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The initial 100-day COVID-19 landscape in Kenya: trends, mitigations and impacts

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Abstract

Since the first case of the novel COVID-19 was recorded in Kenya on 13 May 2020, the increase in positive cases, transformation into community transmission, and emergence of more epicenters, depicts a disconcerting trend despite the multi-phased government-driven mitigations. Hence the urgent need for more robust mechanisms to track and map COVID-19, and design targeted mitigations. Such interventions include GIS-mapping systems coupled with multivariate analysis, to evaluate the internal dynamics based on prevalence, control measures, responses and successes to combat COVID-19.

We applied GIS and statistical analyses to map the 100-day disease pattern, outlined country's preparedness and COVID-19 projections post-100 days. Results indicate an average daily testing capacity of 11% and a corresponding daily detection rate of 7%. Between March-June 2020, the cumulative 122,418 tests reported 4,783 positive cases. The highest figure (2,816) was reported in June against 57,744 tests conducted. These figures represent 0.26% tested and 0.01% positive cases respectively of the country's population. Nairobi, Mombasa and Busia counties were identified as 'hot spots'.

Despite the growing pressure to re-open businesses and public facilities due to socioeconomic challenges, the government should carefully review and rely on expert opinion and initiate sector-specific strategies in combating COVID-19 under the 'new normal'.

Keywords: COVID-19; Community transmission; GIS mapping; Hot-spots; Social distancing; Mitigations; Public health awareness

1. Introduction

The first case of a pneumonia-like disease of unknown etiology, later identified as the Novel Coronavirus (2019-nCoV) disease, was traced back to Wuhan City in Hubei Province of China on 31st December, 2019. In under 5 days from detection, China had reported 44 case-patients and by 20th January, 2020, the confirmed cases had risen to 278 (WHO, 2020d). The first case of the COVID-19 disease in Africa was reported in Egypt by the country's Minister of Health and Population from a 33-year old foreign national on 14th February 2020 (Africa CDC, 2020). Since then, all the 54 countries in Africa have recorded surges in active cases, significant recoveries and deaths (UNDP Africa, 2020). As at 20th June, 2020, the cumulative cases and deaths in Africa had reached 216,999 and 4,874 respectively, representing 2.49 and 1.06% of global incidents respectively (WHO, 2020c). In the same period, the proportion of COVID-19 cases and deaths in Europe represented 31and 43% respectively against the global figures (WHO EURO, 2020). The African Union Commission responded to the

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COVID-19 pandemic by collaborating with the Africa Centre for Disease Control (Africa CDC) and the WHO to invest in preparedness and management of COVID-19.

Since the first case of the novel COVID-19 was confirmed in Kenya on 13 May, 2020 (MoH, 2020), the government progressively enforced multi-staged initiatives (KNBS, 2020), and as advised by the WHO (2020a), to mitigate the pandemic using "black-box" precautionary-measures (MoH/NERC, 2020c). However, the exponential increase in positive cases (Aluga, 2020), transformed into community transmission, and the emergence of more epicenters depicted a disconcerting trend. This was despite the partial lock-downs in four counties considered as "hot-spots" (MoH/NERC, 2020a), public health awareness campaigns (NERCC and MoH/NERC, 2020) and availability of personal protective and hygiene equipment, such as face masks and hand sanitisers to health care providers (MoH/NERC, 2020b) and the general public. This called for more robust mechanisms to track and map COVID-19 in Kenya, and design adaptive mitigations based on scenario analysis. Such applications include GIS-mapping coupled with multivariate analysis, to evaluate the internal dynamics based on prevalence, control measures, responses and successes towards the "plateauing" the COVID-19 curve.

The objective of this study was to employ complementary GIS techniques to map COVID-19 in Kenya to identify patterns, hot-spots and evaluate the effectiveness of the multi-agency approach to combat the pandemic. Similar studies elsewhere have revealed the effectiveness and potential applications of GIS in predicting, preventing and dealing with pandemics (e.g. Datta, 2020; SuperMap, 2020). We hypothesised that GIS-based mapping would enhance the country's targeted responses and result in increased efficiency in managing the COVID-19 pandemic compared to the "black-box" approach initially adopted. The study also aimed at evaluating the socioeconomic impacts of government interventions during the initial 100 days of COVID-19 in Kenya.

