RESEARCH ARTICLE

Recruiting students for the COVID-19 emergency response: lessons from eight African countries [version 1; peer review: awaiting peer review]

Vera Mkenda1,2, Mark Woolhouse2,3, Francisca Mutapi2,4, Geoffrey Banda1,2

1The Innogen Institute, Science Technology and Innovation Studies, University of Edinburgh, Old Surgeons Hall, High School Yards, Edinburgh, EH1 1LZ, UK
2NIHR Global Health Research Unit Tackling Infections to Benefit Africa (TIBA), University of Edinburgh, Ashworth Laboratories, King's Buildings, Charlotte Auerbach Road, Edinburgh, EH9 3FL, UK
3Usher Institute of Population Health Sciences & Informatics, University of Edinburgh, Ashworth Laboratories, Kings Buildings, Charlotte Auerbach Road, Edinburgh, EH9 3FL, UK
4Institute of Immunology & Infection Research, University of Edinburgh, Ashworth Laboratories, King’s Buildings, Charlotte Auerbach Road, Edinburgh, EH9 3FL, UK

Abstract

Background: This paper examines how African countries can innovatively use pre-qualified undergraduate and postgraduate students, as well as retired clinical, laboratory and epidemiological technocrats in dealing with medical emergency situations, such as the COVID-19 pandemic.

Methods: An online questionnaire was sent to key informants in six universities and two research institutions working with the Tackling Infections to Benefit Africa (TIBA) program eight African countries. The return rate was 88.9% and data was analysed using the framework method.

Results: Students and other personnel trained in the medical and health professions are a valuable resource that can be mobilised by African governments during medical emergency situations. These are found in research, academia, non-governmental organisations, and government. However, without clear plans and mechanisms for recruiting, supervising and remunerating or reimbursing the costs of engaging someone not employed by the government, the legitimation and authority for such recruitment becomes a challenge. Currently, postgraduate students in the biomedical sciences are the most preferred because of their level of experience and exposure to medical techniques. They also have a degree certificate, which serves as a quality and competence assurance tool. Engagement of postgraduate medical students undergoing their residence programmes also seems a lot easier. While on the other hand, undergraduate students, who are the majority, are considered underexposed and with low technological capabilities. They also lack certificates needed to ensure competence, although we argue that...
not all tasks during pandemics require specialized skills.

**Conclusion:** As a step towards strengthening national disaster preparedness capacities, African governments need to develop plans that clarify protocols for engaging, training, supervising and protecting students, especially undergraduates and those taking non-biomedical courses. Such plans may form part of the National Pandemic Response Plan, while considering both specialised and non-specialized roles of emergency response.

**Keywords**
COVID-19, pandemic, Africa, medical students, local resources, emergency response, universities
Introduction

The coronavirus disease 2019 (COVID-19) pandemic has created unprecedented human and technological infrastructure challenges to public health systems across the globe. The challenge is magnified for developing countries, which historically have health systems with varying levels of resilience and are already under strain due to diseases such as HIV/AIDS, Ebola, malaria, tuberculosis and the rising burden of non-communicable diseases, such as cancer, diabetes, and cardiovascular conditions. According to the World Health Organization COVID-19 Situation Report1, to date there are nearly 574,464 deaths out of more than 13,150,645 people infected with COVID-19 across 204 countries and territories around the world. In Africa2 confirmed cases are 506,124 with 8,650 deaths. The impact will continue to be felt in many countries and specifically African countries will face greater challenges in managing health systems, which may struggle to have supporting infrastructure, for example oxygen provision (Stein et al., 2020). The International Labour Organization (ILO) estimates that four in ten people in sub-Saharan Africa have no access to medical facilities or personnel, and for those that do have access, the quality of services is often low (ILO, 2019). Murthy et al. (2015) reports that health sectors in a number of African countries are underfunded, underequipped and understaffed. Most do not have ventilators for managing severe respiratory problems and there are insufficient intensive care unit beds for a surge in admission of COVID-19 patients. In addition, laboratory infrastructure may not be adequate to support epidemiological and clinical work, with most of the labs concentrated in capital cities; for example, in February 2020, only Senegal and South Africa in sub-Saharan Africa could test for the novel coronavirus3.

