23

Creating a Set of High-Resolution Vulnerability Indicators to Support the Disaster Management Response to the COVID-19 Pandemic in South Africa

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This chapter presents the "COVID-19 Vulnerability Dashboard" for South Africa, developed by the CSIR for the National Disaster Management Centre (NDMC). It maps vulnerability to COVID-19 for the whole of South Africa, down to the level of the 103 576 enumerator areas (EAs). The COVID-19 Vulnerability Dashboard aims at helping the NDMC, local authorities and other stakeholders with disaster risk reduction (DRR) and evidence based decision making. Several national government departments have used the Dashboard for planning support. South Africa has large populations around the country vulnerable to COVID-19 because of the triple challenges of poverty, inequality and employment, and the high levels of HIV/AIDS and tuberculosis; high potential for rapid spread because of many dense informal settlements; and limited health resources. The COVID-19 Vulnerability Dashboard draws on our expertise in spatial analysis and disaster risk reduction of human settlements, and our tools, data and expertise — including the Green Book*, also developed in partnership with the NDMC, to deal with the likely impacts of climate change. Using a multi-criteria analysis approach, we created a set of vulnerability indicators based on domain knowledge, which was peer-reviewed by expert groups. These are disseminated by dynamic spatial mapping through an interactive, online dashboard.*

23.1 Background

Released in 2019, the *Green Book* is an online planning support tool providing quantitative scientific evidence on the likely impacts climate change will have on South Africa at the local authority level. It was co-funded by the CSIR and the Canadian International Development Research Centre (IDRC), and developed by the CSIR in partnership with the National Disaster Management Centre (NDMC) and others [1, 2]. For more, see Section 23.3.

The CSIR has been helping the NDMC deal with the COVID-19 pandemic in several ways, including disseminating the *COVID-19 Vulnerability Dashboard*, built rapidly using the technologies and expertise (strong spatial analysis and deep understanding of risk and vulnerability analysis of human settlements) used for the Green Book. This dashboard provides indicators at a high resolution for all of South Africa, to help role players understand better the risks COVID-19 poses to communities and the health system, and the associated vulnerabilities. The focus is on the location and vulnerabilities of communities, and the required response mechanisms (coping capacities) [3].

Note that these COVID-19 vulnerability indicators are not based on epidemiological modelling, but were intended to support the early prevention, mitigation and preparedness phase of the disaster management cycle. As more data become available, updated versions of the COVID-19 vulnerability indicators will be released and shared to improve their usability and accuracy. Unsurprisingly, several organisations have been conducting research on SARS-CoV-2 and COVID-19 in South Africa and these initiatives collaborate with one another, such as through the *COVID-19 Modelling Webinar Series* [4].

This chapter then reports on this COVID-19 Vulnerability Dashboard developed following disaster management principals for the NDMC and used by several national government departments (particularly the Department of Health) for planning support. It has three main components: the *COVID-19 Vulnerability Index*, the *COVID-19 Transmission Potential Indicator* and the *COVID-19 Health Susceptibility Indicator*. See Section 23.5 for details.

Significantly, this link between the Green Book and addressing the COVID-19 pandemic demonstrates that modelling climate change risk (a potential disaster) and pandemics (as a disaster emanating from a biological hazard), and their impacts, are closely related. Hence, adaption and mitigation for both could be intertwined [5, 6].

This section has provided the background to the COVID-19 Vulnerability Dashboard. The next section provides some background on South Africa and the context for developing the COVID-19 Vulnerability Dashboard. This is followed by sections on the situation regarding SARS-CoV-2 and COVID-19 in South Africa, the Dashboard itself and the challenges encountered. This chapter ends with some conclusions and a look at the way forward.

23.2 Government Structures in South Africa

Since 1994, South Africa has had a constitutional, multiparty democracy with three spheres of government: national, provincial and local. South Africa has nine provinces and 8 metropolitan (metro), 44 district and 205 local municipalities. Within these, there are 4392 wards and 103 576 census enumerator areas (EAs) [7, 8]. The metros and districts are contiguous, each consisting of a mix of urban, peri-urban and hinterland or rural areas (even in the metros). Within each district, the local municipalities are contiguous. Unfortunately, too many municipalities are dysfunctional, due to corruption, incompetence, limited resources and limited capacity [9].