2. Materials and methods

2.1 Description of Study area

Kenya is located between 34° E – 42° E and 05° N – 5° S in the Eastern region of sub-Saharan Africa, with 580,876 km^2 land area (Fig. 1) occupied by 47.6 million persons. The capital city's Nairobi County hosts approximately 9.1% (4.4 million) of this population. Administratively, the country is divided into 47 counties spreading across 8 regions; Coast, Western, North-Eastern, Nyanza, Central, Rift Valley, Eastern and Nairobi (KNBS, 2019).

2.2 Data collection and analysis

Data collection and verification: The study used data collected between 13th March and 20th June, 2020 from various repositories including the WHO (WHO COVID-19 situation reports), John Hopkins University COVID-19 Resource Center (JHU COVID-19 RS), UNDP Africa (UNDP Africa situation reports), Africa CDC (Africa CDC COVID-19 Dash board) and Global COVID-19 watch platforms (e.g. worldometers, Corona Tracker). At the national level, multiple online such as the Ministry of Health Kenya website (COVID-19 situation reports) and press releases (MoH daily briefs), the National Emergency Response Committee (NERC) on COVID-19 updates (NERC on COVID-19), the Kenya National Bureau of Statistics (2019-KPHC Vol 1), independent citizens observatories, media-houses, and social media platforms (e.g. MOH Kenya twitter page) were accessed.

Desktop studies: The relevant data and information from these sources was collated, cross-checked and cross-compared for similarity (Pickvance, 2005) to ensure accuracy of data used for GIS-mapping, statistical and trend analyses and reporting.

GIS data and mapping: The cumulative confirmed cases by county was used to generate the 100th-day COVID-19 spectral map of Kenya and classified based on the "no-case" to "hotspot" level using QGIS software (QGIS.org, 2020). A similar classification scheme was followed to identify, map and monitor the three most impacted counties, from 01 May, 2020, the start of county-based COVID-19 reporting by the National Emergency Response Committee on COVID-19 to 20 June, 2020, which marked day 100 of the disease surveillance period in Kenya.

Data analysis: Descriptive analysis was conducted to evaluate testing capacity, identify trends and projections of COVID-19 pandemic in the initial 100-day period. The trend and exponential behaviour of the confirmed cases was visualized to depict the likely scenario post-100 days in the country. The

GIS outputs for the three "hot-spot" counties were also studied to give a reflection of the "hot-spot" transition pattern in counties susceptible to exponential increase in COVID-19 cases based on either their proximity to border entry/exit points or neighbouring hot-spots areas within the country.