Besides infrastructure, the continent also has a proportionately lower number of healthcare workers for the population and minimal capacity for critical care to severely ill patients (PERC, 2020). For example, in Ghana, out of 871 medical officers trained between 1993 and 2002, 604 emigrated; in Zimbabwe, of the 1,200 doctors trained during the 1990s, only 360 remained in the country; in Kadoma the ratio of a nurse to residents was 1:700 in 1999, but by 2007 the ratio had deteriorated to one for every 7,500; similarly in Kenya, the country lost 1,670 physicians and 3,900 nurses to immigration within 10 years during the 1990s (Garrett, 2007). Despite this shortage of staff, African countries need to develop the capacity to test, trace, isolate, and treat COVID-19 cases—a necessary foundation for generating evidence to safely reopen society, and engage communities to adapt public health and social measures to local contexts. This is critical for effectively communicating risk to sustain public support, achieve widespread adherence, and shield vulnerable populations (PERC, 2020).

As a response to the COVID-19 pandemic, and as a preparation for the future, the African continent urgently needs to craft social, economic and technological interventions for detecting infections, treating and rehabilitating patients combined with protecting the vulnerable and uninfected communities. The effectiveness of such interventions will depend largely on local health system resilience and the ability to mobilise agile public health supporting infrastructures. This ultimately depends on availability of skills in epidemiological, clinical and pandemic social system management systems, as well as other skills required to support other specialized functions. This paper focuses on how African countries can innovatively use often neglected but useful human resources, constituting pre-qualified undergraduate and post graduate students in biomedicine, social sciences, statistics and mathematical modelling, as well as retired clinical, laboratory and epidemiological technocrats in dealing with the pandemic. The research questions guiding this paper are (i) what are the readily available skills that governments can readily access and rapidly deploy interventions for COVID-19, and (ii) how can under and postgraduate students as well as retired personnel be effectively deployed to improve COVID-19 responses?

In answering the above questions, the study contributes to our understanding of the broader contexts of society’s shared role and the potential resources available to developing countries when seeking to respond to public health emergencies such as the COVID-19 pandemic. It also clarifies the importance of developing a National Pandemic Response Plan that provided for a more comprehensive mobilization of the diverse human resource available in African countries and thus strengthen the current national disaster preparedness capacities. This means taking into consideration the broader context of the pandemics where both specialized and non-specialized roles are involved, as well as the role of other skilled and semi-skilled individuals beyond the medical professions—including students—in responding to such situations.

The reminder of this paper is divided into four sections. The next section provides a literature review on theories and concepts that inform the conceptual framework that guided the study, followed by the methods section, which describes the study methodology. The next section presents the study results and discussions, while the last section presents conclusions and recommendations.

Conceptual framework

Pandemics are characterised by fluidity and dynamism both in their progression and in the responses required to manage them. Consequently, they need agile systems that can marshal and allocate financial, technological and human resources to support robust and resilient health systems that protect society from diseases and pandemics. The political economy has three lenses; agents/actors, infrastructure and institutions, and these are driven by power to collate and allocate resources.
Collinson (2003) argues that political economy analysis focuses on economic and political process interactions in a society and explains the distribution of power and wealth between groups and individuals and the transformation over time. Governance viewed from three dimensions; “authority, decision-making and accountability-determining who has power, who makes decisions, how other players make their voices heard and how accountability is rendered” (Tait & Banda, 2016) is also a useful lens to understand legitimisation and authority invested in institutions set up to manage the COVID-19 pandemic. The governance of the COVID-19 pandemic has been steeped in emergency acts and proclamations by governments across the world, and indeed governance through guidelines, standards and regulation has been critical for assessing the efficacy of diagnostics and therapies proposed for treating COVID-19. However, in this paper, we are interested in the marshalling of resources, their allocation and application using the eco-social framework for epidemiology (Johnson-Walker & Kaneene, 2018). Johnson-Walker & Kaneene (2018) present the epidemiologic triad of infectious diseases where the disease at the centre is driven by three core factors: the host, agent or pathogen, and the environment. The interaction of these three factors provide intervention programming. First, agent/pathogen-environment interaction can be resolved through removal of breeding ground and improvement of sanitation interventions. Second, the host-environment interaction can be controlled by interventions premised on education, changing activity (behaviour) patterns and quarantines. Third, the host-agent/pathogen interaction can be managed through protection, education and altering exposure patterns intervention strategies.

