URBAN FRAGMENTATION AND COVID-19 IN THE GAUTENG CITY REGION DIVERGING VULNERABILITIES, INFECTIONS AND POLICIES

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With 8 figures
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Summary: Urban spatial analyses of the COVID-19 pandemic try to relate the patterns of the spread of the virus to other factors, e.g. vulnerability, as supported by research on health risks of marginalized neighbourhoods. Focussing on the Gauteng City Region in South Africa, we assess whether there is a match between the effects of the pandemic, the strategies to combat the disease, and predicted vulnerabilities. While documented infection patterns are not indicating peripheral areas as most affected, disease control interventions can increase related inequalities. Reflections on South African government challenges provide the context for these concepts and strategies, suggesting that the spatial framing of health and vulnerabilities needs to be adapted.

Zusammenfassung: Stadträumliche Analysen der COVID-19 Pandemie versuchen, Ausbreitungsmuster des Virus mit anderen Faktoren, etwa Verwundbarkeit, in Beziehung zu setzen – informiert durch Forschung zu Gesundheitsrisiken in Marginalvierteln. Wir untersuchen diesbezüglich die Gauteng City Region (Südafrika) und gehen der Frage nach, inwiefern Pandemieeffekte, Bekämpfungsstrategien und prognostizierte Verwundbarkeiten sich decken. Obwohl die dokumentierten Verbreitungsmuster nicht zeigen, dass periphere Gebiete am stärksten betroffen wären, können seuchenpolizeiliche Interventionen damit verbundene Ungleichheiten verstärken. Im Kontext von Herausforderungen der südafrikanischen Regierung verweist der Artikel darauf, dass die räumlich-konzeptionelle Rahmung von Gesundheit und Vulnerabilität angepasst werden müsste.

Keywords: COVID-19 pandemic, South Africa, Gauteng, socio-spatial vulnerability, urban mitigation strategy

1 Introduction

South Africa (SA) – especially its economic powerhouse, the Gauteng City Region – face new and tough challenges brought on by the COVID-19 pandemic. As in most countries, the initial outbreak of the virus occurred in those urban regions that have the strongest international connections (Simon et al. 2021). The first confirmed case in SA was registered on 5th March 2020. The affected person had returned from Europe five days earlier. The initial spread of the pandemic affected the three provinces KwaZulu-Natal, the Western Cape and Gauteng. Together these provinces contribute most to SA's economy, have the biggest airports and the main seaports, the highest numbers of inhabitants, the biggest shares of urban population - and most cases of COVID-19 so far. As expected, the consecutive spatial transmission of the disease moved from the centre to the margins, but much less in line with documented health vulnerabilities than expected. With special attention to aspects of socio-spatial differentiation and vulnerability in the Gauteng City Region, this paper explores this trend. The focus of the paper is on comparing infection patterns and vulnerability predictions (cf. Biglieri et al. 2020 on the spatial diffusion of epidemics and manifestations of socio-spatial vulnerability), in the light of the broader debate on cities in pandemics (cf. Acuto et al. 2020, Ali & Keil 2011, Connolly et al. 2020). In spite of a mainly epistemological motivation, this debate resonates with spatialized mitigation strategies in specific local settings. Therefore, a cursory overview of South African governance challenges as well as of the Gauteng City Region is required to provide a contextual backdrop. The close interlinkages between these elements can be underlined by referring to the medical-anthropological syndemic framework (Ellis et al. 2021), which may contribute to a more holistic perspective on the divergent social embeddings of the pandemic in SA. However, because of the topicality and unexpected outcomes of ongoing COVID-19 processes, descriptive ambitions remain paramount.

The paper is organized into three main sections: The first of these outlines the pandemic experience in SA in the light of crisis-driven develop-

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ments since March 2020. The aim of this overview is to give a general understanding of emergency policies in operation. The next section is dedicated to a comparison of the geographies of reported cases with the spatial differentiation of living conditions and vulnerabilities - to what extent are vulnerability indices supported by available biomedical evidence; and which limitations have to be considered, on both accounts? Finally, the conclusion returns to broader questions of city governance in SA and related reflections on pandemics. Based on this, we sketch out how these observations speak to the spatial dimension of COVID-19 mitigation strategies, and which conceptual challenges result from this.

2 COVID-19 as crisis booster in South Africa

Shortly after the occurrence of COVID-19 in SA, the government took a strong stand against its spread and declared a country-wide lockdown. Over time, the state, through its National Coronavirus Command Council, introduced an alert system with different levels of measures to manage the gradual easing of the lockdown. These included criteria such as "the level of infections and rate of transmission, the capacity of health facilities, the extent of the implementation of public health interventions and the economic and social impact of continued restrictions" (South African Government 2020). Figure 1 provides an overview of lockdown measures, adjustment periods in relation to numbers of new reported infections, and COVID-19 deaths in SA. The state based the manifold and severe restrictions to public life, personal interaction and economic activities on the declaration of a nationwide state of disaster at the end of March 2020. This was a rapid response, when compared to other African states and globally, especially in the light of the fact that the first case of COVID-19 in the country had only been detected three weeks earlier. The seriousness of the potential pandemic was recognized right from the start, in line with advice from the WHO, when several other countries were still ambivalent. Consequentially, the newly introduced alert system started with the highest level 5 on March 26th. The very strict lockdown measures linked to this level remained in place until end April 2020. Slightly relaxed to level 4, strong measures were extended up to end May 2020. Given SA's levels of inequality and following intense lobbying and debate, the state's sensitivity to the threat that the virus presented came into play with a more socio-economically structured sensitivity to the lockdown measures (De Villiers et al. 2020). These two dimensions have to be differentiated socially and spatially, forming a central theme in this paper.

At the start of the lockdown, the demonstration of a 'strong' state – which included strict mobility restrictions, closing of schools and universities, border controls and prohibition of sales of alcohol and cigarettes – gained broad internal public support and international recognition (De Villiers et al. 2020). The scores in the 'COVID-19-government-response-tracker' (Blavatnik School of Government, University of Oxford 2021) illustrate the comparably high level of activities of the government in the first months of the pandemic. In respect to reported cases, the state's strategy during the first lockdown was successful compared, for instance, to the European experience in this period. In spite of this (and similar to other countries), the state's measures

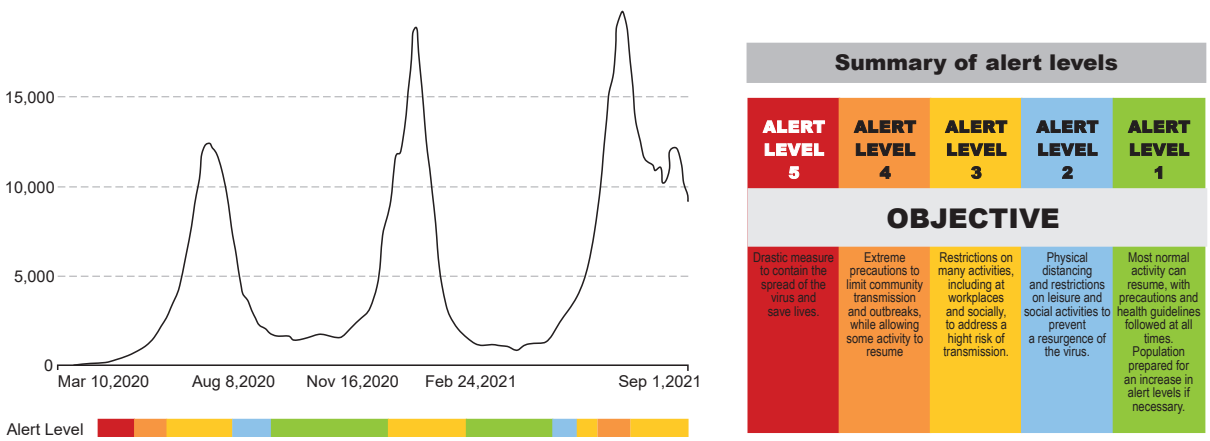

Fig. 1: South Africa – COVID-19 Daily new confirmed cases, government response levels and lockdown periods. Sources: South African Government (2020), Johns Hopkins University (2021)

against the pandemic were soon influenced by factors beyond the emerging biomedical or epidemiologic insights. As we detail below, livelihoods and vulnerability concerns played an increasingly important role, especially when it became evident that the economic crisis caused by the lockdown in SA and corresponding restrictions around the world might threaten social stability. Nevertheless, the initially strict COVID-19-policies can be described as an element of President Cyril Ramaphosa's strategy to gain new public and political support (cf. Simon et al. 2021: 148).

