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Spatial inequality through the prism of a pandemic: Covid-19 in South Africa

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1. Introduction

In early April 2020 half of humanity was in lockdown as a response to the COVID-19 pandemic. Faced with such a novel situation, most governments chose to protect their citizens by temporarily imposing strict restrictions on mobility and by appealing to their sense of solidarity. At the beginning of the pandemic and these lockdowns, everyone was confronted with the same limitations in terms of their daily activities, and everyone was considered equally vulnerable to the virus. Indeed, in the early days of the spread of the virus, those infected were international travellers who often represented a privileged segment of the world’s population. However, as countries moved beyond this initial spread, the epidemic became a pandemic and the number of cases began to rise. As a result, it became increasingly evident that the virus did not affect everyone equally and not everyone had the means to cope with extended lockdowns [4,6].

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The COVID-19 pandemic exposed and reinforced socio-economic inequalities within and across countries. Inequalities in exposure to social determinants of health are associated with inequalities in the prevalence and severity of the COVID-19 pandemic and other major past pandemics [4]. Poverty is often associated with weaker health, resulting in higher vulnerability to Covid-19 comorbidities. In addition, poor people may be more exposed to the virus because their jobs are often in sectors where remote working is not possible, they have less access to facilities such as water and sanitation, and they live in more populous areas. Thus, the initial level of inequality can determine the level of exposure to the virus and its lethality [10]. It is imperative that this is profiled in the context of each country so that it is considered as part of the discussion of the balance between saving the population and saving the economy.

Across the world, interventions such as social distancing and hand hygiene are recommended to break the virus transmission cycle. However, compliance with these guidelines depends on appropriate home-environment and personal behavioral responses [5,6]. Various papers have analyzed how vulnerable or, on the contrary, how ready countries are to face a pandemic like the one we have faced in 2020 [6,9–11]. But, as it is the case with most aggregated measures, these analyses conceal the heterogeneity of sub-national situations. Some preliminary cross-country and within country level analysis has been conducted in Africa (see e.g. [8,9]), but specific attention has not been given to the way in which pre-existing spatial inequalities shape intra-country inequalities in vulnerability outcomes. This spatial inequality is one of the factors that increases actual vulnerability of a country to a crisis such as COVID-19. While remote and isolated areas may benefit from being less exposed to contagion, the lack of access to basic services and health facilities could actually increase fatalities in these areas as the infection spreads. Inequality also affects government’s ability to respond to the pandemic. High inequality and polarization have been shown to negatively affect political institutions and trust in the government, thus limiting the ability to agree on policies to respond to the pandemic and ensure compliance by citizens without harsh enforcement [2,19].

The aim of this paper is to build on existing international work and to extend it by conducting a more geographically disaggregated analysis using data from South Africa. South Africa has been one of the worst affected African countries by COVID-19, with over 2.3 million confirmed case and 68 000 deaths as of July 21, 2021 [11]. South Africa is also one of the world’s most unequal countries, with an income Gini coefficient of 0.67 [22]. One of the key characteristics of inequality in South Africa is the high level of spatial disparity inherited from the Apartheid segregation policies [7,16,24,26]. Despite significant progress in improving access to basic services since 1994, spatial disparities continue to persist. According to a municipality-level study conducted by Anda et al. [26], the proportion of people considered multidimensionally poor is 14% or less in the richest ten municipalities, whereas it ranges between 50% and 54% in the poorest ten municipalities. Similarly, the rate of income poverty is less than 35% in the richest nine municipalities and rises to 83% to 87% in the poorest twelve municipalities. Such large disparities in living conditions can lead to differences in COVID-19 vulnerability and ability to deal with lockdown and social distancing policies.

Such an analysis could start with inequality in terms of exposure, in asking whether all provinces or municipalities are equally exposed to COVID-19. They are probably not in most contexts and have not been in the South African context. Both the national and national travel hubs have been shown to have higher initial contamination rates and then country-specific socioeconomic circumstances mediate the spatial spread of the contamination. This analysis of initial and ongoing intra-regional exposure is an important part of understanding the inequalities in the transmission of COVID-19 and the evolving spatial context of the disease across the country where individuals live, work and go to school. However, as spelt out by Qiu et al. [18], detailed demographic and epidemiological data are required to undertake such an analysis adequately. These data are not readily available in South Africa right now and will not be available in many developing country contexts.

