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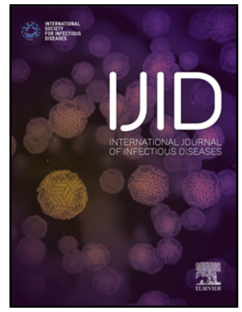

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COVID-19 and routine childhood immunization in Africa: leveraging systems thinking and implementation science to improve immunization system performance

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HIGHLIGHTS

- One of the routine health services that is at high risk of being disrupted by coronavirus disease 2019 (COVID-19) in Africa is childhood immunization.
- Experiences from previous outbreaks on the continent indicates that any disruption of immunization services can result in epidemics of childhood vaccine-preventable diseases which will invariably increase child mortality.
- Contextualized strategies are needed to mitigate the impact of COVID-19 on access and utilization of immunization services.
- Using systems thinking can advance the understanding of the interaction between COVID-19 and immunization by explicitly elucidating the non-linear and dynamic relationships that exist between all elements of the system.
- Implementation science models can be used to fast-track the use of evidence-based innovations to re-design local systems such that it enhances access and utilization of immunization services despite COVID-19 outbreak.

ABSTRACT

One of the routine health services that is being disrupted by coronavirus disease 2019 (COVID-19) in Africa is childhood immunization. This is because the immunization system relies on functioning health facilities and stable communities to be effective. Its disruption increases the risk of epidemics of vaccine-preventable diseases which can increase child mortality. Therefore, policymakers must quickly identify robust and context-specific strategies to rapidly scale-up routine immunization in order to mitigate the impact of COVID-19 on their national immunization performance. To achieve this, we propose a paradigm shift towards systems thinking and use of implementation science in immunization decision making. Systems thinking can inform a more nuanced and holistic understanding of the interrelationship that between COVID-19, its control strategies and childhood immunization. Tools like causal loop diagrams can be used to explicitly illustrate the systems structure by identifying the feedback loops. Once mapped and leverage points for interventions have been identified, implementation science can be used to guide the rapid uptake and utilization of multifaceted evidence-based innovations in complex practice settings. As Africa re-strategize for the post-2020 era, these emerging fields can contribute significantly in accelerating progress towards universal access to vaccines for all children on the continent despite COVID-19.

Coronavirus disease 2019 (COVID-19) is a respiratory disease caused by a novel virus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Gorbalenya et al. 2020). The outbreak of this disease was first reported in December 2019 in Wuhan, China (Lu et al. 2020). The virus can spread from human-to-human through droplets or contaminated surfaces (Lai et al. 2020). It has an incubation period of 2 – 14 days and viral shedding has been reported in pre-symptomatic and asymptomatic carriers (He et al. 2020; Lai et al. 2020). Compared to severe acute respiratory syndrome (SARS), the transmissibility of this virus is higher with an estimated basic reproductive number of 2.24 to 3.58 depending on the setting (Lai et al. 2020). COVID-19 was declared a public health emergency of international concern (PHEIC) on 30th January 2020 (World Health Organization 2020b).

The disease has now spread to most countries in Africa (Nkengasong and Mankoula 2020; World Health Organization 2020c). This is partly because of air travel interconnectivity and volume and the transmission efficacy of the virus itself (Gilbert et al. 2020; Lai et al. 2020). Since the introduction of the first case in February 2020, the number of cases on the continent has grown to more than 100,000 (World Health Organization 2020c). A modeling study conducted by the World Health Organization (WHO) predicted that with widespread community transmission, an estimated 223,281,401 (representing 22% of the continent's population) will become infected within the next one year (Cabore et al. 2020). The highest number of cases are expected from Nigeria, Algeria, and South Africa (Cabore et al. 2020). Out of the total cases, an estimated 36,967,532 will develop symptoms and 150,078 will die (Cabore et al. 2020).

Based on this scenario, 4,637,240 Africans will require hospital admission, out of which 139,521 will require oxygen therapy and 89,043 will require ventilatory support (Cabore et al. 2020). A surge in COVID-19 cases will place enormous strain on the continent's health systems, diminishing healthcare resources as already seen in other places (Emanuel et al. 2020), as well as funds and health worker time among others. The magnitude of this shock can cause the performance of health programmes to drastically decline.