Before the pandemic reached SA, the country was already in a significant economic and political crisis. This can be seen partly as a legacy of the former presidency of Jacob Zuma (2009-2018), which was characterized by a lack of addressing (or even acknowledging) burning issues such as corruption and social inequality. However, the first months of Ramaphosa's government did not yield the turnaround many people hoped for. Instead, the signs of a societal crisis became increasingly visible (Müller 2021): a deeply embedded structural inequality between the population groups, a high unemployment rate (partly due to a lack of skills), and an economy continuously failing to achieve policy targets. However, the core of the internal problems seems to lie in a specific governance configuration, with an elected but saturated ANC establishment, a strong corporate sector with the 'minerals energy complex' at its centre, and a civil society which has been partly co-opted or marginalised (cf. Chipkin et al. 2018, Claar 2017, Hachmann 2017).

Immediately prior to the outbreak of the pandemic, documented unemployment in SA peaked at about 30%. This precarious situation was exacerbated significantly by COVID-19 response measures (cf. De Villiers et al. 2020, Goetz et al. 2022, Ossenbrügge 2021). 'Stay at Home' policies affected the informal sector in particular (cf. Poplak 2020). In general, people with lower formal qualifications are employed in manual jobs, in the service sector, or self-employed. All these types of work (e.g. informal traders, minibus drivers, day labourers etc.) are characterized by little to no opportunities for home-office, nor are they linked to the state or to big companies – no compensation for lost working days can be expected. This applies especially to the non-food retail and to the construction sector, and to the private transport sector. However, based on lobbying, concessions were soon made, and with certain permits, businesses like minibus taxis could continue to operate, albeit with limited numbers of passengers. In spite of this, the closing down of the tourism, as well as leisure and recreation sectors have endangered job security of about one million employees (Posel & Casale 2020, Khambule 2021). Residents of a number informal settlements had to face another challenge: De-densification strategies (aimed at reducing the spread of the virus) effectively translated into relocation efforts reminding of older 'slum eradication' approaches of the 1990s (Poplak 2020, cf. Huchzermeyer 2022).

Thus, as a consequence of the pandemic (including both, the global economic fall-out, and the government's mitigation strategy), the living conditions of a substantial proportion of the work force deteriorated, and the situation for informal traders, informal dwellers, and the unemployed has worsened in particular. In combination with an already high poverty rate and rising food prices, the lockdown increased the existing crisis in a significant way.

Based on earlier experiences of insufficient state action in the face of societal problems, civil society organizations formed the platform 'C19 People's Coalition' as an immediate reaction to the pandemic already in March 2020. The aim was to create a forum for coordinated discussion, protest and relief action 'from below'. While the pro-active role of government (in coordinating COVID-19 responses) is recognized by supporters of this platform, the declarations and activities of the social movement clearly address socio-economic deficits and structural inequalities on local, national and international level. In contrast to this, the well-funded economic support measures, which have been outlined in the 'Statement by President Cyril Ramaphosa on further economic and social measures in response to the COVID-19 epidemic', had only begun to reach affected and disadvantaged groups at the time of writing, and were partly tainted by corruption (Müller 2021: 445). State activities like the Reconstruction and Recovery Plan (RRP) from October 2020 are still embedded in a neoliberal perspective of economic development. The plan is based on targeting privately financed investments to promote domestic production and employment opportunities as the flywheel for the economy. Accordingly, the Department of Public Works and Infrastructure officially announced 62 projects in which the government would like private investors to participate (Department of Public Works & Infrastructure 2021). Though the RRP may be seen as an ambitious attempt to announce a comprehensive recovery strategy during a severe crisis, the effects so far are fragile. Additionally, the November 2021 local government election results indicate a

further decline of trust especially in the ANC: in many municipalities, the party lost former majorities. Though it is too early to evaluate the effects of COVID-19 support programmes in detail, it is obvious that societal inequalities and precarious urban and rural living conditions cannot be addressed sufficiently in this way.

COVID-19 and the lockdown have affected people in SA in significantly different ways (Durizzo et al. 2020). While the RRP is based on this insight, the social unrest in July 2021 indicates an ongoing and accelerating crisis: militant protests of Zuma supporters (the former president had to appear in court to face corruption charges) erupted into riotous violence, looting, xenophobic assaults with several hundred deaths and millions of dollars in damage. Lynch law and activities of vigilante groups point to the state's inability to take decisive action against such social unrest.

To summarize COVID-19 governance in SA, we can distinguish three phases. First, effects of the lockdown undermined the initial acceptance or even approval of the COVID-19 policy. This weakened the state's ability to contain the pandemic with the result of rising infections as of July 2020, with SA then becoming one of the hardest hit countries with well above average infections and deaths, especially in January 2021 (cf. Simon et al 2021: 149). This second phase saw a more pragmatic government approach, trying to keep the socio-economic impact especially for lower income groups at bay. It was not until the emergence of the Delta variant of the Coronavirus in June 2021 that Level 4 was imposed again, implying more extensive restrictions on public life and work practices. Linked to this, a third phase of political action emerged, as the unrest in July 2021 with hot spots in KwaZulu-Natal and Gauteng indicates. What matters here are the strong mutual interlinkages of three dimensions: how a (post-colonial) governance crisis in the face of persisting socio-economic inequalities is linked to a health challenge interwoven with precarious and vulnerable livelihoods. We will now turn to the health challenge and its articulation in Gauteng, in order to question its relation to both of the other dimensions, vulnerabilities and governance.

3 The spread of COVID-19 in Gauteng

Of all South African provinces, Gauteng is by far the most urbanized. The conurbation of more than 17 million inhabitants consists of the three metropolitan municipalities Johannesburg, Pretoria and Ekhuruleni, and a handful of smaller towns embedded in mostly peri-urban areas. With over 30% of all reported cases of COVID-19 and an infection rate of close to 8000 per 100.000 inhabitants, Gauteng became one of the epicentres of the country's COVID-19 pandemic, along with Cape Town and Durban. As of 7 March 2022, almost 1.900.000 total cases and over 20.000 COVID-19 related deaths were reported for Gauteng alone (COVID-19 SA Dashboard 2022). At first glance, thus, COVID-19 in SA can be said to be a particularly urban disease, hitting the nodes of the global economy most severely.

By early 2022, four waves of COVID-19 infections had been registered in SA and a fifth wave has been announced recently. The third wave hit Gauteng particularly hard. In early to mid-July 2021, during its peak, Gauteng reported by far the highest weekly incidences in the country (more than twice as high as the national average) (NICD 2022b). Likewise, in the fourth and most recent wave, which began at the end of November 2021 and was largely brought about by the omicron mutation, the weekly incidence rates in Gauteng were significantly above the national average (ibid.).

The starting point for our regional analysis concerns the initial hot spots of the disease, which resonate with an argument by Ali & Keil (2011) about the urban geographies of new pandemics. According to this, globalized nodes are the initial hot spots, while in the course of a pandemic, socio-economically peripheral zones and groups will suffer most. This is said to be due to a lack of access to modern medicines and to the formal public health system, but also due to their higher vulnerability (i.e., lack of resilience and exposure to a broader set of risks) (cf. Biglieri et al. 2020). These arguments go beyond a bio-medical perspective and factor in a number of economically and spatially differentiated attributes such as the variety of available health care, living conditions, infrastructure (e.g. drinking water, toilets, residential densities), and proximity to clinics. While this seems plausible, it is worth noting that the concept of vulnerability has been interpreted in different ways. Especially 'Northern' positions (to some extent also the discursively dominant perspective of the WHO) have focussed on a predominantly bio-medically informed set of indicators: Old age, obesity or heavyweight, respiratory medical conditions – and to a lesser extent, gender – have all been identified as COVID-19 related factors of vulnerability. However, this is only a fraction of the various forms vulnerability can take (Etzold & Sakdapolrak 2016).

