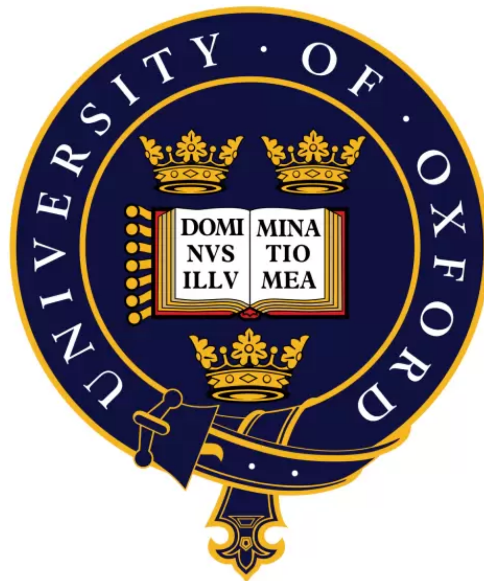
An Assessment of the Funding System for the COVID-19 Health Research Response in Africa: Identifying Lessons for Future Epidemics and Pandemics



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Dedication

For Aseye, my reason for praise.

Abstract

Despite the substantial global investments in the COVID-19 research response, there were significant shortcomings in research funding allocation, demonstrated by fragmentation, funding of poor-quality studies and limited investments in research involving LMICs.

To better understand the factors driving such shortcomings, I undertook "research-on-research", with a focus on Africa. I first conducted a scoping review to assess research priority-setting activities and methodologies. This was followed by a mapping review of the UKCDR and GloPID-R COVID-19 Research Project Tracker to assess the alignment of funds allocated to global and regional research priorities. This was complemented by a qualitative study to explore the perspectives of researchers and grant managers, based in African research institutions, of factors influencing their access to funding for COVID-19 research.

My findings revealed diverse methods applied in priority-setting activities during the COVID-19 pandemic. Moreover, reporting on these did not follow the reporting standards for health research priority-setting. I also found that while COVID-19 research in Africa aligned to global priorities, it failed to address region-specific research priorities. Multiple factors enabled or inhibited access to research funding in African institutions. Among the enablers were: supportive institutional remote work policies; supplementary funding to pre-existing grants; and expedited grant awarding processes. Institutional bureaucracy and unequal power among research partner institutions were barriers to accessing research funds.

Several lessons for strengthening preparedness for future epidemics and pandemics in Africa emerged. These include: improving access to information across the system for financing health research; optimising existing funding models and creating new models for financing

research in emergencies; strengthening research and grant management capacity in African research institutions; and increasing local and regional financial commitments to health research. My findings highlight the complexities in health research funding processes, justifying the need for a holistic approach to implementing research funding policies for pandemic preparedness and response.

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Declaration

I declare that this thesis is my original research work. It has not previously been submitted for a degree from any other university. To the best of my knowledge, this work does not include any material authored by another person or previously published except where acknowledged.

Author's Contributions

All components of this thesis, including figures and tables, are my original work unless where otherwise specified. I was supervised by Prof Proochista Ariana and Dr Alice Norton, from whom I received guidance throughout this research.

The scoping review on COVID-19 research prioritisation drew from a broader scoping review on research priority-setting for high-consequence pathogens which I led on during my DPhil studies. The UKCDR and COVID-19 Research Project Tracker was sustained by a team which I was part of. I was actively involved in data entry, extraction and analysis of this data for purposes unrelated to the DPhil work. My draft thesis was reviewed by both of my supervisors and their comments were incorporated into this final version.

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List of Abbreviations

ABBREVIATION	MEANING
3D CAM	Three-Dimensional Combined Approach Matrix
AAS	Africa Academy of Sciences
Africa CDC	Africa Centres for Diseases Prevention Control
AFTCOR	Africa Task Force for Novel Coronavirus
AMR	Antimicrobial Resistance
ANRS	French National Agency for AIDS Research
ASEAN	Association of Southeast Asian Nations
BMGF	Bill and Melinda Gates Foundation
CAS	Complex Adaptive System
CEPI	Coalition of Epidemic Preparedness and Innovations
CHNRI	Child Health and Nutrition Research Initiative
CIHR	Canadian Institutes of Health Research
COHRED	Council on Health Research for Development
DELTAS Africa	Developing Excellence in Leadership, Training and Science in Africa
DHSC	Department of Health and Social Care
ECDC	European Centre for Disease Prevention and Control
EDCTP	European and Developing Countries Clinical Trials Partnership
EMERGE	Efficient response to highly dangerous and emerging pathogens at the European Union level
ENHR	Essential National Health Research
ESSENCE	Enhancing Support for Strengthening the Effectiveness of National Capacity Efforts
GCRF	Global Challenges Research Fund
GDP	Gross Domestic Product
GECO	Global Effort on COVID-19 Health Research
GloPID-R	Global Research Collaboration for Infectious Diseases Preparedness
GM	Grant Manager
GNI	Gross National Income
GPMB	Global Preparedness Monitoring Board
HRFS	Health Research Funding System
HRS	Health Research System
ICTRP	International Clinical Trials Registry Platform

IDRC	International Development Research Centre
IHR	International Health Regulations
IMF	International Monetary Fund
IPC	Infection Prevention and Control
ISARIC	International Severe Acute Respiratory Infection and Emerging Infection Consortium
LDCs	Least Developed Countries
LMICs	Low-and middle-income-countries
M&E	Monitoring and Evaluation
MRC	Medical Research Council
NIHR	National Institutes of Health and Care Research
ODA	Official Development Assistance
OECD DAC	Organisation for Economic Co-operation and Development's Development Assistance Committee
PHEIC	Public Health Emergency of International Concern
PI	Principal Investigator
R&D	Research and Development
RCS	Research Capacity Strengthening
REC	Research Ethics Committee
REDISSE	Regional Disease Surveillance Systems Enhancement Programme
SSA	Sub Saharan Africa
TGHN	The Global Health Network
UKCDR	United Kingdom Collaborative on Development Research
UN	United Nations
US NIH	National Institutes of Health
WHO	World Health Organisation
WHO AFRO	WHO Regional Office for Africa

Chapter 1 - Background

1.1 Introduction

In January 2020, the World Health Organisation (WHO) declared the outbreak of a novel coronavirus a Public Health Emergency of International Concern (PHEIC)[1]. Under the International Health Regulations (IHR), this represents “an extraordinary event which is determined to constitute a public health risk to other states through the international spread of disease and to potentially require a coordinated international response”[2]. Coronavirus disease (COVID-19) spread rapidly across the globe and was declared a global pandemic in March 2020[3].

As of January 2023, the COVID-19 pandemic had caused an estimated 663 million infections and over 6 million deaths globally[4]. The burden of disease varied globally, as did the quality of reporting on disease statistics. Three years into the pandemic, North and South America alone accounted for almost half of reported global mortalities, whereas the African continent, which recorded only 3% of reported global mortalities, was apparently less affected[4]. Beyond early 2023, the quality of reported COVID-19 estimates globally fell further as many countries ended regular testing requirements[5]. The quality of reporting also likely declined with the WHO’s declaration of an end to the global emergency caused by COVID-19 in May 2023[6].

In Africa, the first case of COVID-19 was recorded in Egypt in February 2020[7]. Within months, infections spread across the continent with cases reported in all 55 countries by mid-May 2020[8]. Varied reporting of COVID-19 infections on the continent posed a challenge to assessing the burden of disease[9]. The trajectory of COVID-19 across African countries was

heterogenous with inter and intra-country variations in prevalence. South Africa, Morocco, Tunisia, Egypt and Libya alone accounted for over 60% of Africa's reported COVID-19 cases as of 9 June 2022[10]. Countries across the continent had multiple waves of COVID-19 infections. Successive waves in 2020 and 2021 had the highest peaks of infections and were the most severe in terms of direct mortalities[4,9]. By 2023, COVID-19 infections were on a downward trend globally and in many African countries. This may, in part, be due to acquired immunity from previous COVID-19 infections and vaccine-induced immunity as vaccines were gradually introduced.

The actual disease burden in the African continent is likely to have been considerably underestimated given the varying levels of testing and inadequate records of mortality statistics[11]. WHO estimates as many as six out of seven COVID-19 infections in Africa were unreported due to limited testing capabilities and testing strategies which prioritised symptomatic individuals[12]. The initial stages of COVID-19 infections also mimic malaria, diarrhoeal diseases and other endemic infectious illnesses, thus increasing the likelihood of COVID-19 being undiagnosed where specific testing was not available[13]. Inadequate Civil Registration and Vital Statistics services for recording births and deaths pre-date the pandemic and contributed to inaccuracies in COVID-19 mortality estimates[11]. Nevertheless, no obviously abnormal increase in deaths was observed in Africa during the pandemic.

Multiple theories have been proposed to explain the apparently milder course of COVID-19 infections in Africa. The relative youth of the African population, as younger age was associated with less severe disease[14], induced herd immunity from a possible historical infection with a coronavirus[15] and comparatively lower prevalence of obesity and other co-morbidities, which worsen COVID-19 outcomes[16], among many others, have been

proposed. However, the presence of similar characteristics in some countries in Asia and Latin America did not appear to confer protection from severe COVID-19 infections[17,18]. Early implementation of stringent public health interventions has also been proposed as an explanation of the less severe COVID-19 mortalities on the continent[19]. However, varied implementation of various preventive interventions within and between countries prevents generalisation of their effectiveness[20]. Further research is required to determine which factor or combination of factors influenced the epidemiological course witnessed.

Despite evidence of widespread community transmission, Africa apparently recorded comparatively lower mortalities from COVID-19 than most of the other continents (as of January 2023)[4,21]. However, the indirect impacts of the pandemic cannot be overlooked. The pandemic and the measures instituted to control infections contributed to global economic setbacks. As a result, Africa retrogressed in some key targets for achieving the sustainable development goals by 2030[22]. The World Bank estimated 30 million more Africans are living in extreme poverty and the pandemic is expected to contribute to the exacerbation of food insecurity and poor child and maternal health on the continent[22].

The pandemic response involved lockdowns, travel bans, mandatory mask wearing and other public health interventions, employed to varying degrees globally, to control the spread of COVID-19 infections[23]. Governments and global financial institutions, such as the World Bank and the International Monetary Fund (IMF), also initiated economic countermeasures to safeguard national and global economies and protect the vulnerable, particularly in low-and-middle-income countries (LMICs)[24,25].

Research provided vital evidence to guide policy, clinical management, prevention and control measures. An unprecedented research output was witnessed during the pandemic with over 100,000 COVID-19 related articles published in journals and pre-print servers in 2020[26]. Although rapid dissemination of research outputs as pre-prints facilitated open science, it also led to the availability of non-peer reviewed research outputs in the public domain. The misinterpretation of these unverified findings, coupled with their amplification in the media, contributed to fuelling misinformation during the pandemic[27].

Findings from the Randomised Evaluation of COVID-19 Therapy (RECOVERY) adaptive clinical trial, which demonstrated the effectiveness of a widely available steroid in improving severe COVID-19 outcomes, have influenced COVID-19 management protocols worldwide[28]. The rapid development of vaccines against COVID-19 also represents an outstanding success for science, achieved through coordinated global efforts, with the first vaccines licensed within just one year of the pandemic[29]. Novel therapeutics to improve outcomes of COVID-19 infections were also developed. Access to these medical countermeasures was limited in LMICs, particularly in the early stages of the pandemic[30]. Although vaccines became more widely available as the pandemic progressed, novel therapeutics remained inaccessible in many low-resource countries[31].

Beyond the successes witnessed, there is evidence of significant research waste associated with the ineffective allocation of research funding and other resources for COVID-19 research in the pandemic response[32]. There was a proliferation of priority-setting activities intended to inform the allocation of resources to the most urgent needs[33–36]. However, the impact of most of these activities on funding decisions during the global pandemic response is unclear. Further research is required to gain insights into these processes.

1.2 The Global COVID-19 Research Response

1.2.1 Global Research Priorities for COVID-19

Prominent among the global priority-setting activities for COVID-19 was the WHO *Coordinated Global Research Roadmap: Novel Coronavirus (2019)*[33]. This report was published in March 2020 following a consultation process to gain consensus on key global research priority areas for ending the pandemic. WHO reported the involvement of over 400 multinational experts, researchers, funders and policy makers to ensure global representation in the process[33]. The report outlined immediate, mid- and long-term research priority areas for research focus (Appendix A)[33].

Having been developed by the WHO, the roadmap facilitated policy alignment by national governments and other stakeholders. Several research funders, researchers and policy stakeholders reported that they engaged with the roadmap priorities and factored them into their funding decisions during the pandemic[37]. However, regular updates on the research priorities identified as the pandemic evolved were not always accessible even though further consultations on research gaps occurred internally to the WHO. The first published update of the global roadmap was in March 2022, two years after the initial publication. The 2022 update focussed on research priorities for preparedness for future epidemics/pandemics [38].

1.2.2 Funding for the Global COVID-19 Research Response

To support transparency and accountability of processes and coordination of pandemic response efforts, multiple activities were initiated to monitor investments made into COVID-19 research. These were of varying scope with some tracking only investments into specific research fields whilst others focussed on specific funders. For instance, COVID-19

NMA, an international multi-institutional effort supported by WHO and Cochrane, tracked funding for COVID-19 vaccines and therapeutics research only[39]. Other trackers, such as *World RePORT*, hosted by the US National Institutes of Health (NIH), only monitored investments of the top funders of biomedical research globally[40].

In April 2020 the UK Collaborative on Development Research (UKCDR) and Global Research Collaboration for Infectious Diseases Preparedness (GloPID-R) launched the COVID-19 Research Project Tracker[41], which monitored funding for research across multiple disciplines. Grants in this global database were aligned to the WHO's mid- to long-term research priority areas (Appendix A).

The UKCDR and GloPID-R COVID-19 Research Project Tracker showed an extensive number of COVID-19 research grants funded, with at least $7.4bn invested in over 20,000 COVID-19 related research grants globally as of 15 October 2022, representing mostly public investments in COVID-19 research[42]. Estimating private sector investments into COVID-19 R&D is challenged by limited publicly available data and a diversity of funding streams such as public-private partnerships. Moreover, there was significant public and philanthropic investment into private pharmaceutical companies for the development of COVID-19 countermeasures[43].

Despite these impressive investments, which reflect the global scale of the pandemic, major shortcomings in the research ecosystem, including those related to the financing of research, were exposed. There is evidence of significant duplication of research efforts, fragmentation and uncoordinated research activities, the funding of poorly designed research studies and a delay in funding for the COVID-19 response[44–47]. A review of COVID-19 therapeutic trial

registrations in the WHO International Clinical Trials Registry Platform (ICTRP) in November 2020 found 95% of registered trials were underpowered and unlikely to yield clinically valid results[48]. There was also limited funding of research in low-and-middle-income countries (LMICs)[42].

These shortcomings in funding allocation during the pandemic are manifestations of pre-existing weaknesses in the global research system which impacted COVID-19 research financing globally[49]. The literature reports historical evidence of these challenges. For instance, the staggering disparities between health research needs and investments were shown in the landmark 1990 Council on Health Research for Development (COHRED) report which highlighted only 10% of global health investments were allocated to the populations bearing 90% of the global burden of disease[50].

Previous PHEICs were similarly marked by shortcomings in the research responses. During the 2013 - 2016 West Africa Ebola outbreak, delays in the initiation of research resulted in the discontinuation of some studies that began when disease transmission was declining and Ebola infections were waning (Figure 1)[51]. As a result, some research projects failed to contribute evidence for the Ebola response. Furthermore, despite the identification of research priorities for the 2016 Zika outbreak, funding for the response fell far short of the estimated $25m needed, with only $0.5m available for R&D as of June 2016[52].

Notable improvements to the global health research system have occurred over the years[53,54]. In relation to disease outbreaks in particular, there have been multiple initiatives to strengthen global R&D preparedness in the aftermath of the 2013 - 2016 Ebola outbreaks[55]. Among these were the WHO R&D Blueprint mechanism, a coordination and convening

mechanism for R&D on high-priority outbreak pathogens[56] and Coalition for Epidemic Preparedness Innovations (CEPI), an international multi-partner initiative for joint funding of R&D for vaccines against epidemic-prone diseases[57]. In Africa, the Regional Disease Surveillance Systems Enhancement Programme (REDISSE)[58] and the Africa Centres for Diseases Control and Prevention (Africa CDC)[59] are key post-Ebola initiatives for strengthening surveillance and public health respectively.

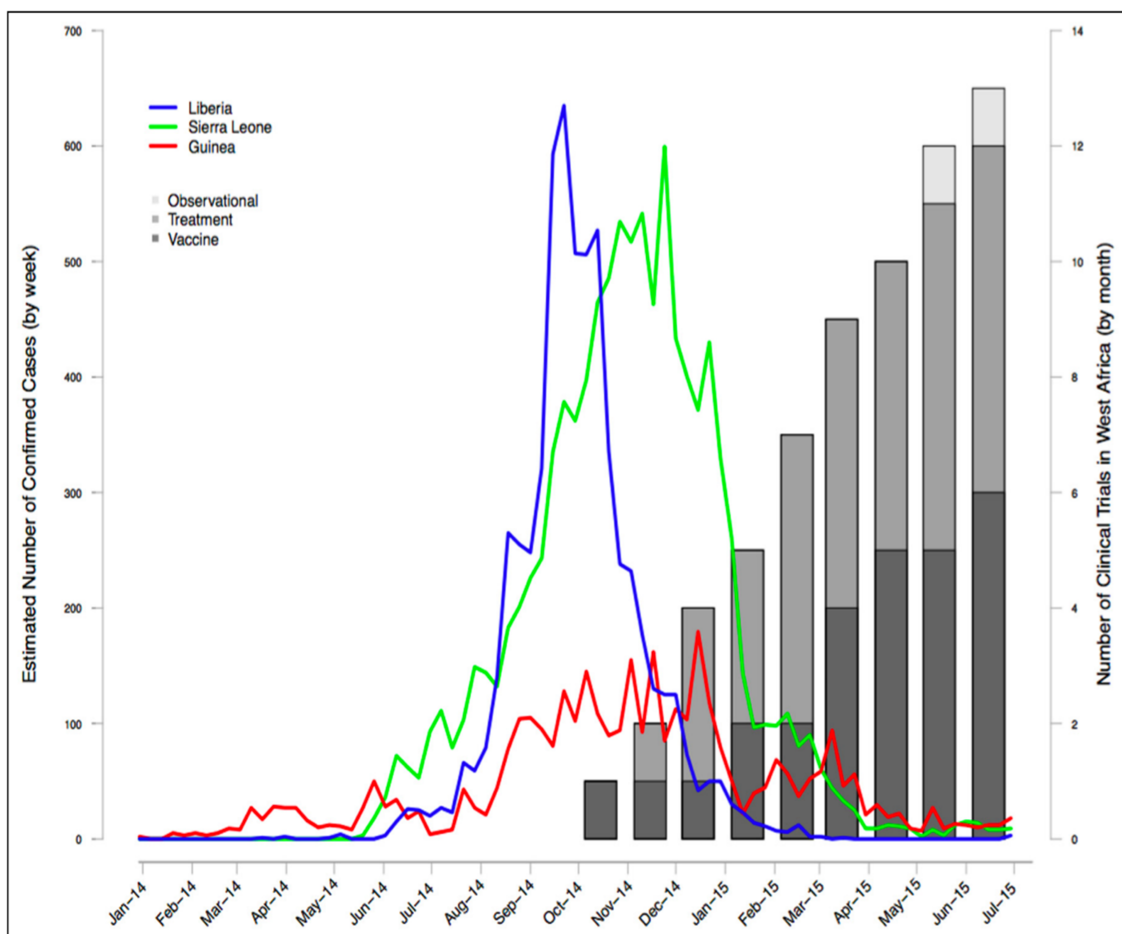


Figure 1: World Health Organisation estimates of Ebola cases in West Africa and Ebola clinical trials located in West Africa, as registered at ClinicalTrials.gov

Source: Thielman NM, Cunningham CK, Woods C, Petzold E, Sprenz M, Russell J. Ebola clinical trials: Five lessons learned and a way forward. Clin Trials. 2016;13(1):84. (CC BY-NC 4.0)

Despite these notable improvements over the years, the literature shows national and commercial interests often drive health research investments[60], with research in many LMICs often driven by external priorities from funders in higher-income settings[61]. There also tends to be a focus on short-term research outputs and prioritisation of publishable research results over wider considerations of research impact. Limited transparency on funding allocations also impacts mechanisms for assessing accountability across the systems for health research financing[62].

1.3 Health Research Systems

Although there are references to “health research funding systems” in the literature[63,64], there is no agreed way of conceptualising them. However, WHO has defined health research systems (HRS) as “the people, institutions, and activities whose primary purpose is to generate high-quality knowledge that can be used to promote, restore, and or maintain the health status of populations”[65]. This definition encompasses features of health systems[66] and research systems[67]. HRS are conceptualised as situated at the intersection of the health system and the research system (Figure 2). Four key functions of the HRS are defined and these are: stewardship; creating and sustaining resources; producing and using knowledge; and research financing (Table 1) [68,69].

In the context of disease outbreaks and health emergencies, Lurie and Keusch explored R&D ecosystems for a background paper for the Global Preparedness Monitoring Board in 2020[70]. Their work describes R&D ecosystems as consisting of a collection of non-linear “mini ecosystems” each with unique features, motivations and interactions. Their paper further

supports the view of exploring these systems using a complex systems dynamics approach owing to the non-linear interactions at play in HRS.

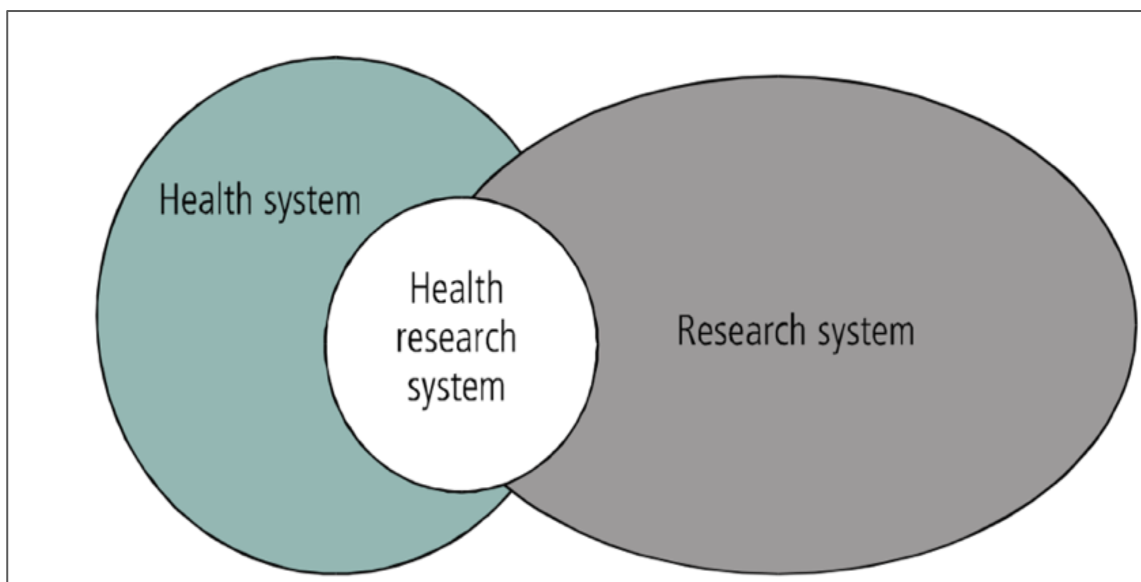


Figure 2: Health Research Systems as conceptualised by Pang et al. (2003)

Source: Pang T, Sadana R et al. Knowledge for better health: a conceptual framework and foundation for health research systems, 2003. (CC BY 3.0 IGO)

Table 1: Functions of the Health Research System defined by Pang et al. (2003)

Function	Operational component
Stewardship	• Define and articulate vision for national health research system • Identify appropriate health research priorities and coordinate adherence to them • Set and monitor ethical standards for health research and research partnerships • Monitor and evaluate them accountably
Financing	• Secure research funds and allocate them accountably
Creating and sustain resources	• Build, strengthen, and sustain the human and physical capacity to conduct, absorb and utilise research
Producing and using research	• Produce scientifically valid research outputs • Translate and communicate research to inform health policy, strategies, practices and public opinion • Promote the use of research to develop new tools (drugs, vaccines, devices, and other applications) to improve health

Reproduced from: Pang T, Sadana R et al. Knowledge for better health: a conceptual framework and foundation for health research systems, 2003. (CC BY 3.0 IGO)

1.3.1 Model for exploring the Health Research Funding System

In this research I considered each of the four HRS functions to take place within a sub-system of the HRS. In particular, I focussed on the research financing function and conceptualised it to take place in a health research funding system (HRFS). To my knowledge, this thesis is the first study to conceptualise HRFS in this way.

In alignment with the WHO definition of the HRS[65], I define the HRFS as the various actors, structures and processes with the goal of effectively procuring, allocating and sustaining financial resources for the generation of high-quality knowledge for the improvement of health of various populations. This definition takes cognisance of the inherent complexities of health research funding, acknowledging the diverse factors which influence the conception, prioritisation, conduct, dissemination, monitoring and evaluation of health research and its funding.

My model aligns with the proposed definition of systems by Meadows as "an interconnected set of elements that is coherently organised in a way that achieves something"[71]. Therefore, all systems consist of elements; interconnections; and functions or purposes[71–73]. Figure 3 depicts the elements, interactions and goal of HRFS and the following sections (1.3.2 - 1.3.5) describe these systems components and processes.

1.3.2 The Health Research Funding System

The financing of research involves activities to procure and sustain financial resources for research processes. Although not required for all research, funding supports activities such as recruitment of research personnel, acquisition of research equipment, data management, research evaluation and the development and maintenance of research infrastructure[74]. Other

inputs into the research process, such as researchers' time, can also be quantified in monetary terms[75].

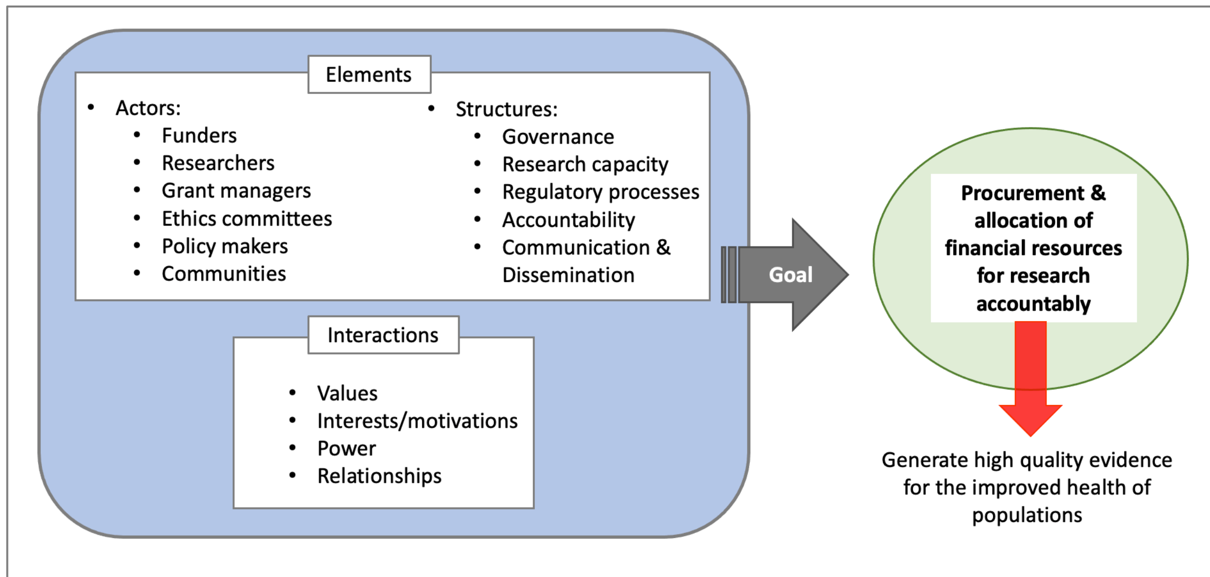


Figure 3: My model for the Health Research Funding System for this research

Model developed by researcher using inputs from: Pang T, Sadana R, Hanney S, Bhutta ZA, Hyder AA, Simon J. *Knowledge for better health: a conceptual framework and foundation for health research systems*. Bull World Health Organ. 2003;81(11):815 (CC BY 3.0 IGO); Keusch GT., Lurie N. *The R&D Preparedness Ecosystem: Preparedness for Health Emergencies Report to the Global Preparedness Monitoring Board*. 2020; Meadows DH. *Thinking in systems: a primer*. Wright D, editor. London: Earthscan; 2009.

1.3.3 Classification of Health Research Funders

Health research funders are key actors within the health research funding system and are individuals, groups or organisations which provide funds for health research. Whereas some entities directly provide funding for research, others are intermediaries (indirect funders) which distribute funding received from other sources[76]. In the literature, entities involved in both direct and indirect funding are designated as funders. Coupled with this, the limited transparency in health research funding poses a challenge for the identification of the actual sources of funding for research in practice. Consequently, a wide variety of entities are considered to be research funders, contributing to the complexity in their classification.

The classification of funders is not well articulated in the literature and could be considered in a number of ways. For instance, when classified by profit motive, funders can be either for-profit (commercial) or not-for-profit (non-commercial). Funders may also broadly be categorised as either public (governmental) or non-governmental funders[77]. Major health research funders such as the United States National Institutes of Health (NIH) and the Canadian Institutes of Health Research (CIHR) are examples of governmental funders as these consist of government departments which fund research projects directly.

Non-governmental research funders are mostly apolitical agencies which, although possible beneficiaries of government funding, are autonomous in funds administration[78]. Another class of funders within the non-governmental group is made up of charities and philanthropies which are “not for profit”[79]. This consists of the most diverse organisations including key global health players such as Bill and Melinda Gates Foundation (BMGF), Wellcome, and smaller charities and disease-specific groups which fund research across specific themes or causes. Finally, private funders are typically industries or companies with a commercial interest in funded projects.

A less substantive proportion of health research funding is also administered through multilateral organisations such as the United Nations (UN) and WHO which receive funding from a blend of the prior described funders or through bilateral agreements between states[80]. Similarly, global health initiatives, which fund research, may themselves also be funded through governments, charities or private donors. For instance, CEPI, receives funding from governments and private donors, charities and civil society organisations[81].

Sources of funding for the various funders and the flows of funds among funders are also variable and complex[82]. For instance, in LMICs funding for R&D can be delivered as a proportion of conditional or non-conditional aid[83]. Taxpayers are ultimately the source of funding for most public funders. Funds may also flow among the various funders such as in co-funding, where more than one funder provides funds for research, or where one funder merely channels funds through another's grant making processes[82].

1.3.4 The Research Funding Process

Funding research usually involves: defining and issuing calls for funding applications, screening and selection of research to be funded, typically via a competitive process; delivery of funds; and monitoring and evaluation of investments[74]. Some processes involved in research funding for funders and researchers are shown in Figure 4[84,85].

Global and/or governmental agendas may influence which research thematic areas are prioritised as does the ethos and remit of individual funding organisations[86–88]. Some funders only fund research in specific health disciplines or are disease-specific. These factors influence the scope of funding calls launched by funding organisations. However, there is limited evidence on the processes funders apply to set their priorities for funding allocation reported in the literature[89]. Researchers and institutions in less-resourced contexts face multiple challenges across the stages of the research funding process which hinder their ability to obtain and manage funds for their research.

The process of developing compelling funding applications is demanding and requires researchers to effectively communicate their proposed research plans, prepare budgets outlining research costs and provide appropriate supporting documentation for the proposed research[90]. Some researchers in less-resourced contexts are frequently at a disadvantage due

to lack of experience in grantsmanship and limited track record of receiving and managing international research grants[91]. These challenges are also prominent in Sub Saharan Africa where many research institutions are limited in capacity to attract funding for health research[92].

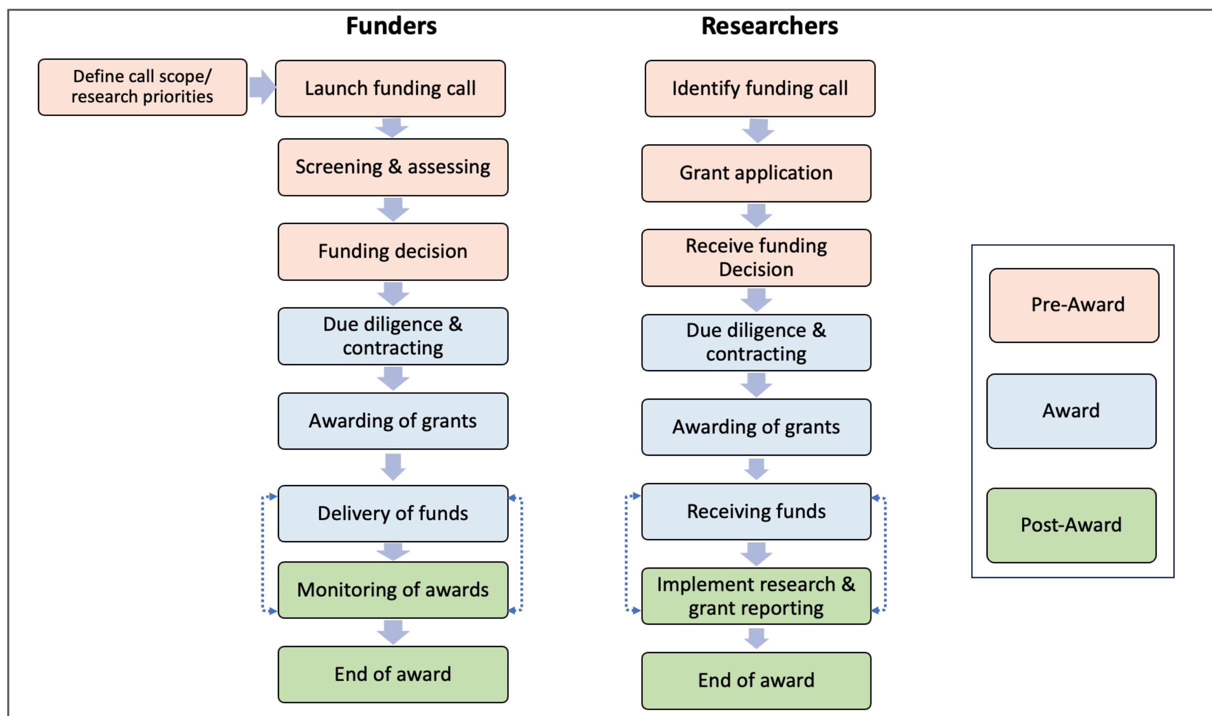


Figure 4: The processes involved in research funding for funders and researchers

Developed by Researcher inspired by: Stergiou J, Timlin et.al. *Due Diligence in International Research - Options for Improved Efficiency, Equity and Quality*.2021; Graves N, Barnett AG, Clarke P. *Funding grant proposals for scientific research: retrospective analysis of scores by members of grant review panel*. BMJ. 2011. (CC BY-NC 4.0)

When successful, most research institutions undergo due diligence checks to assess for potential financial, legal and operational risks associated with the administration of funds for research and mitigation measures to these[93]. The determination of which institutions undergo due diligence checks and the extent of these checks is based on the funders' policies and relates to: the type of research institution involved; the size of funding award; and prior

successful relationship with the institution under assessment, which likely reduces the extent of the due diligence checks[94]. Institutions in LMICs are often perceived to be associated with more risk and as such usually undergo extensive due diligence[95]. They are also often limited in grant management capacity. Due diligence processes are among the causes of delays to the initiation of research in LMICs, many of which are in Africa[91].

In the award stage, negotiations covering financial and project-specific aspects of funding awards, including the coverage of specific costs (direct and indirect research costs) outlined in the grant proposal budgets and grant conditions, are held. Indirect research costs are usually a point of disagreement[96]. For instance, whereas some funders cover a fixed rate of overhead costs, others are open to negotiation[97]. Others still do not cover these costs[98]. A fear of being perceived as "unattractive" for funding often results in LMIC institutions underbudgeting for their activities to the detriment of their research and sustainability of their institutions[91]. A study of UK and US-based research institutions found no significant association between the level of overheads charged and success in obtaining research grant awards[98]. However, I have been unable to identify any similar study in the literature focussing on LMIC institutions or research institutions based in Africa .

In the delivery of funds once agreement is reached, funding may flow in tranches over the course of the research (dependent on the achievement of agreed research milestones) or is delivered upfront prior to research initiation[99]. In some cases, research institutions pre-finance activities and are reimbursed for these by the funder[100]. Less-resourced institutions are usually unable to meet this condition or can only bear this risk where small funding amounts are involved[101]. This hinders the ability of such research institutions to attract funding for research.

The processes discussed show that funders have both implicit and explicit requirements of grantees for successful grant making. The conditions vary and may be dependent on the type of research funding organisation, the size of the funding award, the type of research institution funded, the type of research funded, among many others[74]. Table 2 summarises some common research funding requirements from the processes discussed.

Grant management plays a vital role in ensuring researchers and research institutions effectively navigate the processes in research funding (outlined in Figure 4) and grantees' alignment to the requirements mandated by funders (Table 2)[102]. It involves processes for the oversight and administration of research grants in institutions awarded funding to undertake research[103]. However, there are a number of challenges to grant management discussed in the literature and these are amplified in LMICs, including many countries in Africa[104]. They include inadequate research management governance, corruption and inadequate grant management capacity which negatively impact processes for obtaining and managing funding for research and accountability for grants awarded [91].

