spend 13x as much, and high-income countries spend 38x as much). Each pandemic risk measure is further standardized using a max-min scaling ranging from 0 to 1. A fourth component of the framework uses a simple summary index of need for surveillance capacity combining three elements: health data capacity as measured as birth registration coverage; health workforce capacity as measured by nurse availability per capita; and network connectivity as measured by mobile subscribers per capita. The weights for each of the four components can be adjusted based on consensus. An alternative version of the allocation index uses a logistic function as an alternative normalization from 0 to 1.

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Background

Following the G20 High-Level Independent Panel report recommendation to establish a fund dedicated to pandemic preparedness, the Pandemic Fund was launched in September of 2022 and issued its first call for proposals for surveillance, laboratories, and human resources for a limited budget of $300 million.[1] Countries have submitted letters of interest that indicate a potential demand of more than $5.5 billion, indicating far more demand than available budget. The Pandemic Fund will need to make tough decisions to allocate resources across countries fairly, rather than based on demand or first-come first-serve.

The use of resource allocation frameworks or formulae among multilateral development agencies is common, including by the World Bank International Development Association (IDA)[2], the Global Fund to Fight Aids, Tuberculosis, and Malaria[3], the Global Environment Facility (GEF)[4], and the International Fund for Agricultural Development (IFAD)[5], along with the use of indices such as the United Nations Development Programme Human Development Index (HDI)[6].

This proposed Resource Allocation Framework does not use existing indices available on pandemic preparedness, such as the International Health Regulations Joint External Evaluation Tool, for several reasons[7]: (1) pandemic preparedness indices have not been shown to be correlated with performance against the COVID-19 pandemic; (2) such indices use discretionary, subjective, and somewhat opaque data; and (3) the value and focus of the index is diluted by relying on many components.

Rather than attempt to alter existing indices, we have instead opted to develop a simple index that begins from first principles. We argue that the overarching principle for determining allocations for investing in pandemic surveillance should be based on pandemic risk. Given the current lack of available models or information on international pandemic risks from an international multilateral body or agency, we use the Concentric epidemic risk model which estimates potential losses from infectious disease epidemics across the globe.

Resources should not only be allocated based on pandemic risk, however. Country need is an important consideration; countries which have weaker capacity to conduct surveillance and need additional resources to strengthen health systems should receive more resources.

Indicators

Indicators of pandemic risk

Pandemic risk in this note is measured in three forms:

1. Average annual loss AAL as measured by the expected deaths per year (ranging from 2 to 450,000);
2. Average annual loss population adjusted AAL_p, or the expected deaths per 10,000 population per year, using 2020 population (ranging from 2 to 9);
3. Spark index S, a combined respiratory spark risk value derived from summation of individual spark probabilities for epidemic coronaviruses and pandemic influenza in each country, normalized between 0 and 1;

These mortality risk estimates are derived from its General Respiratory Stochastic Catalog V1.1 (Version Date: February 8, 2023). This catalog quantifies general respiratory disease risk due to pandemic influenza viruses and novel/epidemic coronaviruses, which are viruses of high pandemic potential. The events in the catalog are simulated through Concentric's probabilistic, event-based infectious disease risk model that captures plausible event trajectories. The model incorporates pathogen characteristics, transportation networks, local medical resources, and pandemic preparedness to estimate the likelihood and severity of general respiratory epidemics and pandemics across the globe. Extensive further details about the modeling process methodology will soon be available in a forthcoming Disease Control Priorities 4th Edition Working Paper.[8]

Indicators of need for surveillance capacity C

Adjustment factors across three dimensions of need for surveillance capacity are measured using the following curated indicators to form a summary index of need:

1. Data capacity d measured by birth registration as a key measure of the civil registration and vital statistics capacity of a country;
2. Health workforce capacity h as measured by nurse availability per capita;
3. Network capacity and connectivity c, as measured by mobile subscribers per capita.

Need for surveillance capacity may mean different things to different international agencies and national governments. The overarching concern is for the Pandemic Fund to use a simple and objective indicator for which there are widely available and regularly reported data, rather than an aggregate of many subjective indicators or with unavailable data.

Throughout the COVID-19 pandemic, health data capacity and health information systems were a recurrent challenge, if not failure, in addressing COVID-19.[9] Recent initiatives by the White House (US executive branch)[10] and other organizations have emphasized the importance of health workforce, also known as human resources for health, for pandemic preparedness. Finally, the Mosaic Framework by the World Health Organization emphasizes the importance of networks of communication between data-providing units such as laboratories.[11]. As such, we use elements of data capacity, health workforce capacity, and network capacity or connectivity to adjust allocations according to pandemic risk.