To mitigate widespread transmission, African governments, like their counterparts in other parts of the world, have rolled out several COVID-19 control strategies (Nkengasong and Mankoula 2020). Based on lessons learnt from countries that are at advanced stages of the epidemic (Lau et al. 2020; Prem et al. 2020), physical distancing is one of the key interventions that is being prioritized across the continent in addition to strategies such as hand hygiene and use of facemasks among others. The goal of physical distancing is to limit interaction between people as the disease can be transmitted from person-to-person (Chen 2020). To enforce physical distancing, lockdown are being imposed at national or sub-national level (Hamzelou 2020). In some countries, these lockdown orders are usually accompanied with roadblocks to restrict movement of people and vehicles. These can have unintended negative consequences on access to routine essential health services.

One of the routine health services that is being disrupted by COVID-19 is childhood immunization. According to the World Health Organization, an estimated 80 million children in 68 countries are at risk of developing vaccine-preventable diseases such as measles, diphtheria, and polio because of the disruption of routine immunization services (World Health Organization 2020a). This is not surprising as the immunization system relies on functioning health facilities and stable communities to be effective. In fact, the WHO recommended the suspension of mass vaccination campaigns to prevent the worsening of community transmission of COVID-19 (World Health Organization 2020b) and this can have immediate effect on immunization coverage especially in rural and underserved communities.

Africa is of particular concern because the performance of immunization programmes on the continent even in the pre-COVID-19 era were largely sub-optimal (World Health Organization 2019b). In the WHO African region, coverage with third-dose diphtheria-tetanus-pertussis containing vaccine (DTP3) is stagnated at 76%, a level it attained since 2016 (World Health Organization 2019a). According to the WHO-UNICEF estimates of immunization coverage, national DTP3 coverage level is less than 90% in 26 out of the 47 countries in the region (World Health Organization 2019c). The coverage level for these countries are shown in **Figure 1**. Nigeria and South Africa are among the countries that are expected to have the highest number of COVID-19 cases and their DTP3 coverage level are currently 57% and 74% respectively (World Health Organization 2019c). Countries like Equatorial Guinea, Chad and Guinea have DTP3 coverage as low as 25%, 41% and 45% respectively (World Health Organization 2019c). Single-dose measles containing vaccine (MCV1) coverage for the region is at 74% and only eight countries have attained the recommended 95% MCV1 coverage level (World Health Organization 2019b). At this rate, most countries are unlikely to meet the global vaccine action plan (GVAP) targets for DTP3 or measles elimination (World Health Organization 2013). The impact of the COVID-19 outbreak could cause immunization performance to decline even further.

Historical evidence from previous epidemics like the Ebola outbreak in West Africa has shown that the indirect effect of such events exacerbates morbidity and mortality (Elston et al. 2017). This is because overall healthcare utilization declines (Wilhelm and Helleringer 2019). Suk and colleagues (Suk et al. 2016) found that multiple epidemics of measles occurred in 2015 in Guinea because of the breakdown in public health systems, particularly immunization on account of Ebola. If COVID-19 is allowed to trigger a similar breakdown of immunization systems, child mortality on the continent caused by vaccine-preventable diseases could increase significantly. The recently released World Health Statistics 2020 shows that African countries are already lagging behind in their progress towards achieving the child mortality targets for the sustainable development goals (World Health Organization 2020d).

In a recent study, scientists showed that the benefit of sustaining routine immunization in Africa is greater than the risk of COVID-19 deaths that could result from visiting health services for immunization (CMMID nCov working group 2020). This evidence underscores the value of immunization during COVID-19 and provide justifications for rapid action from governments and their partners. Hence, policymakers must quickly identify robust and context-specific strategies to rapidly scale-up routine immunization in order to mitigate the impact of COVID-19 on their national immunization performance.

Typically, in public health, efforts to explore population-based problems often focus on specific areas without giving due recognition to the patterns that exist within systems (Carey et al. 2015). Nonetheless, the real world continues to function as complex adaptive systems (CAS) (Peters 2014). For this reason, we propose an alternative viewpoint that departs from this reductionist philosophy to systems science in exploring the interaction between COVID-19 and immunization (Luke and Stamatakis 2012). This will inform a more nuanced and holistic understanding of how they interrelate. So, instead of studying individual components of the immunization system (e.g. vaccine supply and logistics), a systems-based approach that conceptualized all components of the system as interrelated entities should be adopted. Though complex, this approach will explicitly expose the non-linear and dynamic relationships that exist between all elements of the system (Luke and Stamatakis 2012).