Consequently, pandemics and emerging infectious diseases, such as COVID-19, are not the exclusive terrain of microbiologists, virologists and practitioners in public health. But there are social institutions embedded in social organisations, and delivery is through other organisations and social processes involving social interactions amongst different actors/agents (Dingwall et al., 2013). Pandemic responses depend on socio-cultural backgrounds, existing knowledge infrastructure, technological capabilities and human resources for managing the various stages of a pandemic. We borrow the eco-social framework for epidemiology from Johnson-Walker & Kaneene (2018:9), and we use the individual, social and structural factors. We are more interested in the social and structural factors as these are critical in pandemic or epidemic programming, and in the case of this paper COVID-19 pandemic preparedness resource allocation for surveillance, testing, contact tracing, clinical management and ensuring societal resilience to national lockdowns. Abramowitz et al. (2015) called for mobilization of experts who bring relevant locally contextualised medical, epidemiological, and political information on global health emergencies. Interventions effectiveness depend on provision of data collection, cleaning and analysis capabilities and this can be aided by mobilising academic institutional resources, sharing expertise and technical information (Abramowitz et al., 2015). Dingwall et al. (2013) discuss that disease is socially produced and requires organisational networks to implement pandemic response strategies. Policy design and implementation are key drivers and, as it is applied in a dynamic society, the public reacts to the interventions. The challenge for many African countries, as described earlier, is resource scarcity, especially skilled health practitioners for epidemiological surveillance and modelling work including wet lab activities. Well-endowed countries are able to leverage infrastructures and institutions that are already in place for pandemic responses. However so huge is the demand for resources for COVID-19 responses that, for example, Public Health England reached out to Universities for skills in molecular biology and diagnostics to aid in testing for COVID-19. This paper considers how African countries can cover the gulf in specific epidemiological and other skills as well as resources. Steyer & Gilbert (2013) assert that co-production of solutions during epidemics depend on collaborations between public authorities and private interests. There are however tensions on legal and reputational issues that the private sector may struggle with, while the government cannot fully delegate all its responsibilities. However trade-offs are required to avoid weak co-production of pandemic solutions. This paper considers the successes and failure of using the private, quasi-public (universities) and public sector resources to manage COVID-19.

Methods
We used the case study approach (Yin, 2009) to study a real-life phenomenon within its context. The paper is based on eight African countries using key informants in research and academic institutions working with the Tackling Infections to Benefit Africa (TIBA) program (www.tiba-partnership.org); namely The University of Botswana, University of Ghana, Kenya Medical Research Institute (KEMRI), University of Rwanda, University of Khartoum (Sudan), National Institute of Medical Research (NIMR) Tanzania, Makerere University (Uganda), and University of Zimbabwe.

Data collection
Qualitative data was collected between February and March 2020 from six universities and two research institutions in Botswana, Ghana, Kenya, Rwanda, South Africa, Sudan, Tanzania, Uganda, and Zimbabwe (as above). A questionnaire was sent by email to TIBA program principle investigators (PIs) in each country with instructions that responses should be based on a team effort to capture as much information as possible. The return rate was 88.9% with only one non-response. The questionnaire was structured to elicit rich data whilst allowing flexibility as an explorative study to unearth new areas of interest. We were guided by Yin (2009) who argued that questions for case studies should include potentially important variables, however, they should avoid linking variables and theories as much as possible.

The questionnaire had nine questions covering three domains: (1) availability of students and other professionals that could be mobilised during the COVID-19 emergency, (2) roles,
arrangements and logistics for engaging these additional resources, and (3) plans and frameworks required to implement COVID-19 resource mobilisation and deployment. The questions included were: ‘Does your institution train medical students or other health care workers?’, ‘Is there provision for your students to be mobilised during a public health emergency?’, ‘Are there plans for this to happen during the COVID-19 emergency?’, ‘How many students are/might be involved?’, ‘What role will the students play?’, ‘What arrangements are in place for continuing their studies after emergency?’, ‘How are the students paid or otherwise compensated for their time?’, ‘Do you have any other cadres of people that could assist during and emergency?’, and ‘Have you any advice to other institutions thinking of implementing a similar scheme?’. The questionnaire has been updated and shared with WHO-AFRO to gather more information including from other African countries.

Data analysis
We used the ‘Framework Method’ for analysis, as recommended by Gale et al. (2013). The Framework Method is appropriate for thematic analysis of textual data where it is important to be able to compare and contrast data by themes across many cases and retain the connection to other aspects of each individual’s account (Gale et al., 2013, p.2). According to Gale et al. (2013), the method originated in large-scale social policy research, but is now popular in medical and health research (p.117). We extracted themes from the responses and compiled a matrix with codes and cases, which we analysed and present in the next section.