This paper therefore goes a different route. It uses survey data that is much more widely available to profile the prevailing circumstances of individuals and households across South Africa who are confronted with the virus. We analyze the vulnerability of provinces and municipalities based on the living conditions of their populations in order to describe the prevailing inequalities in the capacity to respond well to the presence of the virus. Current socio-economic factors associated with the ability of individuals to protect themselves from infection and deal with severe lockdowns are often a reflection of past wealth-related status, which is unlikely to change quickly in response to pandemics such as COVID-19 [6]. We examine whether there is a relationship between household wealth status and vulnerability to COVID-19 infection: whether poorer households/individuals are more likely to be vulnerable to COVID-19 infection due to their living conditions. Given the level of inequality in income and access to basic services in South Africa, the extent to which households are able to follow WHO recommendations to avoid infection and deal with lockdown policy can depend on their poverty/wealth status. The poor, for example, are more likely to live in crowded households and share water and sanitation facilities with many other households. These factors can increase their risk of infection.

Our findings indicate that there are stark spatial inequalities in COVID-19 vulnerabilities in South Africa. We also find a strong positive relationship between household wealth status and vulnerability to COVID-19. Regardless of where poor households live, they are less likely to be able to protect themselves from the virus.

We begin with a description of the dataset used in this paper. Section 3 motivates measures of vulnerability to COVID-19 at national, provincial and municipal levels, and analyses of the relationship between households’ assets/wealth and vulnerability to COVID-19. We conclude by summarizing findings with a particular focus on the implications for budget allocations in response to the COVID-19 pandemic.

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1 The paper by Qiu et al. [18] provides a useful framework on how to do this.
2. Data and measurement

2.1. Data source

We use data from the 2016 Community Survey (CS) because it can support analysis at the national, provincial and municipal levels. The 2016 CS a between census survey that has been conducted every five years. The CS is a household-level survey that collects information on household demographics (such as household size, age, and race composition of each household member), employment status, housing conditions, and access to basic services such as water, sanitation, and electricity, as well as the status of food security. Access to basic services and household size and composition, are used to measure COVID-19 vulnerability. The dataset also collects data on various household asset holdings (Table A1 in the Annexure), which are used to calculate household wealth index.

The 2016 CS was based on a stratified single-stage sample design [21]. All enumerator areas (EAs) from the 2011 Census were included and, within each EA, dwelling units (DUs) were sampled using a systematic sampling technique. However, EAs with a very small number of DUs were excluded from the sample frame. The final sample size is 1,370,809 DUs sampled from a total of 93,427 EAs, with the realized sample size being 984,627 DUs. The purpose of such a sampling strategy was for the 2016 CS to provide representative estimates at the local municipality level.

In a longer working paper [20], we compare our estimates at the national and provincial levels from the CS with estimates based on the 2018 General Household Survey (GHS). The 2018 GHS is fairly recent and contains more detailed information than the 2016 CS. However, the estimates obtained on the bases of both datasets are very similar and given our main objective of providing estimates of spatial inequalities at lower geographic disaggregation units, the CS is useful for providing representative estimates at the local municipal level. In this paper, therefore, we present results based on the CS.

2.2. Vulnerability measurement

While lockdown and social distancing policies are implemented to minimize the risk of infection outside the household, the secondary attack rate (the proportion of people infected as a result of contact with an infected person) varies depending on the living circumstances of the individual. Pre-existing social and economic inequalities may associate with inequalities in the ability of individuals to follow WHO recommendations in order to protect themselves from COVID-19 infection. Gordon et al. [10] suggest nine indicators to measure individual’s vulnerability to COVID-19 infection due to their living conditions. The vulnerability indicators are selected based on how the virus would likely spread. Thus, the vulnerability indicators are intended to identify a household that is at a relatively higher risk of contracting COVID-19 infection due to their living conditions. We are restricted to using six of the indicators that make sense in the South African context and can be measured using the CS dataset. Table 1 provides the vulnerability indicators and the scientific justification for using each indicator.