Formulae

This framework incorporates the three measures of pandemic risk AAL, AAL_p, and S and one summary index of need for surveillance capacity C into an overall Resource Allocation Formula RAF. We first take the AAL and scale it down based on its World Bank income group, by a factor corresponding tothe average differentials in total health spending between World Bank income groups relative to low-income countries (LIC). Using LIC as the base of 1, AAL for lower-middle income countries are divided by a factor of 4 as they spend 4 times as much in health spending per capita compared to LIC; AAL for upper-middle income countries are divided by a factor of 13 as they spend 13 times per person as much compared to LIC; and AAL for high-income countries are divided by 38 as they spend 38 time more than LIC. We label this scaled AAL as the AAL_s

Next, following the UNDP Human Development Index methodology, we apply to each indicator a max-min scaling or normalization, with maximum value across countries set as a goalpost and the minimum value set as the 'natural zero'. Each indicator X for each country is normalized from 0 to 1 into an indicator N:

$$N(X) = \frac{X - min(X)}{max(X) - min(X)}. \tag{1}$$

This normalization is applied to each measure of pandemic losses, namely, AAL_s and AAL_p, and each adjustment factor, namely, d, h, and c. The spark index S is already normalized and hence no additional normalization is required.

For the adjustment factors, a larger normalized number indicates higher performance. In order to invert a measure of performance into a measure of need for surveillance capacity, the normalization function is subtracted from 1, i.e.:

$$AF(X) = 1 - N(X) \tag{2}$$

The max-min normalization function represented in equation 1 is linear, but an alternative normalization could use a logistic function, comparable to diminishing marginal returns. Thus, as an alternative normalization to the max-min scaling of the population adjusted AAL_p (and a substitute to equation 1), a logistic function M compresses the variable between 0 and 1 in the following form:

$$M(X) = \left(\frac{2}{1 + e^{-X}}\right) - 1 \tag{3}$$

Next, we generate a simple summary index of need for surveillance capacity C_i for each country i that combines the three normalized adjustment factors, the geometric mean is calculated:

$$C_i = \left(\prod_{i=1}^{n} (AF(d_i) \cdot AF(h_i) \cdot AF(c_i))\right)^{\frac{1}{3}} \tag{4}$$

Finally, the overall Resource Allocation Formula first generates a country *Score* combining the four components, with a weight of 10 given to the population-adjusted losses, a weight of 5 to the spark index, and a weight of 1 to the absolute population loss and the simple index of need for surveillance capacity C, as follows:

$$\text{Score} = 10 \cdot N(AAL_p) + 5 \cdot S + 1 \cdot N(AAL_s) + 1 \cdot C \tag{5}$$

The alternative form of equation 5 may substitute N with M, i.e. the standard normalized function N in equation 1 is replaced by the logistic-normalized function in M in equation 3. Each country's score is expressed as a country share of the global sum of scores, and then multiplied by the overall budget, e.g. $300 million for the first call of proposals to calculate the country amount, a functional form that is adaptable to increasing (or decreasing) total budget envelopes.

Limitations

The form of equation 5 is comparable to that of other resource allocation formula, but like other formula, it is challenging because the weights represent a focal point of heated discussion and disagreement. The weights provided here are illustrative but may be interpreted to indicate that a country's population-adjusted loss is 10 times as important and spark risk is 5 times as important for resource allocation compared to a country's (income-adjusted) population and a country's capacity. There are other ways to develop consensus on the weights including expert Delphi methods as well as empirical methods that use regression, representing an area of future work. We do not delve into the methods for developing and refining weights, but acknowledge that choosing weights is not easy.

We acknowledge that the indicators chosen are imperfect and not comprehensive of pandemic surveillance capacity. Instead, it reflects a curated set of a wide range of indicators (which had been incorporated in several previous pandemic preparedness indices). Other factors considered for inclusion were doctor availability, electricity access, and death registration coverage. Nurse availability was chosen over doctor availability to emphasize the role of other health workers in pandemic surveillance at primary care centers. Mobile subscribers were chosen over other forms of broadband connectivity, internet use, or electricity given its broad prevalence and importance as an inexpensive form of communication, connectivity, and networking and its role in digital health. Electricity access was also considered, but chosen as a secondary feature relative to mobile subscribers which may not require extensive electricity access to implement pandemic surveillance. Birth registration coverage was chosen over death registration coverage due to the lack of data on death registration coverage for several dozen countries.

Data availability of the indicators was a major hindrance. The most recent data for a given indicator was selected, resulting in a cross-sectional data set in which the indicators reflects different points in time depending on when the country last reported a value for the given indicator. Where a country had no data for a given indicator, the mean for that indicator for the subset of countries classified by the corresponding World Bank country income grouping (low income, lower middle, upper middle, high income) was used. Alternative imputation methodologies may be considered and applied as well. There were more countries missing data for birth registration coverage compared to for nurse availability, which in turn had more missing compared to data for mobile subscribers.

This resource allocation formula is intended to stimulate a discussion and a starting point for further revision and refinement in the Pandemic Fund's inaugural year. Regardless of the final formula to be used, we hope the Pandemic Fund will consider a minimal set of indicators to drive its allocation in order to increase transparency.

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