The analysis involved three steps:

- First, we manually compiled responses for each question from each country into nine individual matrices (i.e. one for each question). The individual matrices enabled us to understand and compare responses per country;
- Second, we manually extracted themes from the nine matrices and compiled them into a separate matrix. This matrix highlighted key themes generated from the different answers provided by the different countries. We used this to create an ‘Analytical framework’, which is defined as “a set of codes organised into categories that have been jointly developed by researchers that can be used to manage and organise the data”, Gale et al. (2013). The framework creates a new structure for the data (rather than the full original accounts given by participants) and summarizes/reduces the data in a way that supports answering the research questions (p.117);
- Finally, we interpreted the results and various themes that emerged, namely: sources of skills; experience categories for students; specialist vs non-specialist skill-sets; planning, training and management of resources; and integrating resources in the epidemic preparedness plans.

All matrices generated during the three steps were shared for analysis with colleagues and sent back to the eight countries for verification and amendment to initial observations. Interpretations from the data are presented in the next section.

Ethical considerations
The study was part of Work Package 6 of the TIBA program, which has prior consent from its Partner countries indicated in the partnership agreements. Therefore, based on the nature of the study, i.e. no clinical trials and no interviews with non-TIBA partners etc. were involved, there was no additional ethical approval process required for this study. All those we interviewed are part of the TIBA Partnership and have agreed to work with the program whenever required.

Results and discussion
Universities, retirees and private sectors as sources of skills
Our study indicates that undergraduate and postgraduate students, as well as personnel trained in the medical and health professions are a valuable resource that can be mobilised in medical emergency situations such as COVID-19. These resources were found in sectors that spanned research, academia, non-governmental organisations and government. An often-ignored source of skilled resources are retirees. However, given our emerging understanding of the age risk factor to COVID-19, it is important to carefully shield this cohort and clearly consider the roles they can safely play without endangering their health. Using Johnson-Walker & Kaneene’s (2018) framework we argue that retired experts may be better placed in strategy formulating roles to deal with issues on dynamics of designing quarantine metrics, mentoring emerging technocrats and education. Their role, according to the Johnson-Walker and Kaneene framework, will be addressing the agent/pathogen-environment interaction and host-agent/pathogen interaction aspects of dealing with pandemics.

Our study revealed that, setting up recruitment, governance and management structures is important in order to ensure effective coordination of human resources mobilization activities during pandemics requires. Respondents reported that one of the greatest challenges was the absence of mechanisms for engaging, managing and remunerating, or reimbursing costs for resources not employed by government. This generates difficulties of legitimisation and authority for recruiting staff. Our study raises the importance of the need for national disaster preparedness plans where they exist, to clearly define governance issues on who has the authority, decision making and resource allocation powers to recruit, manage, and where necessary, remunerate/reimburse mobilised skills. A second issue identified by respondents was the need to proactively consider how private and public actors could be integrated into public health programmes. Government departments have clear reporting lines. However, these transient public private partnerships need clear governance and management structures. Secondary sources (see Dacombe et al., 2019; Nkengasong et al., 2018; Olmsted et al., 2010) revealed that standards, accreditation and certification are critical governance tools for laboratory equipment, diagnostics and reagents, especially for assuring the reliance, efficacy and dependability of results. In Zimbabwe, for

4 http://tiba-partnership.org/projects/wp6-emergency-response
example, COVID-19 tests were delayed because the National University of Science and Technology had equipment, however the laboratory did not have the required accreditation status (personal communication, March 22, 2020). Suggestions were made to move the laboratory equipment and staff to an accredited health institution to avert this anomaly.

Postgraduates preferred over undergraduate students
Students were identified as the largest source of skills by all surveyed countries. However, there was a preference for postgraduate over undergraduate students, and this depended on area of specialisation and levels of competence. Key specialisation categories that were identified were medicine, nursing, laboratory science and public health, with an evident bias towards biomedical sciences because the institutions surveyed work in the biomedical space. However as discussed previously, pandemics and medical emergencies are not the preserve of biomedical sciences. It is therefore important to recognise that since diseases occur in a social setting, students with social sciences, as well as mathematical and statistical skills, need to also be included amongst the mobilised skills.