Wilkinson et al. (2020) define five different categories of vulnerability to COVID-19: Epidemiological vulnerability (referring mainly to age, gender and co-morbidities); transmission vulnerability (encompassing conditions related to physical contacts; housing and infrastructure that could foster increased transmission), health system vulnerability (referring to dangers of overburdening the health system); direct vulnerability to control measures (referring to socio-economic impacts on livelihoods); and systemic vulnerabilities (referring to intersections of health issues, social concerns and environmental factors that interact with the pandemic). Different aspects of vulnerability have been weighted differently in the (global) health policy context. Right from the start of the pandemic, globally dominant health policy aimed at preventing health systems and in particular, intensive health care facilities from becoming overburdened. Other voices have called for African (or 'Southern') approaches which would be more aware of everyday capacities of risk mitigation and of the limitations of modern medicine due to its dependency on cost-intensive health systems lacking accessibility (cf. Macamo 2020). When considering these positions on vulnerability, it seems relevant to reflect on their diverging consequences for managing the challenges of COVID-19 – e.g. how spatially or socially differentiated mitigation approaches should be weighted against demographically informed strategies or pharmacological measures, when available. According to most of these positions, after two years of the pandemic, we should expect a shift from the centre to the margins in terms of where the harshest effects of the disease will occur (cf. Ali & Keil 2011, Biglieri et al. 2020, also Fortaleza et al. 2021: 9 on similar dispersion patterns in a comparable metropolitan context in the global South).

This assumption, however, is not strongly substantiated by available data. By way of example, in Figure 2 the shares of COVID-19 related deaths in the most 'peripheral' (i.e. rural) provinces (the four groups of columns to the right of the graph) are mostly lower, compared to their share of the total population. Only the Northern Cape has higher shares of deaths than of population – even on the national scale, there is no clear evidence that the 'margins' have been hit harder.

We will now focus on Gauteng on a differentiated intra-provincial scale. Empirically, different questions arise: First, which spatial patterns of infection have been observed, and do they correlate with the mapping of social vulnerability and infection risks? Second, can we identify the presumed centre-periphery diffusion and a growing affection of the urban

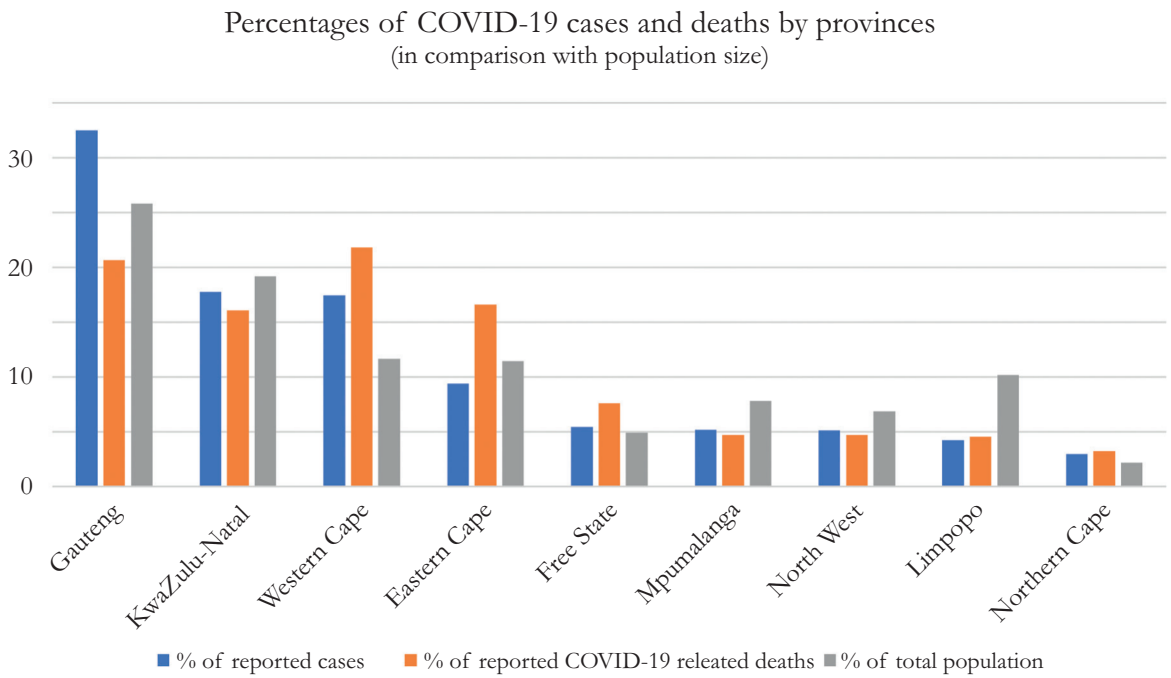

Fig. 2: Percentages of reported COVID-19 cases, deaths and population size by province on 7th March 2022. Data source: COVID-19 SA Dashboard (2022).

poor living in marginalized areas? Third, which areas and groups are affected most severely by the lockdown measures, and do manifestations of social unrest correspond to this pattern?

3.1 Methodology

To explore the questions sketched out above, we analysed secondary data on social factors and the incidence of COVID-19 in Gauteng and visualised this in GIS (Geographic Information System). This data analysis highlights the course of the pandemic in the light of spatially differentiated social conditions in Gauteng.

GIS-based socio-spatial analysis has been widely used since the beginning of the pandemic and with different objectives and epistemological interests, for instance to investigate clusters of infection, to identify spatial vulnerabilities or to target health and social policy measures in a spatially specific way (cf. Franch-Pardo et al. 2020). Vulnerability indexes became an important health geography approach to integrate existing knowledge (or at least assumptions) about the influence of social and environmental factors on the pandemic in a quantitative model (see Shifa et al. 2021, Macharia et al. 2020, Tiwari et al. 2021, Welsh et al. 2022). While this method has also been applied to Gauteng, there is an absence of geographical comparison of predicted vulnerabilities and documented health effects of COVID-19 across urban SA. The following sections seek to address this point.

3.2 Spatial construction of risk areas and the evidence of COVID-19 incidences

When COVID-19 reached SA, the Gauteng City-Region Observatory (GCRO) began investigating localized risk factors that might contribute to the spread of COVID-19 or amplify its health and socio-economic impacts in certain communities (De Kadt et al. 2020). Going beyond an exclusively biomedical understanding of illness, their approach was informed by the concept of syndemics, which has been recently popularized by Richard Horton (2020, also cf. Ellis et al. 2021 for an urban application). The idea behind this was to explore how existing social and health conditions could potentially interact with the pandemic, in conjunction with environmental and economic factors. Horton's interpretation, however, points to vulnerabilities of wealthy lifestyles, whereas De Kadt et al. (2020) argue in line with more established perspectives of problematizing conditions of poverty (cf. Shifa et al. 2021, Smit 2020: 1). The vulnerability index by Shifa et al. (2021), for example, correlates negatively with wealth, similar to De Kadt et al.'s (2020) approach, leading to spatial predictions that differ from the observed patterns. Our exploration of empirical data aims to shed light on this ambiguity.

De Kadt et al. (2020) used data from the GCRO Quality of Life V 2017/18 survey to build two statistical indices to visualize the spatial distribution of conceivable risks and vulnerabilities to COVID-19 in Gauteng. Figure 3 shows a spatial analysis based on the first of these two GCRO indices, exploring the risk of transmitting the virus, i.e., the average inability to maintain basic preventative hygiene and social distancing. To create this map, the same index with the same data (from the GCRO QoL survey 2017/18) as in De Kadt et al. (2020) was used. This index is based on the following indicators:

a) Household crowding: Percentage of respondents per ward who live in dwellings with three or more people per functional room, or where more than one household is sharing a single room dwelling.

b) Shared or inadequate sanitation: Percentage of respondents per ward whose households do not have a flush toilet connected to the sewerage system or septic tank.

c) No access to clean running water in dwelling or yard: Percentage of respondents per ward whose households do not have piped water in their dwelling or in the yard.

d) Reliance on public health facilities: Percentage of respondents per ward who normally use public health services.

e) Lack of access to electronic communication: Percentage of respondents per ward who do not access the internet at all, and who also do not have a TV, satellite TV, radio, or cellphone in their households that is in good working order.

f) Reliance on public transport: Percentage of respondents per ward who did not have a car in good working order in the household, and whose mode of transport for the longest part of their most frequent trips was a lift club, minibus taxi, train or bus.