Table 2: Examples of research funder requirements in funding agreements

Funder requirements	Details/ examples
Legal requirements	Research institutions should be registered as legal entities with valid licences within an appropriate jurisdiction.
Regulatory requirements	Entities should have valid licences to practice research from the relevant regulatory authorities. For example, international or local accreditation of labs or clinical trial sites.
Organisational requirements	Entities demonstrate clear roles and structures as pertains to the research proposed with designated roles for financial management, project management, project oversight, risk management, etc. Organisational polices on data management, security, intellectual property, conflicts of interest, etc.
Financial requirements	Evidence of risk assessment, insurance and record of successful management of grants.
Ethics requirements	Ethics approvals from the relevant review boards are typically required for research involving human subjects. There may also be the need to demonstrate plans for safeguarding of research teams and research participants.
Project-specific requirements	Demonstrating a clear value of the proposed research and meeting clearly defined research needs. Evidence of scientific rigour in the proposed approach to research.
Human resource and infrastructure requirements	Demonstrate expertise in human resources, facilities and equipment as pertains to the research proposed.

Summarised from multiple sources including: Stergiou J, Timlin et.al. *Due Diligence in International Research - Options for Improved Efficiency, Equity and Quality*.2021; Graves N, Barnett AG, Clarke P. *Funding grant proposals for scientific research: retrospective analysis of scores by members of grant review panel*. BMJ. 2011. (CC BY-NC 4.0); Osório A, Bornmann L. *Research calls, competition for funding and inefficiency*. Res Eval. 2022. (CC BY-NC 4.0)

1.3.5 Assessments of Health Research Funding

The goal of the research financing function defined by Pang et al. is to "secure and allocate funds accountably"[65]. Accountable allocation of research funding is considered in various ways in the literature reflecting the inherent complexities of the funding process, the interests of the various stakeholders and the varying contexts and purposes for funding research. A major purpose of funding research is to generate useful results (outputs, outcomes and

impacts) ranging from academic to economic and wider societal research impacts[105]. Figure 5 shows some examples.

Category	Definition
1. Knowledge	Journal articles; conference presentations; books; book chapters; research reports
2. Benefits to future research and research use	• Better targeting of future research • Development of research skills, personnel and overall research capacity • A critical capacity to absorb and utilise appropriately existing research including that from overseas • Staff development and educational benefits
3. Benefits from informing policy and product development	• Improved information bases for political and executive decisions • Other political benefits from undertaking research • Development of pharmaceutical products and therapeutic techniques
4. Health and health sector benefits	• Improved health • Cost reduction in delivery of existing services • Qualitative improvements in the process of delivery • Improved equity in service delivery
5. Broader economic benefits	• Wider economic benefits from commercial exploitation of innovations arising from R&D • Economic benefits from a healthy workforce and reduction in working days lost

Figure 5: Examples of outputs, outcomes and impacts of health research

Source: Hanney S. et al. 2004 Proposed methods for reviewing the outcomes of health research: the impact of funding by the UK's 'Arthritis Research Campaign' (CC BY-NC 4.0)

One view of accountability considers the production of useful results from funded research. However, several elements feed into what is "useful". The definition is subjective, requiring reflection on who outputs are useful for[106]. There are also likely to be variations based on research type (for example, basic versus applied research) and what various actors place value on. For instance, private sector funders may prioritise the potential commercial gains from research whereas charities and philanthropies tend to prioritise public good.

Evaluations of health research funding have often favoured quantitative approaches because of the relative ease of their determination[107,108]. Bibliometric analyses are a common approach which generates quantitative measures of influence for assessing the quality of funded research within an academic field[109,110]. Although useful, bibliometric indicators

have many flaws. The metrics can be inaccurate as they are limited in accounting for the lag between publication of articles and their citation in the literature[111]. Hence, newly published articles frequently have lower citation indices[112]. The indicators are also not fit for assessing research quality across the spectrum of research fields[113,114]. Further, less frequently cited yet impactful research is often not captured[115].

Citation analyses can also be used to assess the policy influence of research. However, given the non-linear pathways from translating research outputs into policy, this does not provide a reliable indication of application to policy in practice[116,117]. Moreover, not all research types have the same potential to influence policy[118]. Basic sciences research, for example, is carried out to broaden knowledge in a particular field rather than to be practically applied to solve specific problems.

Evaluations can also be made of non-academic outputs, outcomes and impacts of funded research[119,120]. Examples are research capacity strengthening, building of partnerships and collaborations among researchers, communities, policy makers and funders, and other wider societal benefits derived from health research.

Often, these assessments are complicated by variable standards applied by the relevant research stakeholders, varying definitions of their optimal attainment, and the need to factor in contextual considerations[121]. For example, research capacity strengthening is defined by the ESSENCE funders (a group of funding organisations coordinating investments in research capacity strengthening in LMICs) as “any efforts to increase the ability of individuals and institutions to undertake high-quality research and to engage with the wider community of stakeholders”[122]. This broad definition is subject to interpretation of what

constitutes high quality research, what the optimal ability to undertake research is and how the increase in ability is measured.

Assessments of the health research funding system have also been challenged by limited data linking research outputs, outcomes and impacts to inputs (funding)[121]. An example of efforts to address this is *Researchfish*, a database for tracking impact of funding via the documentation of impact case studies, policy influence, reports on impact, etc[123]. Many funders require their grantees to regularly report on key milestones of funded research. Another example is *Crossref funder registry* which records acknowledgements of research funding in journal publications and policy documents, linking research grants to outputs[124]. However, caution must be taken in attributing wider gains attained to specific research activities.

Given the limited resources available for undertaking health research, minimising waste of resources and maximising the return on investments is another important consideration in the literature[125–127]. Some ways of enhancing the return on investments are: funding well designed studies[126]; investments in research projects which address priority research questions[127]; collaboration among funders to drive down costs of selecting and managing grants and avoid duplication of efforts[128]; and funding research which results in additional benefits (other than the intended research results) including, formation of research partnerships, strengthened capacity and open resource outputs[129]. Assessments of the extent to which these are achieved often feature in evaluations for research funding[130].

Assessments discussed in the literature also relate to the impact of funding allocation processes on the overall research system[131]. This considers how resource distribution across

funding processes prevents the success of one process from undermining others. For example, the time invested by researchers in the preparation of grant applications is often at the expense of research-related activities[132]. Similarly, extensive post-award processes required by research funders can compromise other research-related efforts as found by Crane et al[133].

Equity is another factor frequently encountered in the literature on research funding assessments[121]. In a report to promote equity and inclusivity in research funding, Gladstone et al. refer to equity as "an environment in which all people are treated fairly, accounting for their needs and positionality, to enable them to reach equal outcomes"[134]. Assessing equity in research funding requires moral judgements to be made on the fairness of research funding regarding specific populations, particularly marginalised groups.

Assessments involve analyses for bias or discrimination in funding research with respect to researchers funded to undertake research, study populations involved in research and the beneficiaries of funded research. Biases related to gender, race and sexuality are commonly discussed [135–137]. The literature also examines equitable funding practices when funders in high-income countries support research in institutions in less-resourced contexts, mainly in LMICs[138]. Here, equity is viewed in terms of allocating sufficient funding to support research into the needs in these contexts, promoting conducive research environments and supporting capacity strengthening when funding research [139,140].

During outbreaks of infectious diseases, rapid research is vital as there is a fixed yet unpredictable period for generating crucial evidence (Figure 6)[141]. Some research areas can only be investigated when there is ongoing disease transmission including epidemiological

research, disease characterisation, evaluation of vaccines, therapeutics, diagnostics and public health interventions. This is particularly crucial for outbreaks caused by novel pathogens such as COVID-19, for which there was insufficient evidence on effective countermeasures at the onset of the outbreak.

	Requires Ongoing Transmission	Does not need virus present
Needed now to tackle COVID-19	• Drug and vaccine clinical trials • Disease characterization studies • Evaluating public health measures • Transmission dynamics • Epidemiology / surveillance • Evaluate point of care diagnostics	• Public perceptions and understanding behavior, treatment seeking practices • Lab work on stored samples; diagnostics, immunology, co-morbidity • Digital technology for track and trace • Impact on pregnancy & child health • Impact on health systems
Needed to learn for next time	• Efficacy of public health interventions in varied global settings • Best approaches for public health messages and engagement	• Factors in zoonotic transfer • Mitigating impact on health systems • Evaluation of PPE use and equipment • Ethics – research governance • Systems for rapid review • Environmental factors

Figure 6: Priority assessment matrix for research within the COVID-19 pandemic

Source: Norton A, de La Horra Gozalo A, Feune de Colombi N, Alobo M et al. The remaining unknowns: a mixed methods study of the current and global health research priorities for COVID-19. BMJ Global Health 2020 (CC BY-NC 4.0)

The need for urgent evidence also factors into what counts as effective funding[49]. For example, timely availability of research outputs might be an important consideration, whereby funding is considered to be effective if it leads to the rapid availability of evidence to address an ongoing outbreak[142]. However, an assessment of the timeliness can be dependent on the type of outbreak, morbidity and mortality profile of the disease, existing evidence and the stage of the outbreak.

Under these circumstances, the value placed on additional benefits resulting from research such as strengthening capacity and forming partnerships, which require time to be developed, may take less precedence if the speed of research is prioritised. It can be argued that under emergency conditions, funding research in better equipped research institutions, as witnessed during the COVID-19 pandemic[143], should be prioritised as these are likely to have the capacity to yield high quality outputs rapidly. Conversely, this approach may be viewed as unfair if equity is the key factor considered[138]. When the timelines for effectiveness are extended beyond an ongoing emergency, longer term impacts and applications of evidence generated beyond the acute outbreak might be considered[34]. Here, the potential for research outputs to be applied in future health emergencies might be a key consideration in funding assessments.

The COVID CIRCLE initiative, in 2020, proposed seven principles for "funding high quality research to address the most pressing needs during an epidemic or pandemic"[144]. These principles are synthesised from existing best practice in the literature on the seven key elements which are: Alignment to global research agendas and locally identified priorities; Research capacity for rapid research; Supporting equitable, inclusive, inter-disciplinary and cross-sectoral partnerships; Open science and data sharing; Protection from harm; Appropriate ethical consideration; and Collaboration and learning through enhanced coordination [129].

The principles encompass elements for improved effectiveness (research leading to useful outputs, outcomes and impacts), efficiency (minimising waste of resources) and equity (fairness in the funding of research). Nevertheless, there is limited detail on how funders can actually apply these in practice. In reality, many factors are at play, such that achieving

effective funding allocation depends on whose perspective is considered and trade-offs made accounting for the interests and desired goals of funders, researchers, communities and other individuals influencing research[145].

The actors, processes, and goals of the HRFS described illustrate the complexity of funding practice and the interplay of factors influencing the allocation of COVID-19 health research investments. As many LMICs are located on the African continent, the challenges to research funding in LMICs across the research funding cycle in the pre-pandemic period, as described in Section 2.2.5, are also prevalent in African countries. The challenges encountered by African research institutions in attracting and managing research funds include limitations to writing competitive grant applications[146], limited research capacity[147], and weak systems for institutional grant management[104]. However, there has been limited empirical evidence generated on the impact of the pandemic on the health research funding processes in Africa.

1.4 Africa's COVID-19 Response

Africa is the only continent to have mounted a coordinated regional response to the pandemic. Under the leadership of the Africa CDC a "Joint Continental Strategy for the COVID-19 Outbreak" was launched in February 2020 with representatives from health ministries of all 55 African Union member states[148]. Under this strategy, the Africa Task Force for Novel Coronavirus (AFTCOR), which focussed on surveillance at ports of entry, infection prevention and control (IPC) measures, communication and community engagement strategies, was commissioned[149]. Africa's coordinated approach was also used to set strategic priorities for research during the pandemic.

1.4.1 Research Prioritisation for COVID-19 in Africa

In March 2020 the African Academy of Sciences (AAS), a regional organisation for strengthening research funding and policy, organised a consultative webinar involving African researchers to gauge the research priorities of relevance on the continent. This followed their concern that globally set priorities potentially left regional/local research needs unaddressed. Discussions from the webinar were summarised into a survey where respondents also ranked the WHO research priorities (Appendix A) by level of relevance to the African context. This work, which was published in April 2020, identified several priorities including research into: the use of local materials to develop PPE; management of COVID-19 in the absence of intensive care units; and the identification of therapeutic candidates from traditional remedies (Appendix B)[150].

These priorities were updated in May 2020 in a collaboration between AAS, The Global Health Network (TGHN), UKCDR, WHO Regional Office for Africa (WHO AFRO) and the African Union Development Agency (AUDA-NEPAD) through a global consultation and survey of researchers to identify the research priorities of relevance to LMICs, working directly from the priorities resulting from the prior AAS study. The AAS update featured those priorities obtained from researchers based in Africa[151]. The updated list of priorities is shown in Appendix C.

The aforementioned priority-setting activities generated a list of over 50 research priority questions for Africa and, in further work, led by AAS, Africa CDC and WHO AFRO, these were reviewed by AFTCOR and consolidated into actionable priorities summarised in a policy paper[152]. Six themes were outlined: Transmission dynamics of COVID-19, Epidemiology and surveillance; Diagnostics; Clinical characterisation of cases; Drug and

vaccine clinical trials; Modelling impact of COVID-19 on the health systems; and Social science and policy research. Further work elaborated on areas under the six themes to be put forward for increased investment (Appendix D)[152].

The policy document developed was disseminated to national health emergency response representatives for countries in the African Union and was intended to inform national strategies for COVID-19 research[152]. However, their actual translation into national policies and research is unknown. Although the priority-setting exercises revealed important research gaps in Africa, there were no efforts to further refine the identified priorities to highlight the most urgent needs or periodic progress evaluations and assessments of their evolution over time as research needs changed during the pandemic. There were also no regularly updated and accessible global COVID-19 research roadmaps which kept up with evolving research needs as the pandemic progressed. These reflect a broader challenge with priority-setting during disease outbreaks and gaps in the evidence on best practice in research priority-setting in this context.

1.4.2 Funding for COVID-19 Research in Africa

There have been limited assessments of funding for COVID-19 research in Africa reported in the literature. In July 2020, following the identification of research priorities for Africa, I undertook a review of the COVID-19 research grants in Africa[153]. This is the only known review of research funding with a focus on Africa which also assessed the alignment of funding to the research priorities defined by African researchers.

This assessment also sought to determine the funders of COVID-19 research in Africa and the locations of funded research. The UKCDR and GloPID-R Research Project Tracker,

which was analysed, was the only database which mapped COVID-19 grants to the WHO and other research priorities, and was the most comprehensive global database of funded COVID-19 research projects[41].

Only about 4.5% of the 1,858 grants recorded as of July 2020 included at least one African country as a research location, with Kenya, Uganda, South Africa and Burkina Faso among the countries involved in the most research[153]. For 19 countries, no research activity was documented. Only about 37% of the grants funded focussed on at least one of the research priorities defined by African researchers[153]. The lack of therapeutic and vaccine clinical trials on the continent was particularly evident. Twelve research funding organisations, none of which were based in Africa, had funded COVID-19 research on the continent[153]. Most of the grants were funded by international research funders based in Europe[153].

A bibliometric analysis of COVID-19 research in Africa focussing on published literature in the first year of the pandemic made similar conclusions, naming Wellcome and US National Institutes of Health (NIH) as the most acknowledged funders in journal publications[154]. Further, indirect social impacts of the pandemic and preparedness were the dominant research themes identified, similar to my 2020 study, where social sciences and epidemiology were the most common research areas [153,154].

At the time of my review, some known research funding calls for Africa and LMICs had not yet been launched or awarded. These included the AAS funding call[155] and Global Effort on COVID-19 (GECO) Health Research call[156] which reportedly aligned to the specific research priorities developed for LMICs and Africa in May 2020 and were both awarded in October 2020. As the pandemic progressed, it was expected that more research would be

funded in Africa. Further, it was likely that there were newly captured research grants in the UKCDR and GloPID-R Research Project Tracker, given the lag between the awarding of grants and the dissemination of information on these by funders,

Ultimately, the research funded depended on what areas and/or factors were prioritised in funding decisions[157]. In a paper on ethical research priority-setting Millum describes prioritisation to have taken place “anytime someone makes a decision or a recommendation about how to allocate a scarce resource”[158]. Hence, the various research actors involved in resource allocation might not engage in formal priority-setting exercises which are explicitly defined. Resource allocation decisions might also be indirect and implicit in the actions of these actors.

The relationship between research priority-setting and funding allocation can be direct such that identified research priorities directly inform which research areas are funded. As discussed in previous sections of this chapter, various other factors can influence how resources are allocated. The outputs and evidence from funded research can be analysed to identify research gaps or further areas to be explored, which can inform future priority-setting. Priority-setting activities themselves require resources and, indeed, some formal priority-setting activities are funded by research grants[157]. Multiple research priorities were identified during the COVID-19 pandemic. However, it is unclear how these influenced research funding globally and in Africa.

Despite evidence of various approaches to research priority-setting in the literature, there is limited discussion of the processes in the context of disease outbreaks. There has been no

research conducted to map the priority-setting activities undertaken in response to the COVID-19 pandemic or to assess the methodologies used.

Beyond prioritisation, funding allocation encompasses more than just the decision by funders to support research as indicated in earlier sections of this chapter. There are several distal factors at play which influence access to research funds by researchers and institutions. Historically, the literature reports multiple challenges faced by African researchers related to access to funds for research[104,146,147,159]. However, no study has explored in-depth the range of factors which might have influenced their access to research funding during the COVID-19 pandemic.

1.5 This DPhil Research Project

1.5.1 Research Problem

The COVID-19 pandemic caused devastating morbidity and mortality globally. The African continent appears to have been less impacted in terms of direct mortality[11]. However, the indirect health and socio-economic impacts have been extensive[160]. Research played a vital role in the response to the pandemic globally. However, evidence suggests significant problems in the research funding system resulting in the funding of poorly designed studies, limited focus on the relevant research priorities, particularly in LMICs, poor coordination among research actors, delayed initiation of research, among many others[161].

The dynamics of funding for COVID-19 research in Africa are less clear. To the best of my knowledge, prior to this thesis, the only assessment of funding for COVID-19 research focussing on Africa was the one I undertook in July 2020[153]. This work, which showed

limited investments in COVID-19 research, was undertaken at a time when only a few COVID-19 specific research funding calls had been launched for Africa and LMICs.

Globally, and in Africa where resources are limited, priority-setting would be expected to play a crucial role in informing the allocation of limited resources, especially in a health emergency such as the COVID-19 pandemic. However, the evidence suggests this might not have been fully realised[153]. The various COVID-19 research priority-setting exercises for Africa revealed important research gaps. Numerous research priorities were identified through the attainment of consensus among various stakeholders. However, there are no clear guidelines on appropriate methodologies for the rapid identification of research priorities during health emergencies. Moreover, limited information on the application of the research priorities identified poses a challenge to gauging the impact of the various research priority agenda on research policy and practice during the pandemic.

African researchers faced particular challenges in accessing funds for health research in the pre-pandemic period. It is unclear how these challenges influenced access to funding for COVID-19 research and what other factors influenced research funding allocation in the pandemic response. These knowledge gaps indicate a need to investigate the processes involved in funding COVID-19 health research globally and in Africa to explore how research priorities were set, what research was funded, and how research projects were funded.

1.5.2 Aim of DPhil Research

This research assesses funding for the COVID-19 health research response in Africa with a view to identifying key lessons and recommendations for improved preparedness for future epidemics and pandemics.

1.5.3 Research Questions

This work sought to answer the following research questions:

1. How did the modalities for COVID-19 research prioritisation shape the identification of research priorities and what were the implications for research funding decisions?
2. What was the landscape of funded COVID-19 health research in Africa and how did research align to the WHO global and Africa regional COVID-19 research priorities?
3. What factors influenced the securing and management of funding for COVID-19 health research by researchers and grant managers in African research institutions?

Chapter 2 - Overview of Research Methods

2.1 Introduction

In this thesis, I undertook "research on research[162]" focussing on COVID-19 research funding processes globally and in Africa. A variety of methods were used to answer the research questions posed, incorporating qualitative and quantitative approaches. I selected methods that were most appropriate to achieve the overall aim of this research: to assess funding for the COVID-19 health research response in Africa with a view to identifying key lessons and recommendations for improved preparedness for future epidemics and pandemics. I also factored in pragmatic considerations (such as resource availability), contextual considerations (such as access to data and research participants) and ethical considerations for research.

2.2 Methods Selected

I conducted a scoping review of the literature on research priority-setting for COVID-19 to address the research question: "How did the modalities for COVID-19 research prioritisation shape the identification of research priorities and what were the implications for research funding decisions?".

Scoping reviews are used to summarise the extent of evidence in a research field and are suited for situations where the breadth of evidence in an area has not been well explored in the literature[163]. In view of this, a scoping review was deemed the best method for mapping the research priority-setting activities undertaken in response to the COVID-19 pandemic and for identifying the methods used to arrive at the research priorities, as these have not been comprehensively explored in the literature.

Both journal databases and grey literature sources were searched using the relevant search terms to yield a number of articles and reports. Following initial screening based on the inclusion and exclusion criteria, the selected publications were reviewed in detail. Publications focussing on COVID-19 were analysed. Full texts of all included articles and reports were reviewed, with data extracted using a pre-piloted table. Descriptive analyses were undertaken and results were presented using figures and graphs.

The research question "What was the landscape of funded COVID-19 health research in Africa and how did research align to the WHO global and Africa regional COVID-19 research priorities?" was addressed by a mapping review of the UKCDR and GloPID-R COVID-19 Research Project Tracker[41].

A review of a global database of COVID-19 grants was the most suitable method as it allowed for the systematic assessment of the scope of COVID-19 grants awarded. It also enabled the use of both descriptive and thematic analyses to provide insight into the characteristics of research grants and identify potential gaps in the landscape of funded COVID-19 research. Furthermore, I selected the UKCDR and GloPID-R COVID-19 Research Project Tracker because it monitored grants covering a wide breadth of research disciplines and the data were openly accessible.

From the global grants captured, those involving at least one African country as a study location were identified. Each grant was assigned to one or more of the research priorities identified for Africa and LMICs. Frequencies for the relevant data fields were calculated and compared. Results were presented using figures and tables.

To address the research question "What factors influenced the securing and management of funding for COVID-19 health research by researchers and grant managers in African research institutions?", I undertook a qualitative study. Qualitative research allows for the exploration of complex phenomena including those associated with human interactions, experiences and behaviours[164]. Hence, it was well suited to address this research question as it enabled me to explore the perspectives of the research participants in-depth to gain an understanding of their experiences with research funding during the COVID-19 pandemic. The qualitative approach also enabled me to synthesise emerging patterns derived from the research participants' varied experiences during the pandemic.

I purposively sampled researchers and grant managers from research institutions identified from the UKCDR and GloPID-R COVID-19 Research Project Tracker. I conducted in-depth interviews to explore their experiences during the COVID-19 pandemic. Following transcription, the data were analysed using an inductive approach to draw out themes from the data. The resulting themes were summarised and compared between researchers and grant managers.

2.3 Model for this Research

My model for thinking about the health research funding system (Figure 3, Chapter 1) draws from the conceptual framework for HRS and systems thinking. These offer a compelling framework for assessing the dynamics of health research funding. By considering the system's complexity, this model allowed for a more nuanced understanding of the interconnected system's components and their interactions.

Complex adaptive systems, such as the HRFS, are a specific type of system comprising multiple interacting elements which exhibit emergent characteristics[165]. Complex adaptive systems present a number of features including emergence, self-organisation, feedback and non-linearity. Emergence refers to the behaviours arising from the interactions among systems elements which are not predictable from considering the individual components of the system[165]. Hence, the emergence phenomenon aligns with the Aristotelian philosophy "the whole is greater than the sum of its parts"[166].

Feedback loops are common in complex adaptive systems and show where the outputs or behaviours of a system influence future states by feeding back into the system[167]. Non-linearity describes a property of complex systems whereby small changes in one aspect of systems result in effects which are disproportionate in scale to the initial change elsewhere in the system[168]. Other features are described in Table 3.

I applied my model in the development of my research questions and subsequent approach to this work where I considered the importance of including the perspectives of multiple HRFS actors. In interpreting and integrating the research results, I specifically explored emergent phenomena including intended and unintended consequences emerging from research funding policies and practices.

Table 3: Examples of properties of complex adaptive systems

Features of Complex Adaptive Systems	Description
Emergence	The interactions among the components of a system produce unexpected behaviours which are not always easily discernible from studying the individual components of the system.
Non-linearity	Minor alterations in the system result in large disproportionate changes elsewhere in the system.
Feedback loops	The outputs of a given system influence future states of the system. The feedback can be positive (producing more of the output), negative (producing less of the output) or balancing (resulting in a steady state).
Adaptation	Systems alter their behaviour in response to their environment or their internal dynamics. Adaptation enables systems to maintain stability, achieve the systems goals or improve system performance over time.
Self-organisation	The emergence of structure within a system without external influence.
Resistance to change	Systems tend to maintain their behaviour, structures and organisation when exposed to external disturbances.

Summarised from: Meadows DH. *Thinking in systems: a primer*. Wright D, editor. London: Earthscan; 2009; Olsson MO, Sjöstedt G. *Systems approaches and their application: examples from Sweden*. Olsson MO, Sjöstedt G, editors. Dordrecht: Kluwer Academic Publishers; 2004; Holden LM. Complex adaptive systems: concept analysis. J Adv Nurs. 2005.

2.4 Researcher's Positionality

Holmes defines positionality as a term which "describes an individual's world view and the position they adopt about a research task and its social and political context"[169]. Hence individuals are inextricable from their social environments and there are multiple personal, social, political and other characteristics which researchers bring to the research process. These shape the entire process of the research enquiry including which research problems are tackled, processes for collecting data, data analysis and interpretation of results[170].

Being reflexive is a crucial factor for ensuring the credibility of my research, particularly regarding the qualitative components of my work. In the conduct of this research, I was conscious of the potential for my experiences and characteristics to introduce areas of strengths or weakness to various aspects of the research process. Therefore, I was reflexive throughout my research in order to identify these actively and mitigate any areas of bias introduced by these characteristics. I have also been open about the potential assumptions and preconceptions I brought to this research work.

I am a Ghanaian-trained medical doctor who has worked in various settings in Ghana. I have been part of a research team carrying out infectious diseases research in a clinical setting in Ghana. This contextual experience improved my understanding of the issues related to research conduct which emerged from this work.

The motivation to undertake this study stems from work I undertook in 2020, at the onset of the COVID-19 pandemic for my MSc dissertation. This work assessed funding for COVID-19 research in resource-constrained countries. The experiences I had while undertaking this work shaped my interest in the area of "research on research" and grew my interest in understanding funding for COVID-19 research in Africa. I was involved in a number of research priority-setting activities during COVID-19 pandemic. I worked with a team to design and implement the collaborative UKCDR/AAS/TGHN study for identifying COVID-19 research priorities for LMICs. I also worked in a similar capacity in the update to the research priorities for Africa, led by the AAS in 2020. I served as an expert consultant for the Africa CDC- led activities to identify policy actions on research priorities for COVID-19 in Africa.

From April 2020 to December 2022, I worked with a data coding and validation team for the UKCDR and GloPID-R COVID-19 Research Project Tracker and led the mapping and analysis of research projects taking place in LMICs. I worked as a Research and Policy Officer with GloPID-R from 2022 to 2024, where I initially supported the activities of a working group of funders seeking to strengthen coordination and practice for research funding in LMICs. I was also involved in work to develop standards for funding clinical trials during disease outbreaks. While conducting this research, I was working on a research funding programme which delivers assessments of funding for research and research-related activities for epidemic-prone infectious diseases and synthesises existing evidence in this area to inform policy actions.

Through my work with research funder coordination initiatives (UKCDR and GloPID-R), I have been exposed to the intricacies of research funding practice, particularly from a funders' perspective. I have also engaged with a broad range of stakeholders in the research ecosystem including: research funding organisations; researchers; ethics review boards and research regulators; advocacy groups; and policymakers.

2.5 Ethics Clearance

Ethics clearance for the qualitative research was obtained from the Oxford Tropical Research Ethics Committee (Reference 508-23) (Appendix E). No ethics clearance was required for the scoping review or the funding tracking analysis.

2.6 Key Considerations in this Work

In reviewing this work, a number of points must be considered. Research is any endeavour which, through the application of systematic processes, leads to the discovery of new evidence, supports existing evidence and raises new research questions for investigation[171]. Considering the broad definition of health, encompassing physical, social and mental wellbeing, and the range of factors which affect health, the scope of research falling into the category of "health research" is broad[50]. For instance, some definitions include economic and behavioural research given their influence on health outcomes[65]. In this thesis, a broad definition of health research was taken and, hence, research across clinical and social sciences disciplines relating to health were considered.

The Africa Union defines Africa to include 55 member states on the continent[172]. Unless specified, "Africa", in this thesis, refers to this definition. In the qualitative arm of this research the WHO Africa region, comprising 47 countries was considered[173]. Researchers in Africa, in this work, means researchers based in research institutions in Africa involved in research taking place in Africa. The qualitative study, which explores researchers' experiences, focuses specifically on principal investigators of COVID-19 research grants.

In each of the following chapters, further detailed methods specific to the relevant research questions are provided.

Chapter 3 - Research Prioritisation for the COVID-19 Pandemic Response: A Scoping Review

3.1 Introduction

Given the myriad of competing priorities and global health threats which require attention, priority-setting can be essential for the efficient utilisation of limited health resources. Diverse approaches to formal health research priority-setting are undertaken and discussed in the literature, including well-known consensus-based and metrics-based approaches[174,175]. For example, the Three-Dimensional Combined Approach Matrix (3D CAM) is a consensus-based priority-setting approach which incorporates values on equity, public health and institutional considerations into the priority-setting process[176]. The Child Health and Nutrition Research Initiative (CHNRI) method utilises a systematic process to generate ordered lists of priorities against specified criteria[174].

Other priority-setting approaches utilise established decision-making methods in their processes. An example is the James Lind Alliance Priority-setting Partnerships which apply the Nominal Group Technique for decision-making in shortlisting priorities[177]. Other approaches are summarised by Yoshida in a 2015 paper which assesses the "approaches, tools and methods used for setting priorities in health research in the 21st century"[178].

Priority-setting can occur at various levels including global, national, regional or local levels. Some approaches are tailored to specific contexts whereas others may be applied across multiple settings. The Essential National Health Research (ENHR) strategy, for example, is oriented toward national-level health research priority-setting[179]. COHRED also set out a process manual for national research prioritisation activities, outlining a systematic process consisting of six steps[180]. In contrast to these, WHO's 2020 research prioritisation

guidance for its staff is applicable across global, regional and other contexts where WHO operates[181]. The guidance also addresses priority-setting in health emergencies including epidemics and pandemics[181].

Varying standards for developing and reporting research priority agenda are used and outlined in the literature. There is a lack of consensus on what constitutes best practice in health research priority-setting across publications and practice. Given the varying purposes for which research priorities are identified and the various contexts where priority-setting might occur, it is likely that there will be a variety of potential "best practices" which will vary according to these contexts.

Some "common themes of good practice" for priority-setting in global health were identified by Viergever et al. in their 2020 paper drawn from evidence from the literature, WHO's priority-setting activities and expert views[182]. Examples are: incorporating plans for monitoring and evaluation into priority-setting processes; involvement of the appropriate stakeholders; acknowledging the relevance of context for priority-setting; and transparency of processes[182].

Speed is likely to be an important factor for priority-setting during outbreak responses, given the urgency introduced by the health emergencies. This could have been the case during the COVID-19 pandemic where various research priority-setting agenda were developed. Among the research priority-setting activities undertaken during the pandemic were the: GloPID-R synergies meetings (July 2020)[36]; long COVID forum organised by International Severe Acute Respiratory Infection and Emerging Infection Consortium (ISARIC) and GloPID-R (December 2020) [35]; and the UN Research Roadmap for Recovery (November

2020)[34]. As in other disease outbreaks, these response agenda sought to identify priority areas for increased research focus for rapid control of the outbreak and its impacts.

Priority-setting in preparedness for disease outbreaks can facilitate the identification of the relevant research to be undertaken prior to the occurrence of an outbreak (in preparedness mode) or be initiated rapidly at the onset of an outbreak, as some specific research questions can only be optimally addressed during an outbreak in real time[141]. An example is research on the effectiveness of various disease countermeasures[141]. This need for rapid evidence during outbreak responses and for proactively planning for outbreak responses is likely to influence the approaches utilised to set research priorities under these conditions.

However, although broad guidance on health research prioritisation is described in the literature[174,181,182], there is limited exploration of their application in responses to outbreaks of epidemic-prone diseases including COVID-19. Further, no study has mapped the scope of COVID-19 priority-setting activities or the approaches to priority-setting. This chapter addresses this gap and examines the research question: "How did the modalities for COVID-19 research prioritisation shape the identification of research priorities and what were the implications for research funding decisions?"

3.2 Aim of Research outlined in this Chapter

The aims of this scoping review were to: map the research prioritisation activities undertaken in response to the COVID-19 pandemic; and describe the methods/approaches used in the research priority-setting processe and the resulting COVID-19 research priorities.

3.3 Methods

This chapter focusses on SARS-CoV-2, the virus causing COVID-19. Data was obtained from a scoping review on priority-setting for preparedness and response to outbreaks of high-consequence pathogens which I led[183]. This review adhered to the guidelines for scoping reviews outlined by the Joanna Briggs Institute[184] and the Arksey and O'Malley framework for scoping reviews[185]. The methods are described under the stages outlined in their guidelines.

3.3.1 Phase 1: Defining Study Scope and Research Questions

Following a non-systematic search of priority disease lists of global and regional scope (where available) and their definitions, high-consequence pathogens were defined as "infectious disease pathogens which cause diseases in humans with the potential to cause outbreaks associated with devastating morbidity and mortality"[183]. A total of 27 high-consequence pathogens (Appendix F) were drawn from: the WHO priority disease list (2020)[186]; Association of Southeast Asian Nations (2021)[187]; Efficient response to highly dangerous and emerging pathogens at the European Union level (2019)[188]; and European Centre for Disease Prevention and Control (2022)[189]. No priority pathogen lists for the Americas or the Africa region were identified at the time this review was initiated.

3.3.2 Phase 2: Identifying Relevant Studies and Consultation Exercise

Search terms were identified for the scoping review using key elements of the review question including the list of priority pathogens, "preparedness", "response", "research priority-setting", their synonyms and related terms, and Boolean operators. Further search terms derived from a Cochrane systematic review on epidemics and pandemics undertaken by Pollock et al. were applied[190].

With support from a medical librarian, a search strategy was developed from a series of preliminary database searches. This was piloted in a subset of databases and refined before the search of all the databases was run (Appendix F). The strategy used text and indexing to identify and retrieve the literature on "research prioritisation for preparedness and response to outbreaks (OR) high-consequence pathogens". There was no date or language restriction. The search was carried out on 16 September 2022 across the following databases: *Ovid Embase*; *Ovid Medline*; *Ovid Global Health*; *Scopus*; and the *WHO Global Index Medicus*. Duplicates from the database search were removed using *Deduklick*[191].

To increase the breadth of data for this review, the database search was complemented with a search of grey literature sources. The grey literature sources searched were *Google Scholar,* the WHO websites and the WHO Institutional Repository for Information Sharing (IRIS). *Google Scholar* and the WHO websites (including IRIS) were searched on 8 November 2022 and 21 April 2023 respectively, using similar search terms to the database search. The *Advanced Google search* function was used to search the *who.int* and *paho.org* websites. Although this search covered both the WHO websites and WHO IRIS, a further manual search of WHO IRIS, using combinations of the search terms, was undertaken to ensure no relevant data was missed.

As recommended in the Arksey and O'Malley scoping review approach, input was sought from an expert stakeholder group, the GloPID-R Research in LMICs Working Group. This group comprises an international group of research funders, supporting research in LMICs, who undertook work to identify lessons from priority-setting during the COVID-19 pandemic in 2022[192]. The group was engaged at a number of virtual meetings held in 2022, where they were requested to suggest references on priority-setting for high-consequence

pathogens for inclusion in the scoping review. From the list of suggested references and the results from the database searches, duplicates were removed before articles were imported into *Rayyan*[193] for screening. Grey literature search results were also deduplicated and exported into *Microsoft Excel* for screening.

3.3.3 Phase 3: Study Selection

Published journal articles (including commentaries, editorials, original research and reviews), reports and roadmaps focussing on global, regional or national priority-setting activities related to the 27 high-consequence pathogens were considered for inclusion. No records were excluded on account of study design, date of publication or language. Non-English records were translated to English with *Google Translate* before screening. Records solely focussed on antimicrobial resistance (AMR) were excluded unless they related to any of the pathogens in scope for this review. The detailed inclusion and exclusion criteria are outlined in Table 4.

Articles were screened for relevance based on their title and abstract followed by a review of full-texts of included articles. The first 100 results from each of the grey literature searches were screened. Screening was undertaken by a review team which I led. Each record was screened by two reviewers with disagreements settled by a third reviewer.

Table 4: Inclusion and exclusion criteria applied in the screening of records in the scoping review

	Inclusion criteria	Exclusion criteria
Pathogens	Records on any of the 27 high-consequence pathogens identified from EMERGE, WHO, ECDC or ASEAN (see Appendix F)	Records primarily focussed on infectious disease pathogens other than the 27 identified from EMERGE, WHO, ECDC or ASEAN
Scope of priority-setting	Records focussing on priority-setting for research on high-consequence pathogens	Records focussing on prioritisation of high-consequence pathogens without a focus on research
Antimicrobial resistance (AMR)	Records on AMR explicitly related to any of the high-consequence pathogens in scope	Records focussing on AMR without a focus on any of the high-consequence pathogens in scope
Scope of infectious disease	Records focussing on human infections	Record focussing on animal infections
Language	No language restriction	
Date/ timing of publication	No date restriction	
Geographical scope of publication	No restriction of geographical scope covered	

3.3.4 Phase 4: Data Charting Process

A data extraction chart was developed, piloted on 15 of the included records and refined for data collection based on feedback from the review team. Each record was double coded with data extraction validated by another independent reviewer. The data collected covered four areas which aligned to the aims of the scoping review: key information; Identified priorities and focus of priority-setting; and approaches used in priority-setting. The specific details are shown in Table 5. Data were extracted directly from the publications for most fields or inferred from details outlined in the publications.

