CREATING A SET OF COVID-19 VULNERABILITY INDICATORS FOR SOUTH AFRICA

Disclaimer: The interpretation and utilisation of the vulnerability indicators and the final combined index are at the sole discretion of the user. Neither the CSIR nor any other associated person or institution can be held liable in any wat whatsoever.

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The indicators described in this document were developed and prepared by the CSIR, with conceptual input provided by the Albert Luthuli Centre for Responsible Leadership.

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Version control and updates: The COVID-19 vulnerability indicators described in this document were designed and developed based on currently available data and knowledge. Given the unfolding and evolving nature of the COVID-19 pandemic, both locally and internationally, the assumptions that informed the creation of these indicators, together with the input data and critical weights used in calculating the indicators should be updated, corrected and refined as new information and understandings emerge. As more data becomes available, the aim is to release updated versions of the COVID-19 vulnerability indicators and to share these to improve their usability and accuracy.

Limitations and considerations in use: The COVID-19 vulnerability indicators presented in this document are not based on epidemiological modelling. The development of the indicators was intended to support the early prevention/mitigation and preparedness phase of the disaster management cycle, and their use should, therefore, be restricted to supporting and informing disaster management decision making. Care has been applied in testing the assumptions on which the indicators are based with a small expert user group, but it is recommended that those who make use of these indicators should familiarise themselves with the input data and assumptions made, acknowledging that the resultant indicators might not reflect the reality on the ground.

Background of the disaster management cycle: Four important phases (mitigation/prevention, preparedness, response, and recovery) are applicable in any disaster management cycle. Disaster management is the process of focusing on reducing and/or avoiding the potential or expected losses from any hazard (e.g. loss of life or livelihoods, economic loss.); ensuring that timely assistance is provided to affected, or potentially affected, communities; and facilitating the rapid and effective recovery from a disaster event through 'building-back' better. When a disaster strikes (e.g. the spread of an infectious disease such as the COVID-19 outbreak), government departments and sectors, businesses, NGOs, industries and civil society will engage and respond differently with the disaster management cycle according to their mandates, responsibilities and contingency plans. Although the

phases can overlap, differ concerning their purpose and objective and last varying lengths of time it is assumed that the phases would strive to:

1. **Mitigation/prevention phase**: Minimising the devastating impacts of the disaster. The focus here is on preventing or reducing the exposure to the disaster and mitigating vulnerability;
2. **Preparedness phase**: Planning the response strategy and capacitating emergency managers to provide the best response possible. The focus here is on strengthening various coping capacities;
3. **Response phase**: Implementing efforts to minimise the consequences of the disaster and reduce associated mortality and morbidity. In this phase, humanitarian action and aid are often applicable. The focus here is on coordinating of various efforts to preserve life and livelihoods, and to provide essential services and/or subsistence to those affected by the disaster; and
4. **Recovery phase**: Returning the community and affected groups to a new state of normal. The focus here is on striving to 'building-back' better.

Purpose of the indicators: In the early phase of the disaster management cycle (mitigation/prevention and preparedness), data and information are vital to the success of the subsequent phases (response and recovery). In the case of the COVID-19 pandemic in South Africa, many sector departments faced similar questions at the start of the outbreak. Departments were concerned with better understanding the risks posed by COVID-19 to communities and the health system, and the associated vulnerabilities.

The questions most frequently asked were:

1. Which communities will struggle to apply the principles of social distancing, and where are they located?
2. Are there areas that will struggle to maintain the principles of good basic hygiene (e.g. hand-washing) due to a lack of basic water and sanitation services?
3. Where are elderly communities (that will be more susceptible to severe disease from COVID-19) located?
4. Where are communities have a high burden of co-morbidities (current disease burden) located?
5. Where are highly vulnerable communities (who may be in need of targeted coordinated interventions and early response) located?
6. Can the potential hospitalisation demand be met with an adequate supply of beds, equipment, health workers and emergency personnel?

Role of the indicators: The questions outlined above can be divided into two groups, those that relate to the vulnerabilities of communities and their location, and those that relate to the response mechanisms (coping capacities) to be put in place to offset these vulnerabilities. In order to anticipate the risks and identify high-risk intervention areas, it is vital to understand the vulnerabilities of communities. The following sub-set of indicators is thus concerned with looking at the vulnerabilities present in communities and identifying areas in need of targeted coordinated interventions and early response.

Risk is assessed as follows:

$$Risk = Exposure\ to\ hazard\ x\ (\boldsymbol{Vulnerability}/Coping\ capacity)$$

COVID-19 VULNERABILITY INDEX

This index provides an indication of the vulnerability of communities to the potential impact of COVID-19, based firstly on how effectively the spread of COVID-19 can be contained (transmission potential) and secondly on the population's susceptibility to severe disease associated with contracting COVID-19 (health susceptibility).