This obviously complicates dealing with the COVID-19 pandemic effectively, efficiently and fairly, such as accessing data and resources. Our COVID-19 Vulnerability Dashboard helps by providing a mechanism to obtain data and map the very vulnerable spaces, etc. The Auditor-General of South Africa (AGSA) has found "*clear signs of overpricing, unfair processes, potential fraud . . . delays in the delivery of personal protective equipment and quality concerns*" and many problems with relief payments [9]. Subsequently, the AGSA has been conducting *real-time auditing*[1] of the key COVID-19 [10].

To deal with the pervasive poor municipal management, the South African Government initiated the *Khawuleza*[2] *District Coordination Service Delivery Model* on 18 October 2019. It aims to break the pattern of municipalities operating in silos and the "*lack of coherence in planning and implementation* [that] has made monitoring and oversight of government's programme difficult", to improve service delivery and beat the triple challenges of poverty, inequality and employment [11]. There will then be a single, integrated plan for each district and the national and provincial budgets and programmes will be referenced spatially to districts. Implementation began with the 2020/21 Budget cycle (from 1 April 2020), though this has probably been disrupted by the COVID-19 pandemic.

The mid-year estimate for 2020 for the population of was 59.62 million, with about 51,1% being female, about 28,6% being aged younger than 15 years and about 9,1% being 60 years or older. Life

[1] As opposed to conventional annual audits in the months after a financial year-end.
[2] *Khawuleza* means "hurry up" in Zulu.

expectancy at birth was estimated at 62,5 years for males and 68,5 years for females, with infant mortality at about 23,6 per 1000 live births. Internal migration is high, estimated to average over 550 000 per year between provinces during 2016-2021 [7, 12]. Many South Africans, even amongst the poorest, have two family homes, one in a traditional rural area and one close to the job market, so there is also much travel between the provinces — adding to the COVID-19 risks.

23.3 The Green Book

In 2008, the South African Department of Science and Technology (DST)[3] published a ten-year Innovation Plan to meet five grand challenges, including "global-change science with a focus on climate change" [13]. DST then published its draft *Global Change Grand Challenge National Research Plan, South Africa* [14] and its ten-year *Global Change Research Plan* [15].

A *flagship science-into-policy initiative* of this Challenge is the *South African Risk and Vulnerability Atlas* (SARVA). The first edition of SARVA was published in 2010 [16]. SARVA targets local government specifically, but is also aimed at academia and was in South Africa's submissions to the COP17 meetings on climate change [17]. The second edition of SARVA was peer-reviewed and published in 2017 [18].

Building on our experience with SARVA, the concept of the *Green Book* was initiated by the CSIR and released in 2019. It is an online planning support tool providing quantitative scientific evidence on the likely impacts climate change will have on South Africa at the local authority level. The Green Book also presents various adaptation actions that can be implemented by local government to support climate resilient development. The Green Book was co-funded by the CSIR and the IDRC and developed by the CSIR in partnership with the NDMC and others [1, 2].

The key problem is the rapid urbanisation in South Africa (largely into informal settlements), but with poor economic performance and growth (now exacerbated by the COVID-19 lockdown) and the constrained capacity of many municipalities to cope. Further, many people are very vulnerable to any shocks, be they social, economic or environmental — or a pandemic. The Green Book has been developed to help municipalities across the country understand their threats and plan suitable adaptation and mitigation [2].

The Green Book integrates the *grounding in science* of climate change adaption (CCA) with the *practical planning and operations* of disaster risk reduction (DRR). This *interplay* or *overlapping-world* for understanding risk better, particularly disaster risk, makes the work multidimensional and opens-up future possibilities — as has now happened with dealing with the COVID-19 pandemic.

The Green Book has been flexible enough to be adapted for other types of disasters, such as the COVID-19 pandemic.

