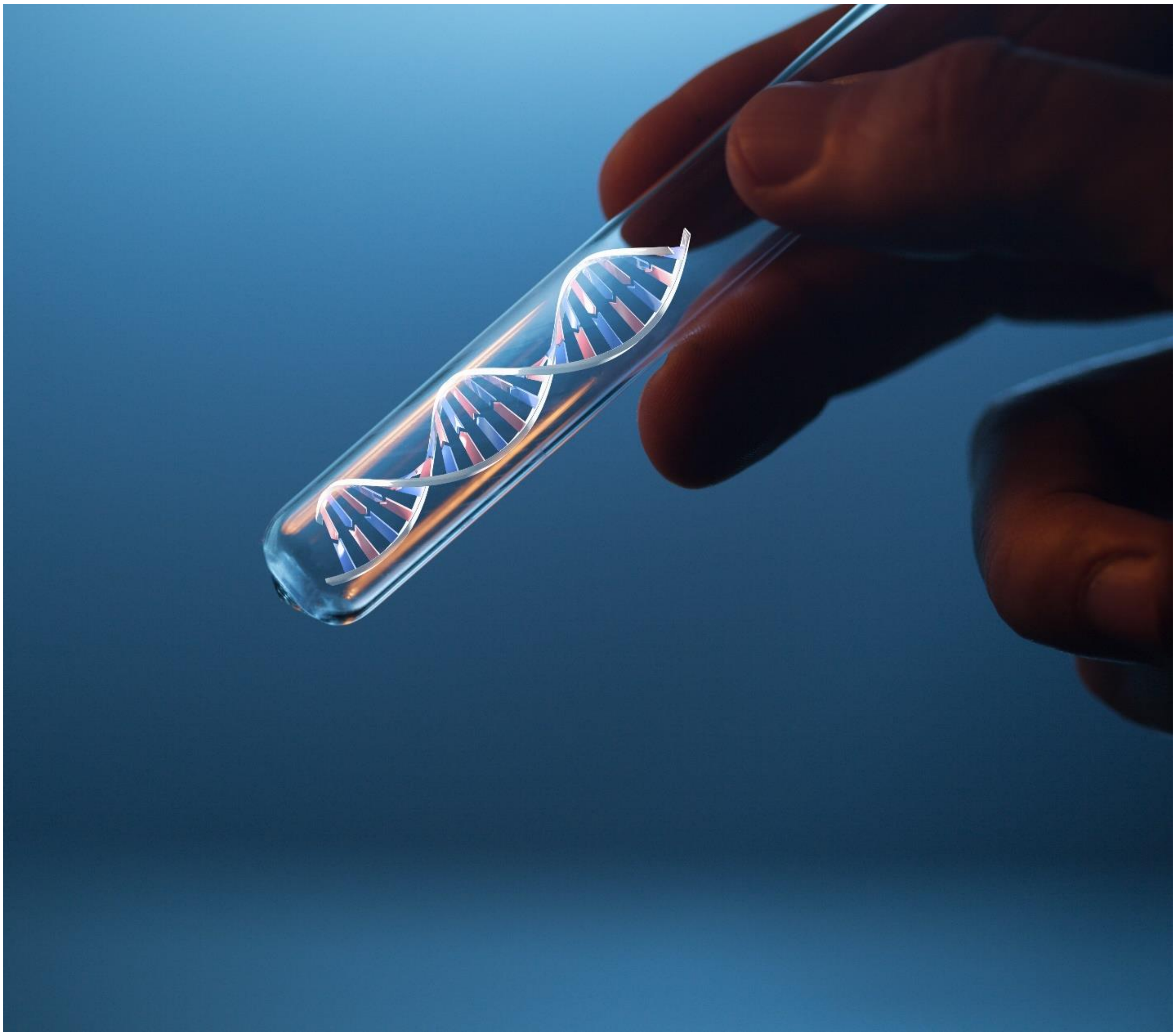

Epidemiological models to assess the Impact of COVID -19 on health systems in Africa

Policy Brief

Key Messages

- The COVID-19 pandemic has had significant impacts on health systems including economic and social impacts.
- There is some modelling to optimise resource allocation and intervention in Africa, but it has not fully captured the components of health systems because there is a lack of data.
- There is need to invest in R&D systems to strengthen data collection and analysis and to enable inclusive/holistic modelling and planning for health systems, and
- African researchers must do more to profile past pandemics to inform the response and management strategies for future pandemics.