A range of methodologies for understanding complexity exist, one of which is systems dynamic modeling (Peters 2014). This modeling technique can be used to analyze multiple, simultaneous, and complex interactions over time (Peters 2014). A commonly used tool in systems dynamic modeling is causal loop diagram (CLD) (Peters 2014). It provides qualitative illustrations of the causal linkages between elements of a system as well as the feedback loops (balancing and reinforcing) that exists between them (Peters 2014).

As an example, the CLD in **Figure 2** was constructed using Vensim PLE version 8.0.6 to illustrate the relationship between COVID-19, its control strategies and immunization. The model revealed that the linkage between COVID-19 cases and lockdown as a balancing loop. This means that an increase in the number of COVID-19 cases will prompt the government to impose lockdown as a containment strategy. This lockdown decreases transmission events, which will then cause the number of COVID-19 cases to decline. If the number of COVID-19 cases should surge, there will be a decrease in the number of health workers that are available to provide routine immunization services. This is because they would be redeployed to COVID-19-related tasks. Similarly, it will decrease available health facilities as hospital and clinics will be converted to COVID-19 treatment and isolation centers. In addition, immunization funding will reduce as they will be diverted to COVID-19 response. All of these will contribute to a decrease in the availability of immunization services.

Lockdown can directly affect immunization services, by constraining access to vaccines. The presence of roadblocks dissuades caregivers from visiting health facilities for routine immunization. Vaccine logistics and supply chain at the first and last mile are interrupted. And public transportation services which facilitate movement of caregivers and health workers to health facilities are stopped. An indirect effect of the lockdown on immunization is through its vicious relationship with the economy. Its restrictive nature can be detrimental to vulnerable individuals whose source of livelihood depends on informal economic activities. The resultant poverty can further widen socioeconomic inequalities and this has been shown to affect immunization coverage (Ataguba et al. 2016).

Community mobilization activities would decrease with resultant decrease in mass vaccination campaigns. This is because of the balancing loop that exist between vaccination campaigns and transmission risk. Conducting vaccination campaigns during the COVID-19 pandemic increases contact rate in communities which accentuates transmission risk.

This simple CLD demonstrated that many elements are interacting with the immunization systems and a change in one part of the system causes a cascade of changes in other parts. The advantage of presenting the structure of a system in this manner is that it explicitly depicts dynamic relationships. Using this to guide planning and prioritization of areas for intervention will pave way for system re-design and improvement.

Implementation science (IS) concepts can support immunization system re-design to adjust it to the pressures of COVID-19 by accelerating the uptake and utilization of multifaceted evidence-based strategies in policies and practice settings to improve system performance (Eccles and Mittman 2006).

For example, risk of health worker infection is a challenge in practice setting that could be minimized by using personal protective equipment (PPE). Tailored implementation strategies could be used to improve the adoption, implementation and scale-up of these PPE in immunization clinics and other facility service delivery points (Powell et al. 2012). In some settings, rapid improvement of PPE use can even be engineered using quality improvement (McLaughlin and Kaluzny 2004).

IS can be used to improve strategy “fit” by ensuring critical consideration for context in COVID-19-related policies (Moullin et al. 2019). This will change how policymakers and public health experts approach the outbreak vis-à-vis the health system. It can encourage the use of differentiated models for communities, population groups, and socioeconomic strata, among others. For example, existing structures like patent medicine vendors can be engaged to provide immunization services in slums and hard-to-reach areas when health facilities are overwhelmed (Adamu et al. 2020). A common constraint is the inability of health workers in some settings to reach health facilities because of the disruption of public transport system caused by lockdown. This is likely to be more prominent in underserved communities where alternative options might be limited. To address this, a special transportation scheme can be introduced to improve the mobility of health workers. To ease caregiver movement through roadblocks and promote adherence to the immunization schedule, the child home-based record can be regarded as a “pass”.