23.4 SARS-CoV-2 and COVID-19 in South Africa

On 15 March 2020, a national state of disaster was declared [19]. A severe lockdown for 21 days was then declared and subsequently extended [20]. The lockdown caused a short-term decline in the rate of new COVID-19 cases [21] ("flattening the curve") and initially, the South African Government received praise for the rapid and drastic response, still before the first death from COVID-19. However, by 22 May 2020, arrests for allegedly contravening the lockdown regulations were made in almost 230 000 cases [22] and as at 29 June 2020, the Independent Police Investigative Directorate (IPID) was examining 588 complaints, including 11 deaths allegedly due to police action [23].

A risk-adjusted strategy of five Alert Levels was created on 23 April 2020 [24], ranging from

[3] Now the Department of Science and Innovation (DSI).

level 1, being almost normal (but with a curfew), to level 5, with drastic measures such as confining everyone to their home (except for essential services and goods), closing most businesses and complete bans on the sales of alcohol and tobacco products [25–27]. The then existing *hard lockdown* effectively morphed immediately into Alert Level 5 on 23 April 2020. Some of the Regulations were found to be distressing, arbitrary and irrational [28]. South Africa moved to Alert Level 1 on 21 September 2020 [29].

Unfortunately, COVID-19 cases increased rapidly in South Africa with 364 328 confirmed cases by 19 July 2020, behind only the USA, Brazil, India and Russia in total cases. From 28 August 2020, the rate of new infections in South Africa slowed to the extent that Peru (621 997 cases) overtook South Africa (620 132 cases), followed by other countries. However, the death rate in South Africa has been relatively lower. As at 30 September 2020, South Africa had the tenth highest number of cases, at 674 339, but the thirteenth highest number of deaths, at 16 734 [30–33]. A sentinel surveillance study in July/August 2020 in Cape Town of women attending public-sector antenatal clinics and public-sector patients living with HIV, found that 40% had SARS-CoV-2 antibodies, but only 4% of those with the antibodies had COVID-19. Such herd immunity "is likely the main contributor to the observed decline in the epidemic curve in the Cape Town Metro" [34].

There has been some contention over the modelling of infections and their consequences, with forecasts of deaths from COVID-19 in South Africa ranging from as high as 351 000 (made in March 2020) [35] to as low as less than 10 000 [36]. Excessively high forecasts of deaths have been made in other countries, as well [37] and there are several reasons for why such forecasting has failed [38]. On the other hand, some consider the actual deaths from COVID-19 to be much higher. The South African Medical Research Council (SAMRC), for example, estimate that the excess deaths (including from COVID-19) between 6 May 2020 and 15 September 2020 were 44 481 [39].

23.5 The COVID-19 Vulnerability Dashboard

23.5.1 Background

With the looming threat of the SARS-CoV-2 and COVID-19 pandemic, the NDMC approached the CSIR in March 2020 to assist with supporting under-capacitated municipalities in responding to the COVID-19 disaster and mitigating all possible risks. The focus was to provide conceptual and guiding input to the NDMC's approach to the national crisis. A key part of this response is the *COVID-19 Vulnerability Dashboard*, developed using the CSIR's tools, data and expertise, including the Green Book [3].

For modelling the COVID-19 risks, we provided conceptual input and supported the NMDC's spatial mapping of the vulnerabilities of communities to COVID-19, packaged into a spatial dashboard with vulnerability indices (using a web-based geographical information system(GIS)) to show how and where the NDMC should focus its efforts. We report here only on this *COVID-19 Vulnerability Dashboard*, which is underpinned by strong spatial analysis and deep understanding of risk vulnerability analysis of human settlements,as gained through the Green Book project [40].

The COVID-19 vulnerability indicators for all of South Africa are calculated at the level of the 103 576 EAs, but are displayed and reported in the Dashboard at the level of the 4 392 wards, as that is the relevant granularity for making interventions (each ward is represented by a municipal councillor). These indicators were developed with conceptual input from the Albert Luthuli Centre for Responsible Leadership (University of Pretoria), and help role players understand better the risks COVID-19 poses to communities and the health system, and the associated vulnerabilities. The questions most often asked by these role players are:

- Where are the communities that will struggle to apply the principles of social distancing?
- Are there areas that will struggle to maintain the principles of good basic hygiene due to a lack of basic water and sanitation services?
- Where are the elderly and other vulnerable communities located?