Table 5: Description of key data fields extracted in this scoping review aligned to the research aims

Field	Description
1. Key information	
Title	Title of the article
Date of publication	Date of publication as documented (DD/MM/YY)
Date journal publication received	Date publication received by journal (DD/MM/YY)
Type of publication	Publication type as documented
Type of article	Article type as documented
Author	All named authors as documented
Version of research agenda	Version of research agenda as documented
Duration of research agenda	Duration of validity of research priorities
2. Identified priorities and 3. Focus of priority-setting	
Key focus	Key discipline area of focus
Geographical target	Countries or region(s) for which the priority-setting is designed
Target population	The populations targeted
Broad priority areas	An outline of the broad priorities set
Categories/levels of priorities	Description of how the priorities were further sub-grouped under each of the broad priorities where available
WHO COVID-19 Roadmap priorities	Classification of research priorities to the WHO Research Roadmap for COVID-19
4. Approaches used in priority-setting	
Named methodology employed	Name of method where available
Duration of priority-setting process	Duration in months
Criteria used to group the priorities	Criteria described in grouping priorities
Method used to group the priorities	Methods described in grouping priorities
Criteria for shortlisting priorities	Criteria used for selecting priorities as documented
Mode of consultation	Mode of consultation used
Stakeholders/contributors	Participants involved in the priority-setting
Communication plan	An outline of strategies to be used in disseminating the set priorities
Processes for M&E	An outline of key M&E activities planned/undertaken for the set priorities
Review period	Indicated planned timeline for review of progress
Responsible entities	Description of entities responsible for the M&E and any regulations or plans for M&E

To explore the focus of the research priorities set, the priority areas/topics extracted from the publications were mapped to the broad research areas outlined in the WHO COVID-19 Research Roadmap (Appendix A)[33]. This provided a standard ontology for research categorisation to which the extracted lists of priorities could be grouped under. Further, it enabled the aggregation and comparison of the identified priorities across the publications reviewed. For each publication, the priorities identified were assigned to one or more of the research areas in the roadmap. For this assignment, the "key focus" field was also reviewed to provide further context for the analysis.

In each case, the broad focus of the publication and the lists of priorities extracted were assigned to one or more of the nine areas outlined in the WHO Research Roadmap or assigned to "N/A" if none of the areas were covered. The occurrence of a broad theme in the priorities listed in publications was designated "1" and the absence was labelled "0". A summary of areas covered was obtained by summing up the number of occurrences.

The Phi coefficient measures the association between two binary variables[194] and, as such, was used to quantify the relationship between the research areas covered in the research prioritisation publications. I calculated Phi coefficients for each pair of research areas. Each coefficient was computed based on the presence or absence (coded as 1 or 0, respectively) of research priorities under each of the nine WHO research priority areas. The resulting matrix of Phi coefficients was then visualised using a heatmap to provide a comprehensive overview of how each pair of research areas was related.

To extract data on the approaches used in priority-setting, a short description of the priority-setting methods based on the processes outlined in the research prioritisation publications

was generated from each publication. From this, the publications were grouped by number of modalities applied before specific details were analysed. Descriptions of intended monitoring and evaluation plans for priority-setting and plans for disseminating outputs from the research prioritisation activities were extracted.

For all data extracted, "not stated" or "no description" was used when no information was available on the relevant field across the publications. Data extraction, processing and validation was done in *Microsoft Excel.*

3.3.5 Phase 5: Collation and Summary of Findings

I undertook descriptive analyses of the subset of data retrieved for this scoping review which focussed on SARS-COV-2. I calculated frequencies of the categorical variables extracted and, where relevant, compared them to priority-setting activities undertaken for the other high-consequence pathogens. Descriptive statistics were used where appropriate. All data related to time and durations (e.g. the duration of priority-setting, date on which journal articles were received by journal, and date of publication) were converted to months before analyses. Qualitative data extracted on the content of the priorities set, dissemination plans and plans for monitoring and evaluation were categorised by theme and described.

The protocol for the broader review on high-consequence pathogens outlined the process for conducting the scoping review in detail[183]. Minor alterations were made in the data collection for the review. The prior published protocol included a search of *Overton* (a database for policy documents) and a review of backwards citations of the included articles. However, due to limited resource in the review team for processing the large number of articles identified from the database search, two amendments were made to the published review protocol. The search of *Overton* and a review of backwards citations of articles were

not done. To address potential limitations introduced by these changes to the scope of publications considered for the scoping review, a search of the WHO websites and consultations with the expert stakeholder group were introduced.

3.4 Results

The process of literature search and study selection are presented in a Prisma ScR diagram, Figure 7. Following deduplication, of the 7,502 records identified from the search of databases and the addition of the references obtained from the reference group, 4,339 records remained. Screening these and the records obtained from the grey literature against the inclusion and exclusion criteria led to the identification of 125 publications on research prioritisation for high-consequence pathogens.

Priority-setting for High-consequence Pathogens

The priority-setting records identified were published from 1975 to 2022. Figure 8 shows the distribution of these publications over time. Most (62.4%, n=78/125) focussed on SARS-CoV-2 followed by Ebola virus (5.6%, n=7/125) and Epidemic/pandemic influenza viruses (4.8%, n=6/125).

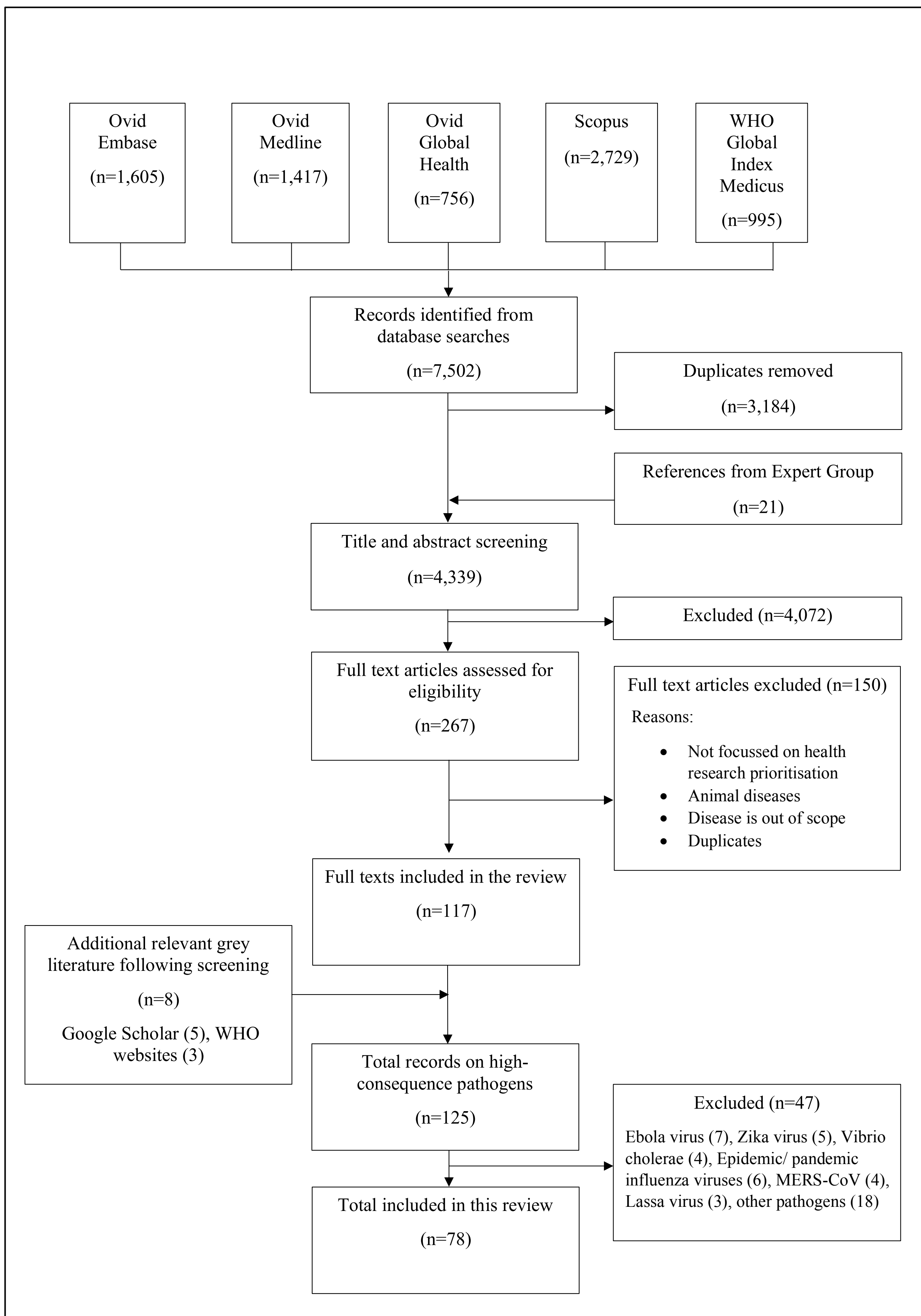
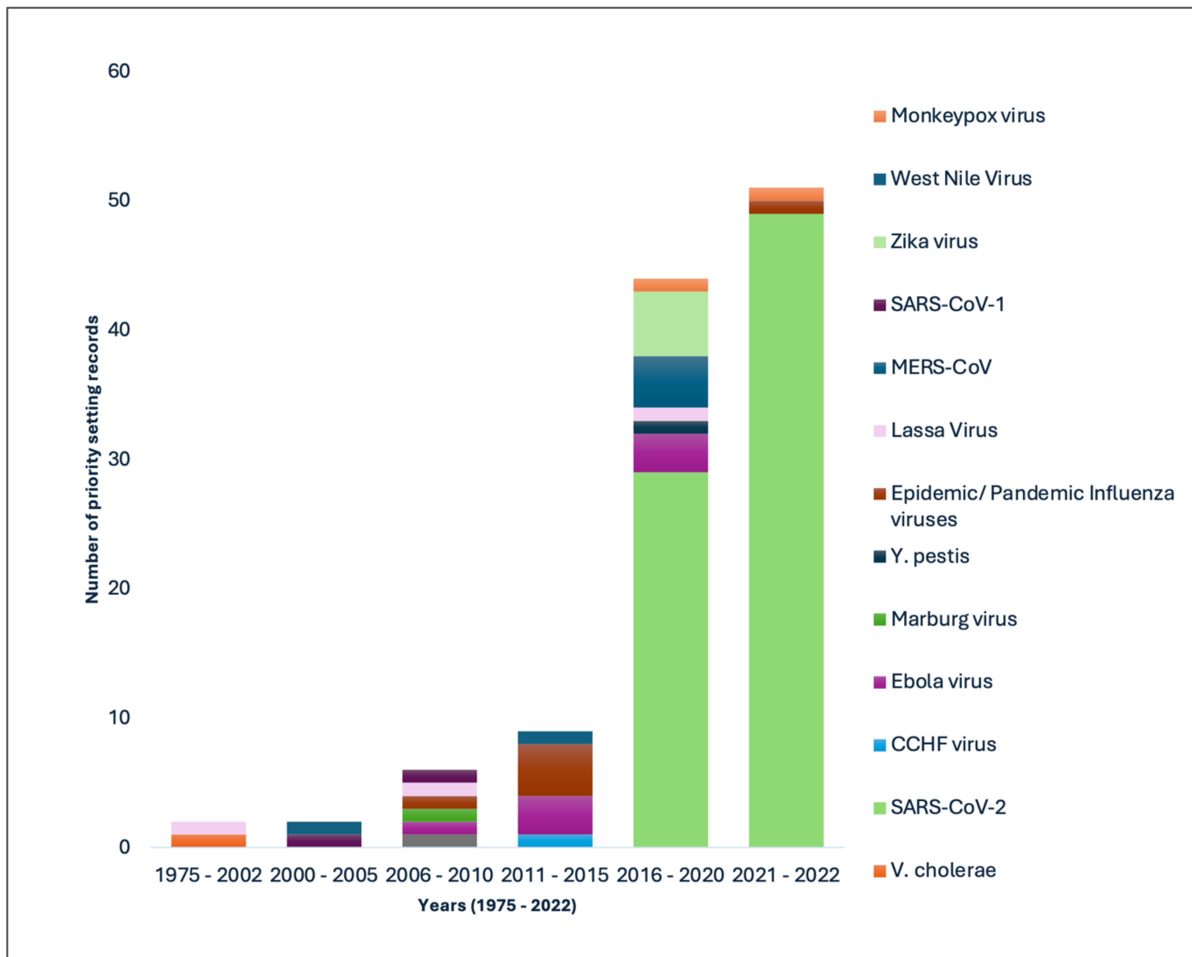


Figure 7: Prisma ScR diagram of study selection for this scoping review



Publications on Epidemic/pandemic influenza virus: Pandemic Influenza A - (**H1N1**; 2009, 2011, 2012, 2015, 2021); Low Pathogenic Avian Influenza **H7N9** (2013); Swine Influenza A (2011); (**H3N2**; 2021); Highly Pathogenic Avian Influenza **H5N1** (2011, 2015)

Figure 8: Distribution of research prioritisation publications on high-consequence pathogens categorised by pathogen focus over time (1975 - 2022)

COVID-19 Research Prioritisation Records

Of the publications focussed on SARS-CoV-2, 88.5% (n=69/78) were journal articles and 11.5% (n=9/78) were reports. Most of the priority-setting activities were published in 2021 (43.6%, n=34/78), followed by 2020 (37.2%, n=29/78) and 2022 (19.2%, n=15/78) as seen in Figure 9.

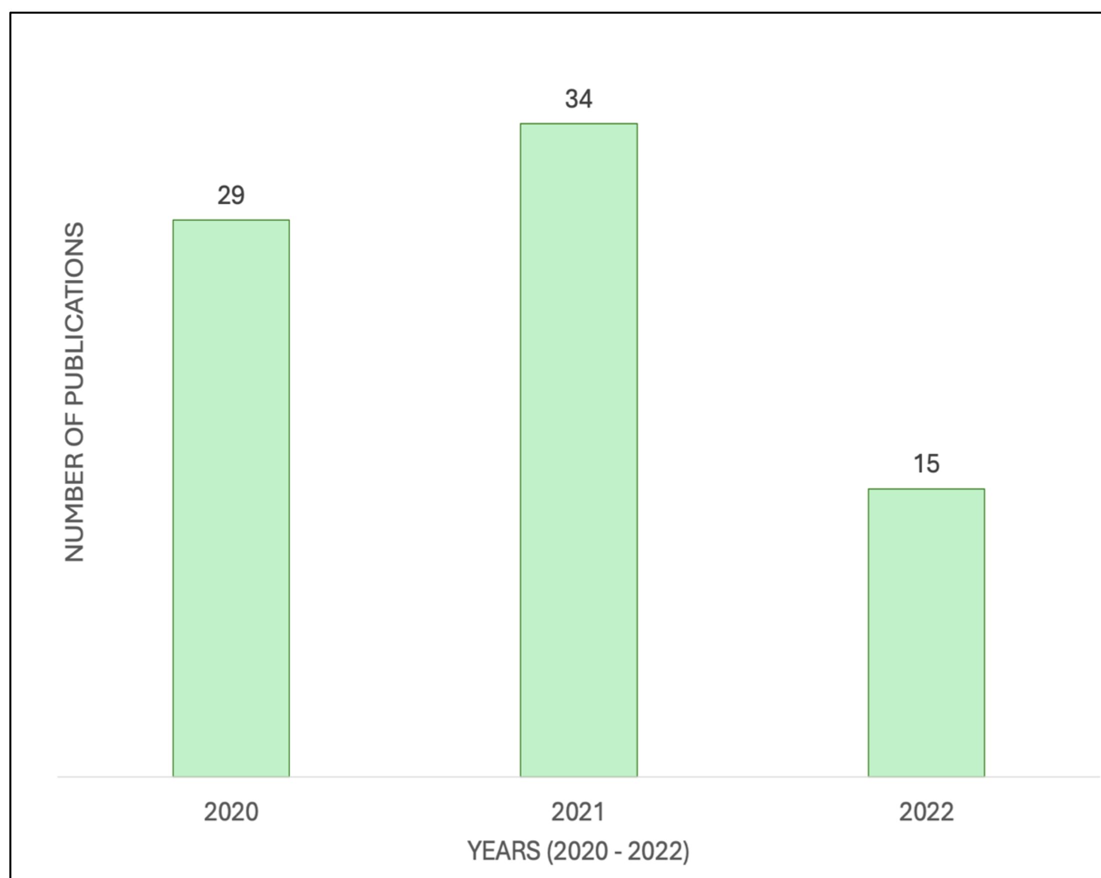


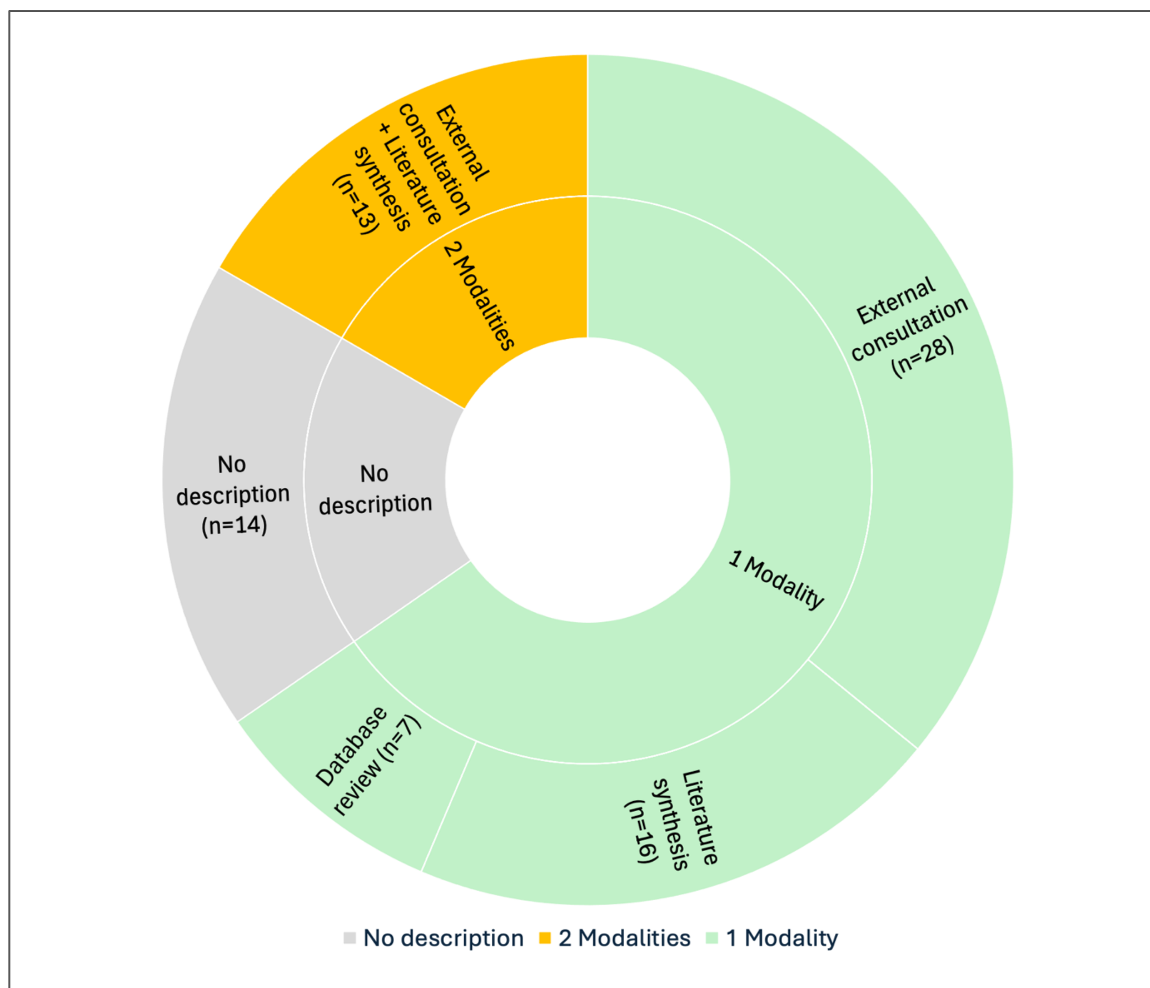
Figure 9: Distribution of COVID-19 research prioritisation publications by year

3.4.1 Approaches to COVID-19 Research Priority-Setting

Three key modalities for priority-setting were identified as seen in Figure 10: external consultation, literature synthesis and database review (analysis of various databases on COVID-19 research to identify research gaps). In 65.4% (n=51/78) of the publications, one modality was applied whilst two modalities were applied in 16.7% (n=13/78). In 17.9% (n=14/78) of publications, there was no description of the approaches used to set research priorities.

The priority-setting activities involving external consultations (52.6%, n=41/78) were via one or more of the following: surveys (n=25), meetings (n=49) and interviews (n=9). These activities took place in person (n=2), online (n=21) or using both modes of

consultation (n=2). In 39.0% (n=16/41) of publications, the mode of consultation was not stated. Publications applying literature synthesis (37.2%, n=29/78) involved: literature reviews (n=21), scoping reviews (n=2) or systematic literature reviews (n=6). The publications which involved the engagement of stakeholders in the priority-setting processes (79.5%, n=62/78) named multiple stakeholders. In most publications, these were stated as being "experts" (n=53), followed by "researchers" (n=11) and "policy makers" (n=6).



Description of approaches: External consultations - involvement of individuals, groups, or organisations in the research priority-setting process; Database reviews - assessments of research gaps from analyses of various databases which collated information on research; Literature synthesis - reviews of evidence from published studies

Figure 10: Approaches to research prioritisation identified from COVID-19 research prioritisation publications

In some publications, specific research priority-setting approaches were named. These were CHNRI (n=3) and ENHR (n=1). On average, priority-setting activities for COVID-19 took 2.6 months (SD ± 1.4 months). In 69.2% (n=54/78) of publications the duration of priority-setting activities was not stated.

Approaches for Grouping Priorities

Research prioritisation took place over multiple stages in the records reviewed. In 33.3% (n=26/78) of publications, the methods of grouping priorities identified were not stated. Pre-defined categories (29.5%, n=23/78), grouping based on emergent areas (24.4%, n=19/78) or a combination of both emergent and pre-determined categories (12.8%, n=10/78) were used.

Approaches to Shortlisting Priorities

The approach to shortlisting priorities from various options identified was not stated in 71.8% (n=56/78) of publications. Where stated, shortlisting was done by ranking (25.6%, n=20/78), selection by experts (1.3%, n=1/78) or thematic analysis to identify emergent themes (1.3%, n=1/78). Ranking of priorities was done by scoring, voting or rating (n=17); expert judgement (n=2); frequency of occurrence (n=2) and assessment made by digital software (n=1). Of the publications which ranked the priorities identified, weighting was done to determine areas of higher or lower priority (n=5).

Criteria for priority-setting

Multiple criteria were mentioned in the publications reviewed and were applied at various stages of priority-setting. They were either stated as the criteria for COVID-19 research priority-setting (where no shortlisting processes were described) or formed the basis for

shortlisting identified priorities from a number of options. The most common criterion stated was "need" (n=56). Among the other criteria stated were "Impact", "feasibility", "relevance" and "equity". No priority-setting criteria were stated in 12.8% (n=10/78) of publications.

Only 12.8% (n=10/78) of publications included a communication plan for the research priorities set. The modalities for dissemination were either via stakeholder engagement (n=3) or publication on websites (n=7).

When only the 69 journal publications included in the review were analysed, 44.9% (n=31/69) did not include information on the date publications were received by journals. The average time taken from the date publications were received by the journal to the date of actual publication was 3.8 months (SD±3.8months). When the records published in 2020 (mean = 2.9 months, SD±3.3months) were compared to those published in 2021 (mean = 4.9 months, SD±4.3months), there was no statistically significant difference in the mean duration from the receipt of the publication by the journal to its actual publication ($t(36) = -1.67$, $M_{diff} = 2$, $p=0.104$, 95% CI [-0.44, 4.49]).

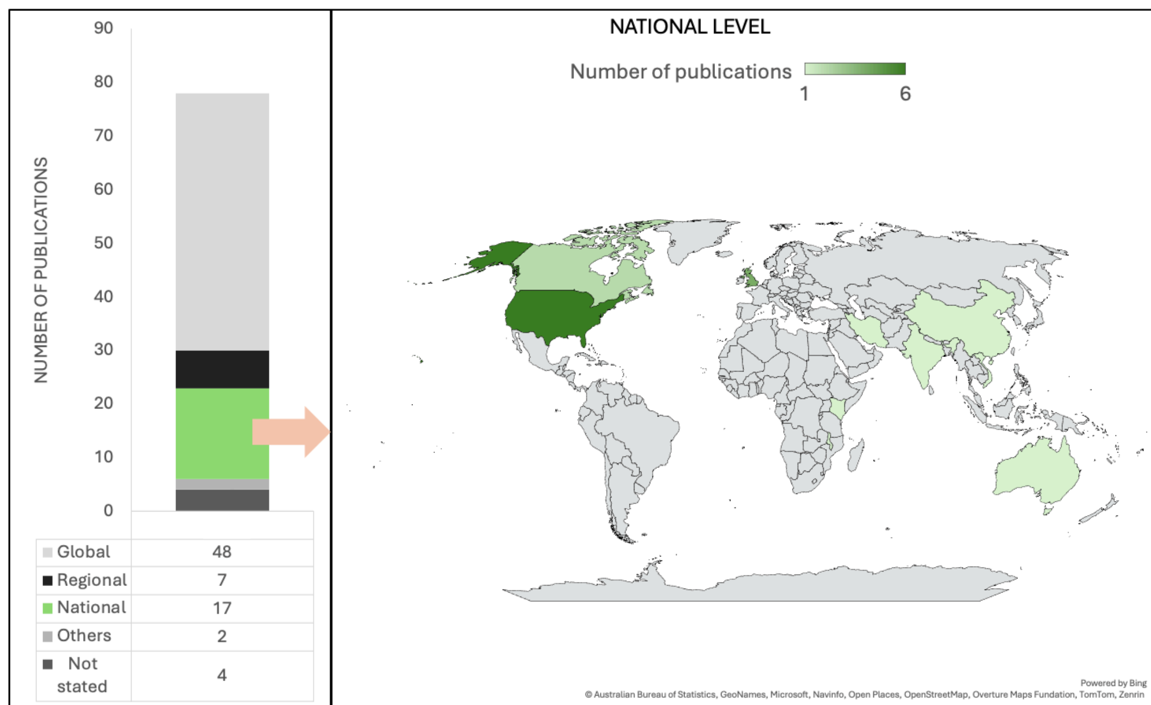
In 91.0% (n=71/78) of the publications, there was no description of plans to monitor progress against the COVID-19 research priorities identified. The publications that did were all in a series of living reviews of funded COVID-19 research.

3.4.2 COVID-19 Research Priorities Identified

Most (61.5%, n=48/78) of the publications were of global scope. The publications targeting the regional level (9.0%, n=7/78) focussed on Africa (n=4), Europe (n=2) and Asia (n=1).

National level priority-setting publications mostly targeted the United States, United Kingdom and Canada, as seen in Figure11.

In 78.2% (n=61/78) of the publications, no target populations for the priorities set were identified. Children, pregnant women, women and healthcare workers were among the target populations listed in the remainder of the publications. The intent of priority-setting was "response" in 57.7% (n=45/78) of publications, "preparedness" in 5.1% (n=4/78) of publications and "preparedness and response" in 37.2% (n=29/78) of the priority-setting publications identified.



Some publications targeted more than one level. Publications focussing on "others" targeted LMICs

Figure 11: Geographical distribution of target locations named in COVID-19 research prioritisation publications

The trend over time for these publications is shown in Figure 12. Most prioritisation publications in 2020 were for "response only" and from 2021, publications focussed on

“preparedness only” were identified. Across the two-year period some publications focussed on both “preparedness and response”. All the records reviewed were published after the declaration of COVID-19 as a PHEIC. The earliest record was published 14 days after the PHEIC declaration.

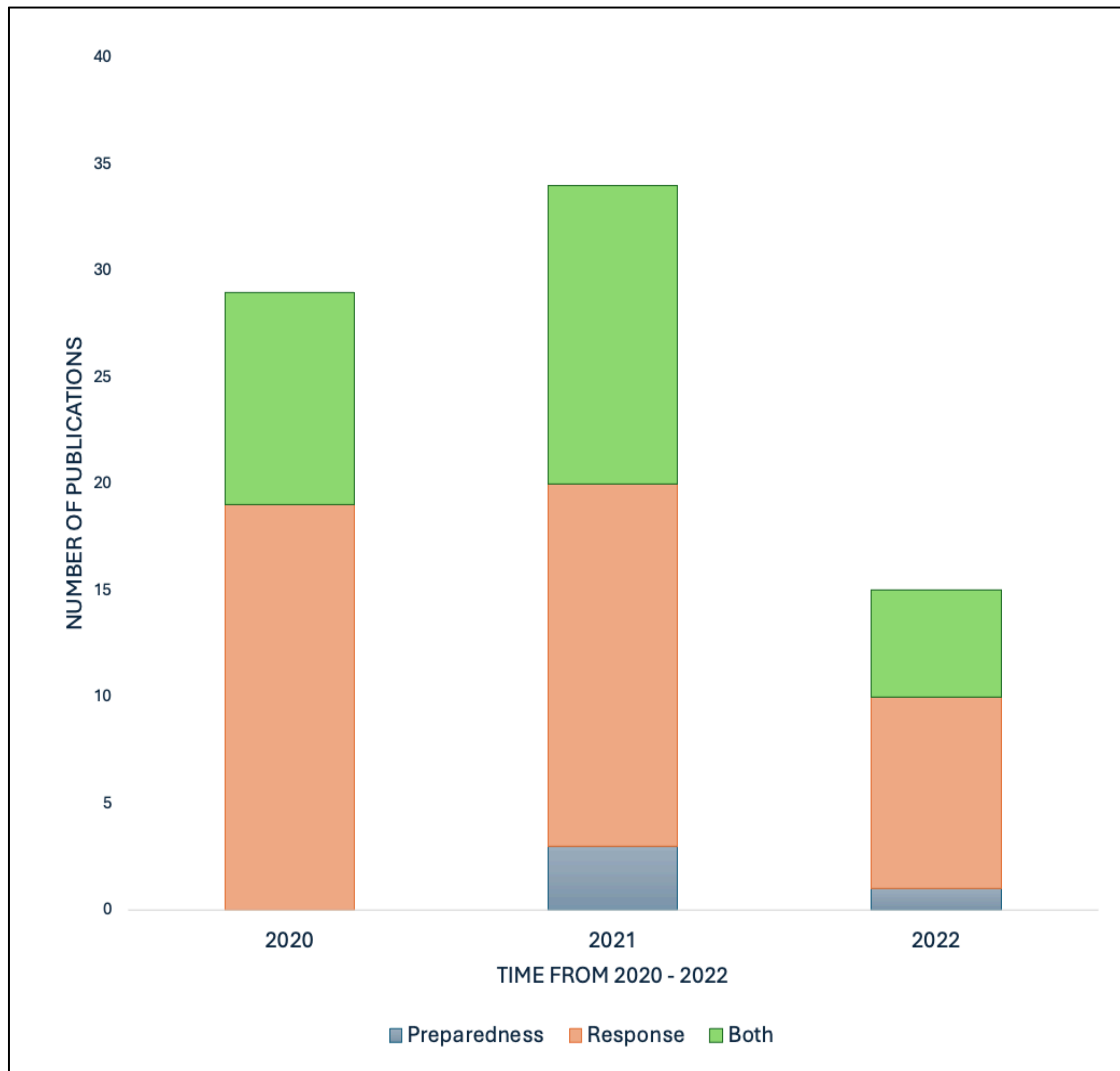
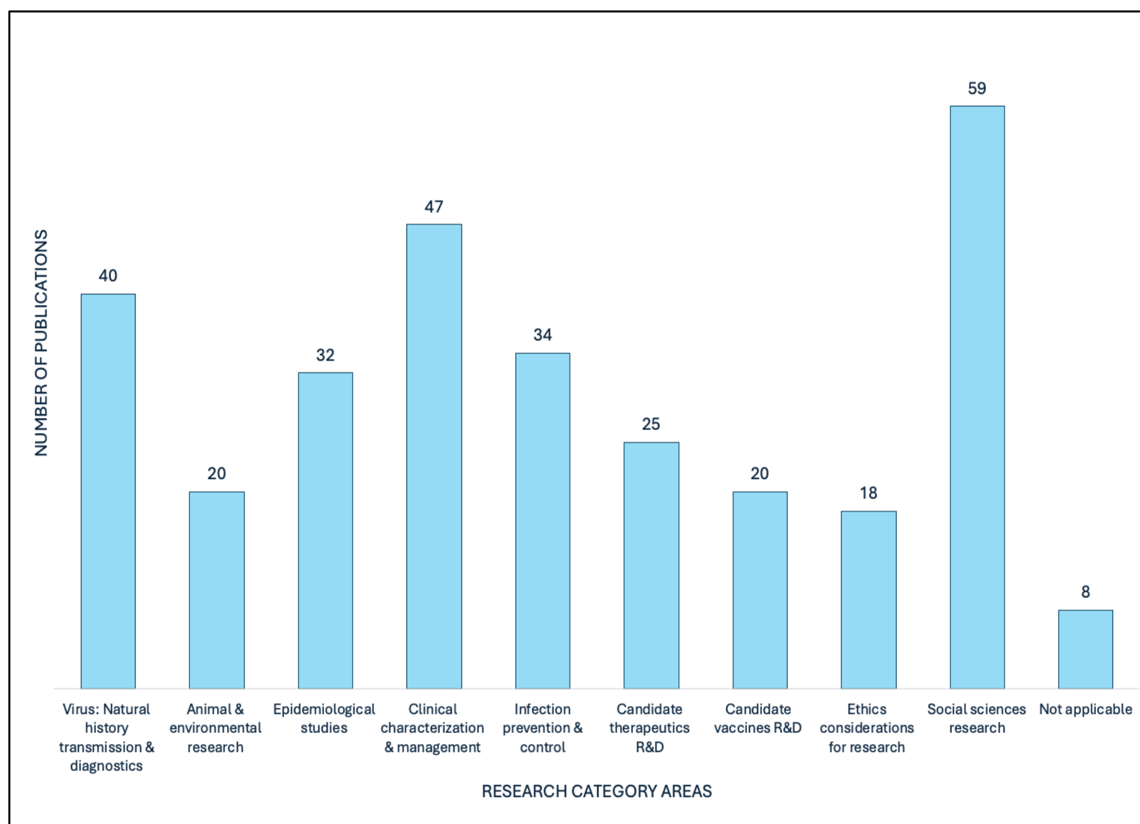


Figure 12: The focus of COVID-19 research prioritisation activities over time

When mapped to the broad category areas outlined in the WHO COVID-19 Research Roadmap, the COVID-19 research priorities focussed on multiple broad research areas as shown in Figure 13 by the wide distribution across categories. On average, each priority-

setting publication mapped to four areas. The priorities set covered a similar scope of areas regardless of whether they were set for preparedness or response. Most publications included priorities which focussed on "social sciences" followed by "pathogen: natural history, transmission and diagnostics" and "clinical characterisation and management". The area captured least in the publications was "ethics considerations for research".

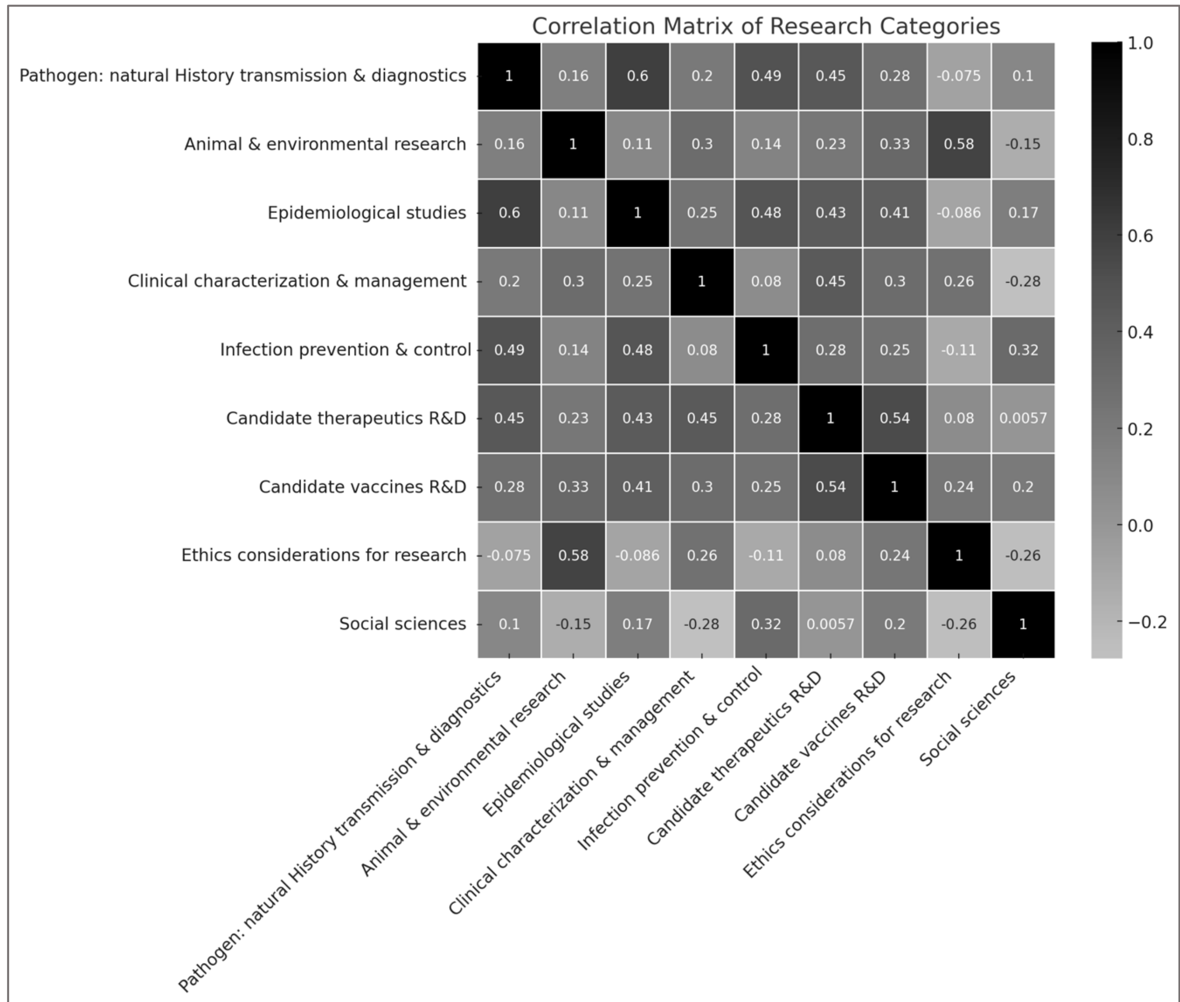


Each publication could include priorities in one or more areas.