The following formula is used:

$$Covid19\ vulnerability\ index = Transmission\ potential + Health\ susceptibility$$

An indicator-based assessment method was used in the construction of the composite COVID-19 vulnerability indicator. The composite vulnerability indicator was computed through the use of multi-criteria analysis (MCA), a spatial analysis technique that combines similar descriptive variables into indicators, and indicators into a final descriptive composite index. The different variables that contribute to the indicators were standardised by making use of the min-max normalisation process, which allowed the different variables to be added together to form the indicators. Min-max normalisation linearly scales data to fall within a specified range. A range of 1–100 was used for the standardisation process. In this process, each Enumeration Area (EA) in South Africa was compared and related to all other EAs in the country, thus ensuring that the COVID-19 Vulnerability Index could facilitate a coordinated national response.

The following formula is used to normalise the data:

$$MinMax = \frac{Xi - Xmin}{Xmax - Xmin} \times (End\ of\ range - Start\ of\ range) + Start\ of\ range$$

After the standardisation process, an equal-weighted multi-criteria analysis was performed in order to add the different indicators (transmission potential and health susceptibility) together to form the vulnerability indicator. A weighted average was calculated to provide the final score for each feature (variable/indicator), thus producing a score between 1 and 100 for each EA, where 1 is least vulnerable and 100 is most vulnerable.

TRANSMISSION POTENTIAL INDICATOR

This indicator identifies areas where existing living conditions could make it difficult to maintain social distancing and practise good basic hygiene in order to contain the spread of COVID-19.

The following formula is used:

$$\boldsymbol{Transmission\ potential} = Informality + Lack\ of\ access\ to\ basic\ services + High\ population\ density$$

This indicator classifies EAs throughout South Africa according to transmission risk, producing a score between1 and 100 (where 1 refers to least risk and 100 to extreme risk), indicating areas where the virus might spread more rapidly than other areas in the country. Three main variables were used as inputs into this indicator:

- **Informality:** Number of informal dwellings per EA (informal dwellings and informal backyard structures)
- **Population density:** Number of people per hectare
- **Lack of access to basic services:** Number of households without basic access to running water and sanitation.

HEALTH SUSCEPTIBILITY INDICATOR

This indicator provides an indication of areas where larger numbers of people are potentially more susceptible to being adversely affected by COVID-19 (suffering more severe disease). Given that current observations indicate that mortality rates associated with COVID-19 tend to be higher in elderly populations and those individuals with underlying health conditions (one or more co-morbidities), these two factors were included in the health susceptibility (sometimes referred to as epidemiological vulnerability) indicator. Since information on the epidemiological vulnerability of population groups is limited, it is suggested that this indicator be complemented and refined based on local assessments and observations. The health susceptibility indicator was derived by assigning specific weights to various age categories and assigning a higher susceptibility to groups of people with known co-morbidities.

The following formula is used:

$$\boldsymbol{Health\ suseptability} = Weighted\ age\ factor + (Amplification\ correction\ factor\ x\ weighted\ age\ factor)$$

Weighted age factor: Weights were assigned according to observed death rates. The known death rates reported for Asian and European countries were used to weight the various age groups in each EA to estimate the amount of people that might be more susceptible to severe disease (the 0–4 age category was elevated in certain provinces/local municipalities based on high infant/child mortality rates in South Africa).

The following formula is used:

$$\boldsymbol{Weighted\ age\ factor} =$$
$$\text{Total [total0\_4 (age0\_4 x CMRF) + total5\_39 (age5\_9 + \ldots\ldots + age35\_39) x 0.002)}$$
$$\text{+ (total40\_49 (age40\_44 + age45\_49) x 0.004) + (total50\_59 (total50\_54}$$
$$\text{+ total55\_59) x 0.013) + (total60\_69 (total60\_64 + total65\_69) x 0.036)}$$
$$\text{+ total\_70\_79 (total70\_74 + total75\_79) x 0.008) + total80over (age80over x 0.21)]}$$

Where,

Child mortality rate factor (CMRF) = Value between 0.002(low infant/child mortality rates) to 0.004(high infant/child mortality rates) based on observed child mortality rates in local municipalities.

Amplification correction factor: This factor was derived from taking both disease burden and known poverty rate into account. Current observations show that people with a history of one or more co-morbidities (disease burden) are at higher risk of more severe disease from COVID-19. There has been much speculation as to the severity of the impact of the COVID-19 virus and whether it will affect low and middle-to-low income countries more severely due to factors such as access to medical facilities, malnutrition, poverty and/or lifestyle.

The following formula is used:

$$\boldsymbol{Amplification\ correction\ factor} = Disease\ burden + Poverty\ rate$$

Disease burden: Prevalence of HIV infections as well as life expectancy (as a proxy for underlying health conditions)
Poverty rate: Household income below R76 400 per annum (as a proxy for malnutrition, healthy food choices, lifestyle choices and access to medicine and health support).

DATA SOURCES

Data sources used in compiling the indicators on the level of StatsSA's Enumerator Areas:

- Population demographics 2018: GeoTerra Image
- Building Based Land Use 2018: GeoTerra Image
- Mid-year population estimates StatsSA 2002-2018 on district council level
- Population census StatsSA: 2011 demarcation
- Health Data 2016: Quantec