- Can the potential hospitalization demand be met with an adequate supply of beds, equipment, health workers and emergency personnel [3]?

These questions fall into two groups: the location and vulnerabilities of communities, and the required response mechanisms (coping capacities). One needs to understand these vulnerabilities to anticipate the risks and identify the high-risk intervention areas. The following are the main indicators that have been developed:

- Risk = Exposure to hazard × (Vulnerability / Coping capacity)
- COVID-19 vulnerability index = Transmission potential + Health susceptibility
- Transmission potential = Informality + Lack of access to basic services + High population density
- Health susceptibility = Weighted age factor + (Amplification correction factor × Weighted age factor)
- Amplification correction factor = Disease burden + Poverty rate

The COVID-19 Vulnerability Dashboard was created on 3 April 2020, made fully public on 6 May 2020 and as of 22 July 2020 had received 2601 views. It has been used by the NDMC, the National Department of Health, other departments, municipalities and others for planning support.

23.5.2 The Dashboard Platform

Esri's ArcGIS Dashboard [41] was used as the technology platform for rapidly disseminating the analytical results and for them to be openly accessible by national, provincial and local government officials and decision-makers in South Africa. The ArcGIS Dashboarding environment was chosen because of the wide user reach, reliability and immediate availability of the data assured by an openly accessible web-based platform. The use of dashboarding technology also allowed users of the COVID-19 Vulnerability Dashboard to explore interactively the COVID-19 vulnerability analysis data by dynamically filtering data for the spatial extent of their choice (national, provincial, district municipal level, local municipality or ward level), making the COVID-19 Vulnerability Dashboard an invaluable decision support tool at all levels of South African government. Lastly, the COVID-19 Vulnerability Dashboard, as the single source for accessing the COVID-19 Vulnerability Index data, ensured decision makers the trusted reliability of accessing the data and metadata for decision making directly from the CSIR as the COVID-19 Vulnerability Index data custodian.

A valuable outcome has been the development and provision of data-sharing facilities, such as the COVID-19 Vulnerability Dashboard, to help with the effective planning and management of the response to the pandemic. Using dashboards for health evolved as web-based GIS platforms became more capable at providing ready access and real-time sharing of spatially-referenced operational data, a vital component for evidence-based decision-making in disaster situations. Dashboarding technology has played an important role in the spatial analysis and rapid data-sharing related to the COVID-19 pandemic around the world (such as [31, 32, 42, 43]), where accurate and timely information is required to support decision-makers so that epidemic prevention, control and management can be efficiently carried out.

23.5.3 Overview of the COVID-19 Vulnerability Dashboard

The following are some details of how the *COVID-19 Vulnerability Dashboard* has been assembled and how it functions.

- **Version control and updates**: The COVID-19 vulnerability indicators 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, 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 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 we recommend that those who use 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 COVID-19), 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). With the COVID-19 pandemic in South Africa, many sector departments faced similar questions at the start of the outbreak. Departments were concerned with understanding better the risks posed by COVID-19 to communities and the health system, and the associated vulnerabilities.

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

23.5.4 COVID-19 Vulnerability Index

The *COVID-19 Vulnerability Index* attempts to indicate the vulnerability of communities to the potential impact of COVID-19, based firstly on how effectively the spread of COVID-19 can be contained (the transmission potential), and secondly on the population's susceptibility to severe disease associated with contracting COVID-19 (the health susceptibility). For this, the following formula is used:

$$Vulnerability\ index = Transmission\ potential + Health\ susceptibility \tag{23.1}$$

We used an indicator-based assessment method to construct the composite COVID-19 vulnerability indicator. This indicator was computed using 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 contributing to the indicators were standardized using 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 and we used 1–100 for this standardization process. In this method, each Enumeration Area (EA) in South Africa was compared and related to all the other EAs in the country, thus ensuring the COVID-19 Vulnerability Index could facilitate a coordinated national response. The following formula is used to normalise the data:

$$MinMax = \frac{X_i - X_{min}}{X_{max} - X_{min}} \times (End\ of\ range - Start\ of\ range) + Start\ of\ range \tag{23.2}$$

After the standardization 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.