The six vulnerability indicators considered are: whether a household was sharing water sources with other households, whether a household was sharing toilet facilities with other households, whether a household have no access to information (Have no access to a radio or TV), whether a household was congested (i.e. Large Household - 6 or more people), whether a household have vulnerable individuals (People over 60 living in households with two or more younger people (Younger individuals are those aged between 7 and 60 years)). Among the variables used by Gordon et al.[10] the following indicators are not included in our vulnerability index: a lack of soap or detergent, obesity, overcrowding (more than three people per room with only one sleeping room), and the need to collect firewood or be unable to cook food at home. For the first three variables, there is no data in the CS. There is information on the use of firewood. However, we do not know if the wood was collected from an open field or purchased from a market. Furthermore, unlike in other African countries, the use of firewood is not prevalent in South Africa (Only 10 percent of the sample households reported using wood for cooking). We included access to information as an additional indicator in our vulnerability index, which Gordon et al. [10] did not include despite listing it as one of the additional indicators that can affect vulnerability to COVID-19.

We provide separate spatial estimates of each vulnerability indicators listed in Table 1. However, we expect as the number of vulnerabilities experienced increases, the risk of infection also increases. In order to examine the incidence of multiple vulnerabilities experienced, we need to combine the various indicators into a single index. Nevertheless, it is important to note that there is not a best way to combine the various indicators into a single vulnerability index, as it is not conceptually clear how the intersections between the indicators work and how each indicator should be weighted. Nonetheless it is important to profile and assess the intensity of vulnerability to the COVID-19 infection. We use two simple approaches: we start by computing a weighted sum of vulnerability scores for each individual with each indicator being equally weighed. The value for the weighted vulnerability scores ranges from 0 (vulnerable in none of the indicators) to 1 (vulnerable in all of the indicators). Then, average values are calculated at province and municipality levels. However, this average can conceal

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2. The GHS is a nationally representative sample of approximately 24,726 households (Stats SA, 2019a). The 2018 GHS sample is based on a two-stage stratified sampling method. In the first stage, primary sampling units (i.e. EAs) were sampled using a probability proportional to size (PPS) method. Dwelling Units (DUs) were sampled using systematic sampling at the second level.

3. More or less the same set of indicators is used by Brown et al. [6] to construct an index called “Home environment for protection” (HEP) that used to assess the ability of households to comply with the prevailing WHO recommendations.
Vulnerability to COVID-19 infection indicators.

| Vulnerability Indicator | Secondary Attack Rate Level | Scientific Reason |
|-------------------------|-----------------------------|-------------------|
| Large Household - 6 or more people | Household | An ill person is more likely to infect their household members than friends, neighbours or the wider community. The larger the household the more household members are likely to be infected. |
| People over 60 living in households with two or more younger people (Younger individuals are those aged between 7 and 60 years) | Household | People aged 60 and over are more likely to die or suffer from a severe Covid-19 infection. Older people are more likely to be infected within the households with younger members i.e. they have a higher secondary attack rate within the household. |
| No refrigerator | Household | Households which do not have a refrigerator will need to leave their homes more frequently to get food and thus be at greater risk of infection. |
| Sharing a toilet with other households (i.e. either households have no access to a toilet facility, or it is shared with other households) | Neighbours/Friends | Sharing a toilet increases the risk of catching Covid-19 from infected people in neighbour's households either by faecal/oral transmission or from close contact in or near the shared toilet. |
| Sharing water sources with other households (i.e. water not accessed from piped (tap) water in the dwelling, piped (tap) water on-site, or in the yard) | Neighbours/Friends | Sharing a water supply increases the risk of catching Covid-19 from infected people in the neighbour's households. Needing to collect water from a public supply increases the risk of catching Covid-19 from infected people in other households due to close contact while queuing to collect water or touching infected parts the water supply equipment e.g. stand-pipe taps, wells buckets, etc. |
| Have no access to a radio or TV | Household | Effective risk communication and community engagement is of key importance to controlling infectious disease epidemics. It is much harder for households without telephones or access to broadcast media to get the correct public health information they need to stay safe as misinformation and rumour during a pandemic can be both extensive and dangerous. |

Source: Gordon et al. [10].
the heterogenous outcomes across indicators and spatial units and so we complete the analysis by counting the number of vulnerability indicators for each individual as a second vulnerability measure. Then, we examine the proportion of people experiencing multiple sources of vulnerabilities. Counting is the approach used to aggregate COVID-19 vulnerability indicators in previous similar research (e.g. [6]).