This method (with similar indicators) was later adopted by StatsSA (the national service of statistics in South Africa) and used for other provinces in SA as the basis of a spatialized health strategy: "The VIndex can serve as a tool to assist with targeted response planning as it highlights areas which are vulnerable to COVID-19 as defined by the rank and

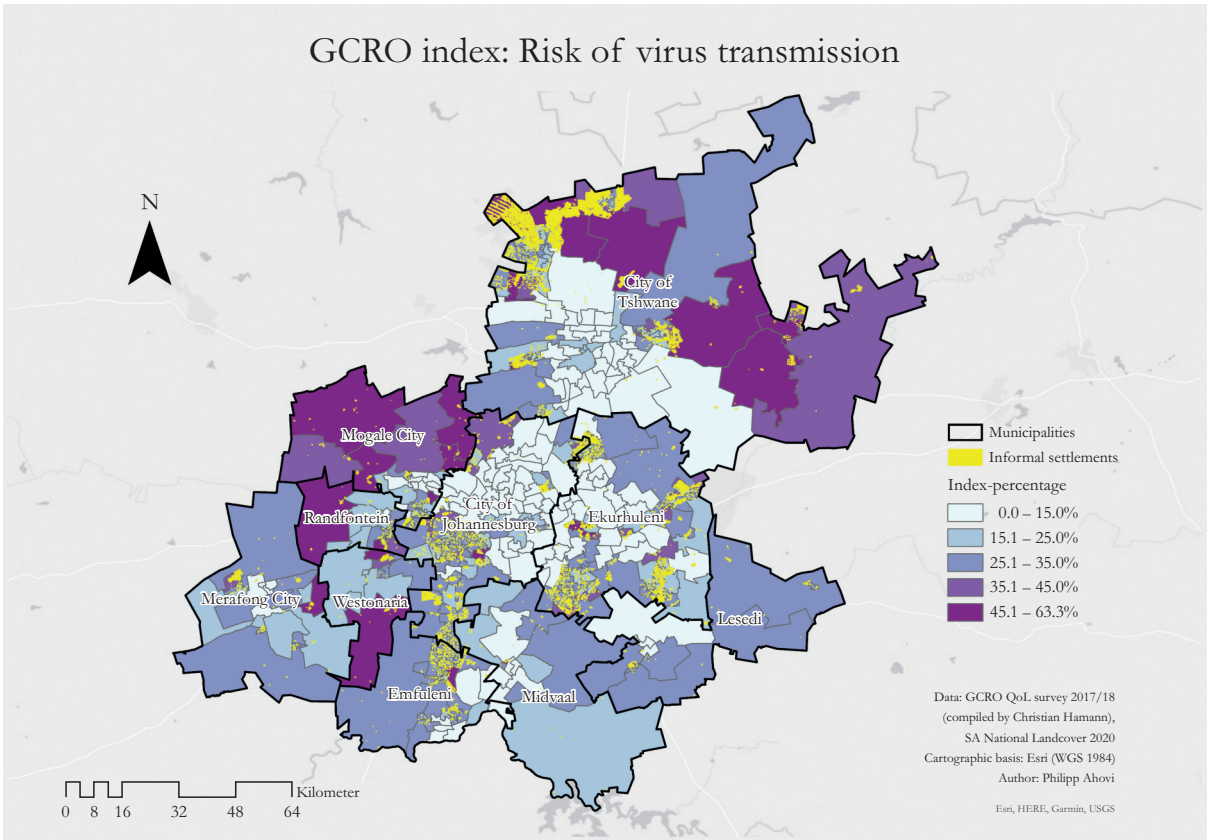

Fig. 3: GCRO Index of risk factors to maintaining social distance and preventative hygiene on the electoral ward level and localisations of informal settlements. Data sources: GCRO 2018, DFFE 2020.

indicators that are most prevalent. The VIndex can also serve as means for evidence-based pandemic management planning to provide the best and most feasible location-focussed response" (Statistics South Africa 2020).

Figure 3 shows how we combined a mapping of the index by De Kadt et al. (2020) with geographical information on the location of informal settlement areas in Gauteng (shaded in yellow), in order to compare their locations with the risk index values. We extracted their locations from the 2020 South African national landcover dataset (DFFE 2020). While the index has informed health policies in the province, including de-densification strategies aimed at informal settlements, the comparison shows a considerable spatial mismatch between informal housing and the highest levels of vulnerability. Except for one instance (north-west of Pretoria), there is no clear coincidence of high index values with clusters of informal settlements. In fact, the majority of informal settlements correspond with medium vulnerability index values. The map is remarkable in that it shows that index-based vulnerabilities are generally high in the most peripheral/rural areas, which are only occasionally those with the strongest presence of informal settlements.

In a second step, we compared this index, which is described by GCRO as a measure of 'transmission risk', with the distribution of reported COVID-19 cases in Gauteng until 4th August 2021, based on cumulative incidence values (Fig. 4, total number of reported cases per 100.000 residents). We sourced cumulative COVID-19 case numbers at the ward level from the Gauteng COVID-19 visual analytics platform (IBM Research 2021). This is a compilation of COVID-19 data provided by multiple third-party sources including South African governmental agencies and other public sources. To calculate the cumulative incidences on the electoral ward-level we used 2017 population estimates from GeoTerraImage (GTI), which are available on the GCRO website (GCRO 2020). The colour classes in Figure 4 are based on the standard deviation of the respective incidence. Again, the infection pattern was overlaid with the localisations of informal settlements (shaded in blue).

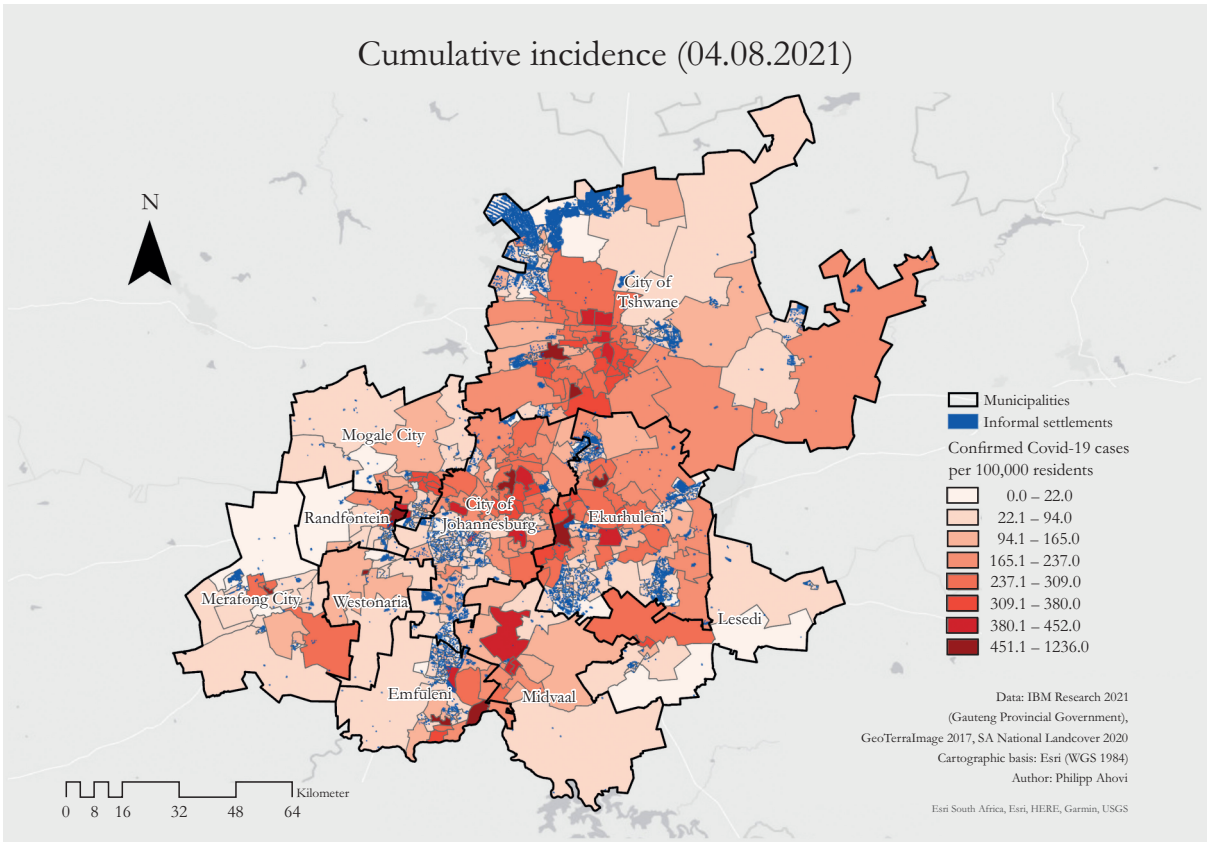

Fig. 4: Cumulative reported COVID-19 incidence (until 4th August, 2021) per electoral ward. Data sources: IBM Research 2021, GeoTerraImage 2017, DFFE 2020.