Figure 23.1 is a screen shot of the COVID-19 Vulnerability Dashboard, showing high vulnerabilities in the rural areas in the eastern areas. However, the extremely vulnerable areas (red dots) are actually scattered across the country, particularly in high density but small EAs in urban areas, though they are unsurprisingly not so obvious in such a small-scale map.

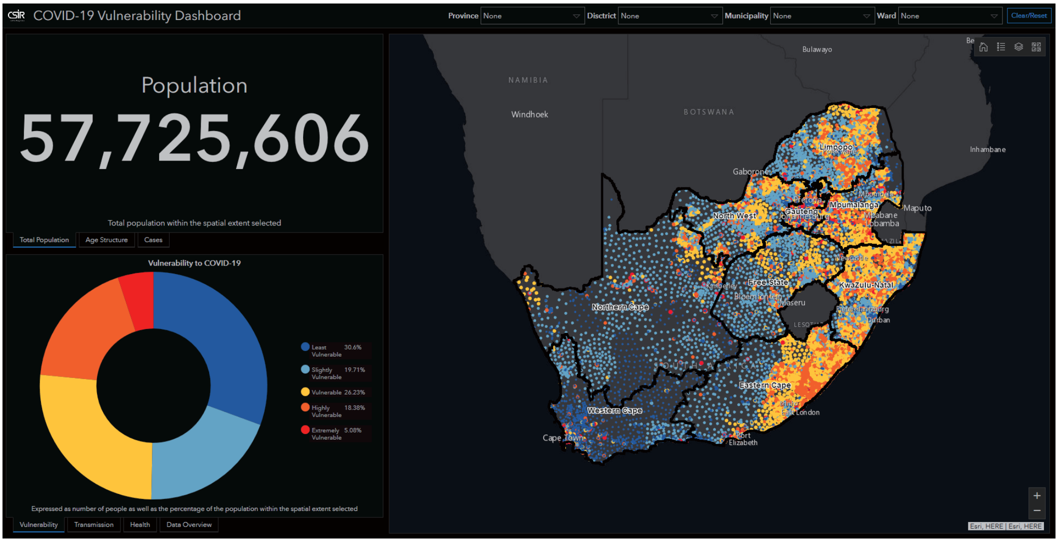

FIGURE 23.1
COVID-19 Vulnerability Dashboard, showing vulnerability [44].

23.5.5 COVID-19 Transmission Potential Indicator

The *COVID-19 Transmission Potential Indicator* identifies areas where existing living conditions could make it difficult to maintain social distancing and practice good basic hygiene in order to contain the spread of COVID-19. The following formula is used:

$$Transmission\ potential = Informality + Basic\ services + Population\ density \tag{23.3}$$

This indicator classifies EAs throughout South Africa according to transmission risk, producing a score between 1 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 (the higher the value for each, the worse the risk):

- **Informality**: Number of informal dwellings per EA (informal dwellings and informal backyard structures).
- **Basic services**: The *lack of access* to basic services, being the number of households without basic access to running water and sanitation.
- **Population density**: Number of people per hectare.

Transmission potential has a similar pattern to that of vulnerability, see Figure 23.1.

23.5.6 COVID-19 Health Susceptibility Indicator

The *COVID-19 Health Susceptibility 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:

$$\begin{aligned} Health\ susceptibility &= Weighted\ age\ factor + \\ &(Amplification\ correction\ factor \times Weighted\ age\ factor) \end{aligned} \tag{23.4}$$

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 how many people 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:

$$\begin{aligned} Weighted\ age\ factor = Total[&total0\_4(age0\_4 \times CMRF) \\ &+ total5\_39(age5\_9 + \cdots + age35\_39) \times 0.002) \\ &+ (total40\_49(age40\_44 + age45\_49) \times 0.004) \\ &+ (total50\_59(total50\_54 + total55\_59) \times 0.013) \\ &+ (total60\_69(total60\_64 + total65\_69) \times 0.036) \\ &+ total70\_79(total70\_74 + total75\_79) \times 0.008) \\ &+ total80over(age80over \times 0.21)] \end{aligned} \tag{23.5}$$

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:

$$Amplification\ correction\ factor = Disease\ burden + Poverty\ rate \tag{23.6}$$

- **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).