IS also emphasizes the need to tailor information needs to the demand of different stakeholders. Community members are prone to misinformation about COVID-19. When coupled with policies like lockdown, they could potentially increase vaccine hesitancy among caregivers. To address this, appropriately tailored information about the novel disease including recommended preventive strategies like use of facemask when in public can be communicated with community members. In addition, the importance of infant immunization can be re-emphasized to motivate caregivers to continue scheduled immunization visits.

In conclusion, integrating systems thinking and implementation science in health planning and decision making can help African countries gain a better understanding of the influence of COVID-19 on health programmes such as childhood immunization and facilitate the implementation of multifaceted evidence-based strategies in complex practice settings. As Africa re-strategize for the post-2020 era, these emerging fields can contribute significantly in accelerating progress towards universal access to vaccines for all children on the continent despite COVID-19.

AUTHOR CONTRIBUTION

AAA conceptualized the manuscript and developed the first draft. AAA, RIJ, DH, and CSW contributed to writing, reviewing, and finalizing the manuscript. All authors approved the final draft.

CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

Not applicable

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Declaration of interests

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

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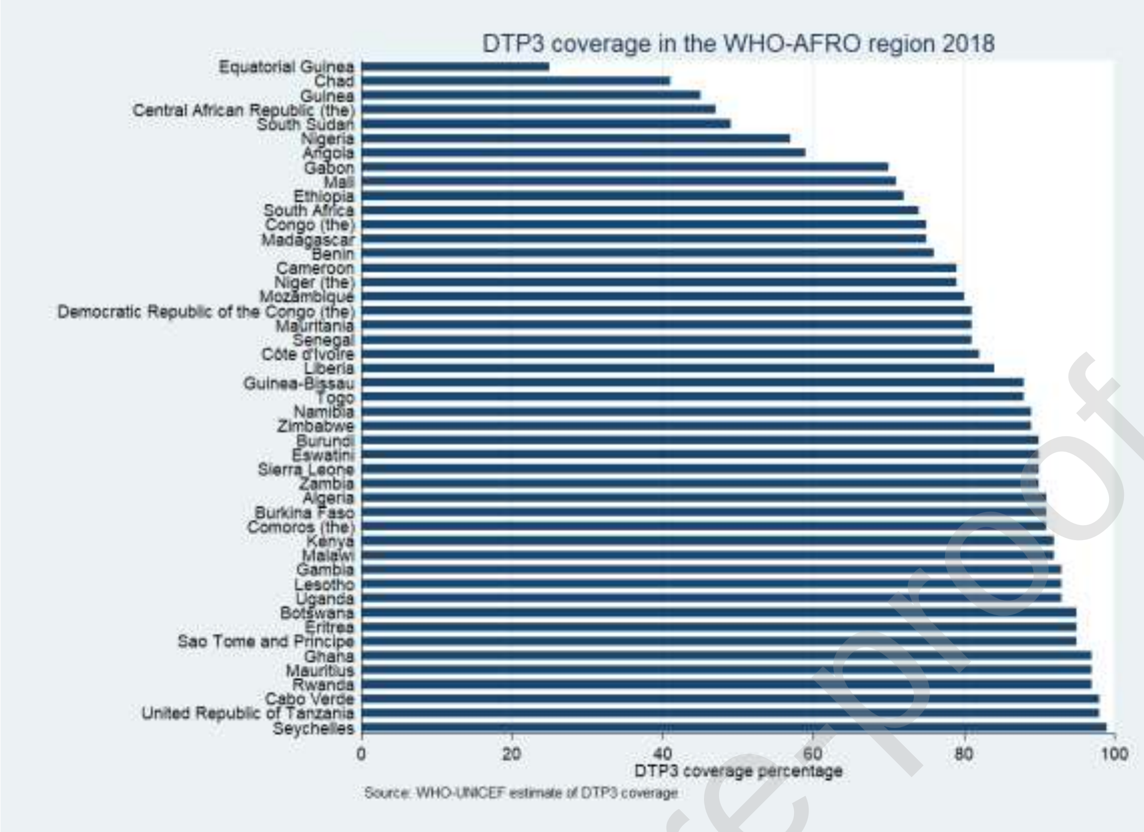
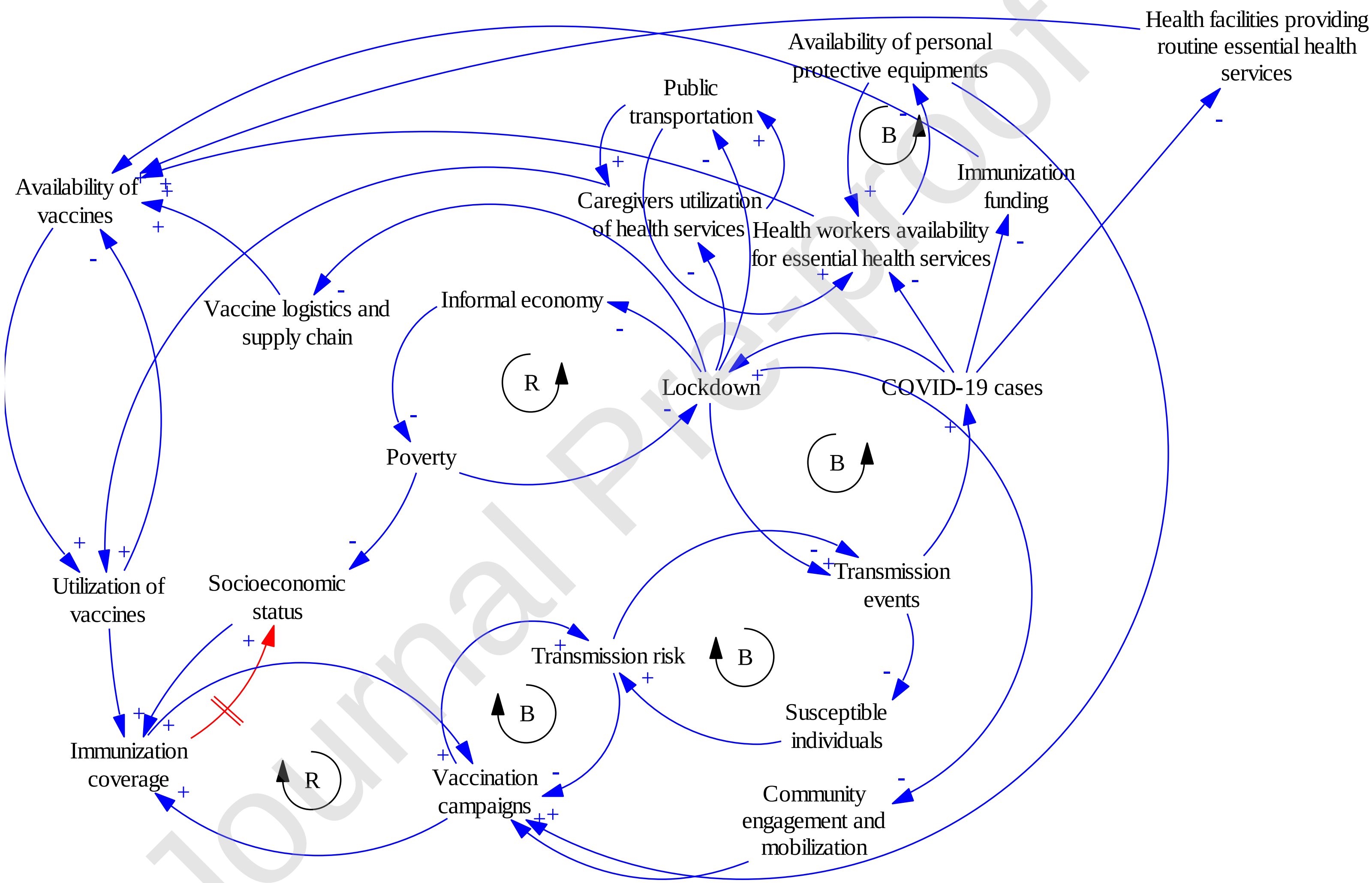


Figure 1: DTP3 coverage for countries in the WHO-AFRO region



B = Balancing loop; R = Reinforcing loop

Figure 2: A causal loop diagram showing the relationship between COVID-19 and the immunization system