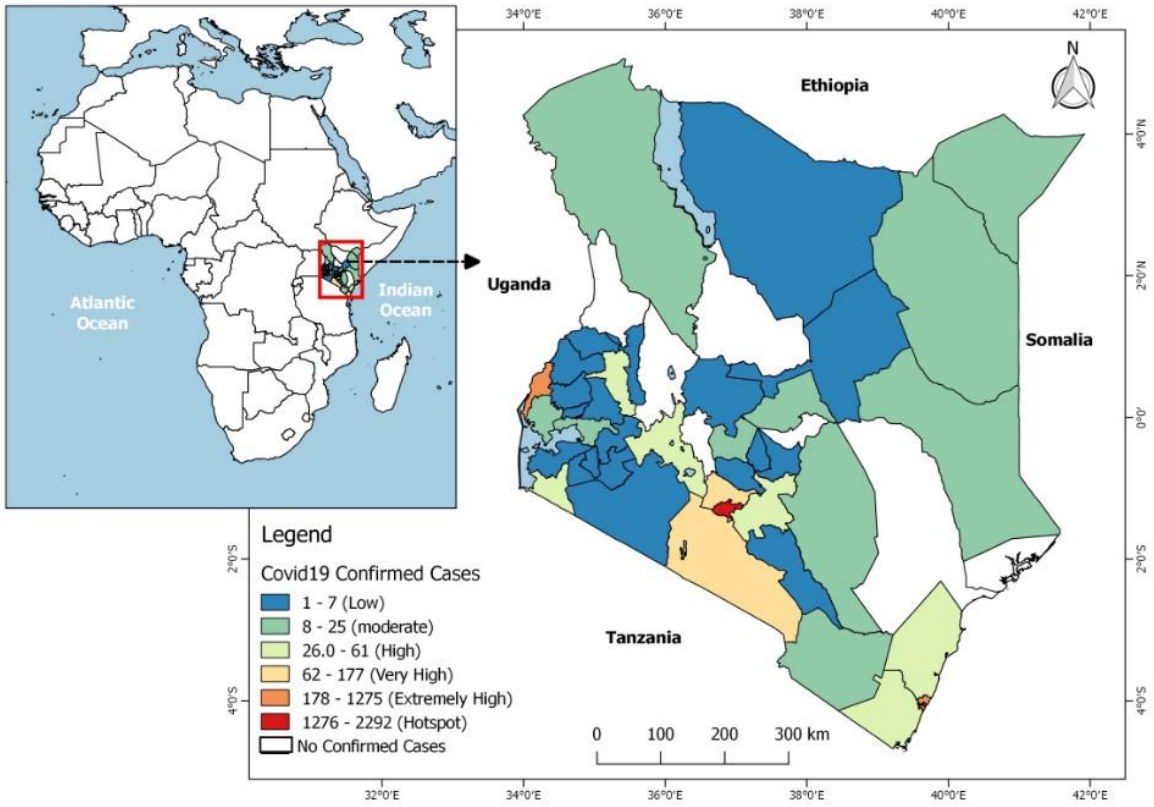


Fig. 1: A spectral map Kenya showing the cumulative county-wise cumulative distribution of confirmed COVID-19 cases across the 47 counties as at 20 June, 2020 (day 100).

3. Results and Discussion

3.1 The COVID-19 patterns and projections

Based on the data collected and verified, statistical analyses revealed an almost similar and predictable pattern on the occurrence of COVID-19 in the country compared to previously reported cases globally. There was a relatively flat and slow rise in confirmed daily cases in the first 28-35 days possibly dues to the low testing capacity, quarantine enforcement on immigrants over March-April, 2020 period. The next 21 days in May, 2020 were characterized by an exponential increase in confirmed daily cases perhaps due to increased interaction with persons and facilities handling COVID-19 and transformation into community transmission of the disease (Fig. 2). The increase confirms the assertions in a previous study on the COVID-19 situation in Kenya (Aluga, 2020). The government had also upscaled the daily screening and contact-tracing capacity compared to the previous period (Fig. 3a) and which corresponded with the numbers of confirmed COVID-19 patients in the country. For instance, in June 2020, the 57,744 tests also produced the highest number of positive cases. However, April 2020 recorded the highest percent rise in testing and confirmed case scenarios of 2,142 and 471% respectively (Fig 3c). This improvement coincided with the acquisition of testing kits, personal protective equipment (PPE), trained personnel and laboratory facilities by the government. April, 2020 also marked start of the rising phase of the exponential COVID-19 curve in Kenya. The numerous public awareness campaigns by the government agencies and the private sector organisations, coupled with the free mass-testing of the public may also have contributed to the increased number of tests between April and June, 2020. Generally, during the initial 100-day period, a total of 122,418 persons (0.26% of total population) had been tested for the SARS-nCOV-2 virus (Fig. 3a). Respectively, 4,783 were confirmed positive for COVID-19 (Fig. 3b). The average testing

capacity through the period stood at 11% (1,224 tests per day) with an approximately 7% (47 persons) daily increase in the number of confirmed cases.

In Figure 4, the cumulative cases of positive patients observed in figure 3b over the 100-days depicted a trend which also corresponded to the exponential equation y=13.31exp0.0645x, where y is the cumulative number of positive COVID-19 cases and x the day from the first detection. If the hypothetical situation remains, then for instance, on day 150, the total positive cases will be expected to reach 211,825 and 5,328,156 by the 200th day, unless targeted interventions and other natural factors come into play to flatten the curve. However, the trend and projections in figure 4 may only be a rough indicator of the potential prevalence of COVID-19 in the country since the results represent a dismal 0.26% of Kenya's 47.6 million persons.