Since the index visualized in Figure 3 is supposed to indicate the probability of virus transmission, one would expect the spatial patterns of reported COVID-19 cases (Fig. 4) to be similar to those of the transmission risk index. In this sense, the maps compare an index-based expectation about possible infection patterns with an empirical observation of reported infection patterns. As it turns out, they are significantly different.

The GCRO index for the risk of COVID-19 transmission (Fig. 3) shows clear distinctions between relatively low index values in suburban areas (in the north of Johannesburg, south-east of Pretoria and central Ekurhuleni) and relatively high index values in the densely populated townships (for instance Atteridgeville, Thembisa or Soweto), informal settlements (for instance Stinkwater, Ivory Park or east Soweto), and peripheral areas in general, where the lack of both basic services and access to electronic communication plays a significant role (De Kadt et al. 2020). In general, all indicators of the GCRO index relate to socioeconomic marginality, which in fact seems to be predominantly located in the spatial peripheries of the province, as well as in certain areas within the economic core of the province (which are mostly former black townships and settlements created in the apartheid era) (Peberdy et al. 2017, Ballard et al. 2021). The reported case numbers in Figure 4 (cumulated for the period from 5th March 2020 to 4th August 2021), however, show a different pattern, with high incidences in the central areas of Johannesburg, Tshwane (Pretoria) and Ekurhuleni, while the incidences in most peripheral, township and informal areas in Gauteng are comparatively low.

To look at whether the virus (i.e., the reported incidences) might be spreading faster towards the risk areas defined by the index, we compared the incidences of two different time periods. Figure 5 shows the spatial distribution of cumulative incidences as of 22nd June 2020, approximately three months after the first documented COVID-19 case in SA, when the first wave of infection in the country was just peaking. With this period, we want to represent the 'initial emergence' of the virus in Gauteng. Figure 6 shows the spatial distribution of cumulative incidences documented since the peak of the first wave, i.e., the

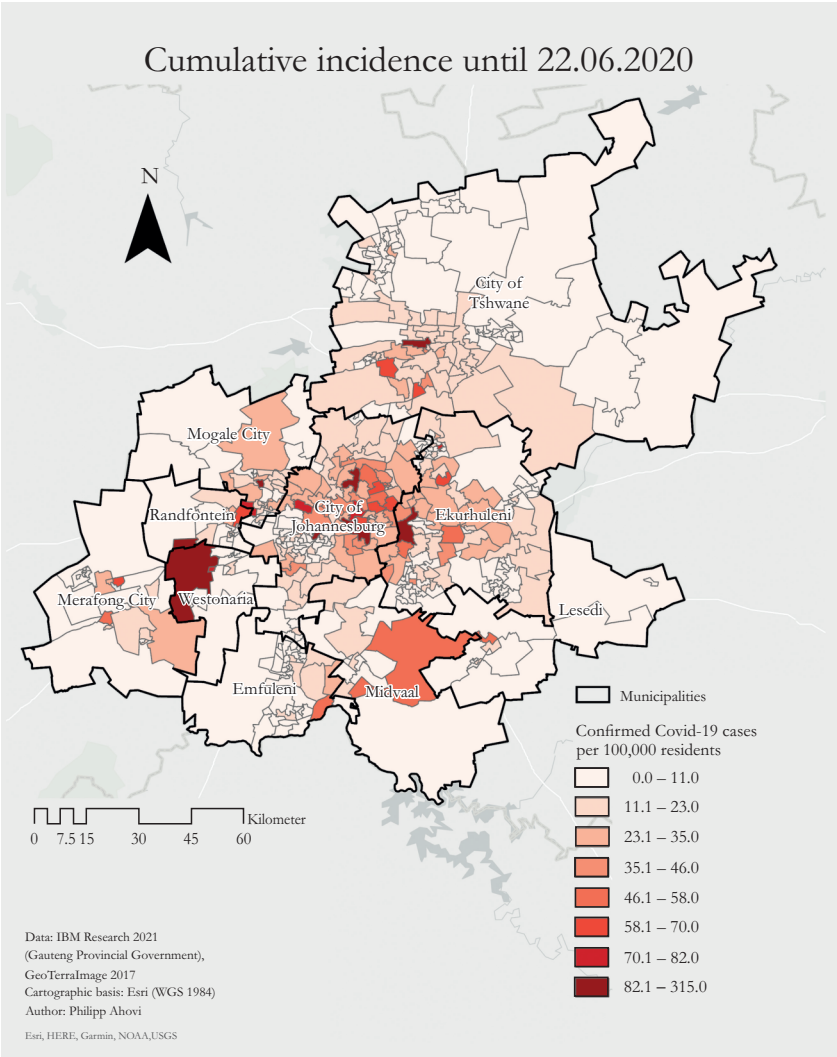

Fig. 5: Cumulative reported COVID-19 incidence until 22nd June on the electoral ward level, 2020. Data sources: IBM Research 2021, GeoTerraImage 2017.

difference between the cumulative incidence of 22nd June 2020 and 4th August 2021. This period covers approximately 14 months and is significantly longer than the first period. Once again, the colours in the legends are based on the standard deviation of the respective incidence. The comparison of the two periods is intended to make visible whether and how the incidence of infection has shifted spatially since the 'initial emergence' of COVID-19 in Gauteng.

With geo-referenced time series of documented COVID-19 cases, much more detailed approaches to the spatial analysis of dispersal dynamics would be conceivable. However, only snapshots of the spatial distribution of reported COVID-19 cases are accessible at the ward level. Nevertheless, even with this comparatively simple approach, a spatial diffusion of high incidences from the centres (Pretoria, Johannesburg and Ekurhuleni) into the surrounding areas (and partly into the socio-spatial peripheries of Gauteng) becomes visible. Nevertheless, the maps from Figures 5 and 6 do not indicate that the virus would actually spread faster in peripheral locations or the risk areas defined by the GCRO index. The cumulative incidences reported in the later period since 22nd June show no relative concentration in the peripheral wards either. In line with this contra-intuitive observation, the GCRO index of transmission risks does not seem to sufficiently explain the patterns of documented cases in Gauteng.

There are several possible reasons for this result. Firstly, there are numerous considerations for why reported case numbers might be unreliable. The pos-

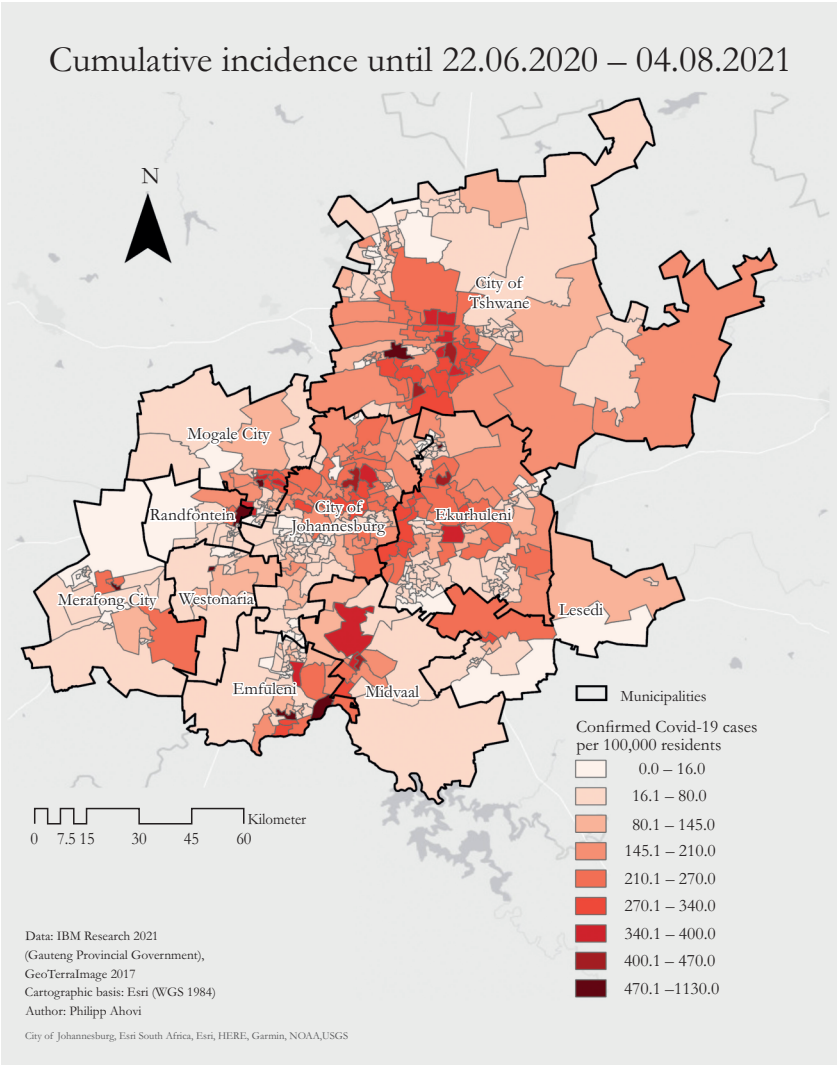

Fig. 6: Differences between cumulative reported COVID-19 incidences of 22nd June 2020 and 4th August 2021 on the electoral ward level. Data sources: IBM Research 2021, GeoTerraImage 2017.