Our study shows that there is a preference for postgraduate students in the biomedical sciences arena. This is an understandable choice given the level of experience and exposure to laboratory equipment and techniques. Overall, undergraduate students in most developing countries tend to be underexposed to complex laboratory equipment and technological capabilities, which needs to be addressed. We surmise that the under-exposure for undergraduates may be driven by resource limitations for practical and is more prevalent for early years of undergraduate compared to final year students. Respondents explained that approaches for engaging postgraduates were easier because countries leveraged their residence programmes especially for medical and wet lab-based students. It is harder to engage undergraduate students. Rwanda and Sudan mentioned the possibility of engaging them only as part of an ‘outreach program’, while Botswana reported that ‘they cannot be mobilized’. Respondents from other countries, such as Zimbabwe, Rwanda and Sudan implied that undergraduate students ‘should volunteer’ or ‘paid in kind’. They wrote: [When students are involved in outreach activities, they are usually not paid… (Respondent, Rwanda)], but also pointed out that there are currently no mechanisms for volunteering. Respondents wrote, [“Difficult to answer but most students will do voluntary work” (Respondent, Zimbabwe)]; and [“Financial compensation is provided to support their thesis research such as provision of support for field work and lab supplies. A few are financially supported by cash payment” (Respondent, Rwanda)].

Specialist vs non-specialist skills sets
Respondents explained that postgraduates are preferred because they already have a degree certificate, which serves as a quality and competence assurance tool. As one Respondent wrote; [“These [i.e. Post-graduate nursing students] are qualified registered nurses and midwives, regarding the role they would play would be determined by the emergency response team. The MMED [i.e. Master of medicine] are also qualified medical officers doing their specialization. Both nurses and doctors will be assuming their roles as per protocols” (Respondent, Botswana).]

Specifically, postgraduate medical students are easier to recruit because they will be undergoing their residence programmes; [“The residence group is made up of qualified medical doctors, the group will be available for case identification, preventive services, case management, sample collection, and offering public health preventive education to the public” (Respondent, Tanzania)]. A key challenge identified was therefore the de-facto position of assuming that recruited individuals would be conversant with basic protocols and be able to make sound judgments during a crisis without much supervision. These are traditional expectations embedded in university structures and the labour market that individuals gain specific skills as they progress through defined academic pathways, which later, and upon successful accomplishment, defines what they can and should do. We argue that mixing these emerging skilled technocrats with retirees provides an opportunity for skills transfer and mentoring through learning by doing as espoused by innovation systems (ref – Lundvall, 2010).

Literature shows that during a public health emergency there are roles that require specialist skills such as surgical work, diagnosis e.g. using rapid tests Reverse Transcription Polymerase Chain Reaction (RT-PCR) or Immunology based diagnostics (Clarke, 2005; Draper et al., 2010; General Medical Council (2008); MacDonald et al., 2007; WHO, 2005). It was emphasised that these roles are better handled by postgraduates compared to undergraduate students who may be better placed for administrative, data gathering or analysis roles. Consequently, undergraduate biomedical students may be useful for non-lab work, such as contact tracing and surveillance, because they understand epidemiology and dealing with pathogens.

Evidence from the literature shows that undergraduate students have performed both technical and administrative duties in emergency situations, such as blood sample collection and issuing laboratory reports (Kshirsagar et al., 2006), working in morgues (Lipkin, 2002) and translations to non-native language speaking emergency responders (Gorry, 2010). In Rwanda, final year medical students participated in airport screening during the COVID-19 outbreak. As Ladds (2010) argues, even without certification undergraduate students can be trusted to perform tasks that need little specialist knowledge, such as providing information, observing patients, clerk work, and even more complex clinical skills and duties tailored to their abilities that maximize their knowledge of the environment (Ladds, 2010). Yonge et al. (2010) explains that medical and health science students are a unique subgroup of the university population who have an invaluable skill set that prepares them to be providers of frontline care, and have been socialized as professionals which would result in the likelihood of their participation in the event of a pandemic. Yonge et al’s argument highlights the socialization process that occurs in universities beyond teaching, which shapes students to adapt to different professional expectations in society.
Planning, training and management of resources