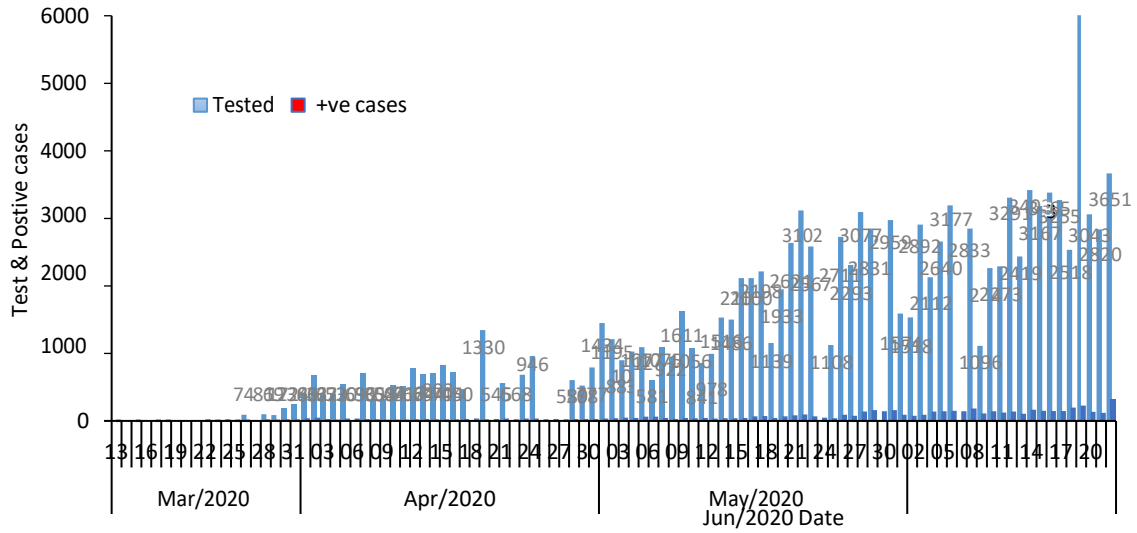


Fig. 2: The trend of daily COVID-19 tests and confirmed cases in Kenya during the initial 100-day (13 March - 20 June, 2020) monitoring period.