itivity rate of COVID-19 tests recorded in Gauteng has been noticeably high on average and rose several times up to approx. 40% (NICD 2022a). The notably higher proportion of private testing compared to public testing indicates disproportionately lower rates of testing in low-income areas (ibid). Likewise, survey data of the GCRO shows that the percentage of people who tried to test for COVID-19 but were unable to do so (presumably due to a lack of access to health services) is considerably higher in marginalized areas (cf. GCRO 2021). Additionally, there is the issue of asymptomatic cases. These problems could be partially circumvented by the choice of data. Small-scale data on the number of tests, test positivity rates or data on excess death could serve as an indication of the level of undertesting. However, small-scale (ward-level) data on these indicators is not publicly available for Gauteng. Another relevant factor that could be explored further is age profile (although this factor may indicate more about hospitalization and death rather than infection). Conclusively, concerning the case-numbers shown in Fig. 4-6, it can be assumed that socio-economically marginalized areas have a higher proportion of unreported COVID-19 cases.

These crucial differences in COVID-19 testing fundamentally compromise the reliability of the infection data under consideration and could have a major impact on the spatial patterns of incidence shown in the maps in Fig. 4-6. Thus, an additional

question arises, how structural (and socio-spatial) inequality regarding the availability of infection data might fuel a pandemic: a higher proportion of unreported COVID-19 cases in socio-economically marginalized areas is itself a risk factor for virus transmission. But beyond this, without reliable data on incidences of infection and their local context, effective and appropriate policy responses are generally more difficult to realise. Wilkinson et al. (2020) more generally identify the lack of reliable data about informal settlements as one of their defining challenges prior to, and during (health) emergencies. This problem evidently manifests itself in Gauteng with regard to reported COVID-19 cases.

One could argue that these uncertainties could be addressed with seroprevalence data. A seroepidemiological survey was conducted by Madhi et al. (2022) in Gauteng Province from 22nd October to 9th December 2021 (before the fourth wave of infection). They used a random sampling methodology, proportionated to the population sizes of the sub-districts to obtain samples from approx. 7000 individuals, of which about 1300 had received a COVID-19 vaccine. The overall COVID-19 seroprevalence rate in Gauteng Province was 73.1%. The map in Figure 7 (based on data sourced from Madhi et al. 2022) shows the seroprevalence across sub-districts. Although a comparison of seropositivity rates with the spatial pattern of the transmission risk index has a degree of inaccuracy due to the different spatial scales (electoral ward and sub-district), it is obvious that the seropositivity rates (in Fig. 7) differ significantly from the spatial pattern of the GCRO transmission risk index (in Fig. 3). Below-average seropositivity rates (mostly below 65%) were measured in large marginal parts of Tshwane, in Mogale City and in Midvaal – these are, however, peripheral areas with above-average transmission risk index values. At the same time, there are several central areas of the province, which have below-average risk index values but above-average seropositivity rates, such as Johannesburg and West-Ekurhuleni (seropositivity rate of up to 84% and above). On average, participants resident in an informal settlement had a lower prevalence of seropositivity (66.3%) than participants living in a stand-alone dwelling (74,2%).

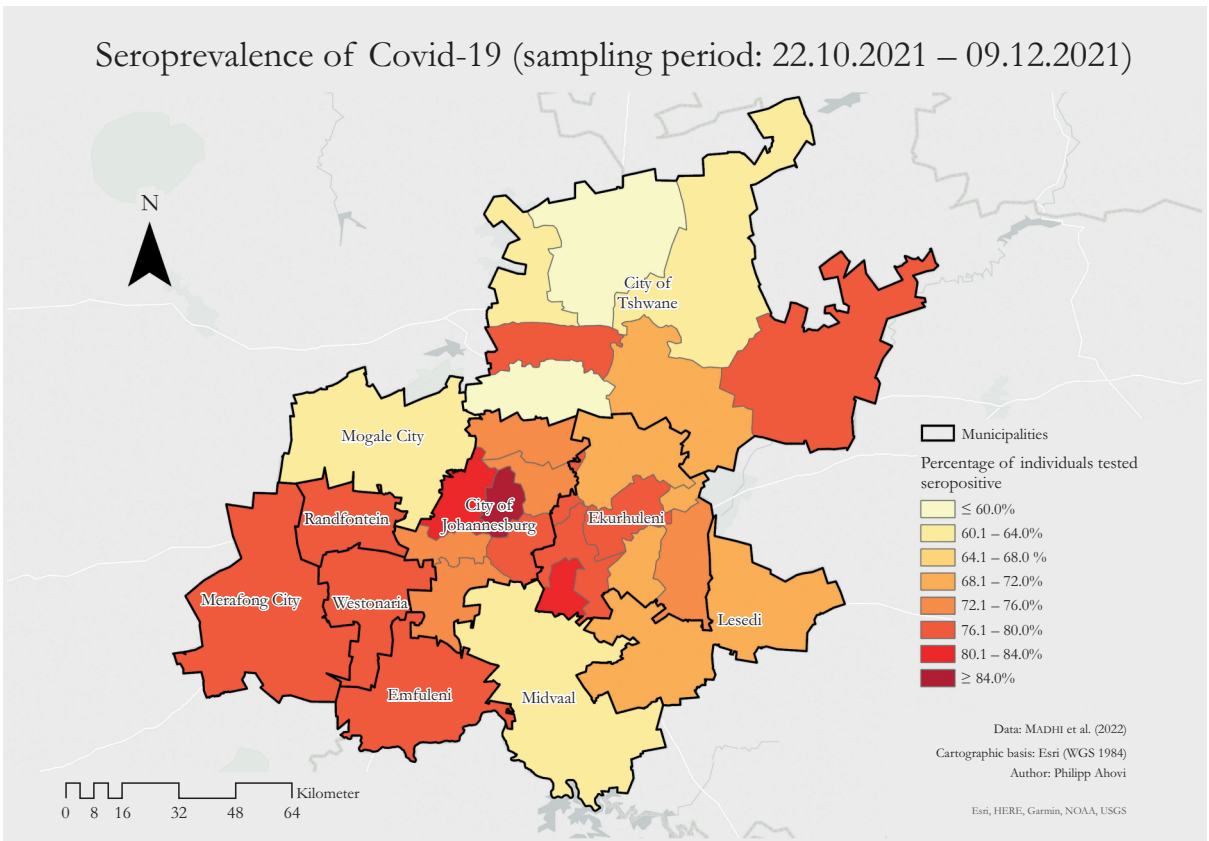

Fig. 7: Seroprevalence across sub-districts (sampling period from 22nd October to 9th December 2021). Source: Modified after Madhi et al. (2022)

The informative value of the seroprevalence data, however, is limited for various reasons. Vaccinated individuals were significantly more likely to be seropositive (vaccinated: 93.1%; unvaccinated: 68.4%). Thus, it remains unclear to what extent these unequal spatial patterns of seroprevalence are also shaped by spatial patterns of unequal access to vaccination. Furthermore, the measurable seroprevalence continuously decreases after an infection. Seroprevalence measured from October to December 2021 can therefore only tell us something about a limited period of the more recent preceding infection. In short, although the COVID-19 seroprevalence data are unable to resolve the assumed bias in the reported cumulative incidences, neither can they confirm the perception of the transmission risk index.

Evidently, up to now, neither measured seroprevalences nor the documented incidences show the spatial patterns to be expected based on the transmission risk/vulnerability index (VIndex, cf. Fig. 3). This leads us to the question of whether lockdown measures and associated spatial controls have any references to social vulnerabilities and marginalizations. Apart from the unreliability of the infection data, limitations of the vulnerability index itself should also be taken into consideration.