2.3. Wealth index calculation

For the purpose of analyzing the relationship between wealth status and vulnerability to COVID-19 infection, we construct a wealth/asset index using the list of variables provided in Table A1 in the Annexure. Asset weights are generated using the uncentered PCA (UCPCA) approach [3,25]. Although some of the variables included in the wealth index overlap with those used in the vulnerability index calculation, these indicators are not defined in the same way. Also, the wealth index includes 18 additional indicators that are not used in the vulnerability indices. As a result, we do not expect the relationship between the wealth index and the vulnerability index to be primarily due to this overlap. That said, we check for this by calculating the wealth index, with and without the variables used in the calculation of the vulnerability index. The rank correlation coefficient between the two wealth indices is very high. In addition, the R² for the variance of the overall wealth index on the variance of the vulnerability index is low (0.12). Thus, almost 90% of the variance in the overall wealth index is due to variables that are not included in the vulnerability index calculation. We use the wealth index calculated using the full set of variables shown in Table A1 in the Annexure in our subsequent work.

3. Results

In this section, we first provide estimates of vulnerability to COVID-19 at various spatial units. Then, we examine the relationship between wealth status and vulnerability to COVID-19.

3.1. Vulnerability indicators

With regard to the individual indicators, about 21% of the population resides in households that consist of at least one older adult (age >60) and two younger individuals (age between 7 and 60). Around 15% of the population does not have access to a refrigerator while 8% of the population does not have access to a television or radio. The percentage of the population living in a family size of six or more is greater in rural areas compared to urban areas. In order to facilitate the interpretation of our vulnerability index, we start by computing average vulnerability scores. Fig. 1 below gives us a first glimpse of spatial disparities in South Africa. The average vulnerability score is the highest for Eastern Cape province followed by Limpopo and KwaZulu-Natal while the figure is relatively lower for Western Cape, Free State, and Gauteng provinces.

But the province level analysis can hide within province differences and the reason why we use the CS to investigate whether intra-province spatial disparities exist and how important they are. The municipality level estimates shown in Fig. 1 do indeed reveal significant variations within each province. For example, whereas the provincial level analysis shows the Eastern Cape province as being the province with the highest average vulnerability score, when we look at the level of municipalities, we see that municipalities with very high average vulnerability scores can also be found in KwaZulu-Natal, North West and Northern Cape.

In probing what is driving these averages, we find significant variations across provinces with respect to some of the vulnerability indicators. Figure A2 in the Annexure shows, for example, that the proportion of the population sharing water is less than 10% in Gauteng and Western Cape, whereas the figure is more than 50% in Limpopo and Eastern Cape. Likewise, a relatively higher proportion of the population in Eastern Cape had no access to a refrigerator (29%), while the figure is only 8% in Western Cape. Based on individual vulnerability indicators, Eastern Cape and KwaZulu-Natal can be considered the most vulnerable provinces. Looking across these provincial boundaries, there are large differences in the degree of vulnerability between municipalities (Figure A3 in the Annexure). For instance, more than 25% of the population did not have access to either TV or radio in nine local municipalities (i.e. Ntabankulu, Elundini, Mbizana, Vulamhlo, Port St Johns, Msinga, Umzimvubu, Ndwe, and Ubuhlebezwe). The proportion of the population that uses shared toilet facilities is between 50% and 68% in seven local municipalities (Naledi-FS, Mandeni, Musina, Camdeboo, Ntambanana, Mookgopong, and Tokologo). There are hotspots of vulnerability in nearly all provinces. The proportion of the population sharing water with other households is 50% and more in 75 of the municipalities, with the figure being 95% and more in

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4 In working paper version of the paper [20], we compared the distribution of our wealth index with the distribution of consumption expenditure from Stats SA (Stats SA,2019). There is close correspondence between the distribution of the wealth index and the distribution of consumption expenditure.