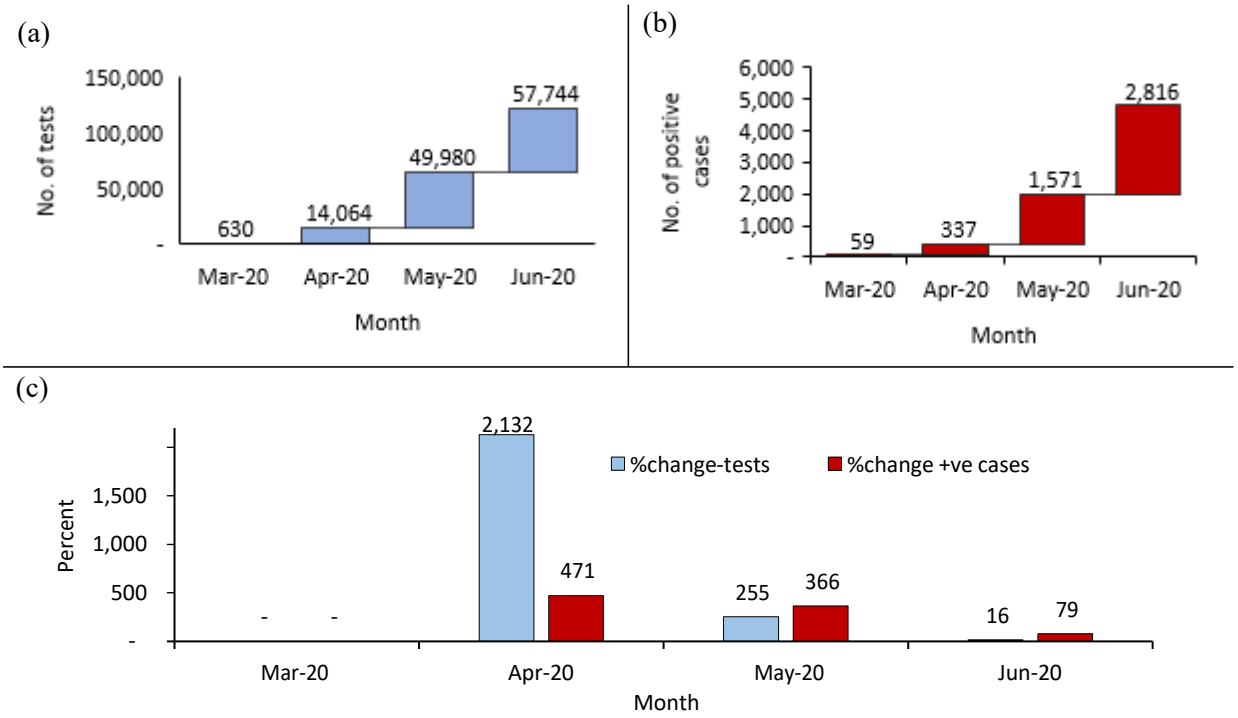


Fig. 3: Figures (a)-(c) showing the transformation in the testing and detection capacity during the 100-day COVID-19 pandemic in Kenya. Figure (d) gives the exponential increase in the cumulative positive cases over the same period.

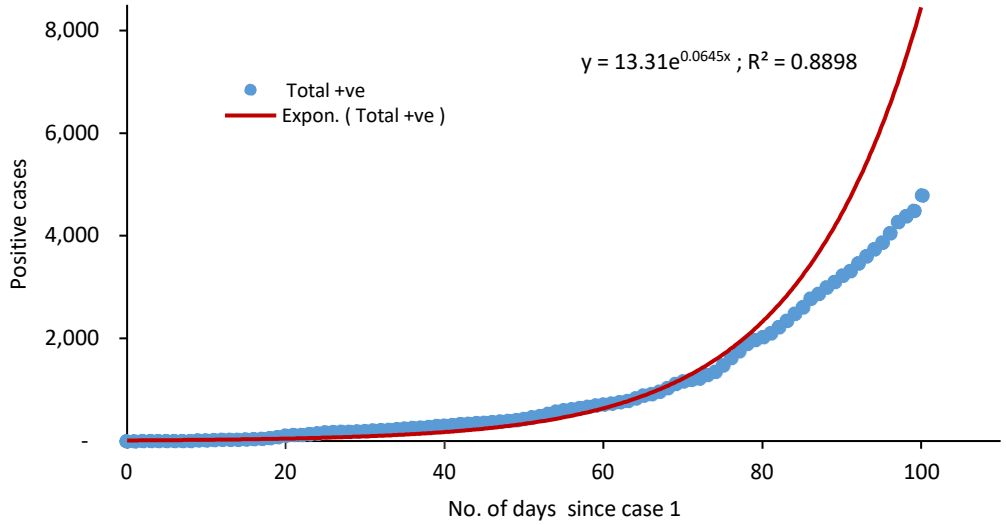


Fig. 4: The cumulative number of confirmed COVID-19 cases and the corresponding exponential increase in Kenya in the initial 100-day (13th March-20th June 2020) surveillance period.

3.2 Hot-spot detection and mapping

According to the MoH/NERC (2020b) April 01, 2020 report, there was cumulative 81 COVID-19 cases since 13 March, 2020 while 1,675 contacts were under surveillance. The disease had unpredictably spread to eight counties some of which were likely to hot-spots. Figure 5 shows the changing patterns of COVID-19 for three counties with the highest reported cases considered over May-June 2020 COVID-19 surveillance period. Nairobi and Mombasa counties are the two major international flights entry-exit points while Busia county's proximity to Uganda is a key entry-exit point via road.