Background

The management and control of COVID-19 is dependent on Africa's healthcare capacity. Compared to developed countries, the majority of African countries have vulnerable healthcare systems[9]. The different manifestations of the virus have created shifts in capacity management, institutional structures and resource allocations in health systems. For instance, as variants of the virus have emerged, most African countries have redirected budgets towards healthcare support. While this may be necessary, there is a risk that it will contribute to economic decline on the continent[10]. Similarly, various social and institutional adjustments made to manage the changing nature of the pandemic may have unintended consequences.

Most African countries are still unclear on how best to prepare health systems to manage this and future pandemics. The direct and indirect impacts of the pandemic on health care systems must be understood to inform planning and preparation of these systems in order to optimise management of a quickly changing pandemic. Stakeholders including experts and policy makers convened in July 2021 to identify priority evidence needs for COVID-19 response on the continent. They noted the variety of practices and tools in use and with potential to shed light on how the pandemic has affected health systems. Among these, epidemiological models are becoming increasingly important in forecasting public health trends. This report documents various epidemiological models used to predict impacts of the pandemic on African health systems, and how effective they are in preparing these systems to handle various aspects of the pandemic. Using these models to forecast the infection, transmission and spread of the virus allows for preparation and planning for healthcare systems that accounts for their capacities, needs and resource allocations.

Methodology

A comprehensive search strategy for peer-reviewed studies published from December 2019 to-date was developed using the PubMed, Scopus, Medline, PsycINFO, PubPsych, Open Grey (grey literature), Cochrane Library, Web of Science (grey literature), Epistemonikos and Cochrane COVID-19 study register databases. The search included the following MeSH terms, text words and entry terms that were developed in PubMed and adapted in the other databases: (COVID OR coronavirus OR SARS-CoV-2 OR Africa SARS-CoV-2) AND (Epidemiology OR Epidemiological Models) AND (Africa OR sub-Saharan Africa) AND (Health Systems OR Public Health). In addition, three preprint servers -- including the Open Science Framework (which hosts 30 other preprint archives, including PsychArxiv, MedrXiv, and the Social Science Research Network

(SSRN)) -- were screened for other potentially eligible primary studies. The search yielded 2,285 studies: these netted 984 after removing duplicates. Sixty-eight studies were considered based on a review of their abstracts; from these, the full papers of 27 were reviewed and 22 of them were deemed to contain relevant modelling and observational peer-reviewed studies and were used for this policy brief. Because of the heterogeneity of these articles, we provide a descriptive analysis of the findings.

Policy Relevant Findings

Global evidence

Tandon et al[12] and Bayyurt[13], among others, have applied autoregressive integrated moving average (ARIMA) models to predict the number of cases and deaths from the pandemic in various European and Asian countries to inform intervention measures through policy and practice. Fanalli and Piazza [14] implemented the susceptible-infected-removed (SIR) model to analyse and forecast the COVID-19 spread in China, Italy and France to aid in healthcare planning and resource allocation. Wang et al. [15] extended the SIR models to evaluate the non-pharmaceutical interventions applied in the outbreak of COVID-19 in Wuhan, China. SEIR and agent-based models have also been used globally, especially in Wuhan, China, to forecast disease.

COVID spread and impacts

SEIR (Susceptible, Exposed, Infected, Recovered) is an extended SIR model that accounts for the portion of the populace exposed to the pandemic. The model has been used widely in the initial stages of research of COVID-19 in China [16], [17], [18] and Italy [19], [20], [21]. In contrast, agent-based models simulate the outcomes of interactions among individuals, using detailed assumptions about their movements, mixing patterns and public health interventions [22], [23], [24]. SEIR and agent-based models are extremely valuable for modelling the impacts of specific behaviours and designing local policy interventions. Though SEIR and agent-based models are applied to specific localities, they have demonstrated the capacity to scale easily across a broad geographic range. However, broader application requires more parameter values that may be untested locally and difficult to calibrate as an ensemble, especially in developing countries with sparse data availability.