Figure 13: Research priorities for COVID-19 mapped to the research areas outlined in the WHO Coordinated Global Research Roadmap for COVID-19

Figure 14 summarises relationships between pairs of research areas covered in each research prioritisation publication. "Pathogen: natural history, transmission and diagnostics" showed positive association with "epidemiological studies". Similarly, "candidate therapeutics

R&D” and “candidate vaccines R&D” and “ethics considerations for research” and “animal and environmental research” respectively were positively associated. “Social sciences in the outbreak response” consistently showed negative or no association across the other research areas.



Each publication could include priorities in one or more areas.

Figure 14: A matrix constructed using Phi Coefficients showing the relationships between the nine research areas covered in the COVID-19 research prioritisation records included in this scoping review

3.5 Discussion

SARS-CoV-2 was the dominant pathogen of focus for the research prioritisation activities for high-consequence pathogens identified from 1975 - 2022. This finding was unsurprising as the COVID-19 pandemic triggered a major global response due to the novelty of SARS-CoV-2 and the limited existing countermeasures for IPC when it emerged. This finding might also reflect more recent developments in information sharing technologies which were less developed during other past pandemics[195]. Furthermore, other recent severe outbreaks were not as prolonged and widespread as the COVID-19 pandemic and possibly led to less research output[196].

This scoping review showed the breadth of research prioritisation activities undertaken in response to the COVID-19 pandemic. The identified approaches to priority-setting including application of reporting standards, plans for monitoring and evaluation and communication of priorities set and their implications for policy and practice during the pandemic are discussed.

3.5.1 Approaches to COVID-19 Research Priority-Setting

In this analysis, a variety of approaches to setting research priorities for COVID-19 were identified. The literature on health research priority-setting shows similar diversity in practice[178]. For instance, a review of global priority-setting activities at the WHO from 2002 - 2017 showed various methods had been applied to identify health research priorities over the period[197]. A systematic review by Lund et al. in 2022 also suggested a lack of consistency in practice and showed a wide range of priority-setting approaches[198].

In the analysis of approaches used for COVID-19 research priority-setting, publications were grouped into those applying external consultations, database reviews or literature synthesis. These three broad approaches are examples of modalities for identifying research gaps. Literature synthesis utilises information available in published evidence to determine research gaps whereas external consultations draw on external stakeholders' expertise in arriving at research gaps. The database reviews identified in this study reviewed data on funding committed to COVID-19 research to determine underfunded areas which could constitute research gaps[199–205].

External consultation, which was the most frequently used approach for COVID-19 research priority-setting identified, was similarly the most frequently identified method in other reviews of health research priority-setting outside the pandemic[197,206]. The main modes of external consultation were meetings, surveys and interviews. While all these facilitate the sourcing of a range of views from the relevant stakeholders, meetings, in particular, have the added advantage of facilitating real-time collaborative engagement of stakeholders[207]. Further, meetings often occur over a set period and are, therefore, enabling of rapid priority-setting processes, which is crucial in the context of responding to disease outbreaks.

Most external consultations were held online and this could be explained by the increase in utilisation of virtual communication platforms during the pandemic as movement restriction policies were implemented[208]. Although these platforms could have improved the participation of often excluded groups in consultations[37,209], their effectiveness would depend on the deliberate targeting of these groups. Furthermore, the utilisation of these platforms can be hindered by unstable internet connectivity, limited access to the requisite

hardware and software, and other technical failures, which could impact effective participation and collaboration in the consultations[210].

Beyond naming stakeholders as "experts", there was limited specificity of which stakeholders were involved in the priority-setting publications reviewed. Neither were there justifications of their inclusion consistently stated. Limited knowledge of which perspectives are represented in priority-setting could challenge the perceived validity of research agenda developed and inhibit their uptake for decision-making.

The inclusion of the "right voices" in priority-setting activities is a recommended practice in the literature on effective health research priority-setting, as it enhances the potential for the activities to identify the pertinent areas of need to be prioritised from the perspective of the relevant stakeholders concerned[182]. Seeking views from diverse individuals or groups is also recommended[181]. However, this can be particularly challenging in the context of an acute outbreak response where prompt action is required. An approach to offset this challenge could be to identify and convene potential stakeholder groups as part of preparedness activities, in advance of outbreaks[192]. These pre-defined groups could then be rapidly consulted when an outbreak occurs.

Literature synthesis was the next most frequently described approach to COVID-19 research prioritisation. It involves the systematic aggregation of evidence on various research areas from multiple literature sources over various time frames to identify gaps in knowledge[211]. The effectiveness of literature synthesis is influenced by its design and conduct, including the determination of scope, screening criteria for the literature and processes for synthesis of evidence, and the quality of evidence assessed.

Furthermore, the extensive time and resource demands of literature synthesis could hinder rapid priority-setting in outbreak responses. Rapid evidence synthesis approaches are described in the literature and are defined by Cochrane to involve “speeding up the ways we plan, do, and/or share the results of conventional structured (systematic) reviews, by simplifying or omitting a variety of methods”[212]. An example of a method suited for outbreak response is the Rapid Research Needs Appraisal methods (RRNA) developed by Sigfrid et al. RRNAs extract evidence on pre-defined research areas utilising workflows across time zones in a pre-positioned global research team[213]. The evidence obtained is then reviewed by disease experts to define the pertinent research gaps[213].

The combination of published evidence reviews with expert input was similarly identified in this scoping review where two modalities were used. In these publications literature synthesis either preceded the expert consultations and provided evidence from which further expert input was obtained or followed expert consultations which defined specific focus areas for the literature synthesis.

Only a few publications applied the specific health research priority-setting methods such as a CHNRI and ENHR methods. This could indicate a limited application of these for COVID-19 research priority-setting. There was significant variation in the durations of the research priority-setting activities for COVID-19. Further analysis to assess for differences in duration, comparing between specific approaches applied or the durations over the course of the pandemic could not be done due to limited data on the duration of priority-setting activities reported in the publications reviewed.

Following the identification of priority areas, 76% of the COVID-19 research priority-setting publications did not report any approaches for shortlisting from the areas identified. In these publications it is possible that shortlisting processes were undertaken (and details not reported) or that shortlisting was not undertaken. Further weighting to enable the identification of the relative importance of various areas prioritised was not undertaken in the majority of the publications reviewed. This results in priority-setting activities producing a menu of choices rather than identifying specific areas to inform resource allocation. This could limit the potential usefulness of the priorities set for informing action, particularly during outbreak response.

From the COVID-19 research priority-setting publications identified, priority-setting activities broadly involved several stages: an initial stage for identification of priority areas, followed by grouping the identified areas and finally shortlisting from the list of identified priorities. In this analysis, I found significant variation in the details on approaches to priority-setting for COVID-19 reported. The findings also show a decline in the available information over the stages of priority-setting (i.e. from identification of priority areas to shortlisting and weighting).

On the whole, my analysis shows the reporting on approaches to research priority-setting during the COVID-19 pandemic were not adequate. This is consistent with findings of other reviews of priority-setting for health research (outside the context of an outbreak) where reporting was similarly found to be inadequate[214,215]. This review also suggests limited application of the existing reporting standards for health research priority-setting including the "Reporting guideline for priority-setting of health research (REPRISE)"[216], during the pandemic. The application of this and other guidelines could improve the transparency of

processes and boost the perceived credibility of the priority-setting activities in future outbreaks.

3.5.2 Communication, Monitoring and Evaluation of Priorities

The processes for sharing and distributing information can involve various channels including journal publications, social media, meetings and other modes of communication[217]. Timeliness of knowledge dissemination is a key factor to be considered in effective communication, particularly during a pandemic where knowledge is required for informing effective responses[218]. The finding of most COVID-19 priority-settings activities to have been published in 2021 might indicate the normal trend in knowledge dissemination where there is a lag between knowledge production and when results are formally published as journal articles or reports. When only the journal articles were considered, there was a notable variation in the time from when the journal articles included in this scoping review were received by the respective journals and when they were actually published during the pandemic. While it took days for some priority-setting articles to be published following submission to journals, others took over a year.

During the pandemic editorial processes were reported to have been altered to facilitate rapid dissemination of knowledge[218]. The findings of this review suggest this to also have been the case for the journal publications on priority-setting reviewed. On average, time to publication in 2020 was found to be shorter than the time to publication in 2021 and this could indicate expedited journal processing activities during the acute phase of the pandemic. However, no statistically significant differences were detected in a paired t-test of these average durations. This assessment was also limited by insufficient data as only 55% of priority-setting publications had details on “date received by the journal” reported.

This could be an area for further work to gain insights into publication practices during the pandemic.

Beyond these publications, only a few records reviewed indicated wider plans for dissemination of the priorities set, listing websites, stakeholder engagement and information briefs among planned activities. The lack of details on dissemination does not preclude other information sharing activities (beyond publishing as journal articles and reports) which might have been undertaken but were not reported in the priority-setting publications reviewed. This scoping review did not include specific search terms related to dissemination of information during data collection. However, as broad search terms on COVID-19 priority-setting were used, it is unlikely that specific publications on priority-setting *and* dissemination activities were missed.

The stakeholders and intended users of the priority-setting activities are likely to influence the approach taken to dissemination of outputs[181]. It is essential that modes of communication suited to intended audiences are selected as ineffective dissemination of information could result in unnecessary repetition of prioritisation efforts and could also constrain the application of the identified priorities.

Tracking progress made against priorities identified is important for making assessments of persisting research needs and evaluating the impact of the prioritisation activities. This was well demonstrated during the pandemic where living reviews of research and research funding commitments influenced the allocation of resources for research[37]. My Scoping review revealed limited M&E in relation to COVID-19 research prioritisation activities. This might reflect the dearth in evidence on how to incorporate M&E into priority-setting

exercises in practice despite M&E being recommended in guidance for health research priority-setting[181]. Key factors to consider may include resource availability, timing of potential M&E activities, stakeholders prioritised and the responsible entities for M&E activities[181].

3.5.3 COVID-19 Research Priorities Identified

Most of the priority-setting publications were of global scope which could be explained by the immense global impacts of the pandemic. Another possible explanation could be that global agenda are more likely to be published and results disseminated, making them more accessible and, hence, findable in this review.

The diversity of contexts for which priorities are set is shown in this analysis which found COVID-19 priority-setting activities targeted global, regional or national levels. Similarly, the populations targeted were varied and included children, pregnant women and healthcare workers. There was insufficient data on populations targeted in the publications reviewed and this was a constraint for assessing the scope of COVID-19 research priorities among specific groups. Nevertheless, it is important for priorities set at any level to be carefully considered when being applied in various settings[182]. For instance, in the application of global priorities set at the national level, effort must be made to contextualise the priorities to avoid misrepresenting the needs of populations at the national level[219].

Predictably, the purpose of priority-setting of the majority of publications was “response” as SARS-CoV-2 was a novel pathogen with limited evidence for disease prevention and control. It was notable that some publications were for both “response” and “preparedness”. This could indicate that even in acute response mode some priority-setting exercises were

also focussed on longer-term research priorities and were planning in advance of future needs (related to the then ongoing COVID-19 pandemic or future outbreaks).

COVID-19 research priorities fell into multiple broad research category areas demonstrating the breadth of areas covered in the publications reviewed. This was expected, given that outbreaks are complex and likely to require research involving multiple disciplinary areas. Linkages between research areas could explain the positive association between publications listing priorities on "candidate therapeutics R&D" and "candidate vaccines R&D", and "pathogen: natural history, transmission and diagnostics" and "epidemiological studies" respectively. Common elements of research exist between these pairs of categories and could account for the association identified. For instance, vaccines and therapeutics research both focus on pharmaceutical countermeasures to disease, and epidemiological studies involve studying elements of disease transmission.

Notably, there was no positive association between priorities in the social sciences category and the other research categories to which they were mapped. This finding likely highlights the practice where social sciences research is often undertaken as independent research endeavours rather than being integrated across other research disciplines. Interdisciplinary research strengthens the evidence identified by providing a more complete view of the research areas investigated, particularly for complex problems such as disease outbreaks[220]. The siloed approach identified in this work could result in inefficient use of resources, limited research application and impact, and stifled research collaboration which are detrimental for research effectiveness[221].

The different priority-setting activities reviewed in this work reported the outputs of the priority-setting exercises in a variety of ways. There was no consistent approach identified. While some activities reported broad research areas to consider, others provided very specific research topics or questions. Others still provided a combination of both. The WHO COVID-19 Research Roadmap framework provided a standard to which the identified priorities on COVID-19 were mapped. This mapping allowed for aggregation of the individual priority areas identified for further analyses of the scope and coverage of priorities set for COVID-19 research. It also demonstrated the usefulness of standardising reporting of outputs of priority-setting activities as discussed by Terry et al[197] in an analysis of priority-setting at the WHO. An additional benefit of standardised reporting discussed in their paper is that it allows for comparisons of priority areas between multiple diseases which could be informative for influencing policy and practice. Further, it could also enable comparison of research priorities over time to assess for the evolution of research needs during the course of an outbreak[197]. However, such an analysis was out of the scope for this work.

While this scoping review provides an analysis of research priority-setting during the COVID-19 pandemic, a number of limitations must be considered in the interpretation of the results. The broader review from which data were obtained on COVID-19 research priority-setting, with results presented in this chapter, considered global and regional priority-setting for high-consequence pathogens. Therefore, the results presented are more representative of global or regional priority-setting activities than those at other levels.

Phi coefficients were used to quantify the relationship between pairs of COVID-19 research priority areas extracted from the publications reviewed. It is important to note that this coefficient primarily detects associations between binary variables. Thus, the absence of a

significant coefficient does not preclude the possibility of more complex multi-dimensional relationships between the research categories. The exploration of these more complex relationships, which would require additional methods to uncover, was not within the scope of this study.

3.6 Chapter Summary

Given the finite resources available for supporting research, prioritisation is necessary to identify the areas to channel resources to obtain evidence for guiding policy and practice. This is especially pertinent in the context of a health emergency where opportunities for certain types of research are unpredictable and time-limited.

This scoping review found multiple priority-setting activities were undertaken during the COVID-19 pandemic focussing on acute response to the pandemic and longer-term preparedness efforts for future disease outbreaks. These activities were mostly of global scope with some publications focussing on regional or the national level. Most priority-setting activities were published in 2021.

The activities used a wide range of methods and approaches including well-recognised consensus-based approaches such as CHNRI and ENHR. The majority of activities did not report sufficient details of the approaches used to set priorities, indicating a lack of transparency of efforts. Experts were consulted in many of the activities identified in this review. However, few publications outlined a clear description of experts who were involved in processes or provided sufficient justification for their selection.

An assessment of lists of research priorities generated showed varied practice with some publications outlined under broad research types while others randomly listed priority research questions. The large breadth of research areas covered in the publications reviewed reflect the scale of the pandemic which, being caused by a novel pathogen, required extensive research to inform IPC measures.

Taken together these findings indicate a lack of transparency in reporting on approaches taken to set COVID-19 research priorities during the pandemic. There was also limited application of reporting standards for health research priority-setting and this has implications for the perceived credibility of the priority-setting exercises and the comparability of priorities set across publications.

Given that priority-setting is a resource-intensive endeavour, it is essential that efforts be made to improve the uptake and utilisation of its results to inform actions, particularly in acute response. In the next chapter, I assess the scope of funding commitments made to research during the COVID-19 pandemic response in Africa. I also assess how the priority-setting activities analysed in this chapter were represented or otherwise in the actual investments made by funders during the pandemic.

Chapter 4 - Assessment of the Landscape of Funded COVID-19 Research in Africa

This chapter is based on a published article[222]:

Antonio E, Alobo M, Bayona MT, Marsh K, Ariana P, Norton A. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023.

4.1 Introduction

The COVID-19 pandemic triggered a massive research response associated with a significant increase in global investments in health R&D[223]. Monitoring investments into health research is important for improving coordination among research stakeholders, identifying research gaps and promoting transparency across the research landscape[53]. At the global level, there was significant waste in the allocation of funds to COVID-19 research resulting in the funding of low-powered, poor-quality studies, and significant duplication of response efforts[32].

There have been few assessments of the COVID-19 research landscape in Africa. To my knowledge, the only one focussing on funding investments committed to research was the one I undertook in 2020, which found that the limited funding for COVID-19 research in Africa failed to address the region-specific research priorities as of October 2020[153]. Various priority-setting activities focussing on identifying the most urgent research priorities for Africa were conducted between 2020 and 2022. Since October 2020, no study has assessed how funds committed for research in Africa aligned to the identified priorities. There has

also not been any studies which have mapped the scope of research funding to gain an understanding of the breadth of research undertaken during the pandemic response.

To address this research gap, this chapter answers the research question: “What was the landscape of funded COVID-19 health research in Africa and how did research align to the WHO global and Africa regional COVID-19 research priorities?”.

4.2 Aim of Research outlined in this Chapter

The aims of this mapping review were to: identify and characterise the funders of COVID-19 health research in Africa; identify researchers and research institutions funded to undertake this research; assess the trends in research funding over time; and analyse how the funded research areas reflect the global and regional COVID-19 research priorities.

4.3 Methods

4.3.1 Data Source

I reviewed a number of databases collating data on funding for COVID-19 research when I began this work. Descriptions of some of these are shown in Table 6. Most of the research trackers were not suitable for addressing the research problem addressed in this chapter as they either had a narrow breadth of focus (in terms of research areas covered and funders represented) or were not open-access.

Table 6: Descriptions of some databases which tracked COVID-19 research investments

COVID-19 Research Tracker	Description	Frequency of Update/Last update*	Open access data
World RePORT	This database collates research funding for 14 of the major funders of biomedical research globally.	Variable status of data from different funding organisations.	Yes
COVID NMA Initiative	This tracker provided living synthesis of preventive interventions, vaccines and therapeutics trials for COVID-19 globally.	Regularly updated	Yes
G-Finder (Policy Cures)	Tracks funding disbursements for infectious diseases research including COVID-19 research funding, for vaccines, therapeutics and diagnostics.	10 September 2020	Yes
UKCDR and GloPID-R COVID-19 Research Project Tracker	Mapped globally funded COVID-19 projects from global funders aligned to WHO, LMIC and UNRR priorities	2-weekly	Yes
Research Investments in Global health Study (RESIN)	This project maps the research funding for infectious diseases provided by G20 countries. The study had a wide scope and tracked research from the basic science to social sciences. During the COVID-19 pandemic it tracked research into coronaviruses from 2000 to 2020.	August 2020	Yes
OEDCD Global Science Forum	Mapped globally funded research for COVID-19.	21 September 2020	Yes
Dimensions AI	Tracks grants, publications and outputs of all types of research globally.	Regularly updated	Full data available with subscription

*Refers to the date of last update or frequency of update of the database as of October 2022 when this research was conducted

Consequently, I chose the UKCDR and GloPID-R COVID-19 Research Project Tracker for this study. This was a database capturing global funding information on COVID-19 research projects directly from research funding organisations or through manual scraping of publicly available sources[41]. As this data formed the basis of my previous assessment of COVID-19 research funding for Africa in 2020, I considered that analysis of this same database at a different time point would enable me compare findings from the two research activities (i.e. findings from 2020 and 2022 respectively).

4.3.2 Data Entry and Coding

From April 2020 to December 2022, I was part of the data entry team for the UKCDR and GloPID-R COVID-19 Research Project Tracker database. Each project captured in the tracker was mapped to the WHO COVID-19 research priorities (Appendix A) by reviewing the project titles, abstracts and lay summaries. Where applicable, projects were similarly classified against the UN Roadmap priorities for the COVID-19 recovery. Further, projects involving at least one LMIC (based on the OECD-DAC classification)[224] were also classified against the COVID-19 research priorities for less-resourced countries identified in May 2022 (Appendix C)[141]. All data were publicly available and downloadable from an online source[41]. Data captured in the database from April 2020 to 15 July 2022 were included in the analyses for this study.

4.3.3 Data Analysis

I undertook both descriptive and comparative quantitative data analysis. Data fields of the tracker which I analysed are summarised in Table 7. I downloaded, cleaned and analysed the data in *Microsoft Excel*.

Table 7: Data fields of the UKCDR and GloPID-R COVID-19 Research Project Tracker reviewed in this work.

Data fields	Description
Project title	Research grant title
Project abstract	Research grant's abstract
Lay summary	Non-technical summary of research grant
Funder(s)	Organisation(s) providing funding for research
Funding amount (in USD)	Research funding amount converted to USD
WHO research priority area(s) - Broad areas and sub-priorities	Primary WHO broad research priority and sub-priority area(s) assigned to research grant
Research location(s)	Countries/ regions where research took place
Lead institution(s)	Institutions receiving funding to undertake research, usually institution(s) holding the grant
Grant award publication date	Date grant award was published on funders' website/ grants portal or date of award provided by funders

I grouped the data by research locations and identified COVID-19 research projects involving at least one African country (one or more of the 55 African Union member states)[172]. Twenty-eight grants with non-specific country details but which were listed to be taking place in "Africa" or in any of the sub-regions in Africa were also included in the analyses. Except where stated, further analyses described in this chapter used only this sub-set of data (research projects which involved African countries or took place in the Africa region).

Funders of research grants in Africa were identified and assigned to one of two groups: funders based in Africa and funders based in other regions. These were then characterised into type of funding organisation via *Google* search and review of websites of funding organisations. First, a list of descriptions of funding entities identified was compiled from the organisations' websites. These were summarised into five categories: Public funders;

Private funders; Philanthropies, Charities and Non-profits; University funders; and Others. A description of these is shown in Table 8.

Table 8: Description of funder classifications used in this study.

Funder type	Description
Private funders	Funding organisations with a profit motive
Public funders	Government funding organisations
Universities	Funding organisations which are universities or affiliated to universities
Philanthropies, charities and non-profits	Funding organisations with a not-for-profit motive
Others	Organisations such as WHO, UNITAID, UNICEF and similar multinational/ multilateral organisations

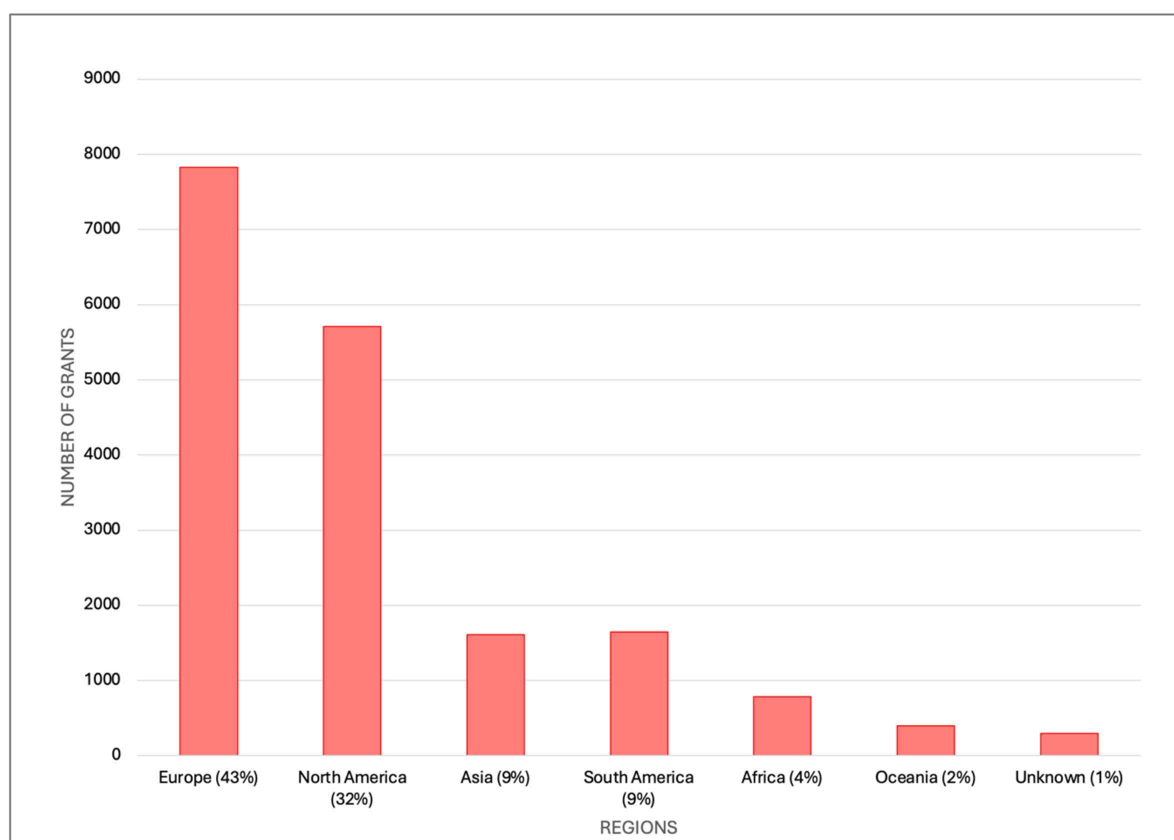
I calculated total funding amounts invested in COVID-19 research in Africa by each funder identified (where available). I also identified co-funded grants (grants funded by more than one funding organisation or funder) and determined the number of co-funding partnerships for each funder involved in co-funding.

I grouped the institutions listed under the "lead institutions" field of the database by country of location and calculated the total number of grants involving each of the institutions identified. I reviewed the grant award publication dates and created trend graphs to show the number of funding awards (both cumulative and discrete) and WHO COVID-19 research priority area(s) of focus of grants over time. For each grant, I analysed the alignment to the WHO COVID-19 research priority areas and the research priorities of Africa and less-resourced countries. I calculated the total number of grants in each research area.

4.4 Results

4.4.1 COVID-19 Research Locations

Figure 15 shows the regional distribution of COVID-19 research projects (by percentage of 17,955 grants in the Tracker). Most of the research projects involve countries in Europe (43.5%, n=7,829/17,955) and North America (31.8%, n=5,711/17,955). For 1.3% (n=238/17,955) of grants recorded in the database, no research location was listed.



No projects in Antarctica. Some projects (3.2% of total projects) took place in multiple countries.

Figure 15: Distribution of research projects in the UKCDR and GloPID-R COVID-19 Research Project Tracker by continent of countries involved in research (as of 15 July 2022).

As of 15 July 2022, only 4.4% (n=786/17,955) of the COVID-19 research grants in the UKCDR and GloPID-R COVID-19 Research Project Tracker involved at least one African country. Of these 786 projects, 85.0% (n=668/786) had research locations in Africa only,

with the remaining 15.0% (n=118/786) involving African countries and countries outside the continent. Research on COVID-19 pertained to 49 African countries. The majority of the research grants focussed on only three African countries: Morocco (n=183); South Africa (n=128); and Kenya (n=91) as seen in Figure 16.

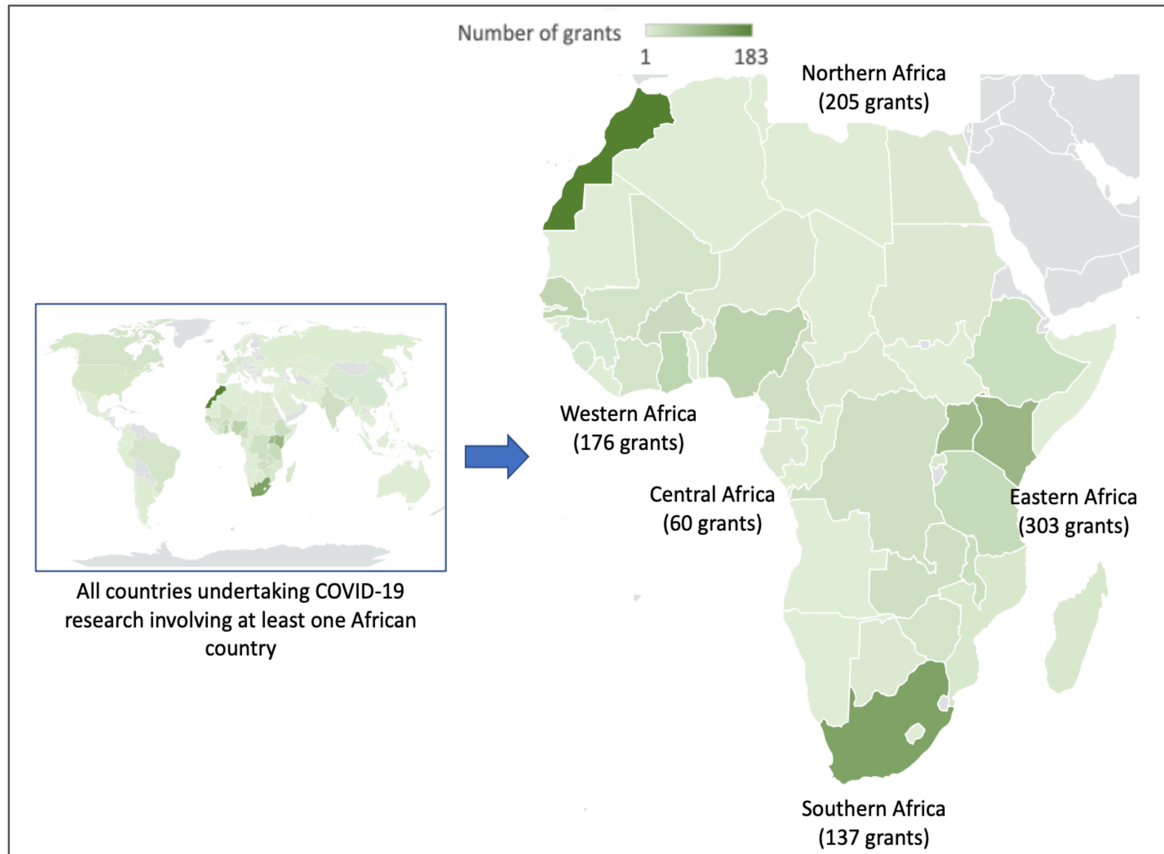


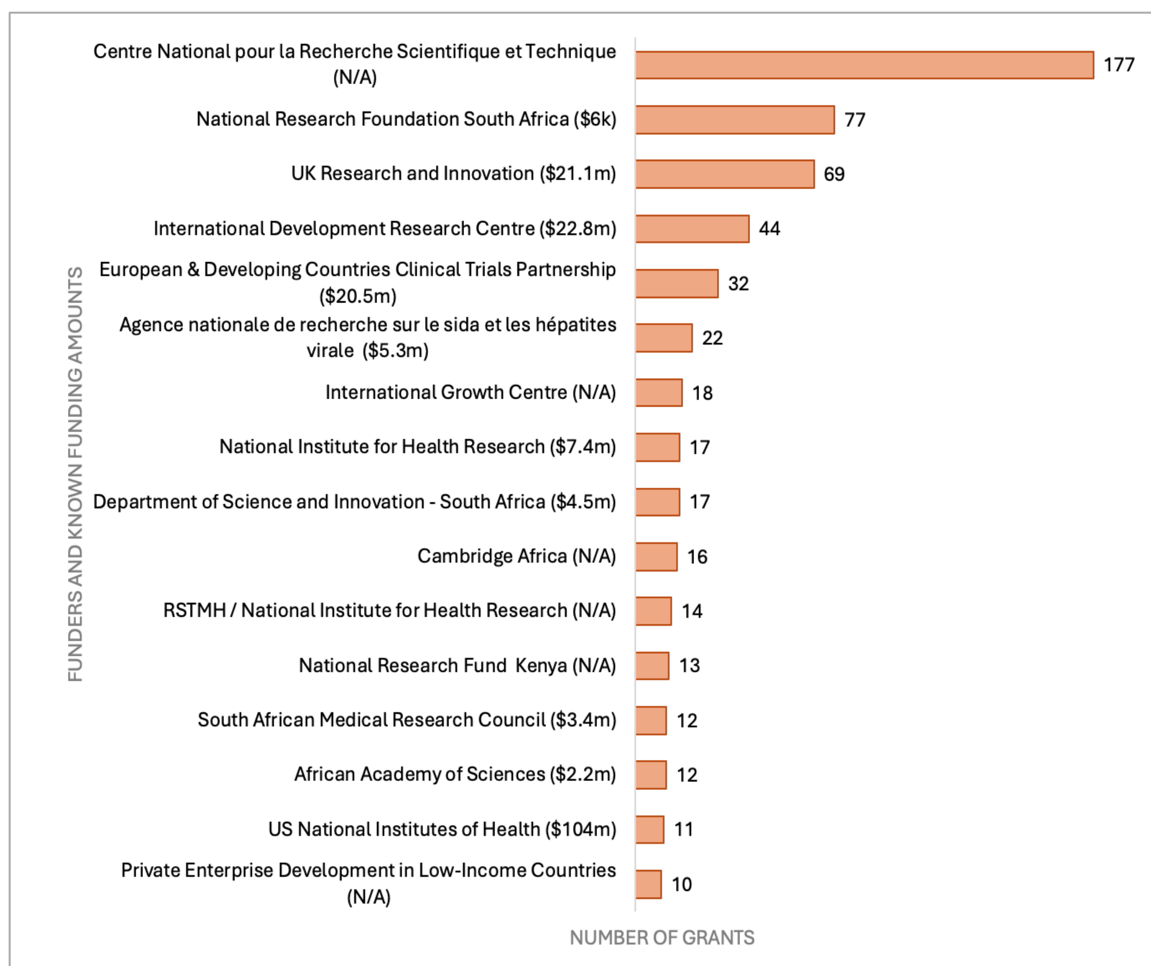
Figure 16: Locations of COVID-19 research projects involving at least one African country identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)

4.4.2 Funding for COVID-19 Research in Africa

Figure 17 shows the funders of COVID-19 research in Africa ranked by the number of grants each supported. Information on funding amounts invested was available for only 39.3% (n=309/786) of grants in Africa; hence, amounts shown are an underestimation of the total funding invested in research in Africa. At least $267 million (USD) in total was invested by 75 funders in COVID-19 research projects involving African countries. As a result of limited funding data in the database, total funding amounts invested by some funders could not be determined. These are shown as "N/A" in Figure 17. National Center for Scientific and Technical Research, National Research Foundation South Africa and UK Research and Innovation funded the most research grants.

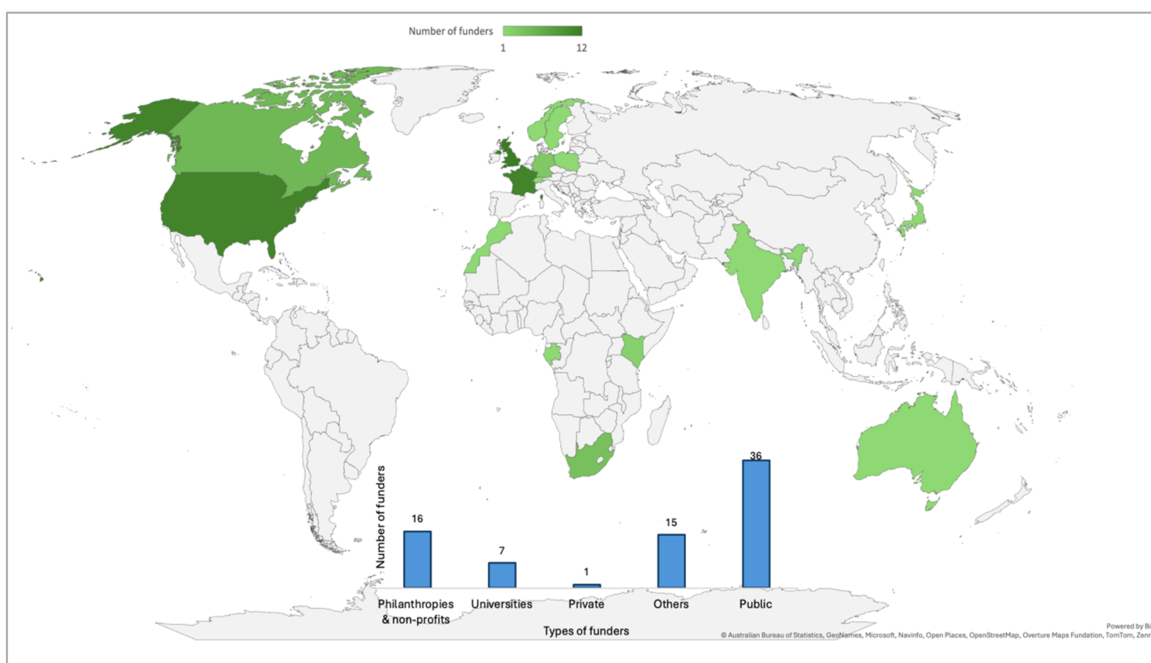
The majority of funding organisations identified were public funders based in Europe and the United States, as seen in Figure 18. The 16 funders classified as "other" included WHO, UNICEF, UNITAID and other similar organisations. Only nine of the funders identified were based in Africa, with the majority in South Africa (Table 9). Most grants were funded by a single funding organisation with only 63 being co-funded. The main funders included: Royal Society of Tropical Medicine and Hygiene and National Institute for Health and Care Research (n=14); Department of Science and Innovation South Africa and Technology Innovation Agency (n=9); UK Research and Innovation and National Institute for Health and Care Research (n=9); and Foreign Commonwealth and Development Office, National Institute for Health and Care Research, and Wellcome (n=8). Funders of less than 10 grants are shown in Appendix H.