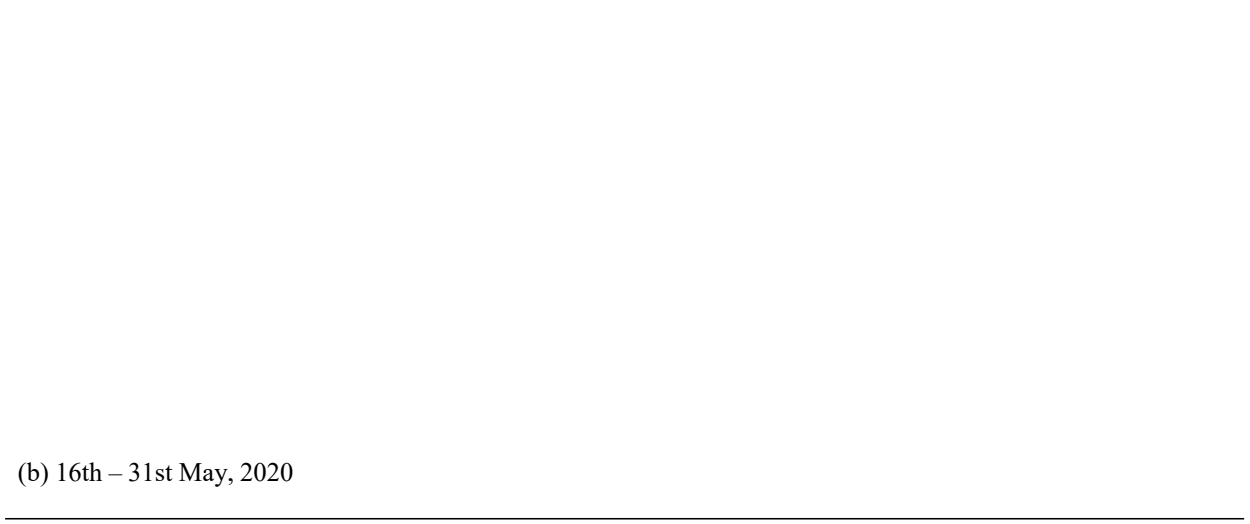
In the first 15 days (May 1-15) of the county-level COVID-19 surveillance (Figure 5a), Nairobi county recorded over 800 confirmed cases although Mombasa county was quickly drawing concern to the NERC/MoH team with a rapid increase in confirmed cases up to 575. The border county of Busia had the lowest figure of 288 cases possibly due to the lock-downs and travel restriction enforced by the government in the first two counties during the 100-days phase. The cases in Busia could have arisen from authorised movement of persons providing essential services during the lock-downs or cross-border contacts.

In the 16th-31st May, 2020 phase of the monitoring (Figure 5b), the cumulative COVID-19 cases were relatively lower in all the three counties. Nairobi and Mombasa counties fell within the 103-153 range while Busia county recorded positive cases below the 100 mark. A plausible explanation for this trend could be the upscaled containment measures given that the COVID-19 disease pattern was getting more understood over time. The increased public awareness campaigns, changes in social behaviour of the citizenry and cessation of travels into and within the country.

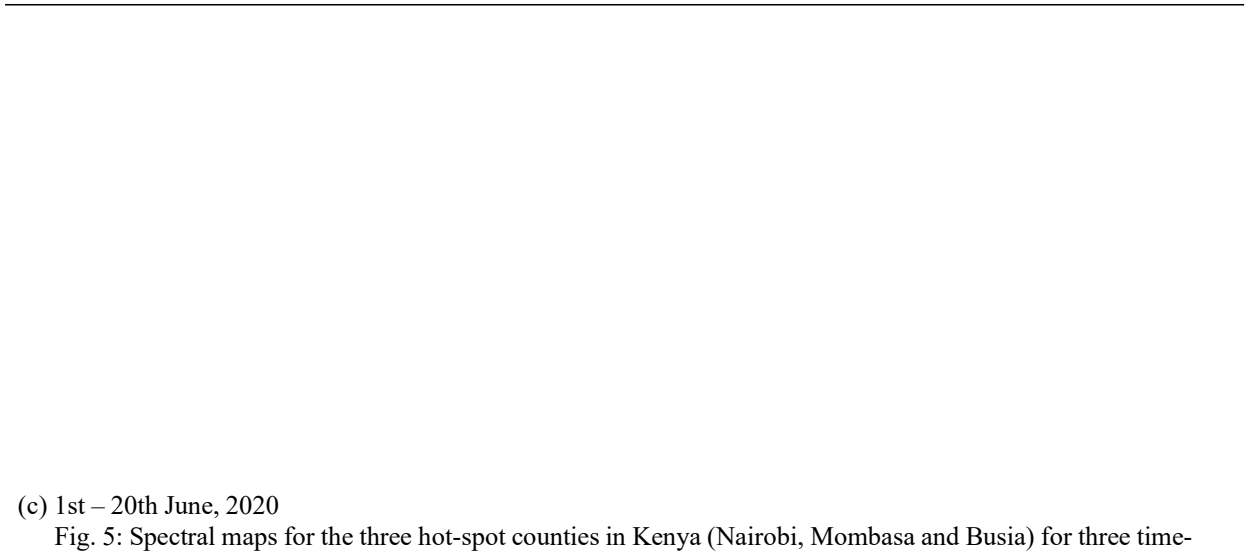
In general, the 100-day scenario mapping isolated the three counties as hot-spots with positive COVID-19 cases between 1275 and 2272 (Figure 1). The implication of the trend is evidenced in the gradual rise in cases in neighbouring counties of the three epicenters. For instance, from the same classification scheme in figure 1, the three counties (Kajiado, Kiambu and Machakos) bordering Nairobi city county Central Kenya recorded extremely high cumulative number of COVID-19 cases between 22-177. Furthermore, Kilifi and Kwale counties, neighbouring Mombasa county, also reported positive COVID-19 cases of up to 60, classified as high, in the same time-frame. This brings to light the essence of counties instituting mitigations to manage the imminent spread of COVID-19 in the event the travel restrictions and lock-downs in the hot-spot counties are eventually lifted. Such mitigations include highly efficient surveillance and contract-tracing systems as reiterated by the WHO that will enhance the control of the spread of the disease (WHO, 2020a). As suggested by