Figure 23.2 is a screen shot of the COVID-19 Health Susceptibility Dashboard. This shows a different pattern from those for vulnerability (Figure 23.1) and transmission potential, with lower risks in the Transkei (eastern part of the Eastern Cape) but higher risks in KwaZulu Natal and the south-western parts of the Western Cape, for example.

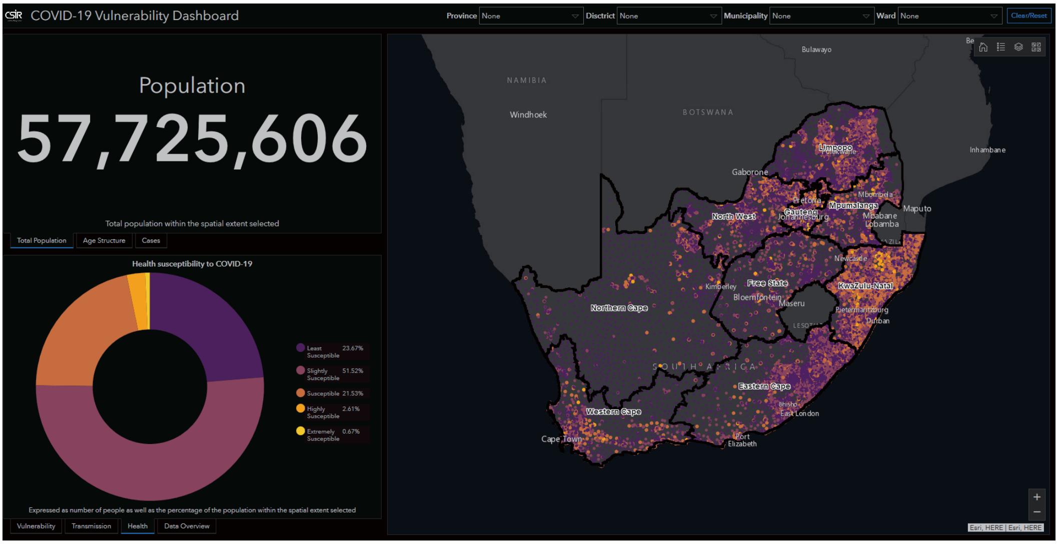

FIGURE 23.2
COVID-19 Vulnerability Dashboard, showing health susceptibility [44].

23.6 Challenges

23.6.1 Data Sources

Concerns have been raised at the general lack of access to data about SARS-CoV2 and COVID-19, which could be constraining unified action against the pandemic [45]. In particular, case data at a high (fine) spatial resolution are critical for complete and full risk assessments for successful disaster response and planning. Many feel that open data should be the default [46], with even the Organisation for Economic Cooperation and Development (OECD) declaring that open science is critical to combatting COVID-19 [47].

Fortunately, we were able to draw on our extensive data holdings, for which we have done quality assurance, cleaning and integration over the years for various products and services. For the COVID-19 Vulnerability Dashboard, the key data sources used to compile the indicators at the EA level are:

- Population demographics 2018, from GeoTerra Image.
- Building Based Land Use 2018, from GeoTerra Image.
- Mid-year population estimates at the district council level for 2002-2018, from Statistics South Africa (StatsSA).
- 2011 Population census and its EA demarcation, from StatsSA.
- Health Data for 2016, from Quantec.

23.6.2 Quality

There are several problems with the quality of the data on COVID-19 cases, recoveries and deaths. The first is identifying the relevant cases and documenting and reporting them correctly. This has been an issue in South Africa, as some clinicians and pathology laboratories did not complete the documentation properly for all the patients who presented for tests, even though it is a notifiable disease. This increased the administrative burden on the NICD, as its staff had to search for the missing patient information of the confirmed cases, so that the patients could be contacted to see if they actually needed treatment and to trace everyone with whom they had been in direct contact, so that they could be warned, etc [48].