As the GCRO index only focuses on inabilities to maintain basic preventative hygiene and social distancing, it does not consider pandemic factors in relation to global interconnectedness and mobility, which are particularly present in the urban cores of Gauteng (cf. Haferburg & Ossenbrügge 2017, Cheruiyot 2018). After all, the main mechanism behind the initial global spread of COVID-19 was air travel. In Gauteng (like in many other regions of the world) the first COVID-19 hotspots occurred in affluent areas, presumably as a direct consequence of global physical connectedness (De Groot & Lemanski 2021). Processes that are related to centrality (e.g. economic networks) are not considered in the GCRO index.

Another factor that might contribute to the spreading of the virus, is indoor encounters with non-household members e.g., in shopping malls, office buildings, at the workplace or in other institutional setups (as opposed to outdoor encounters). Again, one might expect a middle-class lifestyle to be riskier in this regard compared to outdoor interactions in poorer neighbourhoods. While this point has to be speculative, it is striking that the spatial pattern created by the GCRO risk index is reproducing a common perspective of urban fragmentation on the one hand, while showing a considerable mismatch to documented case numbers of COVID-19 infections on the other hand.

3.3 Socio-spatial effects of lockdown-measures

As discussed earlier in this paper, the pandemic situation in Gauteng, including the lockdown and related measures to combat the disease, led to deep socio-economic distress (e.g. income disruption, food insecurity, etc.), exacerbating existing inequalities even further. It therefore becomes no less relevant to approach the issue of vulnerability from a socio-economic perspective. Correspondingly, De Kadt et al. (2020) created an index that explores multiple risk factors that are believed to contribute to increased health and socio-economic vulnerabilities during an outbreak and/or lockdown (in addition to their index of virus transmission risk). Building on this approach, we used data from the GCRO Quality of Life V 2017/18 survey build and map our own vulnerability index that aims to explore in particular the distribution of socio-economic risk in Gauteng. Our vulnerability index includes the following indicators, which are aimed at indicating particular vulnerabilities to lockdown conditions, with a focus on livelihood-related factors:

a) Food insecurity: Percentage of respondents per ward who live in a household where an adult or child had to skip a meal in the past year because there was not enough money to buy food, as well as those living in households where children benefit from a school feeding scheme.

b) Indigency: Percentage of respondents per ward who are registered as indigent in the South African welfare system.

c) Income through informal employment: Percentage of respondents per ward living in a household that earns its financial income partly or completely in the informal sector.

In contrast to the index of transmission risk in Figure 3, this vulnerability index is not intended to say anything about the occurrence of the virus itself. Instead, it could enable insights into the potential socio-economic impact of the COVID-19 pandemic situation on the livelihoods of Gauteng's residents. Most of the factors used in this index are directly related to socio-economic status and can therefore be viewed as intersectional and mutually dependent.

Against this background, we looked at the violent civil unrest breaking out mainly in KwaZulu-Natal but also in Gauteng in July 2021. The exacerbation of social inequalities under the lockdown measures can be seen as an important contributing factor. As Turok et al. (2021) describe, "[…] it is often a sense of unfairness (inequality), not just levels of provision, that lead to grievances and resentment which spark social protest." Nevertheless, it would be misleading to re-

duce the protests and looting solely to socio-economic distress, considering that these events were primarily triggered by the arrest of Zuma (Vhumbunu 2021). However, since our socio-economic vulnerability index deals more broadly with potential vulnerabilities to the impacts of lockdowns on the socio-economic situation of households, we compared it with reported incidents of social unrest in July 2021. We did so using data compiled by PolicyLab (2021). A total of 401 documented cases of civil unrest in July 2021 are included in this dataset. Of these, a total of 112 were documented in Gauteng. Here, 'civil unrest' mainly includes incidences of looting and arson. However, incidences of other forms of instability like other types of violence, road blockades, property damage, xenophobia, and not least major police operations in response to or in prevention of risks of civil unrest were also included in this data set. All identified incidents are based on media reporting.

The map in Figure 8 shows a combination of our index of socio-economic vulnerability with the localisations of reported cases of civil unrest (marked by blue triangles). The resulting spatial coincidence of above-average index values with spatial clustering of reported civil unrest is therefore not surprising.

Nevertheless, the assumed socio-spatial relations (and partly correlations) between focus areas of COVID-19 lockdown measures, socio-economic vulnerabilities, observable socio-economic effects of COVID-19 and not least incidences of civil unrest require further (empirical) consideration. In this regard, we additionally point to a recently published analysis by Goetz et al. (2022) based on data from the Quality of Life Survey 6 (2020/21), which spatially visualizes the unequal distribution of reduced salary and working hours as well as job losses in Gauteng Province since March 2020 (cf. De Kadt et al. 2021).

3.4 Socio-spatial differences: incidences vs. interventions

Based on the observations described above, it is clear that, although the 'peripheralization' of the virus has increased over the first two years of the pan-

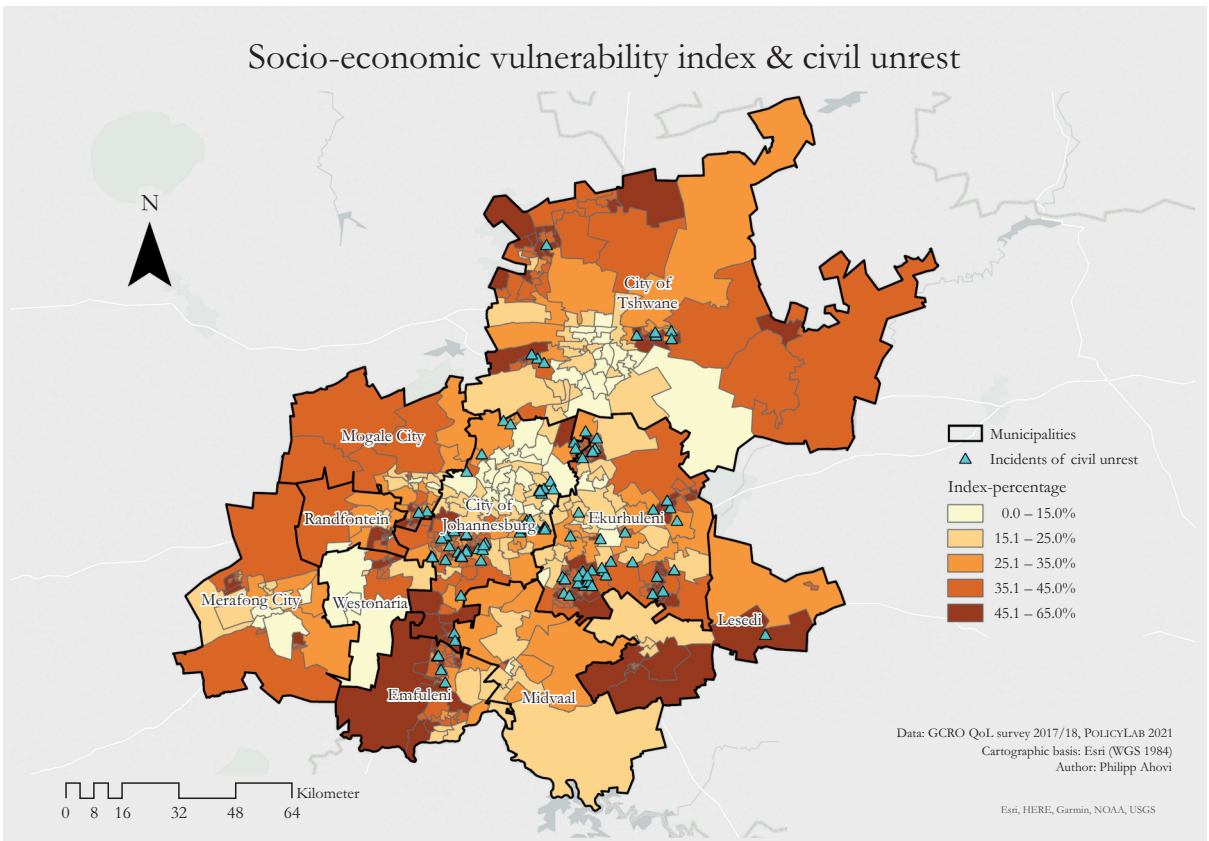

Fig. 8: Index of factors that increase the socio-economic vulnerability during a broader lockdown and reported incidences of civil unrest in July 2021. Data sources: GCRO 2018, PolicyLab 2021.

demic, the available evidence of incidences and seroprevalence rates provides for a blurred relation to predicted vulnerabilities, at best. Neither townships nor informal settlements or peri-urban areas can be labelled as hot spots of infections yet. As outlined earlier, we are aware of the limits to the databases used in the empirical section of this paper. Yet we can state that the data under consideration equally provides no empirical base for opposing interpretations. The claims of the literature on health vulnerabilities would thus have to be critically interrogated – and therefore the strategies based on these claims, e.g., to combat COVID-19 with a spatial approach of de-densifying informal settlements (Culwick Fatti et al. 2020, Smit 2020). This is not to say that problematic living conditions in informal dwellings should not be addressed, but rather that the risk factors need to reflect in a more differentiated way at least two different perspectives of looking at COVID-19 related vulnerabilities. Urban research – especially in 'developing contexts' – was intensely involved in the debates around risk and vulnerability for the past three decades (cf. Etzold & Sakdapolrak 2016). Within this field, the nexus of spatially differentiated living conditions and livelihoods is always present. The same is true for another field of research equally important for epidemics – the geography of health (Ossenbrügge 2021: 7ff).