Known funding amounts (in USD) in brackets, funders of 10 or more grants shown. 39% of research grants in Africa include details on funding amounts. "N/A" is indicated where no information on funding amounts identified. Funders of less than 10 projects and funder abbreviations are shown in Appendix H.

Figure 17: Funders of COVID-19 research in Africa identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)



17 funding organisations are located in multiple countries

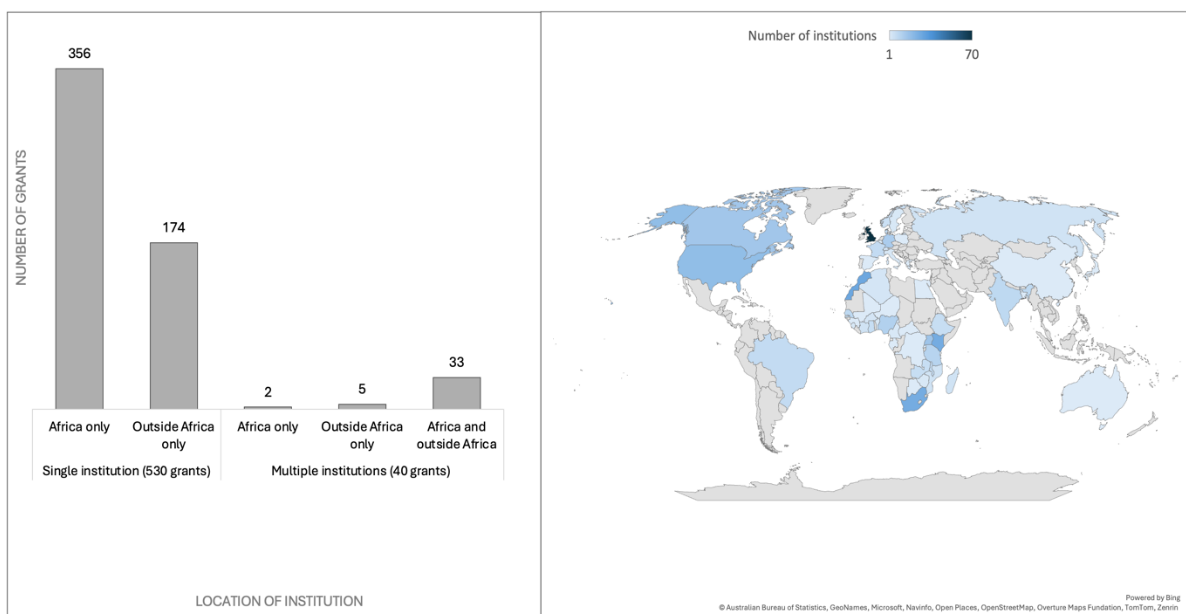
Figure 18: Locations and types of funders of COVID-19 research in Africa identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Table 9: List of Africa-based funders of COVID-19 research in Africa identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Funding organisation/ funder	Country of organisation	Type of funder
African Academy of Sciences	Kenya	Non-profit
National Center for Scientific and Technical Research	Morocco	Public
Technology Innovation Agency	South Africa	Public
Mauritius Research and Innovation Council	Mauritius	Public
National Research Fund Kenya	Kenya	Public
National Research Foundation South Africa	South Africa	Public
South African Medical Research Council	South Africa	Public
Department of Science and Innovation	South Africa	Public
Gabon Government	Gabon	Public

4.4.3 Funded Research Institutions

Of the 786 COVID-19 research grants involving at least one African country, 72.5% (n=570/786) included details on the institutions receiving funding to undertake research (listed as "lead institutions" in the database). Three hundred and sixty-five (365) institutions located in 54 countries globally were identified (Figure 19). The majority of grants (68.6%, n=391/570) involved at least one institution based in Africa (Figure 19). For 31.4% (n=179/570) of the grants, funding went to institutions based outside Africa only.



72% of grants included information on lead institutions

Figure 19: Locations of institutions receiving funding for COVID-19 research projects in Africa identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)

In most grants (93.0%, n=530/570), single institutions were listed as having received funding for COVID-19 research. Multiple institutions were listed in 7.0% (n=40/570) projects. Of these, partnerships involved: an African institution with one or more institutions

outside the continent (n=33); two or more institutions based in Africa only (n=2); and institutions based outside Africa only (n=5).

Most of the recipient institutions are in: United Kingdom (n=70), Morocco (n=29), Kenya (n=26), and South Africa (n=26). Among the top 10 institutions receiving funding (based on number of grants) were the Ibn Zohr University (Morocco) followed by University of Cambridge (UK) and University of Cape Town (South Africa) as seen in Figure 20.

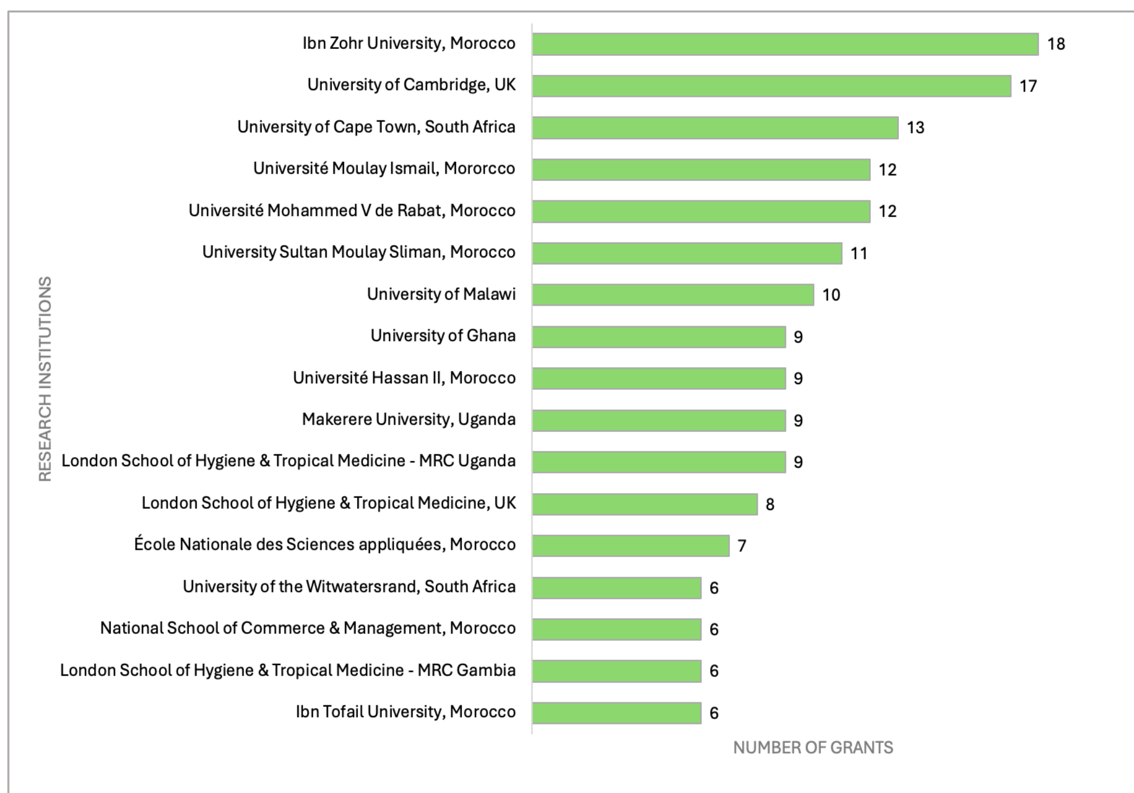
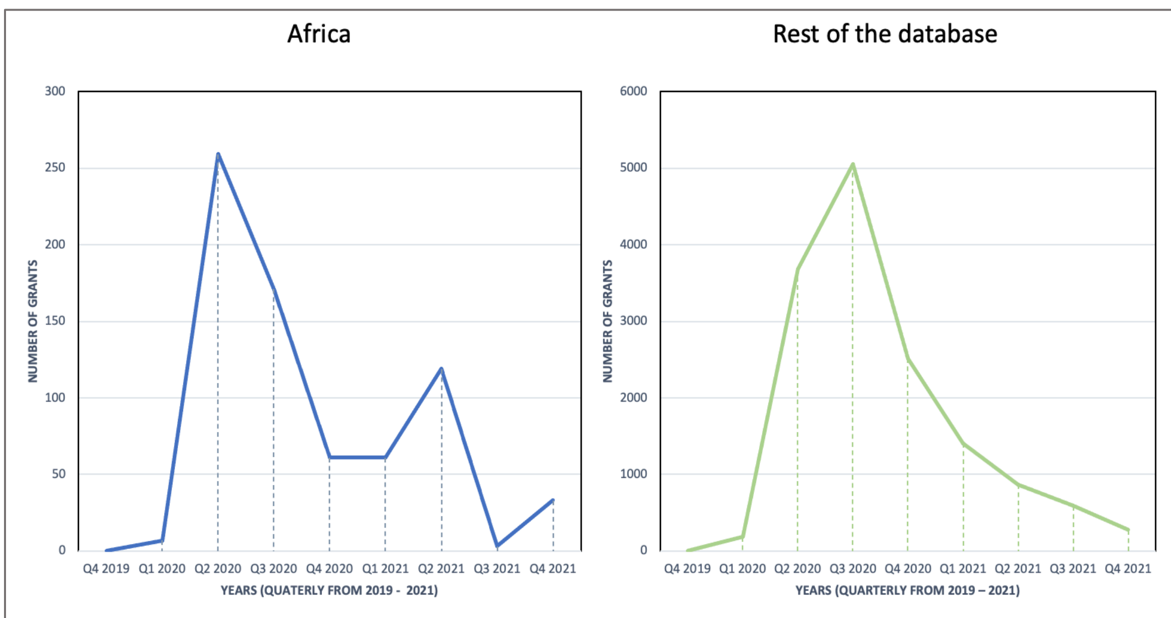


Figure 20: Top 10 institutions (based on number of research grants) which received funding for COVID-19 research in Africa identified from an analysis of the UKCDR and GloPID-R COVID-19 Research Project Tracker.

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)

4.4.4 Trends in Research Funding Over Time

Figure 21 shows the number of COVID-19 research grants funded in Africa and the rest of the regions covered by the database from late December 2019 to December 2021, using available information on grant award dates or dates of grant publication by funders. This information was available for 91.0% (n=713/786) of the grants analysed. None of the grants captured in the database when this analysis was undertaken were awarded after December 2021. The line graphs depict a sharp rise in funded COVID-19 research beginning in the first quarter of 2020. However, grants in Africa peaked earlier (2nd quarter of 2020) than for the remainder of the database (3rd quarter of 2020). From then, the funding of grants goes on a downward trend in 2021. In both line graphs the majority of grants were funded in 2020.



85.0% of total grants in the entire database have a date of grant award or award publication date documented. 91.0% of the grants in Africa had a date of grant award or award publication date documented.

Figure 21: Trend of funded COVID-19 research grants over time based on the number of grants and date of award publication or grant award date.

A plot of the cumulative number of grants funded by WHO research priority area of focus and date of award publication is shown Figure 22. The majority of the COVID-19 grants initially funded in Africa were focussed on the “social sciences in the outbreak response” priority area, with the grants rising in April 2020 and remaining the focus of most funded grants over the period. By June 2020, many grants also focussed on the “epidemiological studies” priority area, followed by “clinical characterisation and management” and “virus: natural history, transmission and diagnostics”. The first two months of the response in the remainder of the dataset focussed predominantly on the “virus: natural history, transmission and diagnostics” priority area, with projects focussed on “social sciences in the outbreak response” dominant from July 2020.

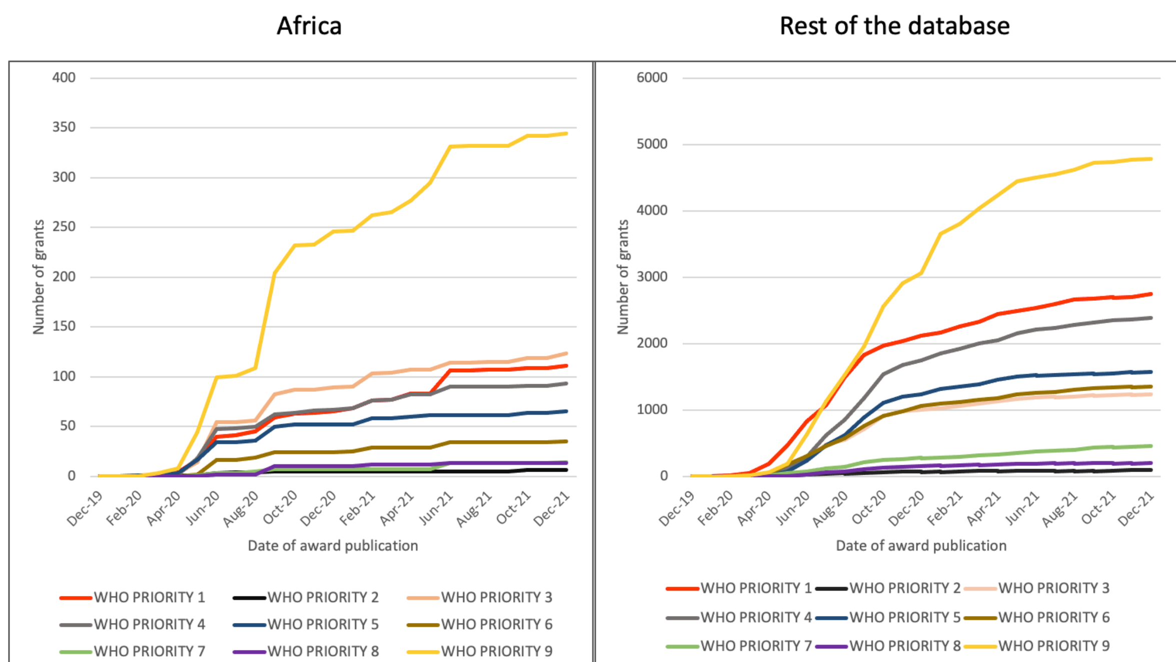
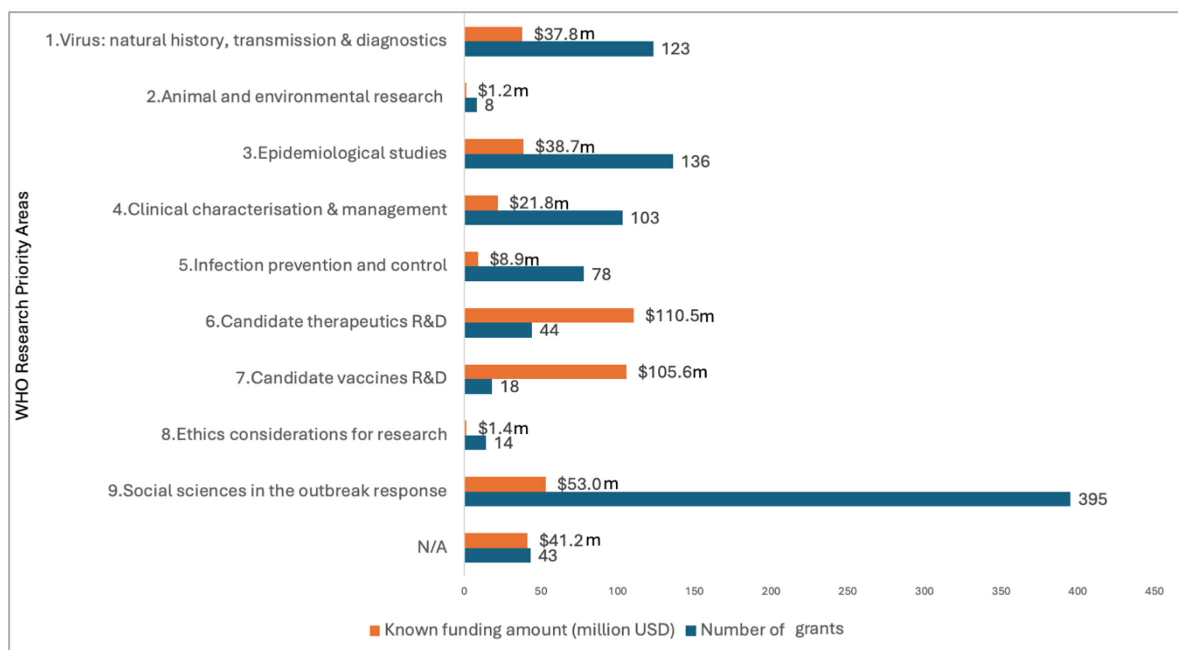


Figure 22: Trend of funded COVID-19 research grants over time based on cumulative number of projects classified by the WHO COVID-19 research priority area of focus (Appendix A) and date of award publication or grant award date.

4.4.5 Alignment of Grants to the WHO and Africa Research Priorities

Ninety-five percent (95.0%, n=747/786) of the grants mapped to at least one of the nine broad WHO research priority areas. Figure 23 shows most fell under the "social sciences in the outbreak response", "epidemiological studies" and "virus: natural history, transmission and diagnostics" priority areas.



Some grants map to multiple priority areas

Figure 23: COVID-19 research grants in Africa classified against the nine WHO research priority areas with known funding amounts invested in each priority area shown

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)

Whilst many grants falling under the social sciences priority area focussed on adherence to public health interventions and media and communication strategies during the pandemic, the majority did not fall within any of the WHO sub-priority areas and were classified as "N/A" (Figure 24). Grants under the "virus: natural history, transmission and diagnostics" were mostly focussed on diagnostics and evaluation of various mechanisms for immunity to COVID-19 including vaccine-mediated and post-infection immunity. Most grants classified under the "epidemiological studies" priority area were on transmission dynamics of COVID-19.

WHO RESEARCH PRIORITY NAME	Sub-Priorities							
	a	b	c	d	e	f	N/A	Funding Amount (USD)
1.Virus: natural history, transmission and diagnostics	61	17	15	34	1	8	3	$ 37,873,132.51
2.Animal and environmental research on the virus origin, and management measures at the human-animal interface	5	2	2				1	$ 1,277,146.23
3.Epidemiological studies	87	29	8	26			19	$ 38,759,661.70
4.Clinical characterization and management	29	44	1	35	0	0	10	$ 21,861,935.71
5.Infection prevention and control, including health care workers' protection	12	20	13	33			12	$ 8,968,854.24
6.Candidate therapeutics R&D	26	6	0	14	3		3	$ 110,589,813.48
7.Candidate vaccines R&D	5	1	0	1	0		11	$ 105,635,184.90
8.Ethics considerations for research	4	0	0	8	0		2	$ 1,411,074.15
9.Social sciences in the outbreak response	79	11	76	29	2	4	265	$ 53,041,602.18
N/A	43							$ 41,257,205.06

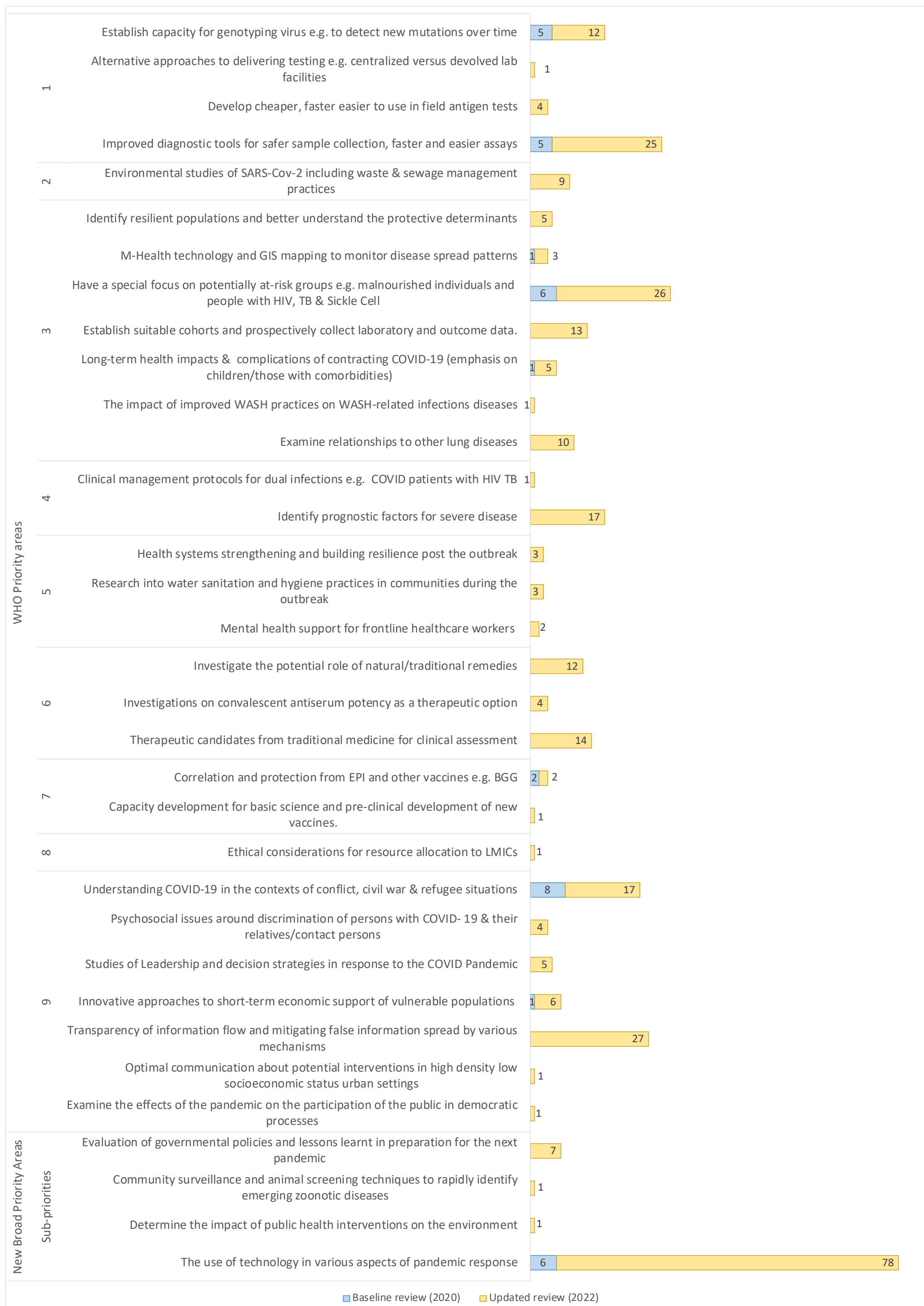
Sub priority areas a-f defined in Appendix A. Some grants map to multiple priority areas.

Figure 24: Heatmap showing COVID-19 research grants in Africa classified against the WHO COVID-19 broad research priorities and sub-priority areas with known funding amounts invested (in USD) in each priority area shown

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0).

Few research grants focussed on vaccines and therapeutics research although these accounted for most (42.7%, n=$114m/$267m) of the known funding investments made into COVID-19 research involving African countries, when total funding amounts were considered. Research on “ethics considerations for research” and “animal and environmental health” were the focus of the least number of grants.

Few grants mapped to the research priorities of Africa and less-resourced countries (Figure 25). Research on the application of technology in the pandemic response was the dominant theme. This was followed by: research on transparent communication and mitigating misinformation; investigating COVID-19 in individuals with Tuberculosis, HIV and sickle cell disease; research into improved COVID-19 diagnostics; and understanding COVID-19 in refugee, migrant populations and conflict zones.



Some grants map to multiple priority areas. Priority areas shown in Appendix C.

Figure 25: COVID-19 research grants in Africa mapped to the COVID-19 research priorities of Africa and less-resourced countries identified in 2020. Results from mapping done in 2020 and this thesis (2022) shown.

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0).

4.4.6 Change in Funding Over Time

Table 10 summarises key changes in the funding landscape from 2020 to 2022. This analysis identified an increase in the number of COVID-19 research grants in Africa from 84 (of a total 1,858 global grants in the database in 2020) to 786 (of 17,995 global grants in the database in 2022). Compared to the review I conducted in 2020, research projects taking place in 13 additional African countries were identified. The number of funders identified also increased from 12 to 75 with an associated increase in known total funding amounts from $22 million (USD) to $267 million (USD).

Table 10: Change in funding landscape of COVID-19 research in Africa from July 2020 to July 2022

Criteria	Baseline analysis (2020)	Current study (2022)
UKCDR and GloPID-R Tracker version	July 2020	July 2022
Number of projects taking place in African Countries	84 of 1,858 total grants (4.5%)	786 of 17,955 total grants (4.4%)
Number of African countries	36	49
Total known funding amount (USD)	$22m of $726m global investment (3.0%)	$267m of $6.5bn global investment (4.0%)
Number of funders	12	75
Number of funders based in Africa	None based in Africa	9

Source: Adapted from Antonio E et al. Funding and COVID-19 research in Africa: two years on, are the research needs of Africa being met? Open Research Africa. 2023. (CC BY-NC 4.0)

4.5 Discussion

I undertook a mapping review of grants in the UKCDR and GloPID-R COVID-19 Research Project Tracker to assess the alignment of COVID-19 research in Africa to the WHO global and Africa regional research priorities. The main findings discussed include: the locations of funded research grants; the landscape of funders supporting COVID-19 research and the

institutions in receipt of the grants; change in grant funding from 2020 - 2022; and how the COVID-19 grants reflected the global and regional research priorities.

4.5.1 Locations of COVID-19 Research in Africa

There was significantly less COVID-19 research activity involving countries on the African continent compared to North America and Europe. The leading countries involved in COVID-19 research are among the countries usually contributing the most to health research in Africa[225]. These countries also emerged as leading contributors to COVID-19 related publications in separate assessments of bibliometric data undertaken by Guleid et al. and Fonkou et al. respectively[154,226]. Compared to the review of COVID-19 research funding in Africa which I undertook in 2020, this analysis includes data from 13 more African countries. This finding is consistent with the observed increase in the COVID-19 research grants awarded in Africa from 2020 to 2022.

Although this analysis provides an assessment of a wide range of COVID-19 research activities in Africa, challenges with accessing grant data might have led to an underestimation of the COVID-19 research activities in some countries. For six African countries (Burundi, Djibouti, Eritrea, Eswatini, Sahrawi Republic, São Tomé and Príncipe) no COVID-19 research was documented in the Tracker. A comparison of the grants analysed to data from other databases found some research activities which were not captured in the UKCDR and GloPID-R COVID-19 Research Project Tracker. For instance, as of 5th March 2023 the *COVID NMA initiative*, which recorded randomised controlled trials on COVID-19 interventions, documented 107 trials in Egypt which were not captured by the current analysis[39]. *World Report* also included one project each involving Eswatini and São Tomé and Príncipe (as of 15 March 2023) where no research was identified in this analysis[40].

These research activities might not have been captured in the UKCDR and GloPID-R COVID-19 Research Project Tracker because the funding organisations did not publicly disclose information on the grants supporting these activities. Another reason could be that the research was supported by funding sourced and managed within the lead research institutions or universities themselves. Information on these intramural funding awards are usually not publicly available.

The aggregation of COVID-19 funding data from various sources was not in the scope of this work and can be an area for further research. This could involve combining data from the various research databases, taking cognisance of the varying quality of data, data compatibility, and deduplication of datasets.

4.5.2 Funding for COVID-19 Research in Africa.

The UKCDR and GloPID-R COVID-19 Research Project Tracker is limited in capturing repurposed research grants, supplemental grants to awards predating the pandemic which were assigned for COVID-19 research, and funding for health research system strengthening activities. Hence, the findings of this study are more representative of "new" funding invested in COVID-19 research during the pandemic response by funders based in Africa and those based outside the continent.

Most COVID-19 research identified in Africa was supported by public funders in Europe and the United States. This finding is consistent with research funding trends before the pandemic where the majority of health research investments recorded were attributable to funders based outside the African continent. Unsurprisingly, of the funders based outside Africa, major players such as UK Research and Innovation (UKRI), International Development Research Centre (IDRC), French National Agency for AIDS Research (ANRS), National Institutes of Health and Care Research (NIHR) and US NIH dominated.

These funders are also among top funders of COVID-19 research globally identified by Mugabushaka et al. in a review of funding acknowledgements in COVID-19 research publications in 2020 and 2021[227].

This propensity for funding of research to originate outside the African continent has potential implications for which research agenda are prioritised, as external priorities may differ from local research needs. The alignment of externally sourced funding to context-specific research needs has been widely advocated in the promotion of effective funding practices. High level agreements including the Paris Declaration (2005) and the Accra Agenda for Action (2008) emphasise these elements, calling for external funding organisations to align with locally identified priorities[228]. These considerations are even more crucial during a pandemic, where evidence is required to inform IPC measures and for saving lives locally and globally, as investments supporting the generation of evidence relevant to local needs can be beneficial in the grand scheme of controlling pandemics globally[229].

Nine research funders based in Africa were identified in this analysis. All but one of these is a public funder. South Africa has established itself as a leader in health research on the continent with consistent investment in health sector and R&D[230]. It is therefore not surprising that four of the nine funders based in Africa emerging from this analysis are based in South Africa. From this study, South Africa was also among the leading countries involved in COVID-19 research in Africa.

The limited number of funders based in Africa identified in this analysis could be due to a lack of capture of data from these funders in the database analysed in this study. This data might not have been made publicly available. In particular, core funding from African governments for research might not have been accessible or documented. Moreover, the

challenges associated with obtaining health-related data for Africa are well known and are contributed to by the poor record-keeping culture and inadequate investments in data systems on the continent [231].

Some models of co-funding among funders promote greater effectiveness in funding research by: facilitating the pooling of funds for research; driving down administrative costs of funding research, where one funder administers funds on behalf of co-funding partners; and allowing for improved coordination of funding processes to minimise duplication of efforts[232]. Only eight percent (63 of 786) of grants involving African countries were co-funded with the remainder funded by individual funding organisations. This low level of co-funding might suggest a missed opportunity in gaining from the potential benefits associated with co-funding. However, co-funding partnerships can introduce complexities in coordinating partner funders and aligning funding processes among co-funding partners[233].

4.5.3 Research Institutions Funded for COVID-19 Research in Africa

Research institutions which receive funding to undertake research are responsible for the grants they receive and, hence, the delivery of the research for which grants are awarded. These institutions are bound by the conditions outlined in grant agreements including requirements for the ethical conduct of research, safeguarding of research participants and researchers, and grant reporting. During the COVID-19 pandemic several institutions based in Africa and other continents received funding to undertake research. Those identified in this analysis include universities, research institutes, non-governmental organisations and research groups (not affiliated to universities).

Figure 26 depicts three examples of these relationships among lead institutions, collaborating institutions and funders. A grant can be awarded to a single lead institution, which is solely responsible for delivering on the grant conditions, to undertake research. In the second example, funding is awarded to a lead institution which then works with other collaborating institutions to deliver on the grant, as in many grants involving partnerships between LMIC institutions and partners in higher-income settings[234]. Funding may also be provided for two lead institutions to undertake research collaboratively. Each institution reports to the funder and is responsible for its share of the grant. However, partner institutions may be bound by collaborative agreements dictated by the funder in the delivery of the research.

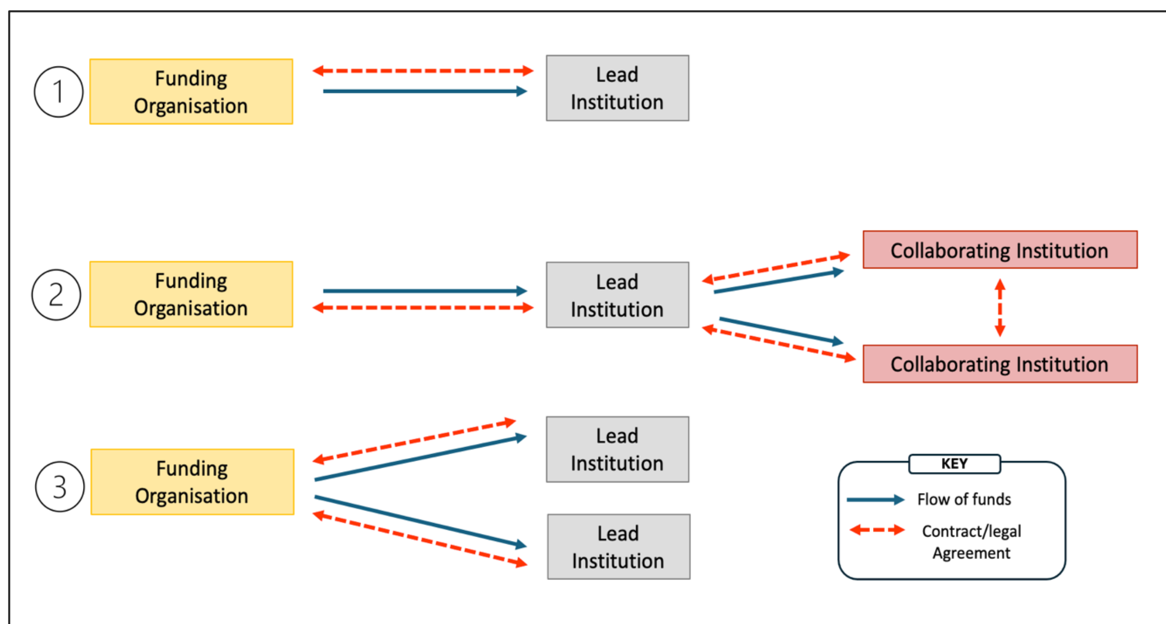


Figure 26: Examples of relationships among lead institutions, funders and collaborating institutions in grant agreements.

In the current study, the database analysed provides information on "lead institutions" only. There is insufficient granularity of the data captured such that, the roles of "lead institutions" are not defined, particularly where multiple institutions received funding for COVID-19

research. To avoid misinterpretation of the data, this analysis did not assume which institution "led" on the grants awarded and made broad interpretations based on the institutions named to have received funding for COVID-19 research in Africa.

From the analysis, the Ibn Zohr University, Morocco, was named lead institution for the most COVID-19 grants involving African countries. Second to this was the University of Cambridge, UK. Almost all the grants with the University of Cambridge listed as lead institution were funded by Cambridge Africa, a programme supporting long-standing partnerships between the University of Cambridge and African research institutions[235]. Hence, for these grants, the University of Cambridge and another research institution in Africa were listed as lead institutions in each case.

Other grants were funded by the European and Developing Countries Clinical Trials Partnership (EDCTP) which focusses its activities on mutually beneficial research partnerships among European research institutions and research institutions in Sub-Saharan Africa[236]. Medical Research Council/ Uganda Virus Research Institute and London School of Hygiene & Tropical Medicine Research Units in Uganda and the Gambia were also among the top institutions receiving funding for COVID-19 research in Africa (based on number of research grants funded). These findings speak to the importance of long-standing research partnerships which can be rapidly harnessed in an outbreak[237].

For those grants where lead institutions based outside Africa were identified (one-third of all grants with data available), there could have been local partners involved in the delivery of the research although these were not named. Funders have an important role in setting the tone in partnerships through grant conditions and through the appropriate recognition of all institutions involved in research when providing data on their grants or making this information public[61].

The inherent complexities of the research funding processes at play in research institutions in Africa during the pandemic are explored in Chapter 5. This includes exploring the challenges encountered by African researchers and institutional grant managers in research funding processes during the response to COVID-19.

4.5.4 Trends in COVID-19 Research Funding Over Time

On 30 January 2020, WHO declared the outbreak of the novel coronavirus a PHEIC[1]. It was not until 11 March 2020, six weeks after the PHEIC declaration, that COVID-19 was classified as a global pandemic under the IHR[3]. These designations of the severity of outbreaks are important for streamlining global responses and triggering the release of resources for responding to health emergencies[2]. The trends observed during the COVID-19 pandemic suggest a rapid rise in the number of research projects in the second quarter of 2020 following the declaration of a pandemic in March 2020. Proponents of IHR reform have criticised the processes for the declaration of a health emergency as PHEIC as being inconsistent[238] and often delayed resulting in delayed responses to outbreaks when they occurred[239]. In 2024, WHO introduced a new designation; " pandemic emergency" to which a PHEIC caused by infectious diseases can be upgraded[240]. However, it is unclear how the term will be operationalised in practice suggesting that it could suffer similar shortfalls as the PHEIC designation[241].

Aside from the research grants involving African countries, most of the remaining grants in the Tracker involved countries in Europe and North America. This analysis shows the research response to COVID-19 in Africa lagged behind Europe and North America. One possible explanation for this might be that the research response followed the evolution of the pandemic where infections emerged in China, spread to Europe and America and then to Africa.

Research to understand the "virus: natural history, transmission and diagnostics" dominated in the early response in Europe and North America. As COVID-19 was a novel pathogen, research in this priority area focussed on unravelling the viral morphology and pathogenesis of the coronavirus. Research also focussed on the development of diagnostics which are crucial for the detection of infections and for several aspects of monitoring effectiveness of IPC measures. Some research grants in the early response also focussed on candidate therapeutics and diagnostics, but these were much fewer in comparison to some of the other research priority areas. When the research response was initiated in Africa, albeit later than the trend shown in the rest of the database, research on the "social sciences in the outbreak response" was the focus of most of the grants funded.