African Continent Evidence

Several studies have applied various modelling techniques with a special focus on health care systems to support policy and decision making in Africa. Zhao et al. [25] applied the Maximum-Hasting (MH) parameter estimation method and the modified SEIR model to predict the spread of COVID-19 in South Africa, Egypt, Algeria, Nigeria, Senegal and Kenya under three scenarios of suppression, mitigation and mildness. The model was used to predict the spread in the targeted countries under the three scenarios based on the model outputs, using them to propose a series of epidemic control methods including patient quarantine, close contact tracing, population movement control, government intervention, city and county epidemic risk level classification and medical cooperation. A study by Aidoo and colleagues [26] involved modelling COVID-19 incidence in the African sub-region using a smooth transition autoregressive model to predict COVID-19 incidence and transmissibility rates. This prediction in turn informed disease control policy development, guided limited resource allocation and helped to prepare to meet healthcare system demands. The study demonstrated the capabilities of the nonlinear smooth transition autoregressive (STAR) model application to improve the forecasting of COVID-19 incidence in the Africa sub-region. Mukandavire and colleagues[27] conducted a study in South Africa in 2020 by applying a mathematical model of observed cases of COVID-19 to estimate spread and critical vaccination coverage to control the disease in different theoretical vaccine efficacy scenarios. It was also used to estimate the reduction of spread rate due to social distancing containment measures implemented in South Africa. The study revealed that the model estimated the reproductive number of 2.95 and that a vaccine of 70% efficacy has the capacity to contain the spread of the pandemic only when supplemented with vaccination coverage of 94.44%. The study further shows that a vaccine of 100% efficacy will contain the spread at a coverage of 66.10%. The use of the containment measure of social distancing in South Africa has reduced social contacts by 80.31%. The study concludes that a high efficacy vaccine must be coupled with higher vaccination coverage to fully contain COVID-19 in South Africa.

Challenges and Opportunities of COVID -19 Impact Modelling

Synthesis of key global and Africa-specific findings reveals the various challenges, gaps and opportunities for COVID-19 impact modelling, especially in Africa. First, reliable data is required to promote data-driven decision making for health care system management [28]. Most African states have limited capacities and systems in place to effectively gather the required population social and cultural data specific to COVID-19. These are associated with the limited capacities and systems for testing, contact tracing and treatment. These limitations are reflected in the baseline data collated and used as inputs to the various models. While these may give an indication of the infection rates and be used to model the transmission, spread and impacts on health care system capacities and needs, they may misrepresent a true reflection of the realities of the population. COVID-19-related data thus reflect the quality of data available from local sources, with varying capacities and resources available[29].

Proper modelling in Africa is also impeded by the absence of a solid history of data-gathering and modelling from previous pandemics, including databases and protocols developed from the experience, models used for intervention and even response strategies. The continent has prevailed in past pandemics such as Ebola, Swine flu, HIV and Tuberculosis. However, there is no clear documentation of the models used to respond and manage these past pandemics[31]. COVID-19 response modelling could draw from this history to better calibrate and customise current epidemiological models in the same locations and specific contexts if they existed. This gap reveals the lack of adequate knowledge management in modelling pandemics on the continent. This reality adds to the opportunity and responsibility of stakeholders in the current pandemic to be aware of the challenges to be confronted by their successors and change the narrative by promoting knowledge production, management, sharing and preservation in the COVID -19 pandemic. Modelling techniques that are informing response and mitigation strategies must be profiled and archived to help address future pandemics in recognition of a shared responsibility between public institutions and private entities to produce, collate and provide access to historical data and information to promote data-driven decision making. This will ensure that models are more accurate and relevant contextually to local contexts. It will require political and social will to fulfil the responsibility of institutions, agencies and other stakeholders to document lessons and data effectively[32].

Moreover, existing models fail to capture multiple components of health systems, which limits holistic planning, again attributable to insufficient data availability. An investment in data-supportive R&D systems is necessary to strengthen more inclusive/holistic modelling and planning for health systems. There has been insufficient investment in research and development especially on data and modelling techniques for pandemics in Africa, resulting in a largely reactive posture to disasters in Africa, increasing dependence on and vulnerability to external partners and stakeholders.

Policy Recommendations

1. Establish local and continental data management policies to promote coordinated data gathering and sharing. To address the needs for data collection, management, archiving and the sharing of information about gaps and limitations, governments and continental bodies under the African Union can establish policies, pandemic data collection structures, management practices and sharing protocols to ensure coordinated institutional data collection and a robust management framework;
2. Evidence-based health care system planning and decision-making must be a priority and anchored in relevant laws and policies at the local and continental levels. Data-driven policy development must be promoted and preserved to manage pandemics;
3. Record-keeping and archiving of data and modelling frameworks is essential to build on lessons learned and strategies to contain and manage pandemics. Systems must be established to enable institutionalisation of lessons and strategies for future reference. Government and non-state actors must develop preservation systems to favour profiling and ease of retrieval, and
4. There must be an investment in research and development to enable early preparation through pandemic impact modelling. Through clear research and development policies around modelling, states and indeed the continent can memorialise adequate expertise, resources and research infrastructures to position itself for subsequent potentially disastrous events.

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