Smith (2020b), information about the pandemic will be crucial in preparing countries to better manage COVID-19 and reduce transmission by creating informed public communications and education strategies.

(a) 1-15 May, 2020



(b) 16th – 31st May, 2020



(c) 1st – 20th June, 2020

Fig. 5: Spectral maps for the three hot-spot counties in Kenya (Nairobi, Mombasa and Busia) for three time-steps, (a) 1st-15th May 2020, (b) 16th-31st May 2020, and (c) 1st-20th June, 2020, as observed during the 100-day monitoring period based on the disaggregated county-based statistics by the country's Ministry of Health.

3.3 Sectoral pressures: Social and economic dynamics

Since the first reported case of COVID-19 in Africa, governments all over the continent have taken different approaches in implementing a raft of measures to curb the spread of the disease within their borders (Deloitte, 2020). In Kenya, among the measures taken include quarantines, curfews, full or partial lockdowns, and social distancing in areas where contact is common such as shopping places, eateries, transport vehicles, and markets. These restrictions have also affected social gatherings such as church services, family gatherings, weddings, parties and funerals. A total shut down of learning institutions due to concerns about ability to control movement and contagion has also brought physical learning to a screeching halt. Directives on wearing of masks in public always, handwashing and regular use of sanitizers also changed aspects of social behaviour for many. Eateries and bars allowed to offer take out services only were subjected to stringent hygiene and distancing certifications in order to stay open (Deloitte, 2020).

3.3.1 Commerce and Industry

The ban on international and local air travel, partial lockdowns and social distancing measures have seen many people forced to take unpaid leave. Disruptions in foreign trade has caused huge losses in some sectors and driven others to near collapse. The flower, vegetable and fruit industries in Kenya, livestock producers and exporters, and poultry farmers are experiencing loss of income and face imminent collapse. International and local leisure as well as conference tourism has also suffered due to travel bans and social distancing rules. Many employees have taken pay cuts due to revenue losses across the economic sector (Deloitte, 2020). The pandemic has also hit the region at a time when agriculture is already facing challenges dealing with desert locust invasion which has compromised food security in some places. The impact on agriculture may not be felt as immediately as on other sectors since rural areas were not as badly hit as urban areas where food is still available due to recent harvests. However, industries supported by agriculture and economies that rely heavily on food imports will suffer should the prevailing situation remain. The threat to food security could increase if production suffers due to changes in production rules.

In Kenya, a survey conducted between May and June, 2020 indicated that nearly 78.8% of the households experienced increase in food prices due to shortages caused by the COVID-19 situation in the country (KNBS, 2020). In response, nearly 42% of households had reduced expenditure on non-essential items or services while 21.6% were mainly worried about food security which also negatively impacted trading and business activities (KNBS, 2020).