By early July, 2020 most African countries were at the peak of the first wave of COVID-19 infections[9]. Although many were presumed to be infected, the death tolls recorded were lower than in Europe and North America and the direct mortalities from COVID-19 were much lower than predicted[4]. This apparently lower severity of infections might account for the early peaking of research in Africa. Research funders, most of whom were based outside the continent, might have prioritised research where significantly greater mortalities were recorded.

By early 2021 the number of COVID-19 research grants funded globally and in Africa was on the decline. The pandemic was a significant event with far-reaching effects, prompting several research funders, who typically invest outside the infectious diseases field, to respond quickly[42]. Some of these likely reverted to supporting research in their usual remits and this could account for the decline in COVID-19 research funding. Furthermore, as the

world shifted gradually into recovery mode, many funders in infectious diseases likely ceased to launch COVID-19 specific research funding calls and incorporated COVID-19 into their regular infectious diseases research funding activities.

The trends revealed in this study are based on dates of funding award publications as specified on funders' databases or websites. Typically, these dates align with public announcements of funding awards and, therefore, do not necessarily indicate the timing of other downstream processes leading to the actual delivery of funds to researchers and institutions for the initiation of research. Chapter 5 explores some challenges to receiving and managing funds from the perspective of research institutions in the post-award stage of the funding process.

4.5.5 Alignment of COVID-19 Research to Research Priorities

One outcome of the 2020 research prioritisation activities in Africa was the consensus among scientists on the importance of the WHO research priorities for managing the pandemic in Africa[150]. The findings from mapping the research efforts in this thesis suggest agreement with this outcome, as 95% of all the grants taking place in Africa mapped to at least one WHO research priority area.

Most grants in Africa fell in the "social sciences in the outbreak response" priority area which encompassed all the non-clinical areas of research. The six sub-priority areas outlined in the WHO Roadmap did not capture the full spectrum of funded research grants. Hence, a significant number of grants, although mapped to the broad social sciences area, could not be placed within any of the sub-categories defined by the WHO. Most of these projects focussed on mental health, economic impacts of COVID-19 and other longer-term

considerations which were likely not deemed to be priorities at the time of development of the WHO Roadmap, in early 2020. Many of these areas are captured in the UN Research Roadmap, which was published in 2021, and considered longer term priorities for the recovery from COVID-19[34]. This roadmap complemented the WHO Research Roadmap and outlined areas for research focus to promote an equitable and sustainable post-pandemic recovery[34].

Unsurprisingly, research on “epidemiological studies” and “virus: natural history, transmission and diagnostics” were the second and third commonest areas of focus of research grants in Africa. Many African countries benefitted from investments in laboratory and surveillance capacity following the 2014-2016 West Africa Ebola Outbreak[58,242]. This strengthened capacity, coupled with capacity established rapidly at the onset of the pandemic, are credited with Africa’s swift detection of novel viral variants and contributions to global genomics databases[243,244]. A notable example is the Omicron variant which was first detected in South Africa and Mozambique [245,246].

“Ethics considerations for research” and “animal and environmental research” were the areas with the least number of research grants when all funded grants in Africa were considered. The sub-priorities outlined by WHO under “Ethics considerations for research” are focussed on actions which the WHO itself undertook in response to the pandemic[33]. An example is the development of guidance for ethical conduct of research during the pandemic[247]. Other sub-priority areas in this category were on non-research actions and might explain the low number of projects in this area. Research on the “animal and environmental research” priority is a recognised gap in funded COVID-19 research globally[42]. From my analysis, it is evident that more research is needed in this area in Africa as well.

In the pandemic's early stages, resources might have been preferentially allocated to institutions in higher-income countries with the requisite research capacity to address the pressing need for effective medical countermeasures including vaccines and therapeutics R&D. These institutions are also more likely to succeed at competitive grant applications for these research awards. This could explain the low levels of COVID-19 vaccines and therapeutics R&D projects in Africa, as there was insufficient capacity to conduct these types of research on the continent[159].

In my study, research grants in Africa were assessed for alignment to the research priorities of Africa and less-resourced countries. The activities for determining the research priorities in less-resourced countries were undertaken in a collaboration of organisations which included the AAS. The initial list of priorities ranked in the process was based on the WHO research priorities and priorities emerging from prior activities undertaken by the AAS to define research priorities for Africa[151]. Hence, the emerging list from the priority-setting process also encompassed the COVID-19 research priorities of relevance to African researchers.

Moreover, as the majority of research projects in Africa were funded in 2020, the priorities identified in 2020 are more likely to have influenced the funding of projects identified in this analysis. Mapping to the Research and Development Priorities Report published in January 2021 is out of the scope of this work and can be considered for future work.

The proportion of projects focussing on the research priorities in Africa from this analysis and the one I conducted in 2020 are similar[153]. However, some priority areas not previously covered were included in funded projects reviewed in this current analysis. Notable among these is research into transparent and effective communication strategies during the

pandemic and research to identify prognostic factors of severe COVID-19 infection in Africa. Another is research to identify therapeutic candidates from traditional and herbal remedies.

The four topmost research areas were: investigating COVID-19 in persons living with HIV, Tuberculosis and Sickle cell disease; improved diagnostics for COVID-19 detection; COVID-19 in refugee and conflict-affected contexts; and using technology in the pandemic response. The majority of research priority areas to which no grant mapped from this analysis concerned clinical management of COVID-19. These were on defining clinical protocols in the absence of ICUs, post-hospitalisation community rehabilitation for COVID-19 survivors and the impact of the COVID-19 response on the management of other infectious diseases. Others were on: the ethical considerations in expedited research ethics review processes; research to support local PPE production; and the environmental impacts of the use of large quantities of disinfectants, among many others.

Throughout my study, I have focussed more on the number of grants funded rather than the amounts invested due to incomplete funding data in the UKCDR and GloPID-R Research Project Tracker. Assessments based on funding amounts could underrepresent the value of investments made by funders based in less-resourced contexts particularly when funding amounts are converted to stronger currencies such as the USD[248]. These funders contribute comparatively lower amounts than their counterparts in higher-income settings where the cost of undertaking research is usually higher.

However, focussing on numbers of grants which, although useful for assessing funded research, does not reveal impact. The notion of greater investments in research equating to greater funding effectiveness must therefore be tempered with wider considerations of quality and impact (including outputs and outcomes) of funded research. This was shown

during the pandemic where multiple funded research projects of questionable quality contributed to excessive research waste globally[32].

The UKCDR and GloPID-R COVID-19 Research Project Tracker, which I analysed in this chapter, was limited by the varying completeness of the data captured. Data obtained from publicly available sources or directly from funders did not consistently include details which matched the research fields required for the database. This was particularly relevant when research grant amounts were considered. Only about 61% of the entire global dataset analysed included information on research funding amounts. Hence, the results I have presented underestimate the grant funding amounts.

The varying level of information provided per grant can also impact the assignment of projects to research priority areas. For example, insufficient project information increased the risk of potentially missing some priority areas in classifying the research grants. To address this limitation, all available project information, including title, abstracts and lay summaries, was reviewed in the grant classification process.

This analysis primarily shows new funding invested in COVID-19 research due to limitations in capturing pre-existing non-COVID-19 grants which pivoted to the pandemic response or were supplemented with funding for COVID-19 research. Moreover, capturing broader pre-pandemic investments in research systems, which supported the pandemic response, was limited.

The UKCDR and GloPID-R Research Project Tracker database was designed to capture research activities from funders across the globe via searches of online sources and direct sourcing from funders. However, closer engagement with UKCDR and GloPID-R funders,

who collaborated to initiate the database, might have skewed data to these funders. Furthermore, data on contributions made by industry and funders with a commercial interest was limited in the database.

As the world entered a recovery period from the pandemic, it is also likely that many funders ceased to launch COVID-19 specific research funding calls and incorporated these into their routine activities, making it challenging for these to be captured in the Tracker. Nevertheless, the UKCDR and GloPID-R Research Project Tracker database was considered to have been one of the most comprehensive for funding investments into COVID-19 research during the pandemic, having been acknowledged by the WHO as being "instrumental in reaching global funding decisions[249]".

4.6 Chapter Summary

In this chapter, I have presented findings from a two-year assessment of funded COVID-19 research in Africa. This study included analyses of research institutions receiving funding for COVID-19 research and an assessment of trends in funding of COVID-19 research in Africa over time. Despite the increase in funding for COVID-19 research since 2020, the finding of only about 4% of global projects taking place in at least one African country suggests limited involvement of African countries in the COVID-19 research response, more than two years into the pandemics. Research was supported by funders based in Europe and North America, with few funders based in Africa identified.

My analyses highlight the relevance of the WHO research priorities for the response to COVID-19 in Africa. Research in the social sciences was the dominant theme of funded research projects. The few research grants on vaccines and therapeutics R&D suggest a

limited capacity for research under these themes in Africa. Although grants addressed some of the research priorities for Africa, several areas remain unexplored, suggesting a missed opportunity to address pertinent research questions during the pandemic. Some of these questions focus on: understanding resilience and protective factors against COVID-19 in African populations; clinical management protocols for co-infection with COVID-19 and other common lung infections; and protocols for disease management in the absence of intensive care facilities.

Institutions based in Africa and other continents received funding to undertake COVID-19 research in Africa. For about a third of grants, the lead institution was located outside Africa. Others were partnership grants involving institutions in Africa and those based in Europe and North America. It is relevant to consider the strength and equity of research partnerships formed and assess partner interactions across the research cycle. This could also involve an assessment of funding flows which impact local investigators' access to research funds. These and other themes are explored in the next chapter of this work.

Chapter 5 - Factors which Influenced Securing and Management of Funding for COVID-19 Research in Africa

5.1 Introduction

Despite notable improvements over the years[250,251], Africa only contributed 1% of research outputs globally as of 2018[252]. There are wide intra-regional disparities in research outputs. For example, researchers from five countries contributed to 67% of research recorded in a bibliometric assessment of cancer research in Africa from 2012 - 2020. The barriers to health research conduct in Africa recorded in the literature include challenges with research governance[253], limited research infrastructure[254], brain drain[255] and limited research funding[256].

The financing of health research involves multiple processes which are outlined in the previous chapters of this thesis. Across these processes, the challenges encountered by African research institutions in accessing and managing funding for health research in the pre-pandemic period are well known. The literature reports limited funding, especially from local funding organisations[257], inadequate skills in grantsmanship[146], inadequate research capacity[147] and limited grant management capacity[104], among the challenges to research, which restricted African researchers' ability to attract research funding awards, particularly from international funders.

The aforementioned challenges are more pronounced in the WHO Africa region which comprises mostly countries in Sub Saharan Africa (SSA) as seen in Figure 27[173,258]. Despite variations across the region, SSA has a lower density of researchers than their counterparts in Northern Africa[259]. Furthermore, funding for research in the WHO Africa region is more

often sourced from entities based outside Africa than Northern African countries which invest more local funding into health research[257]. This was demonstrated in the findings from my assessment of the funding landscape of COVID-19 research in Chapter 4, which showed most grants in North African countries were funded by their national public funding organisations.

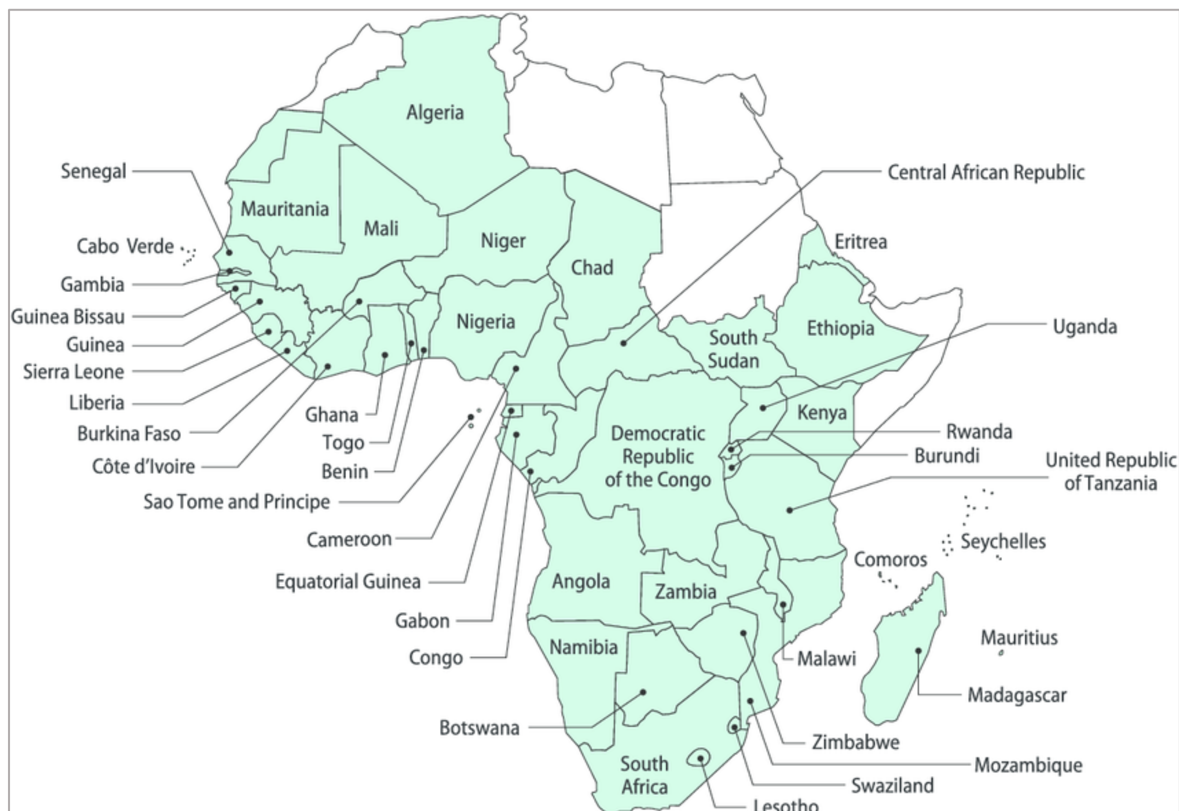


Figure 27: Map showing countries in the WHO Africa region

Source: World Health Organisation Regional Office for Africa. Promoting Oral Health in Africa. Pg. 3. World Health Organisation. 2016.

There is a paucity of literature on how the pre-pandemic challenges to health research funding in Africa influenced the COVID-19 pandemic response and what additional factors influenced access to research funding during the pandemic. This chapter seeks to address this gap in knowledge, focussing on the WHO Africa region, and addresses the research

question: “What factors influenced the securing and management of funding for COVID-19 health research by researchers and grant managers in African research institutions?”

5.2 Aim of Research outlined in this Chapter

The aim of this qualitative study was to explore factors which influenced the identification and management of funding for COVID-19 research from the perspective of grant managers (GMs) and researchers based in African research institutions.

5.3 Methods

I used a qualitative research approach to enable an in-depth exploration of research funding processes in African research institutions during the COVID-19 pandemic to gain a deep understanding of the processes which impacted research funding.

5.3.1 Worldview and Philosophical Assumptions

Research worldviews encompass the “philosophical orientation of the world and the nature of research that a researcher brings to the study”[164]. Lincoln and Guba describe the various examples of worldviews in their paper which distinguishes between naturalistic paradigms and rationalistic paradigms, which represent positivist and constructionist worldviews respectively[260]. The positivist paradigm favours reductionism and considers reality to be singular and objectively knowable. The researcher is “independent” of the research process[164]. Conversely, the social constructionist paradigm considers there to be multiple dimensions to reality which can be understood subjectively through the exploration of experiences and interactions[164].

This research is grounded in the social constructionist research paradigm and adopts the view of reality and how we make meaning of it to be created by shared social constructs based on social consensus on what is[261]. These constructs are formed and shaped by social, political, religious, cultural and other factors which give rise to subjectivity of experience and interpretation[262]. The researcher is actively part of the research process and shapes the research through the experiences they bring to the research process[262].

The social constructionist paradigm aligns with qualitative research approaches, which I used in this work to explore the factors influencing the access of researchers and grant managers in African research institutions to funding for COVID-19 research. The qualitative methodology offered a set of tools and methods which I felt could best enable me to answer the research question posed. It enabled the exploration of the complexities around the processes in research funding with particular consideration of the contexts within which these factors played out during the COVID-19 pandemic.

In alignment with the social constructionist paradigm, I prioritised research participants' perspectives and explored their experiences, acknowledging that these are shaped by their social environments. My worldview guided the processes I undertook throughout this research. I selected interviews as a data collection method because it enabled me to obtain an in-depth view of the participants' lived experiences and their perspectives. In data analysis, I focussed on identifying patterns in how meaning was collectively constructed while remaining mindful of variations in individual experiences.

5.3.2 Reflexivity

Being reflexive was central in the conduct of this research. I constantly reflected on my positionality as both an "insider" and an "outsider" in the context of this work[263]. I have

worked as a researcher in a teaching hospital in Ghana. While conducting this study, I was working with a research funder coordination initiative focussed on strengthening the coherence of activities among global funders of research for preparedness and response to epidemics and pandemics. A detailed statement of my positionality is presented in Chapter 2 (Section 2.4).

I was conscious that my experiences could influence various aspects of this research, including my interactions with research participants and the interpretation of data, which could diminish the credibility of my work. Therefore, I took a number of measures to minimise the impact of my biases on this work. I kept detailed notes throughout this study to document the processes, decisions and assumptions I made, particularly during data coding, analysis and writing up of the results. These records enabled me to remain aware of how my personal biases and experiences influenced this work and to take action to mitigate these. Furthermore, discussions of my themes and codes with my supervisors served as a form of "debriefing", further facilitating the identification of my assumptions during the conduct of this work.

5.3.3 Ethics Approval for this Research

Ethics approval for this study was obtained from the Oxford Tropical Research Ethics Committee, Reference 508-23 (Appendix E).

5.4 Sampling

In identifying researchers and GMs based in African research institutions for inclusion in this study, I considered a number of factors. Table 11 shows a description of some characteristics considered in sampling for this study. For researchers, this included: role in research project; research discipline; and stage of career/level of research experience. For

GMs, I considered the level of experience in grant management. The factors which cut across both researchers and GMs were: type of research institution; location of research institution; size of funding award; and gender.

Table 11: Characteristics considered during sampling of researchers and grant managers for this study

Characteristics	Description / Reason for consideration
Role in research project/ grant	The role played by the researcher in the research project. E.g. Principal Investigator, Collaborator, Research support staff, Lab-based Researcher etc. Researchers play different roles in research grants which determines their degree of involvement beyond undertaking the research itself.
Research discipline	Primary academic area in which researcher's work is focussed. The experiences with research funding practice might vary for various health research disciplines.
Stage of career	Researcher's career level e.g. early career, or experienced/ established researchers. Career level can be a factor for determining a researcher's experience with application for research grants, grant management and research processes.
Level of grant management experience	The level of experience of grant managers e.g. based on the number of years in grant management role can be a factor in their understanding of grant management processes and experiences with the diversity of practice in this area.
Size of funding award received	Quantum of funding received for research. Funding experiences and processes might vary depending on the size of funding awards received and managed in research institutions.
Gender	Researchers' or grant managers' gender (male, female or other gender identity). Gender could influence experiences with research funding processes.
Type of institution	The type of research institution where researchers or grant managers are based e.g. University, Research Institute, Hospital, Government entity etc. Various institutions might differ in their processes related to research funding and grant management.
Location/ country	The country of institution where researchers or grant managers are based. Funding practices and experiences are likely to vary across different regions/ countries of the continent.

However, sampling was hindered by limited information which compromised prior knowledge of some researchers' and grant managers' characteristics. Consequently, the researchers' role in the research project and level of experience in research (career stage) and level of grant management experience, which could be obtained from the UKCDR and GloPID-R Research Project Tracker and the researchers interviewed respectively, were prioritised in drawing a purposive sample for inclusion in this study. Sampling was restricted to researchers and grant managers in the WHO Africa region on account of the unique challenges to research conduct faced in this region[259]. Therefore, this study excluded participants from Northern African institutions.

5.4.1 Researchers

Only researchers who led the process of research funding acquisition, referred to as principal investigators (PIs) in this study, were considered during sampling. The term PI can be misinterpreted since, in some instances, it refers to researchers leading in grants acquisition and grant management, whereas in others, the term relates to the level of researchers' experience or career stage[264]. In this study, I align to the former definition where the designation as PI is solely based on the role played in obtaining and managing funding for research. In addition to leading on grants acquisition, PIs are also responsible for the implementation of research projects and have oversight of research teams[265]. Given that this study seeks to understand research funding processes, PIs were deemed to be a suitable data source for achieving this study's objectives.

To identify PIs on COVID-19 research grants, I reviewed the UKCDR and GloPID-R COVID-19 Research Project Tracker. The data fields used were: Research location; PI

name; PI's Open Researcher and Contributor ID (ORCID), a unique identifier for researchers[266]; Research Institution; and Research funder (see Chapter 4).

From the 17,955 COVID-19 research grants recorded in the UKCDR and GloPID-R Research Project Tracker as of 15 July 2022, I reviewed the research location of grants and identified those taking place in at least one country in the WHO Africa region. From this subset of the data, I reviewed the research funder/funding sources for the grants and excluded those awarded through funding schemes specifically targeting early-career researchers. This enabled the identification of PIs with greater experience in obtaining and managing research grants.

Next, the research grants without PIs name and PIs institutional affiliation listed were excluded. The country of location of the research institutions was determined following *Google* search and review of institutional websites. Research institutions based outside countries in the WHO Africa region or whose location could not be determined were excluded. For the remaining 191 grants, PI name and affiliation were validated with the ORCIDs available in the UKCDR and GloPID-R Research Project Tracker. For grants where no ORCID was listed in the Tracker, I conducted a search of the ORCID database to match PI names and their affiliated institutions listed in the Tracker. I extracted publicly available email contacts for 37 PIs at this stage.

Given that very few publicly available email contacts were identified from this process, further contacts were obtained through research networks at the University of Oxford that collaborate with researchers in African research institutions including the Centre for Tropical Medicine and Global Health and the Global Health Network, which hosts the

EDCTP Africa Knowledge Hubs. I obtained contacts for an additional 75 PIs. From the combined list of 112 PIs, prospective participants were emailed a description of the study and a request to participate in the research. Participants who consented were interviewed in this study. The process of sampling researchers is summarised in Figure 28.

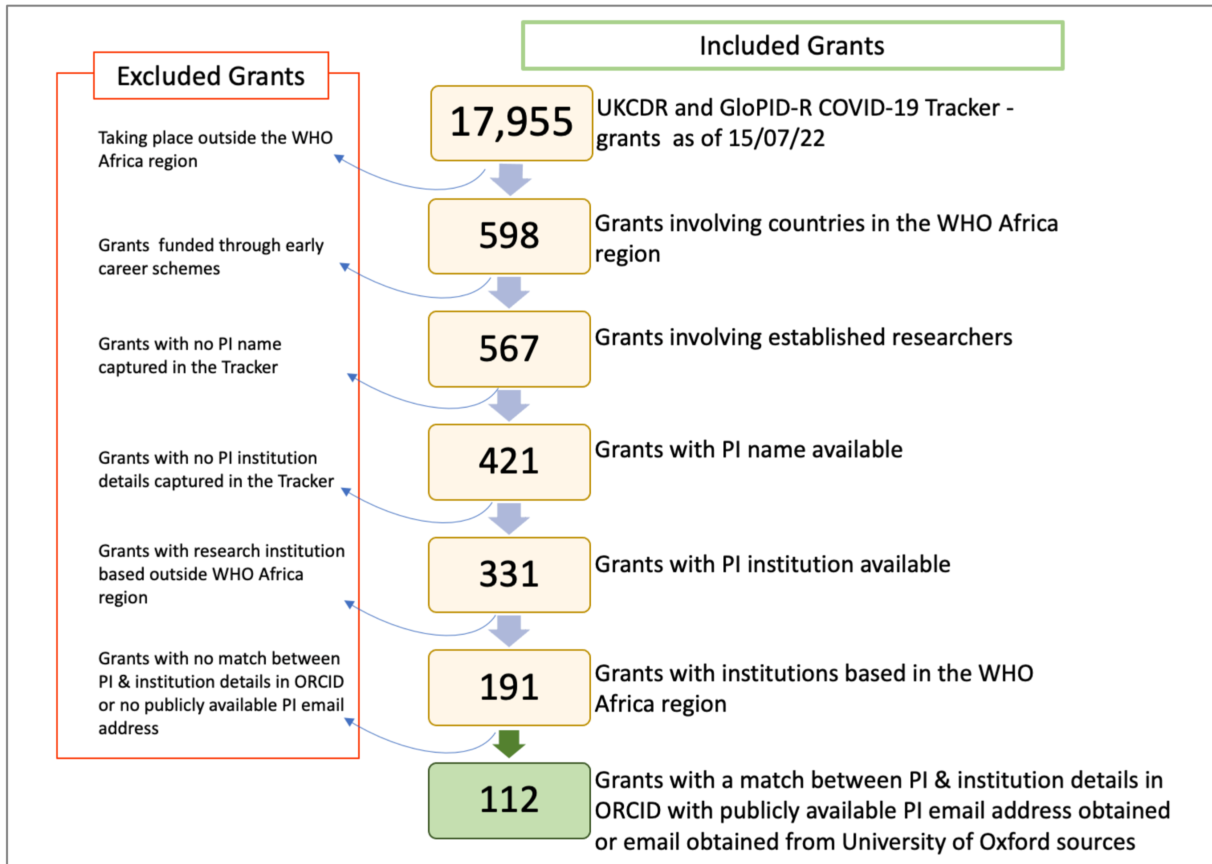


Figure 28: The process for sampling researchers for this study

5.4.2 Grant Managers

The goal of sampling was to identify GMs from a range of research institutions and geographical locations in Africa for inclusion in this research. A minimum requirement of at least four years of grant management experience was set to ensure the inclusion of GMs with experience with grant management prior to and during the pandemic. I searched the websites of the research institutions identified in the UKCDR and GloPID-R Research

Project Tracker during the sampling of PIs to obtain information on institutional GMs. However, as this information was not available, GMs recommended by the PIs participating in this study were interviewed. The PIs were requested to facilitate an introduction to individuals playing a longstanding grant management role (4 years or more) in their institutions who had also managed COVID-19 grants. Eighteen prospective participants were contacted via email with a description of the planned research. My affiliation with the University of Oxford was also disclosed. The 10 GMs who consented to join the study were interviewed.

5.5 Data Collection

Data collection was by semi-structured interviews conducted online via *Microsoft Teams* from May to September 2023. Written consent was obtained from all participants prior to the interviews. An interview guide (Appendix I) was developed incorporating insights from the quantitative study (Chapter 4). Consequently, among the questions included in the interview guide were those focussing on the research disciplines funded, speed of funding processes, various funding mechanisms (new or repurposed grants) and research partnerships.

The questions were piloted with two global health researchers based in African institutions and the insights gained were used to refine the interview questions. I asked open-ended questions to elicit responses, and the order questions followed was guided by the natural flow of the interviews. All interviews were in English and lasted 40 minutes on average. I audio-recorded all interviews.

I considered the concept of information power in sampling for this study. According to Malterud et al. the adequacy of a sample is determined by the degree of richness of information and experiences which the participants bring to the research[267]. Carefully sampling the researchers and GMs for this research ensured that the data obtained were insightful. Data collection ended when the addition of new research participants did not provide any substantially new insights.

5.6 Data Analysis

5.6.1 Transcription

I undertook all the interviews and transcription of the data. Following an assignment of anonymised identifiers to each transcript, I undertook non-verbatim transcription, where the transcripts developed adhered closely to the conventions of written communication[268]. The audio recordings of the interviews were transcribed shortly after the interviews occurred to minimise errors with recall. This improved the accuracy of the data by capturing closely the insights I gained from the interviews while being reflexive in my role in the creation of this knowledge.

5.6.2 Coding and Analysis

A large amount of empirical data is generated in qualitative research and various approaches can be taken to process this data and to make meaning out of it. Thematic analysis is "a method for identifying, analysing and reporting patterns within data"[269]. It is applicable to an array of conceptual approaches to qualitative research and to various methodologies and is a flexible way of navigating complex data[269,270].

I first familiarised myself with the data by reading and re-reading all the interview transcripts. I also listened to all audio recordings from the interviews conducted to better acquaint myself with the range of responses from the researchers and GMs. Since I transcribed all the data from this work, listening and re-listening to the recordings during transcription also facilitated data familiarisation. From this stage, I identified some initial codes, and patterns in the data.

I piloted the initial codes on ten interview transcripts following which they were refined before I applied the codes to the entire dataset. I followed an iterative process while coding the data. I revisited the transcripts and codes and amended the codes as I went on, ensuring the codes represented the views in the data. I maintained an inductive approach while coding in order to identify new ideas from the data. I also looked for "expected codes" as described by Creswell and Braun & Clarke[164,269]. This was informed by my review of the literature and the results of the funding tracking analysis for the COVID-19 research (Chapter 4).

Next, I organised the codes into themes by considering the relationships between the codes, patterns and the insights gained from coding. This was also done iteratively, where I constantly compared codes within and between themes, to ensure that the emerging codes were representative of the perspectives of the researchers and grant managers I interviewed. After I identified some themes, I used the "One Sheet of Paper (OSOP) approach"[271] to further flesh out the ideas within each theme and to identify linkages and relationships within themes leading to the development of a thematic map. Finally, I considered the themes identified in relation to my research questions and developed a report of the findings.

Throughout the process, I maintained reflexivity, being conscious of my preconceived assumptions introduced into the analysis process. I kept a careful record of my processes, and thoughts and any assumptions I might have made while coding. I examined how these could have impacted on the analysis process. The processes for data analysis are summarised in Table 12 under the six phases proposed by Braun and Clarke[269]. Data coding and analysis was done using *Nvivo 14*[272].

Table 12: Summary of the data analysis process for this work

Phase of analyses	Description / details
1. Data Familiarisation	Transcription of data, reading and re-reading the transcripts identifying initial codes
2. Generating initial codes	Piloting initial codes, code refinement and coding entire dataset
3. Developing themes	Aggregating codes into draft themes and collating data on each potential theme
4. Reviewing themes	Reviewing themes to ensure the associated codes align well within the themes, checking that themes align with other themes identified from the data, undertaking an "OSOP" exercise
5. Defining and naming themes	Writing descriptions for each theme, checking alignment to research questions and overall questions, and finalising theme names
6. Producing a report	Writing up results, selecting compelling quotes which showcase results, discussing findings in relation to literature, including personal view of findings, discuss limitations

Table is adapted from Braun and Clarke's 2006 phases of thematic analysis

5.7 Results

5.7.1 Researchers

A total of 24 PIs from institutions based in 12 African countries were interviewed. There were 16 males and 8 females. The institutions represented were: Universities (n=9); Research institutes (n=9); Research Programmes (n=5); and Research Unit (n=1). This

classification was based on the institutional affiliation indicated by the research participants as the distinction between the institution types can be challenging[273]. For example, some research institutes might be embedded in universities. The common factor here is that these entities all conduct research. Table 13 summarises the key PI characteristics.

Table 13: Characteristics of researchers interviewed in this study

Participant ID	Gender	WHO Africa region	Type of institution*
PT1	Male	West Africa	University
PT2	Male	West Africa	University
PT3	Male	West Africa	University
PT4	Male	West Africa	University
PT5	Male	West Africa	Research Institute
PT6	Male	West Africa	Research Institute
PT7	Male	West Africa	Research Institute
PT8	Male	West Africa	Research Institute
PT9	Female	Southern Africa	University
PT10	Female	Southern Africa	University
PT11	Male	Southern Africa	University
PT12	Female	Southern Africa	Research Institute
PT13	Female	Southern Africa	Research Institute
PT14	Female	Southern Africa	Research Programme
PT15	Male	Southern Africa	Research Programme
PT16	Female	Southern Africa	Research Programme
PT17	Male	East Africa	University
PT18	Male	East Africa	University
PT19	Female	East Africa	Research Programme
PT20	Male	East Africa	Research Programme
PT21	Male	East Africa	Research Institute
PT22	Male	East Africa	Research Institute
PT23	Male	Central Africa	Research Institute
PT24	Female	Central Africa	Research Unit

*Type of institution reported is as indicated by the research participants

5.7.2 Grant Managers

A total of ten grant managers from institutions based in seven African countries were interviewed. They included an equal number of males and females with an average working experience in grant management of 8.2 years (SD ±5.0years). While the majority of participants worked at the level of their institution only, others managed grants across multiple institutions usually within their sub-regions. These GMs oversaw activities for large formal collaborative partnerships between multiple research institutions in Africa typically designed to pool expertise and other resources for research. Table 14 shows the participant characteristics.

Table 14: Characteristics of grant managers interviewed in this study

Participant ID	Gender	WHO Africa region	Number of years in role	Type of institution*	Level of grant management
GM1	Male	West Africa	16	University	Institutional
GM2	Male	West Africa	8	Research Institute	Sub-regional Consortium
GM3	Female	West Africa	5	Research Institute	Sub-regional Consortium
GM4	Female	West Africa	10	University	Institutional
GM5	Female	West Africa	18	Research Institute	Institutional
GM6	Male	West Africa	7	University and research institute	Sub-regional Consortium
GM7	Female	Southern Africa	4	University	Institutional
GM8	Female	Southern Africa	4	Research Institute	Institutional
GM9	Male	East Africa	4.2	University	Institutional
GM10	Male	Central Africa	6.2	University and Research institute	Sub-regional Consortium

*Type of institution reported is as indicated by the research participants

5.7.3 Factors Influencing the Securing and Management of Research Funding

The factors influencing the securing and management of COVID-19 research funding are summarised under four themes: Institutional and structural factors; Human resource factors; Funders' policies and practices; and Communication and information. The findings are depicted in a thematic map in Figure 29.

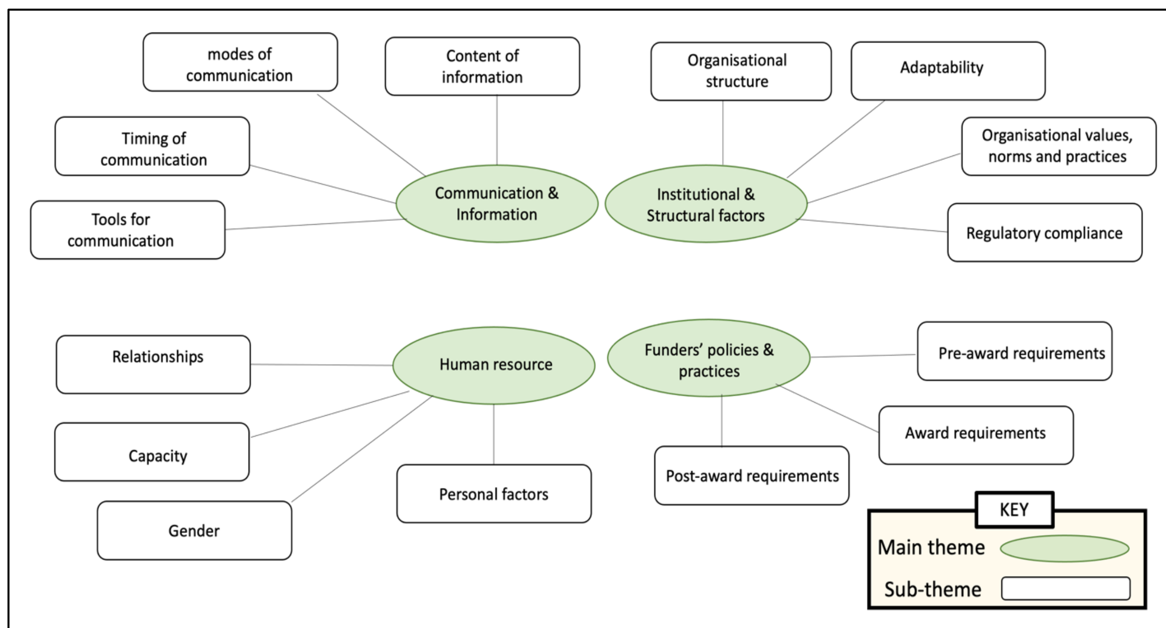


Figure 29: Thematic map depicting the main themes of factors influencing research funding emerging from this work

5.7.3.1 Institutional and Structural Factors

The institutional and structural factors identified refer to the arrangements which define how research institutions are organised and operate in the research funding process. They comprise both tangible and intangible elements such as buildings and other infrastructure, as well as institutional culture and norms.

The PIs and GMs interviewed described various ways in which their organisations were set up and function. Both centralised and decentralised systems were described. Some research institutions consisted of multiple small units or departments organised around a central coordinating structure. These units were often independently governed at the sub-unit or departmental level and had significant autonomy over their processes. The PIs favoured this structure because it facilitated access to grant management support at the unit level. They felt this set-up facilitated various processes, particularly at the grant application stage where substantial support was required to acquire documents for making effective applications. The GMs in contrast perceived the centralised organisation to be more enabling of their oversight of the multiple grants they managed. It improved their ability to coordinate and monitor grants across their institutions.

Institutional structure also dictated the roles played by PIs and GMs and the flow of processes related to research funding. For example, the responsibility for identifying funding opportunities typically fell to the PIs. PIs who were part of research networks felt that these networks promoted their access to notifications of funding opportunities. However, in a few institutions GMs also actively searched for funding opportunities and routinely disseminated these to their researchers which further aided PIs' efforts in finding grant opportunities. Further, while financial reporting activities on grants were led by GMs the technical/ scientific reports were led by the researchers.

Grant applications were typically initiated by the PIs and processes varied across the institutions. For some, the PIs applied for funding with minimal input from their GMs and only notified their institutions upon a successful application. It is at this stage that the institutions were involved with managing the awarded grant. These PIs described

themselves to "have a free hand" as they understood their institutional guidelines on budget preparation for applications. In other institutions, there was active involvement and approval from the institutions prior to proposal submission, with GMs involvement in the entire process.