This obstacle is systematic, unfortunately: Table 23.1 shows *Number and percentage distribution of deaths by method used to ascertain the cause of death, 2017*, from the report, *Mortality and causes of death in South Africa: Findings from death notification, 2017* [49]. The data for this report are "completed by medical practitioners and other certifying officials", yet in one third of the cases (33.3%), these professionals did not know how they ascertained the cause of death!

TABLE 23.1
Method of ascertaining the cause of death [49]

Method of ascertaining the cause of death	Number	Percent
Autopsy	44 848	10,0
Post mortem examination	116 246	26,0
Opinion of attending medical practitioner	64 663	14,5
Opinion of attending medical practitioner on duty	7 777	1,7
Opinion of registered professional nurse	52 810	11,8
Interview of family member	5 238	1,2
Other	6 033	1,4
Unknown	344	0,1
Unspecified	148 585	33,3
Total	**446 544**	**100,00**

Then comes tracking each case to its conclusion: recovery (which requires the case file to be closed and reported properly) or death. A key issue with the latter is the structuring of the death certificate and whether COVID-19 gets recorded as the immediate cause, an underlying cause, a significant condition contributing to death, or not at all [50].

It is also necessary to get accurate data on the locations of cases, for tracing potential contacts and other interventions. While South Africa has a suite of standards for addresses [51], it is not yet widely used and the forms for COVID-19 do not cater for it. The result is that municipalities, provinces and national departments are having to manually and laboriously geocode the addresses [52]. A consequence is over-counting, such as when an infected person is tested several times but each test gets recorded as a separate case of COVID-19: this could result in the total number of cases fluctuating as the duplicates get identified and removed later.

Finally, of course, there needs to be metadata, that is, documentation of the data.

23.7 Conclusions and the Way Forward

This chapter has presented the *COVID-19 Vulnerability Dashboard* for South Africa, developed by the CSIR originally for the NDMC. The Dashboard provides the *COVID-19 Vulnerability Index*, *COVID-19 Transmission Potential Indicator* and *COVID-19 Health Susceptibility Indicator* at ward level. It provided critical information for sector departments and under-capacitated municipalities early in the disaster management cycle. The purpose was to highlight the high-risk intervention areas so that decision makers could intervene with the appropriate adaptation measures where needed. The COVID-19 Vulnerability Index, COVID-19 Transmission Potential Indicator and COVID-19 Health Susceptibility Indicator were made available for free and were peer-reviewed by various stakeholders.

The ESRI dashboard environment was used as this supported an interactive, dynamic and accessible approach in which to convey these critical datasets in an open-access manner. Open access to data is critical in the disaster management cycle if anyone is to respond effectively and timeously. The open access nature of the dashboard proved highly affective as more than 2600 entries to the dashboard where recorded between May 2020 and July 2020. Since the dashboard was created, published and hosted by the CSIR infrastructure, it provided the opportunity to correct, alter or add any information deemed necessary with little additional effort.

When the open dashboard was released, many of the users of the dashboard requested additional supportive information to be added and loaded. The most requested included the location and capacity of hospitals, hospital admission rates and the location of quarantine facilities. Including these datasets into the COVID-19 Vulnerability Dashboard proved a much harder task as the team ran into data custodian restrictions, data censorship, fragmented data capturing techniques and a general lack of critical information being made open and accessible to decision makers. The lack of cooperation and sharing of critical datasets resulted in these datasets being excluded in the dashboard.

An additional request made by users was to gain access to the spatial information in the back-end. Many of the decision makers and researchers with in-house GIS and analytical capability requested copies of the information for their own decision-making purposes. Since the dashboard did not support the functionality to download the spatial information, a file hosting service was set-up in the cloud to share the information with these decision makers. This resulted in many copies of the various vulnerability indicators being used even more effectively and widely for various processes.

Acknowledgement

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