5 See Figure A1 in the Annexure.

6 Figure A2 in the Annexure maps each indicator by province, showing the complementarity among indicators and thus the need to pull them together into an aggregate index.
Mbizana, Ngquza Hill, Mbhashe, Nyandeni, and Port St Johns. Thus, the use of shared water sources is prevalent in most local municipalities.

We now move to finer grained analysis by adopting a counting approach for the vulnerability indicators. Figure A4 in the Annexure shows the percentage of the population by the number of vulnerability indicators and the relative provincial shares of the population that are likely to be vulnerable to COVID-19 infection. The results show that the intensity of vulnerability to COVID-19 infection is the highest in Eastern Cape, Limpopo, KwaZulu-Natal and North West provinces. When this intensity is twinned to population shares, the relative shares of the population that is estimated to be vulnerable due to two or more indicators is relatively higher in the Eastern Cape, Limpopo, KwaZulu-Natal and Gauteng provinces. In the Eastern Cape and KwaZulu-Natal this is due to both high provincial intensities combined with large shares of the national population. Limpopo does not have such a large population share (10%) but the intensity of vulnerability within this population is so high that it still has a high national share.

The municipality level analysis shown in Fig. 2 also reveals that the intensity of vulnerability to COVID-19 infection is highest in municipalities located in Eastern Cape, KwaZulu-Natal and North West provinces. The proportion of people who are vulnerable due to three or more indicators is between 30% and 37% in 17 municipalities, mainly located in KwaZulu-Natal and Eastern Cape. On the other hand, the figure is less than 5% for 19 municipalities largely located in Western Cape and Northern Cape.

The relative share of the population that is likely to be vulnerable to Covid-19 infection due to two or more indicators is higher in municipalities located in Gauteng, Eastern Cape, Limpopo, KwaZulu-Natal and Mpumalanga (Figure A5 in the

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7 The relative provincial share of the population that are likely to be vulnerable to Covid-19 is measured as the number of vulnerable populations in each province divided by the total number of vulnerable population in the country.

8 The population share for KwaZulu-Natal and Gauteng is 20% and 24% respectively, while the figure for Eastern Cape is 13%. On the other hand, the population share for Northern Cape province is only 2%.
Annexure). Results from analyzing the retaliative share of the population that is likely to be vulnerable to Covid-19 infection are useful in making two important points. First, even in the least vulnerable provinces, there are local areas that contain sizeable shares of the national population who are highly vulnerable. Second, even in provinces with high vulnerability, the combination of high vulnerability with large population share is quite localized.

Overall, the analysis in this section shows that both the incidence of vulnerability to COVID-19 infection and the relative shares of the population estimated to be vulnerable due to multiple vulnerability indicators are relatively higher in the Eastern Cape, KwaZulu-Natal, Limpopo and North West provinces. But there are significant spatial inequalities in each province.

The vulnerability index considered in this paper mainly reflects on living condition factors that are likely to increase the secondary attack rate in the population. Thus, our vulnerability index may not necessarily correspond to reported actual infection cases and death figures for various reasons. The observed cases are the result of a variety of factors that vary over time and location. For example, at the outset, the provinces most affected were Gauteng, KwaZulu-Natal, Western Cape and Eastern Cape (Table A2 in the Annexure). According to the National Institute for Communicable Diseases [2020, 15], imported cases were the main source of early transmission in Gauteng, KwaZulu-Natal, and the Western Cape, which significantly reduced as a result of flight restrictions and school closures, followed by the level 5 lockdown. According to recent estimates, the four most affected provinces are Gauteng, KwaZulu-Natal, Western Cape, and Eastern Cape. However, we do not know what factors facilitate transmissions across and within provinces. Furthermore, estimates of actual cases and transmission rates can be influenced by different testing practices, making comparisons difficult (Table A2 in the Annexure).
3.2. Relationship between wealth status and COVID-19 vulnerability

Current socio-economic factors associated with the ability of individuals to protect themselves from infection and deal with severe lockdowns are often a reflection of past wealth-related status, which is unlikely to change quickly in response to pandemics such as COVID-19 [6]. As a result, vulnerability to COVID-19 infection is expected to vary with household wealth. In this section, we examine whether asset poor people are more vulnerable to COVID-19 infection due to their living conditions. To undertake this analysis, we use the wealth/asset index calculated using the list of variables provided in Table A1 in the Annexure.