In order to cushion businesses and individuals from the COVID-19 onslaught, the Kenyan government instituted tax based and fiscal measures as follows (PSCU, 2020): Reduction of the turnover tax rate from the current 3% to 1% for all Micro, Small and Medium Enterprises (MSMEs); reduction of VAT to 14% from 16% and disbursement of accumulated VAT refunds of KES 10 billion; a 100% tax relief for persons earning up to KES 24,000 monthly; reduction of the highest income tax band from 30% to 25%; reduction of corporate rate tax from 30% to 25%; reduction of the Central Bank of Kenya lending rate from 7.25% to 7%; increased maximum tenure for repurchase agreements; lowered cash reserve ratio for banks; flexibility in loan provisioning requirements for performing loans; appropriated KES 10 bn in cash transfers to the elderly, orphans and other vulnerable groups; and a 20-80% voluntary salary reduction for senior government officials. These targeted interventions were to cushion Kenyans against the socioeconomic impacts of the COVID-19 pandemic.

3.3.2 Education, science and technology

Owing to closure of all learning institutions in Kenya, there have been negative impacts on education such as exposure to undernutrition for learners who come from schools where meals are offered free of charge. There has also a lag in learning outcomes for those in remote areas or areas where access to electricity or internet is constrained a well as those with low initial digital skills (Areba, 2020). Moreso, students are anxious, especially those at the terminal stages and expect undertake various forms of summative evaluation (UNESCO and IESALC, 2020). About 17% of households with students reported challenges in accessing distance or self-learning during the pandemic (KNBS, 2020). Cases of bad behaviour such as substance abuse and involvement in sex are on the rise with concern being voiced over the high numbers of teenage pregnancies. Child abuse,

gender based and domestic violence is also on the rise (KNBS, 2020). Students studying abroad were either forced to return home and have not resumed their studies or were stuck abroad where they underwent difficult conditions. Returned students are facing psychological insecurity which may cause them to resign from their studies or facing cancellations of their scholarships due to economic impacts of the pandemic on the countries offering them (UNESCO and IESALC, 2020). To date, the re-opening of learning institutions in the country is uncertain. The KNUT/UASU/KHRC (2020) evaluation report recommend an "inclusive and comprehensive data-driven process of ascertaining how schools, teachers, non-teaching staff, students and communities are coping with closures and the pandemic". Further suggested in the report is that resumption of learning should largely be determined by the status and evolution of the pandemic, and as advised by the Ministry of Health in Kenya.

Health and psychosocial aspects

Sub-Saharan Africa is characterized by high poverty, weak institutions, armed conflict and crowding in urban areas (WFP, 2020). The resultant conditions are those of undernutrition, low literacy levels, adverse underlying health conditions and poor access to services. These have been exacerbated by lockdown measures instituted to curb the COVID-19 pandemic causing disruptions to food, water and medication access. Dense populations in urban areas where the pandemic first entered these economies has had adverse effects on mitigation measures (Smith, 2020a), especially in informal settlements where WASH is a chronic challenge. Adopting some of the measures such as hand washing, work from home orders and social distancing rules has proved impossible due to lack of access to clean water, the nature of their employment (casual/low skilled labour and petty trade) and size and distribution of dwellings. Closure of eateries, micro and small enterprises and entertainment places has led to job losses for these populations. Reduced spending power may mean nutritional insecurity for many Kenyans. In case of infection, this increases the risk of poor outcomes as it compromises the immune system of the individual.

4. Conclusion

Evidence from the 100-day scenario shows the current and projected negative economic, social and health impacts of COVID-19 in Kenya. The exponential pattern of the disease warrants proactive multi-targeted measures and more 'accurate' responses to flatten the COVID-19 curve. The supportive role of GIS in monitoring and management of the COVID-19 pandemic in Kenya is viable in to enhance targeted and timely cross-sectoral interventions. The government should priorities expert-based knowledge, including multivariate and geospatial analysis, during decision-making for increased effectiveness in combating this pandemic. This will minimize the negative economic impacts on human and capital resource use, and restore normalcy in the shortest reasonable time under the 'new normal'.

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