Training emerged as a key requirement for preparing individuals, especially students, for pandemic work because they are not conversant with such situations. The question of whether undergraduate students have the skills and mental readiness to work in an emergency situation, and how to impart those skills is widely discussed in the literature (see Weiner, 2006; Yonge et al., 2010). According to Weiner, being a university student is not enough and they may be ill-prepared to fill frontline roles. Weiner advocates for their training in advance since educating them ‘at the scene’ is not nearly as effective (Weiner, 2006). In this study, the respondents recommended training in biosecurity and biosafety, as well as the importance of personal protective equipment for those likely to come into contact with patients or handling samples and equipment used in diagnostic tests. The training should provide the latest knowledge on COVID-19, using different platforms that observe social distancing rules. The offered knowledge should focus on aetiology, diagnosis, case suspicion and handling, isolation, sample collection, information transfer about the suspected cases, management and preventive measures at health facilities levels, and public preventive measures to the general public. Given the unprecedented occurrence, respondents impressed that a crash programme in training was unavoidable. Respondents wrote: ‘...Biosecurity and biosafety training is needed’ (Respondent, Sudan); and ‘Just to emphasise training on use of complete PPE and very strict infection control measures, at personal level and at institutional level’ (Respondent, Botswana); and ‘The most important thing is to plan to offer correct knowledge about COVID-19 to students using different platforms which do not bring them to normal lecture halls. The offered knowledge should focus on aetiology, diagnosis, case suspicion and handling, isolation, sample collection, information transfer about the suspected, management and preventive measures at health facilities levels and public preventive measures to the general public’ (Respondent, Botswana). However, we argue that countries will always face one or another medical emergency, and it is therefore important to develop programmes for disaster preparedness that cater for continuous training for students and people identified as first responders in emergencies. Recruited students should also be properly screened to prevent them from infecting others and also be provided with insurance cover in case they get infected or face any other form of accident. Essentially, these findings highlight the need to develop a comprehensive understanding of the complex web of activities performed during pandemics, the wide range of skills and qualifications required, the need for training and coordination. We argue that although our study was specific to COVID-19 pandemic, the findings can be applied to other disasters that include public health emergency, fire outbreaks, environmental catastrophes and epidemics.

Conclusion

The challenge for many African countries is resource scarcity, especially skilled health practitioners for carrying out epidemiological surveillance and managing pandemics. This calls for innovative measures to mobilise experts who bring relevant and diverse locally contextualised information on global health emergencies (Abramowitz et al., 2015). Findings from this study show that although African countries have significant numbers of undergraduate medical and allied health students, not many are already involved, or might be involved in responding to the COVID-19 emergency. The study also shows preference to recruiting postgraduate students who already have degree certificates and thus considered to have specialized knowledge than undergraduates. This means special mechanisms are needed if undergraduates are to be recruited during pandemics. Managing the logistics and meeting the costs of engaging such resources also need to be addressed by both the national governments and university administrations. Issues of training, protection and compensation of students and other non-government recruits were also raised by the study, which need strategic responses.

The observations surrounding national policies and governance issues discussed in this paper are likely consistent with many African countries where lack of purposive programming and planning affects the ability to integrate different skill resources available in these countries, especially those beyond biomedical staff employed by the government. The paper therefore advocates for policy makers to look at the broader context of pandemics and emerging infectious diseases, such as COVID-19 disease, and not as an exclusive terrain of microbiologists, virologists and practitioners in public health, but as social institutions embedded in social organisations, which deliver through other organisations and social processes that involve social interactions amongst different actors/agents (Dingwall et al., 2013). Looking at the broader context when planning for disaster and pandemic management could address some of the systemic challenges discussed in this paper, specifically, this could be in mobilizing, training, equipping and managing human resources currently outside the government payroll. This will also help in framing policy narratives and practice for managing pandemics and epidemics by involving both private and public institutions and all government sectors rather than making it an exclusive role of the ministries of health. The shift in thinking and planning required to achieve this is expected at two levels: the central government level where planning and high-level decisions are made; and at the level of institutions, such as universities, hospitals, borderer posts and laboratories, where students are managed and expected to work (see Figure 1).

This study highlights the importance of integrating social and structural factors in pandemic programming (Johnson-Walker & Kaneene, 2018) and building organisational networks (Dingwall et al., 2013) needed to mobilise resources to implement pandemic response strategies. It emphasizes the need to identify and engage locally available resources beyond the traditional pools, such as those of doctors, nurses and lab technicians, by identifying such resources and developing strategies and mechanisms to effectively engage, manage and supervise them. Engaging students and retired professionals in disaster and public health emergencies might pose some challenges to most African governments, but it is an important step towards strengthening their national disaster preparedness capacities.
**Figure 1. A possible framework for engaging students in public health emergency response.**

**Data availability**

Underlying data


This project contains the following underlying data:

- TIBA recruiting student for COVID response data 2020.docx.xlsx (spreadsheet containing country responses)

- TIBA COVID response and analysis notes.docx

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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