Fig. 3 depicts the distribution of the average wealth index by municipality. According to estimates, there are significant regional disparities among municipalities. The poorest municipalities are concentrated primarily in the provinces of Eastern Cape and KwaZulu-Natal, which contain 34 of the poorest municipalities. In these municipalities, the average wealth index ranges between 1.1 and 2.3. In contrast, the 25 richest municipalities with an average wealth index value of 6 or higher are mostly concentrated in the Western Cape and Gauteng provinces, with the Western Cape province accounting for 52% of them.

As per our analysis in the previous section, the municipalities with the lowest wealth indexes also have the highest proportion of people who are vulnerable to COVID-19 due to their living conditions. Testing this, Fig. 4 shows the relationship between the average wealth index and the average vulnerability index by municipality. A simple linear regression of the vulnerability index on the wealth index indicates a negative and significant relationship (Coef = −0.05299, se = 0.01939, t = −27.32) between the vulnerability index and the wealth index. These results show a significant relationship between the average wealth index and the average vulnerability index across municipalities. The average vulnerability index decreases with higher wealth index values. Furthermore, plotting Lorenz curves using both municipal and individual level data reveals similar distribution patterns of vulnerability index and wealth index values across municipalities and individuals (Figure A6 and Figure A7 in the Annexure).

Next, we examine whether the extent of vulnerability for the poor is disproportionately higher irrespective of their location. Table A3 in the Annexure shows the vulnerability index values by wealth quintiles at the national level and by province. The average vulnerability index is the highest for those in the poorest quintile in all the provinces. In addition, a relatively large percentage of the population in the poorest quintile is vulnerable to the virus due to multiple factors (Table A4 in the Annexure). For instance, 29% of the population in the poorest quintile are vulnerable to the virus due to three of the vulnerability factors while the corresponding figure for the richest quintile is only 3%. For those in the first wealth
quintile, the percentage of the population vulnerable to the virus due to four or more vulnerability factors is 34% and 30% in Western Cape and Gauteng, respectively. These figures dropped to 0.1% for those in the richest quintiles in both provinces.

Fig. 5 depicts the distribution of the average vulnerability index at the municipal level for the poorest and richest wealth quintiles. The average vulnerability index ranges from 0.3 to 0.6 among the poorest wealth quintiles across municipalities. The estimate also shows a high level within province inequality. Even in provinces with relatively higher average wealth, such as the Western Cape, the average vulnerability index in some municipalities is among the highest in the country. Two of the seven municipalities with average vulnerability index value of 0.6 are located in the Western Cape province (Saldanha and Stellenbosch). This suggests that, across all provinces, the poor are disproportionately vulnerable to COVID-19 due to their living conditions.

The average vulnerability index for those in the richest wealth quintile ranges from 0.1 in most municipalities to 0.3 and 0.4 in 34 municipalities. The provinces of KwaZulu-Natal and the Eastern Cape are home to the majority of the relatively most vulnerable in the richest wealth quintile. With a vulnerability index of 0.4, the four most vulnerable municipalities in the richest wealth quintile are Hlabisa, Maphumul, and Ntambana in KwaZulu-Natal province, and Ratlou in North West province. The findings also show that there is disparity across municipalities in the extent to which those in the richest quintile are vulnerable to COVID-19 due to their living conditions.

Overall, the findings in this sub-section indicate that the living conditions of poorer households may restrict their ability to follow the WHO recommendations in order to prevent themselves from becoming infected with the COVID-19 virus. This is relevant in view of the fact that, in addition to their uncondusive home-environment and often having a higher number of known underlying risk factors for infection, poor people are more likely to be exposed to the virus because their jobs are often in sectors where remote work is not possible [12,17]. Poorer individuals are also more likely to use public

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9 These are the two wealthiest provinces with only 4% of the population in Western Cape and 8% in Gauteng are in the poorest quintile [20]. In contrast, the percentage of the population in the richest quintile is the lowest in the Eastern Cape and Limpopo provinces, while a relatively large percentage of the population (about 30%) in those provinces is concentrated in the poorest quintile.
transport, making it difficult to practice social distancing. Such factors make poor households more vulnerable to exposure to an infected person. This, in turn, is expected to increase the rate of the secondary attack rate in their communities and the country as a whole.