If we look at health challenges, especially at infectious diseases, a popular, yet heavily contested, approach would thus consist of identifying places and zones with sub-standard living conditions as high risk areas and then selecting these as targets for prophylactic interventions like de-densification schemes (cf. Huchzermeyer 2022). On the other hand, in the case of COVID-19, epidemiologic studies have pointed out that indoor encounters are linked to much higher risks than outdoor interaction, since the virus is mainly spread by aerosols. Beyond the mere infection, though, serious illness and morbidity is linked to another set of risk factors, which are statistically more prevalent in wealthy population groups: old age, a high body mass index, diabetic conditions, among others. In terms of infectious diseases, and especially in the case of COVID-19, vulnerability needs to be 're-calibrated' somewhat, and spatial traps (a problem not uncommon in the context of advocacy for marginalized neighbourhoods) need to at least be taken into consideration. This brings us back to the concept of syndemics, which stresses the importance of societal factors in order to assess the impact of infectious diseases in a more differentiated way. This perspective would ideally enable governments and public health institutions to better judge the appropriateness of mitigation measures. As stated, this reflection is important since health policies are not only informed by our understanding of how specific diseases spread, but also by concepts of vulnerability.

When comparing the patterns of the spreading of COVID-19 with the strategies to combat the disease, it becomes clear that these strategies are guided only to a certain extent by the aim of bringing down the number of infections or to reduce the mortality rate. Governments will always consider additional factors which might come into play through an epidemic situation and lead to aggravation of its societal effects. By way of example, this could be socio-psychological dynamics, the threat of irrational and potentially disastrous mass panicking leading to storing food and fuel, or singling out presumed individuals and groups and attacking them (cf. reports of anti-Asian xenophobic action in the early stages of the pandemic in many countries across the globe). Other examples of factors influencing health strategies which have featured prominently in the public discourse are: Economic repercussions, social isolation of vulnerable groups, and of course, the question of showing political power/agency in a state of emergency. While it was not always clear by which perceptions and analyses governments and states were guided, though, governments *had* to (and did) take decisions on how to act in the face of this health challenge. Each response to the pandemic bore the risk, however, the identified strategies would create undesirable repercussions, regarding the containing or proliferating of the virus, but also beyond this, by affecting and interfering with a complex web of societal arrangements.

3.5 Limitations

As already discussed in the preceding sections, the empirical considerations of this paper are constrained by a number of limitations. Both the COVID-19 case data used and the seroprevalence data considered are subject to uncertainties and biases that make it difficult to draw empirically robust conclusions about the socio-spatial distribution of infection incidences in Gauteng. This also means that even though the data under consideration does not show anything of this sort, there is no certainty that informal settlements have not become hotspots of virus transmission. On the other hand, the data does not provide evidence for identifying these settlements as transmission hot spots.

4 Conclusion

This paper has analysed socio-spatial patterns and diffusion processes of the COVID-19 pandemic in the Gauteng City Region. By relating these patterns to characteristics and effects of the lock-down measures imposed by the state to contain the pandemic, we have shown how both aspects are interwoven with unequal social conditions. Effects of this context are visible in the state's handling of pandemic hardships, from the allocation of social support packages to de-densification strategies for informal settlements. The Gauteng City Region offers valuable insights in this regard, due to its complex structure with globally integrated areas, as well as rather peripheral and informal communities. Therefore, a regional analysis of the pandemic provides for more than descriptive results: we can also put previously foregrounded bodies of knowledge on pandemics in urban contexts to the test. Especially the diffusion thesis of a pandemic moving from the global centres to the socio-economically disadvantaged periphery of an urban region, ultimately affecting the population living there most severely, seems important to us in this regard. According to this thesis, COVID-19 – as a disease – would have been a catalyst of existing urban inequalities. Our analysis shows, however, that this assumption cannot be substantiated with existing data, so far. Based on this assessment, the paper points to the necessity to apply a relational perspective on the entanglement of global and local conditions, in order to reflect the mutual constituency of both (cf. Haferburg & Rothfuss 2019). A main achievement of our empirical analysis, then, is to highlight the weak relation of expected and documented spatial patterns of COVID-19 infections in one of the biggest metropolitan regions on the African continent.

It is nevertheless premature to make conclusive judgments about the effects of the COVID-19 pandemic on urban development and on the dynamics of socio-spatial inequalities in SA. Some trends, however, can be identified: First, the observation that the initial spread of the virus took place in urban nodes integrated into global networks. This might be a reason why the most globalized province, Gauteng, has been affected disproportionately. The subsequent pattern of spread is somewhat more difficult to understand. Explanations that assume a diffusion from globalized centres to the periphery are empirically supported to some extent, depending on the scale and level of data aggregation. It is less obvious how the socio-spatial dimension is linked to this process. On the one hand, the capacities of coping with COVID-19 are distributed unequally across diverse socio-economic groups. In the case of Gauteng, this is demonstrated by GCRO's 'transmission risk index'. On the other hand, however, the distribution of incidences does not follow the path laid out by the patterns of social vulnerabilities. Certainly, it must be kept in mind that we can currently only look at a slice of the spatiotemporal dynamics, but it should be acknowledged that the intuitive assumption of a greater impact of the pandemic, for instance on informal settlements, cannot be substantiated so far – at least not in terms of the documented cases of COVID-19 infections, seroprevalences or related fatalities. The pandemic, then, does not vouch for spatialized interventions like de-densification or resettlement programmes. This is not to say that people living in informal settlements are not in need of state assistance – but that the strategies to alleviate their living conditions might need to be recalibrated.

In contrast to the immediate effects of the virus, the lockdown-measures have direct references to socio-spatial vulnerability, as disadvantaged populations are hit harder by 'stay at home' and 'physical distancing' measures. This is a general phenomenon and has particular significance in urban situations, where dense housing and job losses create additional challenges. Therefore, it is plausible that a hard lockdown (Alert 4 and 5 in the case of SA) contributes to hardship and stress, unless a generous and lasting social policy is put in place as a cushion. While not directly triggered by these hardships, the 2021 events of mob violence and looting in the Gauteng City Region, in Durban/Ethekwini, and in other places in KwaZulu Natal, highlight SA's limited capacity to address these tensions and needs

The debate on the societal consequences of COVID-19 points to the possibility of the pandemic to act as a catalyst for social problems. In this light, the state's approach to combat the disease – affecting the urban poor more than others – would appear as a contributing factor to the civil unrest. Early lockdown measures in SA could be read as an expression of authoritarian neoliberalism, by which the state attempted to contain, control and shut down protest against the social consequences of the economic crisis that had already existed for some time. In July 2021, more than a year after the first lockdown, however, the state did not clamp down on the unrest in a consistent and committed way. Governance in SA, thus, is continuously challenged by circumstances created by earlier (non-)interventions.

These considerations also lead to the conclusion that it will be crucial not only to relate the pandemic (including the measures to combat it) to the general patterns of the spread of the virus and resulting containment measures. The specific social and spatial conditions under which they unfold must be examined as well. Our case study shows a clear divergence between the theoretically assumed transmission processes, spatially delineated vulnerabilities, and the actual occurrence of infections. In contrast, state action guided by vulnerability-based predictions on 'typical' transmission patterns relies on containment measures which seem to hit the most vulnerable groups the hardest. Only a combination of urban geographies of health (based on a broader syndemic perspective) with the political and socio-economic geographies of the respective society will thus provide us with a differentiated understanding of COVID-19 in a globalized and localized urban perspective.

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