The processes via which institutions operated was cited by both PIs and GMs as a factor which affected the securing and management of research funding.

"*Previously, what you needed to do was to submit physical papers plus, send an e-mail with some of the documents online, plus you need to send the physical sheet and it would take an average of two weeks for you to get the funds to do the work you did".*

- *Principal Investigator, Research Institute.*

"…You know the rector needs to sign, the vice rector needs to sign, then you have to go back to the rector before going to the finance department, and if the person is not there, the file will wait there till he comes back. I mean it's always a headache".

- *Grant Manager, University and Research Institute.*

They described the processes they had to navigate as long and inefficient. Some attributed their delays in making research funding applications or accessing awarded funding to undertake their research to these processes. Some identified institutional processes as a much greater contributor to challenges with research funding than funder-side processes and requirements.

"Well, for me, I don't think it's in terms of on the side of the funders because they were prompt, I think more of the problem with funding is from our own side here…. Some of the problem with funding that we had were more with the internal system in our organisation".

- *Principal Investigator, University.*

"Disbursements of funds when you win the grant was also quite quick, but disbursing the funds from the institution to you, was where the challenge was".

- *Principal Investigator, Research Institute.*

The challenges introduced by this institutional bureaucracy were exacerbated during the COVID-19 pandemic where there was a breakdown in institutional processes as a result of the restrictive measures introduced to control the spread of infections.

Processes for procurement of reagents, equipment and other research supplies, were particularly adversely impacted. The interviewees described institutional procurement processes as being unfit for rapid response during the pandemic. Coupled with navigating these processes, including obtaining multiple levels of institutional approvals and multiple quotes from potential suppliers, institutions had to contend with lengthy national procurement policies where research supplies were sourced from other countries.

Waivers to by-pass these processes were granted in some cases enabling research to commence more rapidly. However, even where the waivers were in place, the breakdown of global supply chains, caused by closures of international borders, movement restrictions and the sudden increased demand for specific research equipment, laboratory reagents and materials, resulted in severe shortages which further frustrated procurement processes.

"*…but movement of supplies and equipment was also very difficult. Cost of supplies and equipment was a real burden which got worse with the fact that the things couldn't move. We had lots of delays in terms of goods - you order something and it would get there six months later or three months later".*

- *Grant Manager, Research Institute.*

Processes for obtaining research ethics approvals from the local Research Ethics Committees (RECs) also impacted funding for COVID-19 research. Delays in the research ethics approval processes contributed to delays in accessing research funding. These delays were attributed to lengthy institutional processes for preparing and submitting documents to

RECs and to the slow processes of the REC themselves. The interviewees reflected that these delays were not unexpected as they appeared to be the norm in the pre-pandemic period. In contrast, some interviewees experienced expedited ethics approvals and described these to have been facilitated by amended ethics review processes by the RECs during the pandemic.

"*I think it was pretty much the same. For example, the expectation was that you would have expedited ethics if you wanted to collect time-sensitive data. But it wasn't like that".*

- *Principal Investigator, Research Institute.*

"They couldn't even develop a protocol without an approval that there is funding for the research, which means they couldn't even touch the (ethics) review process until their funds hit their accounts. That had a ripple effect on the entire research until there was delay of eight to nine months. Just the ecosystem didn't work, so that's why".

- *Principal Investigator, Research programme.*

Institutional factors also impacted PIs' capacity to conduct research. This limited capacity was cited by PIs in relation to their ability to undertake specific types of research. They described "some general limitations in infrastructure and facilities for research" which was a barrier to them developing competitive grant applications, particularly those for clinical trials. They felt that although they had the technical capacity to design research studies, the lack of a supportive institutional infrastructure put them at a disadvantage in funding applications.

"The summary is that we didn't succeed, but we had a very good concept, and yes, we could see the gaps are not inherent in us…in the sense that, there are some things…. infrastructure we needed, some background data, background publications…these are some of the challenges.

- *Principal Investigator, University.*

Established research partnerships formed by groups of research institutions often involved in collaborative research were described as an enabling factor for various research funding processes. For example, partnerships improved researchers' knowledge of funding opportunities. In response to a question on how funding opportunities for COVID-19 research were identified, one PI responded:

"I would say yes, there were a number of funding opportunities that arose. I got wind of many of them because I'm involved in multiple networks across. So, I would say that ability to identify funding opportunities is the function of the extent of the network that we had".

- *Principal Investigator, University.*

Training and knowledge sharing were other benefits which were derived from research partnerships.

However, working in research partnerships also introduced some challenges for the grant management process. Managing internal institutional processes among the various partners resulted in delays in developing research applications, securing relevant support documents, accessing funding and grant reporting. Movement restrictions associated with pandemic control measures prevented research site visits and limited the ability of primary award holders in partnerships to effectively monitor research activities among their research partners.

"*The delay could come from the (partner) institutions, because by the time we finished procedures, writing a consortium agreement, asking people to bring documentation - this can take long and this can really delay funds distribution".*

- *Grant Manager, Research Institute.*

The arrangements in partnership awards where a lead institution administered funds to the other institutions also introduced unequal power dynamics whereby the sub-awardee was dependent on the primary award holder for funding. A GM describes this:

"*But if it is a sub-awardee that has been sub-awarded by a prime institution, that is where sometimes you put in the request that you need funds to go to the field and you hear that: we ran out of funds and we don't have staff or we have money but we don't have staff available to process your request. So sometimes it delays".*

- *Grant Manager, Research Institute.*

These dynamics were described for partnerships led by institutions based outside Africa and those between two or more African institutions where the lead institution was also based in Africa.

Despite these issues, the interviewees felt that experience working with various partners promoted an understanding of partners' processes and built trust over time in working collaboratively together. Furthermore, they felt this trust enabled them better navigate the challenges described.

The interviewees described various measures introduced by their institutions to facilitate their ongoing operations in response to the pandemic. Some institutions initiated remote work policies which enabled employees to work from remote locations outside their institutions, typically from home. These policies resulted in minimal interruptions to grant management functions in the research institutions and enabled PIs to continue to receive support during the grant application stage and also in the administration of grants when their applications were successful.

The measures introduced were associated with an increase in the application of digital tools. Video conferencing tools such as *Microsoft Teams*, *Zoom* and *Google meetings* facilitated virtual interactions among PIs, GMs and other institutional staff. Furthermore, shared working platforms enabled collaborative work in the various stages of the grant application processes. For example, in the preparation of applications PIs could convene virtual meetings of their research teams to plan and strategise for the grant application despite the restriction of face-to-face interactions during the pandemic.

This switch in institutional practices was easier to implement in institutions where remote work policies, digital tools and protocols for their application were in place prior to the pandemic. To ease the adaptation of staff into these new practices, certain institutions offered additional support to their staff by swiftly guiding them through courses to enhance their proficiency in utilising various digital tools. Furthermore, some provided internet subscriptions for staff in their remote work locations.

"So, what happened is we actually supported some staff with the data. Like if you didn't have access to internet at home, we then supported you with that."

- *Grant Manager, University.*

At the height of the pandemic and also when COVID-19 restrictions began to ease, some institutions initiated shift systems whereby essential staff, who could not work remotely, worked over rotating shifts. This ensured coverage over the institution's operational hours. The shift system was described as being successful when government policies on movement restrictions in the relevant countries allowed for exemptions for "essential workers". However, individuals dependent on public transport for commuting to work faced challenges in adhering to these policies because of restrictions on public transport during the pandemic.

For the PIs, this enabled continuity of research particularly lab-based work and research involving in-patients. For the GMs it enabled continuity of grant management support. For instance, some of these essential grant management staff were signatories to documents required for grant applications or for the release of funding for research. A GM cited an instance where signatories were supported by their institution to temporarily be relocated to live in close proximity to the research institution to ensure their availability for signing documents when required.

Other policies resulted in the reallocation of responsibilities within the research institutions in the provision of grant management support to researchers. Specific tasks were delegated to other staff members. For instance, a GM described:

"*Sometimes we had to use electronic signatures from the comfort of our homes. The chief executive - We take permission to use his electronic signature.....then we do official signing of those documents. Even for withdrawal of funds for the research, we do it from home, taking permissions from the chief executives of the authorising department of the institution".*

- *Grant Manager, Research Institute.*

This delegation of tasks enhanced the efficiency of grant management processes in the research institutions employing this approach as it promoted expedited funding approval processes. Other policies to address shortfalls in human resource capacity also saw the diversion of non-technical staff to support research efforts.

"*Everybody started working on COVID. Everybody without exception, even the administrative staff became very important because they were actually capturing data".*

- *Principal Investigator, University.*

Implementation of the changes in institutional processes was challenging. The switch to online, paperless processing of documents was particularly met with significant resistance in some institutions. The conflict between the new policies and existing organisational culture and practice is shown in this quote where individuals opposed the changes in practice in favour of maintaining the status quo.

"……Especially, our colleagues in the accounts office…they don't understand online [work].. So, our workflows into the accounts office and when our functions end at post-award, they will print everything".

- *Grant Manager, University.*

PIs and GMs reflected that the pandemic improved their working relationships. The state of urgency during the pandemic instilled a deeper sense of shared responsibility in the delivery of effective research. It resulted in a situation where "all hands were on deck" in responding to the COVID-19 pandemic where PIs and GMs and their teams worked more collaboratively.

A number of the aforementioned changes in practice in the research institutions were perceived to have had a lasting effect which persisted after the pandemic. For instance, as of the time when I undertook these interviews, the PIs and GMs attested to the continued use of digital approvals and signatures for documents related to grant management.

"I think it was a very positive thing because initially we always used to do everything [in] hard copy…….We've been able to move to a complete online platform. Gone are the days where you have to now print the documents and leave on our director's desk for approval. Now we just communicate by e-mail, send everything to him, it's approved signed and it's gone. It's much easier working online than it was printing copies, waiting for someone to sign, running to another office, getting the next person to sign..."

- *Grant Manager, Research Institute.*

"I feel like when it comes to signing documents and approvals and all those things, those things are now done through technology. So, for example, my institute now uses DocuSign for most documents. When it comes to matters of grant support, I feel like most of that is now done online using technology".

- *Principal Investigator, Research Institute.*

This highlights the perceived positive legacy of practices initiated during the COVID-19 response.

5.7.3.2 Human Resource Factors

The human resource factors which influenced research funding in African research institutions related to personal factors and those concerning the capacity of PIs and GMs to undertake research funding related activities.

GMs described their roles as involving coordinating and interacting with the broader research management activities including human resource management, risk management, procurement and communication. While some were part of organised teams of officers providing various forms of research support, others described themselves as "jack of all trades", being responsible for multiple activities in their institutions. Some grant managers also specialised in specific aspects of the funding process, for example pre-award phase only, while others worked across the various stages.

Given the diversity of tasks performed, some GMs felt their teams were inadequately staffed to meet the demands of the grant management role. Further, some expressed the feeling that training opportunities made available to them by their institutions, to boost competency for their roles, were insufficient or lacking.

"*Being able to build our capacity is very key, but that is lacking and so, for those of us who have been doing it for some time, we have self-tutored ourselves and built our own capacity largely".*

- *Grant Manager, Research Institute.*

Others felt insufficiently equipped to undertake their roles and described the lack of grant management software, in particular, to hamper their activities significantly. Their perception was that improvements to grant management role was not prioritised by their institutions, and that capacity strengthening efforts supported by funders tended to focus on researchers' capacity and not grant management activities.

"I also think that some of our funders need to think about capacity building for research administrators also and not only for faculty. Because you can provide the funding for faculty to do the research, but if we [grant managers] don't understand and manage the funding.... it goes against the institution but it also goes against the funder ....because then you've given funding that was not well managed".

- *Grant Manager, University.*

On grant reporting specifically, GMs attributed delays to some PIs limited training in preparing grant reports. Significant effort and time was required to improve inadequate reports which could delay grant reporting processes.

"So specifically related to grant management, we feel that we need to capacity build, especially even our own researchers on things like technical report writing.... for them to learn the responsibility to be accountable…how they can be able to account for those grants in an efficient manner and how they can be able to be responsible and account for those grants, feeling that, this is part of my responsibility and therefore I'm helping the institution to grow in terms of research, when I do the correct accountability".

- *Grant Manager, University.*

Managing funding for research partnerships was described as being resource intensive as it requires extensive capacity to navigate the processes within various institutions to

successfully administer funds. This was particularly the case for the primary awardees who coordinated the research activities. One PI describes the increased workload:

"….The same person who's an authorised signatory having to peruse so many documents and being sure that everything is in order, following the institutional rules or signing was just an increased workload resulting in more delays.".

- *Principal Investigator, Research Institute.*

During the COVID-19 pandemic a mixed picture of workload was described. While some grant management teams described a higher workload resulting from the increased demands placed on their units, others described a significant reduction in their workload attributed to the suspension of work on non-COVID-19 related research projects with a shift in focus to the fewer COVID-19 related research grants, which they managed.

"Most institutions were focussed on ramping up their testing and reporting capacity and so scientists have their time really taken up by the national assignments that they all had, [which] was for testing and reporting. …. I would say that is what would account for some of the delays…. that is divided attention".

- *Principal Investigator, Research Institute.*

The PIs described an expansion in the range of responsibilities they were involved in. They expressed facing challenges with balancing competing priorities including teaching commitments, clinical work and involvement in other national response endeavours with their research. Many "did not have the time" to apply for grants and faced difficulties in meeting tight deadlines for grant applications.

"*The challenge is multipronged because on one side, as one of the leading physicians, there are few ID physicians. So, I'm both involved in training, doctors and other healthcare workers I'm involved direct patient management and also travelling across the country…. for training on infection prevention control across the country and also trying to do some administrative work with the hospital. Then at the same time, trying to write proposals. So, it means that I and my colleagues needed to work much more than usual. We had to work more than 24/7".*

- *Principal Investigator, University.*

Difficulties with completing grant applications was especially prevalent among PIs whose first language was not English, who faced additional challenges with applying for grants particularly within short time frames.

"Sometimes I apply and for many times, but it's really difficult for French country….. And when we apply, most of the time we don't win the grant".

- *Principal Investigator, Research Institute.*

Both GMs and PIs described a range of personal factors which impacted their capability to undertake their roles during the pandemic. They were directly affected by the pandemic itself with some reporting personal illness with COVID-19 or illness of their family members and colleagues. They suffered the mental strain introduced by losses of staff members and family members during the pandemic which had a detrimental impact on their research and grant management activities.

Furthermore, PIs and GMs with caring responsibilities faced additional challenges with the various working arrangements implemented during the pandemic. One GM reflected:

"In fact, there are times when 12 midnight, I'll send something and the person will respond and I'll say, why are you awake? And the person will say, why are you also awake? …. some of my colleagues who have young kids, they could not function during the day. They had to wait for people to sleep before they could work"

- *Female Grant Manager, University.*

They described how these adjustments made to accommodate their additional responsibilities resulted in long working hours and burnout. The individuals whose roles required them to be physically present at their institutions faced similar challenges. One PI reflected that this was particularly the case for the female professionals.

"I came into work to do my clinical work and the people I would see in the building tended to be two career couples, of whom the person who was there was usually not the woman……..the people staying at home tended to be the woman even though she was a professional".

- *Female Principal Investigator, Research Programme.*

"*Younger staff found it harder, particularly women. They seemed to have more difficulty in finding a quiet space to work. So yes, I would have thought that many of them will have reported significant challenges in either getting power or internet, or both, or quiet space to work".*

- *Male Principal Investigator, Research Programme.*

Interpersonal relationships within research institutions also affected research funding processes. To navigate institutional bureaucracy PIs and GMs drew on their personal relationships with institutional staff to expedite processes within their institutions. The institutional structure and individual interactions introduced various dynamics within the research institutions which impact its activities and processes.

"For instance, if an investigator gets new funding and they needed to submit a standard operating procedure for withdrawal of funds….. and that document is in the file or [with] the authorising official, …..and you can't get him to the office because he is a big man".

- *Grant Manager, University.*

This quote exemplifies how hierarchical structures within the research institutions may impede processes.

5.7.3.3 Funder's Policies and Practices

The requirements and processes of research funders in the various stages of the funding cycle are described under this theme.

The interviewees observed an increase in COVID-19 funding calls and noted that funding organisations which had not previously funded their research were offering funding opportunities.

"Things moved much more quickly where organisations that weren't normally funding infectious disease research, were now coming on board and other organisations that we were currently funded by were now opening new opportunities".

- *Grant Manager, Research Institute.*

Funding opportunities were identified from various sources such as from funders' websites, social media platforms or direct notification by funders. The latter was more likely where there was an existing or previous relationship between the funders and the researchers or their institutions. Direct notification from funders was associated with closed funding calls and these were perceived to have increased during the pandemic. A GM reflected "we had never had the situation whereby funders contacted us to submit applications for grants".

The majority of funding calls were open, competitive calls and spanned various research disciplines irrespective of the call type. However, the interviewees perceived there to be fewer funding calls addressing research in the social sciences. They described funding calls launched early in the pandemic focussed on disease diagnostics and epidemiology with social sciences related calls featuring only later in the pandemic.

The funding calls were open for shorter durations than the pre-pandemic period. Funders were considered to have been less strict with their requirements, allowing for submission of grant applications even when deadlines for submission had passed. For the grant application process, a mixed picture emerged. While some interviewees perceived there to have been no difference in the processes for applying for grants during the pandemic, others described significant changes which simplified and shortened the process. For example, some funders only required short concept notes rather than fully fledged research proposals.

"For sure, it [funding] was more streamlined... The applications were sometimes shorter, sometimes even very short, two-page application with a budget attachment and you send it in"

- *Grant Manager, Research Institute.*

The turn-around time from grant application to receipt of an outcome was also shorter during the pandemic even though some delays were reported.

"Usually, even if you win a grant, under normal circumstances, you can take a year before the grant comes in because there's a lot of due diligence, there's a lot of back and forth. What I realised during COVID was that release of funds was actually quite rapid. It wasn't as cumbersome as it used to be".

- *Principal Investigator, Research Institute.*

For some projects, existing funding for research awarded before the pandemic was diverted to COVID-19 research. This was usually the case where institutions had long-standing funding agreements with funders prior to the pandemic or were already funded to undertake research falling under broad thematic areas which could easily pivot. Other ongoing studies added on COVID-19 specific research questions. However, in many instances, funders' terms and conditions prohibited the diversion or repurposing of already awarded funding. Therefore, most of those pre-COVID projects were suspended during the pandemic. Many of these projects received non-costed extensions and resumed in the post-pandemic period.

The PIs perceived funders to have had additional requirements beyond those in their funding calls based on which they awarded grants.

"..the feeling that they really wanted people who already had a certain amount of capacity. they just needed reagents, things which you are able to acquire quite fast and then you start working, you know, because if you fund equipment, [it] has a tendency to take a bit longer to set up.

- *Principal Investigator, University.*

They felt that lack of existing equipment and other infrastructure in their institutions put them at a disadvantage in being successful at grant applications.

Experiences with the awarding of grants were mixed. Some interviewees felt due diligence checks were relaxed during the pandemic such that funders upheld existing eligibility from previously funded research grants or reduced the documentation institutions had to provide to satisfy the grant terms and conditions. Others felt the due diligence was as stringent as in the pre-pandemic period and that these extensive checks delayed the institutions receiving funding for research.

"There wasn't actually any change in the contracting process…the conditions or the complexity of the contracts seem to be the same actually".

- *Principal Investigator, University.*

Coupled with these extensive due diligence checks were unfavourable grant terms and conditions imposed by the funders. Some funders disallowed overhead costs of research institutions, research equipment costs or staff salaries from inclusion in grant costs. These conditions negatively impacted on the conduct of research.

"*……for social science the biggest budget are the staff salaries……some funders have got a fixed amount like 70% must go to research, 30% must go to staffing, but we are in a pandemic where people are losing jobs, so it's not like they have a funder or an institution that is supporting 70% of the deficit".*

- *Principal Investigator, Research Programme.*

"And we were telling them that when you stop the acquisition or the inclusion of equipment, the inclusion of our salaries in the grants, the inclusion of research assistants in the grant, the inclusion of some consultants in the grant, it severely cripples some of us because sometimes we have the idea, but we do not have the equipment to do it.".

- *Principal Investigator, Research Institute.*

"*For some of the grants that we received specific for COVID-19 work, the funders said this is a pandemic, we are not allowing you to incorporate your overheads in the budget and we had to understand …. and were able to go with the funders' regulations."*

- *Grant manager, Research Institute.*

For the PIs and GMs there was concern that failing to agree to these funders' conditions would risk not obtaining funding for research. The unequal power dynamics at play here impacted their ability to negotiate for more favourable conditions. Hence, institutions tended to agree to funders' terms and conditions even when these were detrimental to their operations. A GM when describing closed funding calls commented "the funder giving you money on the silver platter and you now want to request for overheads?"

Delays with the disbursement of funds once awarded were also reported; and for the PIs this impacted on their research negatively. The delays hindered the prompt initiation of research such that research questions either had to be changed or proposed methodologies modified in order to address the questions.

"I lost several months where I could have collected the samples from the initial wave of COVID and I couldn't."

- *Principal Investigator, Research Programme.*

"…with COVID it [disbursements] stretched up to a year. It was frustrating, especially because a lot of the things you needed money to do them: you have to pay salaries, you have to buy reagents and budgets had even gone up. Like, if you got a grant in early 2020 by mid-2021 the budget had shot up but the funders will not add any budgets to it. So, it was really a struggle".

- *Principal Investigator, Research Institute.*

Further, re-imbursements were also delayed and institutions struggled to secure alternative funds to continue their research. Some even incurred costs which they could not recover.

"But the funds were delayed. In fact, we haven't recovered from that up till now. For one of the projects, we haven't gotten the money up till now".

- *Principal Investigator, University.*

There were challenges with adhering to budgets proposed for research given the difficulties associated with procurement during the pandemic. The interviewees acknowledged some funders' coverage of additional costs introduced by the pandemic response. These included the cost of PPE, disinfectants and hygiene products for COVID-19 infection prevention and control. Unpredicted costs, such as increases in procurement costs caused by price fluctuations related to the breakdown in global supply chains and currency fluctuations, were also covered.

There were varied experiences on grant reporting processes during the pandemic. For some PIs and GMs, the frequency for grant reporting was unchanged whereas for others it was increased. Some felt the increased frequency was justified given that COVID-19 was a significant health emergency.

"We reported more frequently because it was an evolving situation from this and other stakeholders needed to understand what was going on… I think many funders had less onerous reporting requirements and timelines because of the pressure that there was to deliver results and also to manage the pandemic".

- *Principal Investigator, Research Institute.*

However, other PIs found the increased frequency to be detrimental to their research since it took away from the time spent doing the actual research.

"..there were others that were asking for monthly and quarterly reports and that was a nightmare, especially when you are also trying to deliver on the project in the midst of COVID".

- *Principal Investigator, Research Programme.*

"I would say to the funders, if we are given funding to institution, I think you should trust the institution to deliver what they have said they would do. I don't think monthly meetings with people who are very busy is very helpful".

- *Grant Manager, Research Institute.*

The PIs appreciated having the time to focus on the conduct of research rather than having frequent meetings which were perceived to be unproductive. Most M&E activities were also done completely online during the pandemic due to COVID-19 related movement restrictions. For example, site visits were limited. Some PIs felt this negatively impacted the M&E process since it took away from funders' experiencing the realities of the research context.

"I don't think it's better because electronically you cannot really cover everything. You could upload documents and even send pictures, but it's not the same. If someone comes and you take them through the flow of your clinic, they see the staff, they see the challenges in real time. For example, if you are in the clinic and lights goes off, if you say it in a report or in an online meeting they'll say oh ..lights went off.. But when they are there and the light goes off, they feel it.

- *Principal Investigator, University.*

Some funders delayed in the provision of feedback on grant reporting and this resulted in institutions incurring significant costs particularly where funding agreements involved re-imbursement for costs incurred rather than upfront provision of funding.

"When it comes to reporting, we realised that some funders took too long in getting back to us on the financial reports. And now that the grant's ended, they are telling us ABC has been disallowed. Why were the reports not reviewed thoroughly and the expenses disallowed then? .....and that means basically we kept making the same mistakes which were not disallowed because there was nothing clear in the agreement".

- *Grant Manager, Research Institute.*

PIs and GMs also felt funders did not always live up to their commitments. They reported sudden changes to funders' policies which had detrimental impact on their research and operations. For example, some funders announced cuts to research grant awards when research had commenced and institutions had already incurred costs with implementing the projects.

"... so we got the first tranche [of funds], at the next tranche, [it] was not available because it was no longer priority by the funder".

- *Principal Investigator, Research Programme.*

"They [funders] just cancel it. Then they give you apologies. If there's money that they had also lost, they don't ask".

- *Principal Investigator, Research Institute.*

Conversely, the willingness of funders to grant costed or non-costed extensions to research projects which were delayed was seen as a positive practice by funders which enabled continuity of research projects.

The PIs felt the funders were more engaged in the research funding process. In particular, funders facilitated PIs' interaction with other stakeholders and supported the formation of new partnerships and collaborations during the pandemic.

"They put us in touch with some other good collaborators that I wouldn't have known before".

- *Principal Investigator, Research Programme.*

"*We could engage programme officers more regularly than before. Previously, you get your money and do what you're doing, and then maybe just send a report".*

- *Principal Investigator, University.*

5.7.3.4 Communication and information

Factors relating to communication and information focus on how information was shared and interpreted within research institutions and between research institutions and other external entities including governments, research regulators and other research institutions.

Formal and informal modes of communication were described by PIs and GMs in the research funding process. The existence of formal channels of communication facilitated the transfer of information within the research institutions. For example, formal channels were used for the internal dissemination of research funding opportunities. Formal structures were also utilised in the transfer of information during grant application processes and in the management of awards.

"Well, in my own institution we have a research office which sends every week, research opportunities through the emails and university websites…But apart from that, we have a cohort to which they also send research opportunities and things like that".

- *Principal Investigator, University.*

However, these channels followed established organisational hierarchy and, hence, communication was often hindered by the bureaucratic processes within research institutions leading to delays in the transmission of information. Less formal channels for

communication such as instant messaging applications were also used and these were perceived to expedite the transfer of information.

Similarly, funders communicated with PIs and research institutions via formal and informal channels. However, GMs reflected that they particularly benefitted from informal channels for communication during the pandemic. These channels promoted timely transfer of information and also provided safe spaces for them to seek clarification on some aspects of the grant conditions.

"But just having more frequent touchpoints, but in a setting that's not high-stakes can really help to move the project along… I think it was helpful to have a direct line and some more informal lines of communication with the funder. So, some people we could just message on WhatsApp and we could just share some ideas or some documents".

- *Grant Manager, Research Institute.*

"There was really strong openness and flexibility on side of the funders and some funders would just say, look, you don't have to send me a long text, just WhatsApp project managers just for information".

- *Principal Investigator, University.*

The clarity of messaging in communication was also a factor described by PIs and GMs. For the majority of interviewees, messaging from funders was clear and outlined the funders' expectations of grantees. Funding calls clearly spelt out funders' requirements and, hence, they understood the processes for grant application. Although as these were often written in English, non-English speakers were at a disadvantage.

Communication within institutions, however, was less clear. Messaging from GMs and institutions was often contradictory or ambiguous.

"*Currently, if a PI needs letters of support for an application submission, they have to send it to a specific e-mail depending on which college they are in. Sometimes it is confusing for them".*

- Grant Manager, University.

A number of digital tools were used for communication among institutions, PIs, funders and other stakeholders. These included collaborative work platforms, social media platforms and videoconferencing software. There was a surge in the use of these tools during the pandemic, enabling the continuity of information transfer. The main challenges with these tools related to internet access and sustained electricity to power computers and other devices. Personal instant messaging platforms such as *WhatsApp a*lso facilitated rapid information exchange and enhanced rapid dissemination of funding opportunities during the pandemic.

The timing of communication was also a factor described by both PIs and GM. Delayed transfer of information among funders, researchers and other stakeholders contributed to delays in research funding and ultimately the delays in the conduct of research activities.

5.8 Discussion

This research identified multiple factors which influenced access to funding for COVID-19 research. These cut across the stages of the grant cycle from identification of grant opportunities to receiving and managing awards.

The findings underscore the pivotal role research institutions played in the funding process and demonstrated how their operations affected access to research funding. Institutional governance emerged as a key factor for which there was divergence of views between the

GMs and PIs. The merits of decentralisation in health systems governance, including increased responsiveness and flexibility, are described in the literature and these align well with the reasons cited by the researchers, who favoured this form of governance[274]. Conversely, centralisation, which the GMs preferred for facilitating oversight of grants and coordination of activities, also has its advantages[275]. Consequently, there are likely to be trade-offs between these two governance systems[276] and these must be carefully considered in efforts to promote optimal processes within research institutions in relation to research funding.

Slow institutional processes also emerged as a major bottleneck to expedited access to funding identified from this research similar to findings of a review of research management support in SSA[104]. With a focus on accountability, many institutions operated via set processes, often with multiple layers of checks built in, to ensure adequate oversight. From the literature, the benefits of institutional bureaucracy include improving consistency and predictability of practice, promoting efficiency, transparency and accountability[277]. The experiences described by this study's participants, however, suggest these were not realised.

Inadequate structures for communication within institutions resulting in impaired mechanisms for oversight could be one explanation for this finding. For example, the lack of centralised grant management software could have frustrated monitoring efforts and also affected efficiency of processes, preventing prompt interventions where there were delays[278]. Poor communication of institutional requirements also meant PIs were often left ignorant of how to navigate the processes for applying for and accessing funding for their research. This suggests that although checks and balances are important for oversight, they must be complemented by supportive structures for effective operations.

Multiple challenges related to research partnerships were identified in this work. Notable examples are increased complexity of grant management and administration, challenges with communication and power imbalance. These are consistent with results of other assessments outlined in the literature outside the pandemic[95,279]. Often the challenges to research partnerships are discussed in the context of North-South Partnerships[280]. In addition to discussing these challenges with North-South partnerships, PIs and GMs in this study highlighted similar limitations with South-South partnerships during the pandemic. Guidance documents on strengthening partnerships and promoting equity in their operations recommend fairness in research conduct, equitable benefit sharing and inclusive agenda setting[95,139]. Further work can be undertaken to explore these in context of South-South partnerships and partnerships at all levels in the research system.

Nevertheless, the benefits of partnerships were cited consistently among both the PIs and GMs interviewed. This highlights the perceived importance of partnerships for enabling access to funding for research during the pandemic. Partnerships may take many forms, ranging from collaborations among a few institutions to large research consortia involving multiple entities. They also operate via different models for channelling funding as described in Chapter 4, Section 4.5.3. Partnerships can drive innovation, fairness and research capacity strengthening more broadly in the research system[281]. They enable access to funding by promoting identification of funding opportunities[237], strengthening of capacities for grant proposal development[237] and grant management capacity[281], as indicated from this work .

Efforts to build effective research partnerships and strengthen research capacity in Africa have been on the rise[119]. The EDCTP[236], Africa Institutions Initiative[282] and the Developing Excellence in Leadership, Training and Science Initiative (DELTAS Africa)[283] initiatives

are notable examples. DELTAS Africa, in particular, employs a unique funding model which delivers funding directly to the participating African research institutions[284].

The results also highlight the interactions between research institutions and other external entities and their impact on research funding during the pandemic. They show that research institutions do not operate in isolation and are embedded within systems which impact institutional processes. For instance, national procurement policies influenced procurement procedures in public institutions including universities, leading to significant delays in research initiation. Similarly, regulatory approvals stalled the flow of research funding in some instances.

Researchers were also required to support their national public health responses in activities which did not necessarily relate to research, resulting in an increase in their responsibilities during the pandemic. Those who were clinicians were obligated to devote significant time to patient care and clinical duties as found in a cross-sectional study of Canadian clinical researchers during the pandemic[285]. These conditions could have contributed to burnout and anxiety among researchers in Africa and impacted on their capacity to apply for research grants or deliver on funded research awards.

Inadequate capacity to support grant management and research were among the issues raised by PIs and GMs to impact access to research funding. These were cited consistently as barriers to research funding in African research institutions pre-pandemic and are discussed in the literature[104,146,147]. Poor grantsmanship, in particular, was highlighted by the PIs and, coupled with the challenge of inadequate research infrastructure in some African research

institutions, resulted in a significant disadvantage in competitively bidding for and winning grants for COVID-19 research. This was a particularly dominant view with respect to COVID-19 clinical trials of which only five percent involved sites in Africa according to one review[286]. These findings are consistent with historical trends of comparatively lower health research outputs from the African continent [252,287].

Globally, the COVID-19 pandemic led to alterations in work life[288]. The remote work policies introduced in response to the pandemic led to a blurring of the boundaries between work and personal life. Women with caring responsibilities, in particular, were disproportionately affected as existing gender disparities were exacerbated[289]. In a study comparing bibliometric data on scientific publications prior to and during the pandemic, Kwon et al. demonstrated that the negative impacts of the COVID-19 on female researchers varied depending on the career stage of female scientists[290]. Those earlier in their career were more impacted as they most likely had younger dependants. Babalola et al. also found female African researchers reported additional domestic responsibilities, inability to apply for research grants and losses of opportunities for professional advancement among the impacts of the pandemic[291]. Female scientists in Africa are faced with multiple impediments to their career progression including cultural gender expectations, gender biases in employment, lack of role models and lack of a supportive research environments[292]. Further studies are required to understand the long-term impacts of the pandemic on their careers and to identify strategies to ameliorate these impacts.

The varied experiences of this study's participants with respect to funders' policies reflects the complexity of funding processes and the reality in practice. The mix of both enabling factors and unfavourable terms and conditions described was, therefore, expected as the

diverse funders supporting COVID-19 research in Africa had varied requirements and terms for funding. Historically, these differing demands have placed a huge burden on African research institutions as they have to navigate multiple funder requirements. For example, Harste et al. report that in 2018 and 2019 an African university responded to over 20 due diligence requests for various funding organisations[91].

The lack of an agreed standard for due diligence among funders led to the development of the Good Financial Grant Practice standard (GFGP)[91]. GFGP is an international standard for certifying research institutions based on their grant management capabilities. Although uptake of GFGP is progressively increasing, cost of undertaking the assessment might be a limiting factor for less-resourced institutions[91,293]. An increase in the funders recognising GFGP as a common standard for grant making could further boost uptake among research institutions. GFGP could be important for addressing the challenges associated with disparate funder requirements in the research funding process.

The experience of shortened times for funder processes highlighted in this work aligns well with the reported modifications made by some funders to their operations[294]. These include shortening of grant proposal review durations, shortened contracting and due diligence processes and reduced frequency of grant reporting. The Research for Health in Humanitarian Crises (R2HC) funding scheme is a notable example which reduced its entire process from grant proposal submission to funding disbursement from 12 months in the pre-pandemic period to just 13 weeks during the pandemic[294].

Conversely, some funders did not modify their processes or only made minor amendments to their pre-pandemic policies. This could explain the views expressed by some PIs and grant

managers, who felt there was no difference between funding processes during and prior to the pandemic. Similar to the pre-pandemic period, unfavourable terms for the re-imbursement of research administrative costs in research institutions emerged as a challenge to research effectiveness[101].

The influence of governmental policies on research funding during the COVID-19 pandemic is well demonstrated by the cuts to public funding for research which resulted from the UK Government's reduction of Official Development Assistance contributions from 0.7% to 0.5% of Gross National Income (GNI) in 2021[295]. This impacted funding for health research broadly and some COVID-19 research projects globally and in Africa. Despite measures implemented to ameliorate the impacts of the reduced funding on ongoing COVID-19 projects, a review of Global Challenges Research Fund (GCRF) grants, published in 2024, reported many grant holders had to make significant changes to their planned research, resulting in "delays and wasted time and resource, which impacted project progress"[296].

Research funding organisations also faced significant challenges with their operations during the pandemic. The challenges cut across the grant cycle and included: processing large numbers of grant applications[37]; shortages of peer reviewers[37]; and technical failures such as those related to failures in grant management software[297] . These could explain the delays in processing funding for COVID-19 research emerging from this work. Few funders have made their assessments of the impact of the pandemic on their internal processes public[297–299]. Some of their assessments might still be ongoing. A comprehensive review incorporating funder perspectives of the impact of COVID-19 on their organisations can be an area for future work.

This work also highlights the key role of power as an important factor influencing access to funding for COVID-19 research in Africa. Power was exercised at various levels of the research funding process and various sources of power were described. For example, bureaucratic power[300] is seen at the level of grant management where the main authorisers of documents delegated their responsibilities to others to enable expedited document approvals. Power was also variably enforced such that, despite there being formal processes in place requiring institutional endorsement, PIs could freely apply for grants without institutional approvals. Unequal power between primary grant holders and sub-awardees in partnerships which delayed access to funding were also described in this study.

In particular, funders demonstrated their financial power via their terms and conditions. Some interviewees described feeling pressured to accept unfavourable terms, as they risked being denied funding for COVID-19 research if they failed to do so. The interviewees perceived that funders were not transparent in their processes for selection of awarded grants and thought funders did not fully disclose all the conditions attached to grants in the pre-pandemic period. This was also found in other assessments of open availability of grant terms described in the literature[301]. Here, the use of communication as a tool of power, to regulate the flow of information among the actors involved, is demonstrated.

This study sought to explore the experiences of researchers and GMs with accessing and managing research funding during the COVID-19 pandemic. However, among researchers, only PIs were included in the study. Although, it is likely that other researchers (with different roles and at earlier career stages) could also provide insights into the grant application, award and grant management processes, experienced PIs were selected because of their leadership role in grant applications. The interviews for this work were undertaken

using an online videoconferencing application. While this approach enabled me to access views from a range of participants across Africa, virtual interactions limited my appreciation of non-verbal cues and the observation of the research setting in some instances where video functions could not be used due to poor internet connection.