4. Conclusion

In this paper we draw on an international literature profiling COVID-19 vulnerability across countries to look, within the South African context, at differences in vulnerability across space. The analysis indicates strong correlations between low access to assets and high vulnerability. Thus, those with the least general material resources to draw on entering into this specific COVID-19 pandemic are shown to be the most COVID-vulnerable. This is particularly disturbing. Of course, COVID-vulnerability becomes a binding consideration at the point at which the COVID-19 virus enters the specific areas within which people work and live. The usefulness of this profiling of households will be greatly enhanced by giving more specific recognition to the fact that the epidemic has spread across South Africa in uneven ways and to twin the analysis of vulnerability to the arrival and spread of COVID-19 into different parts of the country. As mentioned in the introduction, this requires combining the analysis of this vulnerability index with fine-grained epidemiological data. Qiu et al. [18] offers a very promising approach based on Chinese data. Dynamic municipal COVID-19 prevalence data will allow for very interesting and useful work and we are exploring the possibility of this twinning.

The analysis of individual indicators and their aggregate indices show stark inequalities across space in COVID-19 vulnerabilities. The municipal analysis shows that this is true even within provinces that have low aggregate vulnerability. Thus, this paper raises the importance of being explicit about the spatial conceptualizations that are implicit in designing the targeting of COVID-19 policy responses. It also provides initial evidence to inform this thinking. As they stand therefore, these indicators have useful implications for policy.

At face value, “different indicators of vulnerability to COVID-19 infection require different policy solutions, e.g. providing a household with soap and providing an infected person from an overcrowded household somewhere isolated and safe to
recover require different kinds of public service interventions" (Gordon et al. [10]; p. 5). But, the inequalities across space that we profile in each of our individual indicators also make a strong case for the need for spatial targeting even if policy is implemented as a set of focussed interventions by a number of different ministries.

Certainly, this is not an academic curiosity in South Africa. It resonates with the prevailing approach to anti-poverty budget allocations. Policy takes place via initial national line ministry budgets being disbursed to provinces and then to municipalities based on aggregate indices of need. The municipal equitable share formula includes:

“A basic services component that helps municipalities provide free basic water, sanitation, electricity and refuse removal services to households that fall below an affordability threshold. … A monthly household income of R2300 per month (in 2011) has been used to define the formula’s affordability threshold. Statistics South Africa [23] has calculated that 59 percent of all households in South Africa fall below this income threshold.” National Treasury [14]

On 24 June 2020 the South African Minister of Finance read a COVID emergency budget [13]. It was needed in order to tighten up fiscal thinking on the stimulus package and the COVID relief measures. In it the Minister says:

“Local government is at the heart of our response to the pandemic. Accordingly, an additional R11 billion is allocated to local government through the equitable share.” (p. 12).

The use of the equitable share formula in allocating budget to local government for COVID relief makes a policy case for the kind of indicator development that is our focus in this paper. The free basic services that are considered in the equitable share formula are closely aligned to the indicators we use to ascertain COVID vulnerability. At the least, our work on vulnerability shares could be used to cross check the standard equitable share allocations against their direct COVID related values.

Recently government has spoken frequently of a direct district development approach to policy. Our indicators have shown that within all provinces, from the most ready and least vulnerable to the least ready and most vulnerable, there are municipalities with intense vulnerabilities and some of these contain large populations. Our local-area work allows us to explore the different rankings of need implicit in a direct targeting of policies at municipalities from the national level versus rules that target provinces and then municipalities within provinces. Indeed, the municipal work makes a start on the data analysis that will be required to back up a district development approach. Perhaps the strongest example in this paper is our derivation of asset indices and our profiling of the pernicious correlations between prevailing inequalities in assets and COVID-19 vulnerability across the length and breadth of this country.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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