I also encountered some challenges with data collection in the conduct of this qualitative study. Limited publicly available email contacts constrained access to research participants for this work. I addressed this by sourcing additional email contact information, for my identified sample, from research networks within the University of Oxford. GMs were identified through the PIs who participated in this research. Many of the PIs interviewed were involved in multiple activities across their institutions. Many interviews had to be rescheduled or cancelled at short notice due to their demanding schedules. Flexible scheduling to allow for interviews to be held out of normal work hours and on weekends helped deal with the scheduling challenges encountered in this work.

5.9 Chapter Summary

The aim of this qualitative study was to explore the factors influencing access to funding for COVID-19 research in Africa from the perspective of researchers and grant managers based in African research institutions. The factors identified fell under four broad themes: institutional and structural factors; communication and information; human resource factors; and funders' policies and practices. These factors are interlinked and overlapping and should not be considered in isolation from each other.

The factors hindering access to research funding relate to institutional factors, funder-side factors, and challenges introduced by other external entities which delayed access to research funding during the pandemic. They included: institutional bureaucracy; stringent procurement policies; staff illness; long working hours leading to burn out; miscommunication; lengthy due diligence processes; and increased frequency of grant reporting. The factors which promoted access to research funding during the pandemic were institutional policies for remote work, shift system of operations in research institutions, expedited ethics approvals, supplementary funding, pivoting grants, shortened grant application processes, and no cost extensions.

The work described in this chapter shows multiple factors influenced access to funding for COVID-19 research in Africa. Lessons can be learnt from these in planning for responses to future epidemics and pandemics, and these are discussed in Chapter 6.

Chapter 6 - Key Findings, Lessons Learnt and Future Directions

6.1 Introduction

In this thesis, I sought to assess the funding system for the COVID-19 health research response in Africa to identify key lessons for future epidemics and pandemics. I addressed three research questions to achieve this aim:

1. How did the modalities for COVID-19 research prioritisation shape the identification of research priorities and what were the implications for research funding decisions?
2. What was the landscape of funded COVID-19 health research in Africa and how did research align to the WHO global and Africa regional COVID-19 research priorities?
3. What factors influenced the securing and management of funding for COVID-19 health research by researchers and grant managers in African research institutions?

To understand the scope of COVID-19 research priority-setting activities and identify the modalities by which priorities were set, I conducted a scoping review. I found multiple priority-setting activities were undertaken in response to COVID-19 from 2020 to 2022. Among these were those conducted by the AAS, Africa CDC and other regional partners to identify the COVID-19 research priorities relevant to the African continent. The research priorities identified from these activities focussed on several context-specific areas including research on COVID-19 co-infection with Tuberculosis, HIV and other infectious diseases prevalent in Africa, management of severe COVID-19 in the absence of ICUs, identification of COVID-19 therapeutics from herbal compounds, and understanding and managing COVID-19 in conflict-affected regions.

Diverse approaches were used to identify research priorities, consistent with reviews of broad health research prioritisation exercises undertaken outside an outbreak context[178,197]. Furthermore, there was limited application of known reporting standards across the research priority-setting activities for COVID-19 identified, potentially limiting their impact in influencing research funding allocations during the pandemic.

I undertook a mapping review of the UKCDR and GloPID-R COVID-19 Research Project Tracker to assess the landscape of funded research in Africa and its alignment to the global and regional COVID-19 research priorities. The main finding was that although there was an increase in grants awarded for COVID-19 research in Africa between 2020 and 2022, the investments made in Africa were delayed and were much lower than in Europe and North America. Further, funded research did not align well to the region-specific research priorities, leaving key research questions unaddressed.

To gain an in-depth understanding of the research funding processes and the factors influencing management and access to funds for COVID-19 research, I conducted a qualitative study focussing on the perspectives of researchers and grant managers in African research institutions. I identified factors under four interrelated themes which encompass both enabling factors and those hindering access to COVID-19 research funding. The themes which emerged were: institutional and structural factors, human resource factors, factors related to communication and information, and factors related to funders' policies and practices. Many of the challenges to research funding were pre-existing barriers which were exacerbated by the pandemic, including inadequate grant management and research capacity, and restrictive funder policies. The pandemic also introduced specific challenges,

such as those related to remote work which was raised as an important factor which influenced access to COVID-19 research funding.

The findings of my work showcase the complexities in the funding system for COVID-19 research in Africa and the interactions among various actors which impacted the processes for funding allocation and research during the pandemic. These findings can help explain factors driving the COVID-19 health research response witnessed on the African continent.

6.2 The System for Funding COVID-19 Research in Africa

In previous chapters of this thesis, I have outlined elements of the pre-pandemic research funding context in Africa. Despite evidence of the benefits introduced by increased collaborations through North-South and South-South research partnerships and investments in research capacity strengthening across Africa, there were persistent challenges to accessing research funding[282]. These challenges related to limited research and grant management capacity, and the use of research priorities that are largely externally driven[236,284]. The COVID-19 pandemic impacted the HRFS in Africa and its functioning to achieve the goal of allocating resources effectively (Chapter 1, Section 1.3.5).

The novel nature of the SARS-CoV-2 largely drove the urgency required in the pandemic response. There was a need for research across disciplines to fill the gaps in knowledge on various aspects of COVID-19. This urgency resulted in the need for speed of research funding processes to ensure rapid availability of resources for research. Consequently, various activities across the health research funding cycle were impacted, giving rise to new challenges for research funding or exacerbating those existing prior to the pandemic. Conversely, activities which enhanced effective funding processes for COVID-19 research

also emerged. This chapter discusses the barriers and enablers to COVID-19 research funding in Africa as emerging from this thesis and identifies key lessons for future epidemics and pandemics.

6.2.1 Research Prioritisation

COVID-19 priority-setting activities undertaken by funders, researchers, governments and other players in health research funding, as published at various timepoints during the pandemic, were identified in this DPhil research (Chapter 3). The availability of priorities at the time of funding allocation could have influenced whether they were factored into funding decisions. My review of awarded COVID-19 grants (Chapter 4) suggested that funders aligned more to the global priorities set by the WHO. This finding is consistent with the reported practices of some key global health funders during the pandemic[302]. The timeliness of identification of the global research priorities, having been set early in the pandemic, may have played a key role in this.

Delays in the availability of research agenda could have resulted from lengthy processes in their identification or delays in dissemination of the outputs of the activities. My scoping review of COVID-19 research prioritisation indicated that a majority of the priority-setting activities took significant time to be conducted and for the results to be disseminated (through journal publications), although data on these timelines was limited across the publications I reviewed. There is a need for further work to assess the suitability of the existing priority-setting approaches for rapid response.

Access to information plays a vital role in systems dynamics and influences the actions of the actors within systems[71]. The limited detailing of the approaches taken to arrive at the various priorities identified could have called into question the credibility of the resulting

priorities, with implications for their uptake. Furthermore, none of the COVID-19 priority-setting activities reviewed cited the application of any of the existing reporting standards for health research prioritisation. This could have undermined the trust in the priority-setting processes and hindered their uptake. Furthermore, few COVID-19 priority-setting activities identified in my work included the determination of the relative importance of the emerging priorities in their priority-setting processes, making it challenging to inform the allocation of available funds for research.

Results of the initial activities for identifying research priorities for Africa were published in April 2020[150]. This was before the launch of funding calls by the funders of COVID-19 research in Africa. It is unclear if funders designated specific funding calls targeting the research priorities in Africa and if African researchers responded to these. However, my mapping of COVID-19 grants (Chapter 4) showed persistent knowledge gaps pertaining to the Africa research priorities, indicating funding did not align to these research priorities. These findings show that even when regional priorities are available, there are likely to have been other factors at play which influenced the areas which were prioritised in funding allocation, as discussed in Chapter 1, Section 1.3.4.

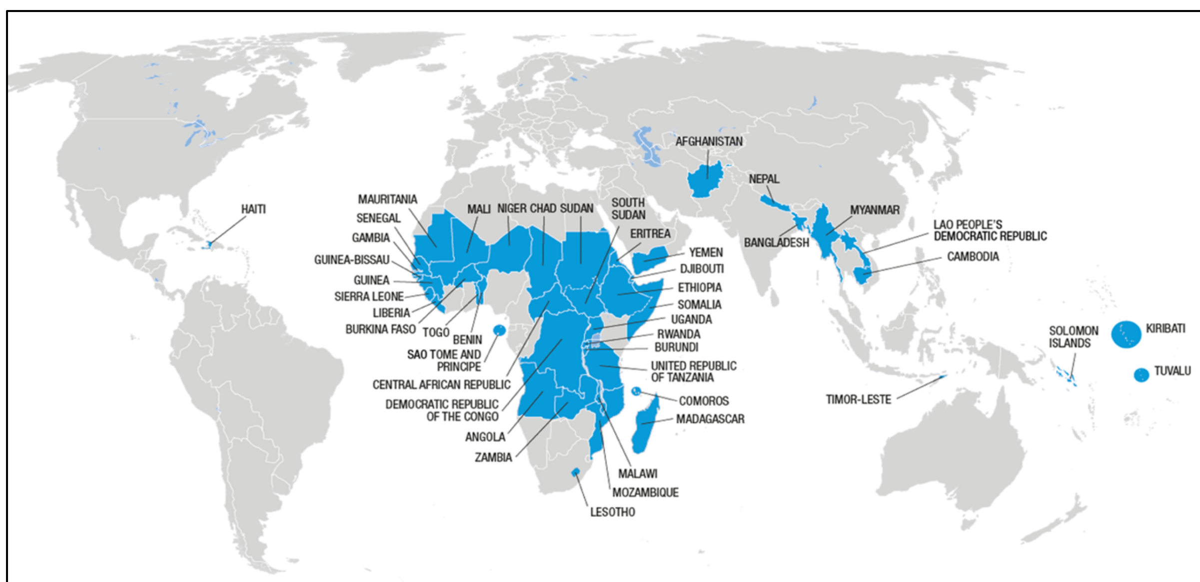
The trend in funding for COVID-19 research in Africa did not differ from the pre-pandemic period where the majority of health research funding was supported by public and philanthropic organisations in the United States and Europe[257]. This could have contributed to the delays in the initiation of COVID-19 research as the external funders had to deal with their local research responses in addition to supporting research outside their countries/regions. The limited local funding for COVID-19 research found in this DPhil research might explain the limited focus on the regional priorities as external funders'

priorities could have differed from those identified locally. Pre-pandemic trends in health research demonstrate this dominance of external priorities in research funded in Africa[256]. The pre-existing research structures in Africa are perceived to have been shaped by various factors, including the legacies of colonialism[303], factors perpetuating dependence on external funding sources[304,305] and chronic underinvestment of African governments in health[257].

Historically, African countries have made minimal investments into health research. This has been ascribed to multiple competing health, social and political priorities in African countries, many of which are resource-limited. Thirty-three of the least developed countries globally, based on Gross Domestic Product (GDP per capita), are in Africa, as seen in Figure 30[306]. Despite the recognition of the importance of promoting investments in health for development as outlined in the Abuja Declaration, progress has been limited and inconsistent over the years[307]. Few countries have reached and sustained investments in health at the target of at least 15% of GDP[307]. As of 2018, the average investment in R&D in Africa was 0.5% of GDP[308]. This is significantly less than the proposed investments by the Africa Union Assembly of at least 1% GDP in R&D on the continent[309].

A 2016 WHO report on health concluded there is no direct association between African countries' income and the level of investments made into health[310]. Despite this lack of a direct association, resource-limitations are likely to influence resource allocation, given that there are multiple competing priorities. However, the report's findings suggest that African countries have the capability to be intentional in their prioritisation of health R&D in governmental expenditures. The Africa Union recognised the importance of local investments in strengthening research infrastructure on the continent. Therefore, increased investments in research by African countries is among recommendations in the Africa

Health Strategy (2018 - 2030)[311], a key strategy and policy plan for improved health in Africa.



*Number of LDCs by region: Africa - 33, Asia - 8, Caribbean -1, Pacific – 3

Figure 30: Map showing the least developed countries globally (based on OECD DAC classification).

Source: United Nations, List of least developed countries, 2024.

6.2.2 Institutional Capacity

The persistent inadequacies in research and grant management capacities in Africa constitute a vicious cycle whereby inadequate capacity inhibits competitiveness for funding which, in turn, reinforces inadequate capacity. On the other hand, access to funding can facilitate improved institutional capacity, thereby enhancing competitiveness for further funding awards. These are examples of the "Matthew Effect", a term coined by Robert Merton which describes the phenomenon of positive self-reinforcing feedback resulting in a compound advantage[312]. Bol et al. quantified the "Matthew Effect" in health research funding among early career Dutch researchers and found winners of grants had a significant advantage in

future grants and career progression over non-winners over the period studied[313]. However, I did not identify a similar study undertaken in Africa.

Meadows recommends that in breaking a vicious cycle, interventions should target the processes which feed the re-enforcing feedback loop[71]. Therefore, addressing the challenge on inadequate research capacity in Africa could involve multifaceted interventions targeting wider systemic issues which affect research capacity. Among those cited in the literature are tackling brain drain via interventions to train and retain research talent[314,315], sustainable resourcing of the R&D system[316] and investments in research infrastructure[317].

In the aftermath of previous major epidemics in Africa, the continent benefitted from some research capacity strengthening initiatives which were harnessed during the COVID-19 response[58,242]. In particular, strengthened laboratory capacity played a vital role in diagnosis and surveillance of COVID-19 in Africa[243]. There were also rapid capacity building efforts undertaken during the pandemic. An example is the rapid training of African scientists in disease diagnostics and genomics led by the African Centre of Excellence for Genomics of Infectious Disease (AGECID) in 2020[19]. However, the effectiveness of these rapid capacity strengthening interventions and their long-term impact in African research institutions post-pandemic is unclear and could be an area for further research.

6.2.3 Research and Funding Partnerships

Established relationships among funders, researchers, institutions and other funding system actors were leveraged during the pandemic and enhanced the effectiveness of research funding processes. My findings illustrated how pre-existing successful relationships between funders and research institutions led to expedited research funding as some funders waived lengthy checks or significantly shortened processes for their existing grantees, as

discussed in Chapter 5, Section 5.8. During the COVID-19 pandemic, partnerships among research institutions supported the identification of funding opportunities, created avenues for strengthening research proposals and promoted the conduct of research.

Building partnerships among research institutions requires processes for aligning goals and setting the terms for the operations of partners[139]. These processes are more complex in international collaborations and where multiple partners are involved[95]. Partnership relationships can also be complicated by disparities in resource allocation and research capacity which can breed tensions related to unequal power and assignment of roles among partners[237]. Building trust and practical experience in the operations of partnerships takes time and, hence, it could be challenging to set up new effective research partnerships during an emergency. This might explain the reliance on existing successful research partnerships in Africa, which played a crucial role in the pandemic response regionally and globally.

Among funders, co-funding relationships enabled the pooling of resources for supporting research. These also drew from existing experiences with coordination of efforts. During the COVID-19 pandemic, UK MRC and Department of Health and Social Care (DHSC) rapid initiation of co-funding calls were facilitated by previous joint-funding experiences between the funding organisations[37]. Despite the benefits of co-funding, this research indicates that only a few research grants supporting research in Africa were co-funded. This suggests the potential benefits from co-funding for funders and African research institutions, such as increasing the pool of research funding and simplifying grants administration, were not fully realised.

6.2.4 Interdependent Processes

In response to the pandemic, there was an increase in COVID-19 research funding opportunities from both funders typically investing in health research and those usually funding outside this remit (Chapter 4 and Chapter 5). The expansion of funders offering opportunities for COVID-19 research demonstrated their flexibility to override their existing norms and expand their mandates beyond the disciplines or areas they usually funded. However, the introduction of these new funders into the HRFS likely increased the system's complexity as new systems actors are associated with emerging intra-system dynamics and interactions which can affect the system's goals[318].

Funding policies and practices among the new funders, who likely had limited pre-existing experience in funding health research, might have impacted access to research funding. Researchers and institutions might have been required to navigate new complex processes which could have delayed access to research funding. Some researchers interviewed (Chapter 5), however, reflected that some new funders had simpler processes that enabled their rapid access to research funding.

The increased complexity of the system and the scale of the required research response might also have affected the visibility of activities among the funders and impacted their coordination of efforts. This could explain some of the shortcomings witnessed in the COVID-19 research response globally where there was significant duplication and fragmentation[32,48].

When the research landscape in Africa was compared to the other continents, my review of the COVID-19 research funding landscape showed funded research in Africa was limited despite the increase in the available funding for COVID-19 research globally. Pre-existing

limitations among African researchers in attracting research funds prior to the pandemic[104,146,147,257] could have also impacted their competitiveness for COVID-19 grants, resulting in the trends witnessed.

In my research, I identified both enabling and restrictive funder policies and processes (Chapter 5). Across the research cycle, some processes applied by funding organisations during the pandemic promoted rapid COVID-19 research funding allocation and effective grant management. These processes emerged as either being the usual practice for some funders prior to the pandemic or, for others, constituted adaptations made during the COVID-19 response.

Despite the enabling funders' policies and processes, this research found that expedited access to funding was not achieved in some instances if the process within the grant recipients' research institutions did not support rapid completion of grant applications, due diligence checks, access to disbursed funds or prompt grant reporting (Chapter 5). Similarly, restrictive funding policies and inadequate institutional processes acted in synergy to delay or deny access to research funding. The synergy between funders' policies and processes and institutional processes for achieving the system's goals highlights the interdependence of processes, a key feature of complex adaptive systems.

6.2.5 Institutional Adaptation and Resilience

From the findings outlined in Chapter 5, some research institutions in Africa introduced measures to facilitate their continued operations as the pandemic led to the restriction of face-to-face interactions. The adaptive responses involved alterations in institutional processes including adoption of remote work policies, working by shift rotation, digitisation of processes, and modifications to institutional roles and responsibilities. The changes

enabled institutions to continue to provide grant management support and for COVID-19 research to be undertaken despite the challenges introduced by the pandemic. As a complex system, the HRFS adaptation to the pandemic resulted in changes to some prevailing norms and values underpinning institutional operations[71]. For example, re-distribution of some decision-making powers to lower levels in the organisational hierarchy facilitated expedited decision making.

The switch to remote work was easier for those institutions which had previous experiences in conducting some operations remotely, such as prior remote interactions with external partners or digitisation of some processes prior to the pandemic. Other enabling interventions were provision of: assistance for staff to establish internet connectivity in their remote work places; hardware and software for remote work; training in digital software use; and flexible work arrangements which women and other individuals with caring responsibilities, in particular, benefitted from. Therefore, institutions which adapted more easily were those which created enabling environments for change and had built more resilient infrastructure prior to the pandemic.

One purpose of systems' adaptation is to enhance resilience to shocks[319]. The findings of my research suggest that some institutional changes, particularly those related to digitisation of funding processes, had persisted post-pandemic. These changes could be important for boosting the resilience of African research institutions to future epidemics and pandemics. Further research can assess the impact of other adaptive measures introduced into African research institutions on pandemic preparedness.

6.2.6 Information Flow

There was a lack of clear and open information amongst research funding actors evident across the research funding cycle. As previously discussed in this chapter, there was a lack of transparency in reporting the methods applied to identify research priorities during the pandemic which might have had implications for the perceived credibility of the priorities identified.

Inadequate open sharing of data on funded research grants was a major challenge to accountability pre-pandemic[320]. I found there were similar challenges with accessing complete data on funded COVID-19 research in Africa during the pandemic despite commitments made by funders and other HRFS actors "to ensure that research findings and data relevant to this outbreak are shared rapidly and openly to inform the public health response and help save lives"[321].

At the level of the research institutions, my findings indicated that funding terms and conditions were sometimes not openly communicated by the research funders to the recipient institutions. This resulted in mistrust of funders and challenges with COVID-19 research implementation in African institutions. The flow of information within the research institutions themselves was challenged by rigid hierarchical structures, ill-defined roles and responsibilities, and inadequate structures for communication.

Transparency of processes can foster trust, improve accountability and ensure informed, timely decision-making, which is crucial in responding to pandemics. The theory of bounded rationality proposed by Herbert Simons describes incomplete information as a key constraint to decision-making[322]. Meadows suggests the various actors in systems operate within this "bounded rationality" and are thereby limited by the degree of information available to them

for decision-making at any particular point in time[71]. Incomplete information across the research funding system might have contributed to the poor coordination of efforts, malalignment of funding to research needs and other inefficiencies witnessed during the pandemic.

6.3 Lessons Learnt for Future Epidemics and Pandemics

A number of key lessons can be drawn from my assessment of the funding system for COVID-19 research in Africa which can contribute to considerations for strengthening responses to future epidemics and pandemics in Africa. These lessons indicate potential actions for various actors across the health research funding cycle which can either be undertaken in the interpandemic period or when a new outbreak occurs. The COVID-19 pandemic was distinct in its global scale and scientific response. Therefore, engaging with the lessons identified from this work requires the consideration of wider factors specific to the future epidemics and pandemics.

This DPhil research has demonstrated that processes in health research funding are interrelated and that actions by one actor can act in synergy or undermine the overall effectiveness of funding across the HRFS. These findings suggest that any planned interventions for strengthening the system in preparedness for the future should take a "whole systems" view accounting for both intended and possible unintended effects of the proposed interventions.

The finding of limited research investments in Africa during the pandemic and historical trends in research investments in the pre-pandemic period[257,308] suggest a need for increased funding for research and research-related activities in Africa. In particular, increasing local

investments during the acute response to a pandemic situation, where evidence is required urgently, is a key lesson. Local investments can also increase the pool of resources available to address region-specific research priorities during an outbreak response.

Funding is also required in the interpandemic period for pandemic preparedness efforts. African governments can increase their national funding commitments to research and invest in research infrastructure development to bolster institutions' readiness for new outbreaks. Other assessments of pre-pandemic health research funding have suggested limited local philanthropic contributions and minimal engagement of the private sector in research investments on the continent[257]. This is an area that can be further explored and promoted in preparedness efforts.

African research institutions can take various actions to strengthen grant management capacity via designated training activities, provision of resources such as grant management software, and recruitment of adequate numbers of personnel to address some of the challenges emerging from this work. Researchers are also likely to benefit from efforts to improve their grantsmanship and training to improve their technical skills, which can improve their competitiveness in research grant applications.

Further activities to strengthen their grant management and research capacities can include interventions to tackle inefficiencies in the operations of the African research institutions. These interventions should be tailored to the various research contexts in Africa to be most effective, as discussed by Pulford et al. in their review of research management capacity in research institutions in SSA[104]. The interventions can involve streamlining processes,

defining personnel roles and responsibilities, and the optimisation of processes in the African research institutions.

Factoring in the key elements enabling accesses to research funding emerging from my DPhil research, research institutions can consider setting up protocols for their operations during health emergencies. These plans can take cognisance of the direct and indirect health impacts of outbreaks on research staff and anticipate the provision of additional support to staff during an outbreak, the possibility of remote work, and potential restructuring of processes to enable delegation of roles and responsibilities. Defining these pre-emptive steps in the interpandemic period and embedding them in institutional practice can support rapid adaptation of their processes in the event of an outbreak.

External funders can also play a key role in system-wide strengthening activities which can improve preparedness for future outbreaks in Africa. Across the system, efforts to strengthen equity in funding practice as recommended by Charani et al. could address broader systemic challenges related to power asymmetries between high-income country funders and institutions in less-resourced settings[61], many of which are in Africa. Specifically, funders can consider funding research on outbreak preparedness priorities of the continent, funding via schemes which shift leadership of grants to institutions in Africa, designating funding calls for disadvantaged researchers and institutions, and supporting grants which take a longer-term view to capacity strengthening and research partnerships.

Learning from the findings of this DPhil, funding organisations can consider building flexibilities into their funding practices for acute responses to health emergencies. Designating funds to address research gaps in Africa will increase funding opportunities

during future outbreaks. They can also consider models for expediting processes across the grant cycle such as those for expedited grant proposal review, funding award decisions, delivery of funds and simplified grant reporting. Furthermore, procedures for expediting funding via pivoting research grants, repurposing existing grants and making supplementary awards can be embedded in funder practice such that they can be rapidly activated in an outbreak.

These modifications can be piloted as part of funders' internal emergency funding protocols in readiness for future outbreaks. To minimise due diligence checks in African research institutions, funders can consider universal standards such as GFGP[91] which might reduce the administrative burden on institutions. In exploring these amendments to their processes, funders should ensure that amendments made do not compromise the quality of grants funded or result in poor accountability of the awarded funds.

Activities to promote partnerships among funders to enhance coordination of their activities can also be considered. Given the challenges associated with funding partnerships, these can be piloted outside a health emergency context to enhance preparedness for similar activities when an outbreak occurs. Co-funding partnerships can strengthen transparency across funders' portfolios and minimise duplication and fragmentation. Broader efforts to strengthen transparency of activities across the system can also strengthen the HRFS for accountability and improved coordination of actions among actors[320].

My work highlighted the potential for the approaches used in setting priorities to impact their application in practice during the pandemic. Key lessons which can be considered in the next pandemic are similar to recommended best practice in health research priority-setting outlined in the literature[174,181,182] and include applying existing reporting standards

for health research prioritisation and embedding dissemination and M&E plans in priority-setting processes. Others emerging from this work are timely identification of research priorities to promote their uptake and including processes for weighting priorities to determine their relative importance among options.

The key lessons emerging from this research are summarised across the stages of the grant cycle in Table 15. Some cross-cutting lessons are also listed. The HRFS actors involved under each area are listed.

Table 15: Summary of emerging lessons from this DPhil research grouped by the stages of the grant cycle

Processes in Research Cycle	HRFS Actors Involved	Proposed Lessons Emerging from this Work	Potential Benefits
Pre-Award Stage			
Identifying Research Priorities	All	•Use systematic processes in priority-setting •Weighting various priorities to determine their relative importance among options •Apply existing reporting standards for health research prioritisation •Inclusion and meaningful participation of target populations in priority-setting processes •Timely identification of research priorities •Rapid dissemination of identified priorities	•Enhanced credibility and trust in research priorities identified •Enhanced uptake of research agenda to inform funding allocation
Applying identified Research Priorities	All	•Contextualise priorities identified to the settings in which they will be applied (e.g. global, regional, national, local level) •Embed monitoring and evaluation of progress against priorities identified in priority-setting processes	•Enhanced alignment of funding to the relevant priorities
Research Funding Opportunities	Funders	•Commitment of local funding in acute response to outbreaks •Designate specific funding for regional research needs •International funders commit funds to address specific research needs in Africa	•Expedited research response •Increased funding for addressing relevant research questions in Africa

Processes in Research Cycle	HRFS Actors Involved	Proposed Lessons Emerging from this Work	Potential Benefits
Scope of Funding Calls	Funders	•Broaden disciplinary scope of funding calls to capture the multidisciplinary areas of research required in an outbreak response •Designate opportunities for disadvantaged researchers and institutions	•Strengthened response by generating relevant multidisciplinary evidence •Increased research by disadvantaged researchers and research institutions
Grant Application and Proposal Review	Funders	•Expedite grant application and review processes in funding organisations	•Expedited funding decisions
	Research Institutions	•Streamline processes in research institutions •Grantsmanship training for researchers	•Expedited grant applications •More competitive funding applications
Award Stage			
Contracting and Due diligence	Funders	•Shortening and simplifying contracting and due diligence processes	•Reduced administrative burden on research institutions
	Research Institutions	•Streamline processes in research institutions	•Expedited awarding of grants
Research Ethics Approval	Research Institutions	•Expedite ethics review processes in Research Ethics Committees	•Expedited awarding of grants and initiation of research
Post-Award Stage			
Delivery of Funds/ Receiving funds	Funders	•Expedite delivery of funding e.g. via pivoting research grants, repurposing existing grants and supplementary funding •Costed and non-costed grant extensions •Predictable and sustained funding for grants •Coverage of additional costs e.g. unexpected costs resulting from increased budgets, PPE costs etc.	•Expedited initiation of research •Increased effectiveness of conduct of research •Promotion of fairness in research funding processes
	Research Institutions	•Streamline processes in research institutions	•Expedited initiation of research

Processes in Research Cycle	HRFS Actors Involved	Proposed Lessons Emerging from this Work	Potential Benefits
Conduct of Research	African Governments	•Simplify national procurement policies	•Expedited procurement of supplies for research in African research institutions •Expedited initiation of research
Grant Monitoring	Funders	•Simplify and streamline grant reporting processes	•Reduced administrative burden on research institutions
	Research Institutions	•Streamline processes in research institutions	•Expedited grant reporting
Cross-Cutting Areas			
Transparency	All	•Improve information flow across system actors e.g. transparency in: reporting of priority-setting activities; provision of data on awarded grants; communication of funders' terms and conditions; internal communication of research institutions' processes; and communication among research partners	•Improved visibility of activities of actors •Improved coordination of activities across HRFS •Expedited processes in grant cycle
Institutional Capacity	African Governments	•National investment in research and research related activities, channelled into strengthening research infrastructure and systems in African research institutions	•Improved competitiveness of research institutions and researchers for grants •Strengthened research and grant management capacity
	Funders	•Invest in long-term and sustainable capacity strengthening efforts in African research institutions	•Strengthened research and grant management capacity
Organisational Processes	Research Institutions	•Streamline processes in research institutions •Implement responsive work policies e.g. remote work, task delegation and policies to reduce direct and indirect impacts of outbreak on staff	•Expedited research funding processes in African research institutions •Improved efficiency of processes in African research institutions

Processes in Research Cycle	HRFS Actors Involved	Proposed Lessons Emerging from this Work	Potential Benefits
Research and funding partnerships	Funders	•Set up co-funding partnerships among funders •Promote equity in funding partnerships e.g. through grant conditions	•Increase pool of funding for research in African institutions •Promotion of fairness in research partnerships
	Research Institutions	•Streamline processes in African research institutions	•Improved competitiveness of research institutions and researchers for grants

6.4 Strengths and Limitations of this DPhil Research

My research has a number of strengths which position it to be a valuable contribution to knowledge. The use of a scoping review enabled me to explore a wide breadth of literature sources in the conduct of my research. Analysing a funding tracking database, covering a wide range of research activities across multiple countries and funders, allowed me to make a comprehensive assessment of the research funding landscape in Africa. The qualitative research approach allowed for an in-depth exploration of the factors influencing research funding access in Africa. In particular, incorporating perspectives of research grant managers was notable, as there is limited representation of their voices in the literature on health research funding.

The data collection instruments used in the scoping review and qualitative research were pre-piloted to ensure data collected met the aims of this DPhil research. In analysing data from the qualitative component of my work, I aligned to Braun and Clark's guidelines for qualitative data analysis. I was reflexive throughout the research process, acknowledging the strength and weaknesses my experiences and characteristics introduced in this work. This work was conducted in compliance with ethical standards. I received ethics clearance

from the Oxford Tropical Research Ethics Committee (Reference 508-23) (Appendix E). Conceptually, the use of a systems-based model to frame my research questions and interrogate the findings from this work allowed me to take a holistic view of health research funding in Africa during the pandemic.

However, there are some limitations which should be considered when reviewing this DPhil research. This work used data on priority-setting activities, research funding commitments and perspectives of grant managers and researchers in African research institutions to make inferences about research funding practices during the COVID-19 pandemic. There are other key actors in the health research funding system such as funders, communities and governments (Chapter 1, Section 1.3.2) which could have also provided insightful perspectives. However, this work provides useful insights, dealing as it is with the actual grant recipients and grant managers in African research institutions. Assessments focussing on other actors in the HRFS can be an area for future work.

This work did not directly explore the perspectives of research funding organisations owing to challenges with accessing data from research funders. Their perspectives could have been explored via interviewing research funders who supported COVID-19 research or reviewing funding policy documents associated with the various COVID-19 research funding calls launched. However, at the time I undertook this work many funding organisations' funding calls, and conditions for funding during the pandemic were not publicly available, having either been archived or removed from the public domain. For instance, I searched websites for the top 20 funders of COVID-19 research in Africa (Chapter 4, Section 4.4.2) and found only two funders had call texts and funding conditions publicly available.

A more comprehensive assessment would also require an assessment of a range of funding organisations, including those which supported research in Africa and those which did not. Building on my review of COVID-19 grants in Chapter 4, I considered including all 351 global funders identified from the Tracker database. However, this would have required a longer timeframe and resources beyond the scope of this research. Other options including reviewing only the 75 funders supporting research in Africa or focussing on commitments made by existing funder groups such as GloPID-R funders, which includes 43 funding organisations, would have limited the scope of funders considered. As a result, a review of funder policies was not undertaken as part of this work but is an interesting area for further research.

There were also limitations with the data sources for this research. The search for literature in the scoping review focussed on global or regional priority-setting activities. This implies that the findings of this work are more representative of those contexts than national or other levels of priority-setting. Data in the UKCDR and GloPID-R Research Project Tracker was obtained from publicly available sources or sourced directly from funders. Data on funding amounts for some grants were not publicly available and this limits the interpretation of results on research funding amounts presented in this work.

Finally, the qualitative study to explore the enablers and barriers to COVID-19 research funding focussed on research institutions in the WHO Africa region. This limits the transferability of some findings of this work to the entire African continent. A separate study exploring the experiences of researchers and institutions in North Africa is an area for future research.

6.5 Future Directions

Beyond those discussed, there are several other areas for further investigation which arose from this work. An analysis of repurposed research grants and supplemental awards made to pre-pandemic research grants can provide evidence on other avenues for COVID-19 research funding, which were not well covered in the scope of this work. Further, my assessment of funding commitments does not show the full picture of funding flows for COVID-19 research. Analyses of the dynamics of research funding flows from funding organisations to the institutions implementing research can also yield additional evidence on research funding processes. This can be done by analysing funding disbursement processes and comparing funds disbursed at the end of awards to funds committed when funding awards were announced.

The academic impact of funded COVID-19 research in Africa and globally could also be explored. This could involve bibliometric analyses of publications resulting from funded research projects and could directly link research investments to published outputs. My research has revealed multiple effects of the pandemic on research institutions and the wider HRFS with a focus on newly funded COVID-19 research. Pre-existing health research projects are likely to have also been impacted. A study to assess the impacts of the pandemic on other ongoing, non-COVID-19 research, initiated prior to the pandemic, could provide important insights for preparing for future epidemics and pandemics.

Another finding from this current research was that pre-existing research capacity was a significant factor contributing to effective COVID-19 responses in Africa. It is important for

future research to assess the impact of pre-pandemic capacity strengthening efforts on research effectiveness during the pandemic. Furthermore, there is a need for research to explore the impact of the rapid capacity strengthening efforts implemented during the pandemic response on the broader HRFS. This could also include a review of new research partnerships formed during the pandemic and the exploration of models for partnership development during an emergency.

Finally, relationships were identified as a central factor influencing processes in the HRFS during the pandemic. Studies to understand the dynamics of relationships across systems actors can uncover the structures which perpetuate power imbalances in systems. For example, research can apply a power lens to exploring the dynamics in South-South research partnerships, in particular, which appear to have received less attention than North-North partnerships.

6.6 Conclusion

In this thesis, I assessed the funding system for the COVID-19 health research response in Africa with the specific aim of identifying lessons for preparing for future epidemics and pandemics. I conducted a scoping review on COVID-19 research prioritisation activities, a mapping review of the landscape of funded grants for COVID-19 research and a qualitative study to explore factors influencing access to funding for research in African research institutions during the pandemic.

I found the varied modalities used in COVID-19 priority-setting were not reported using the existing standards for health research prioritisation, potentially limiting the trust and credibility in the priority-setting processes. Limited funding was allocated to COVID-19

research in Africa. Although grants aligned to global research priorities, they did not align to Africa's COVID-19 research priorities resulting in persistent knowledge gaps. Several interrelated factors which enabled or inhibited access to funding and management of funds for COVID-19 research in African research institutions were identified. Enabling factors included no-cost extensions to research grants, supplementary funding to pre-existing research grants, expedited grant awarding processes, supportive institutional remote work policies and expedited research ethics approvals. Conversely, lengthy due diligence processes, institutional bureaucracy, unequal power in research partnerships and delayed communication were barriers to effective research funding.

The findings give rise to key lessons for the improvement of future pandemic responses to save lives and improve health in Africa and globally. These lessons include increasing local and regional financial commitments to health research in Africa, optimising existing funding models and developing new models for financing health research in emergencies, strengthening research and grant management capacity in African research institutions and improving information flow across the system for financing health research.

To respond effectively to epidemics and pandemics in the future, strengthened health research systems will be essential for effective and efficient research processes. This thesis highlights the need to take a holistic view in considering interventions for improving responses to epidemics and pandemics. The findings outlined here can contribute to the evidence in this field, drawing attention to salient areas requiring focus in the preparedness efforts for the next epidemic or pandemic.

"History teaches us that the next pandemic is a matter of when, not if".
- Tedros Adhanom Ghebreyesus, Director General, WHO.

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Appendices

Appendix A: Mid- to long-term research priorities outlined in the WHO Coordinated Global Research Roadmap

1	**Virus: natural history, transmission and diagnostics**
1.a	Support development of diagnostic products to improve clinical processes.
1.b	Understand virus compartments, shedding and natural history of disease.
1.c	Develop tools and conduct studies to monitor phenotypic change and potential adaptation.
1.d	Characterize immunity (naturally acquired, population and vaccine-induced, including mucosal immunity).
1.e	Develop disease models (animal models and 3Rs approaches)
1.f	Virus stability in the environment
2	**Animal and environmental research on the virus origin, and management measures at the human-animal interface**
2.a	Investigation of animal source and route of transmission
2.b	Socioeconomic and behavioural risk factors for spill-over
2.c	Risk reduction strategies at the human-animal environment interface
3	**Epidemiological studies**
3.a	Transmission dynamics- Clarify the relative importance of pre-symptomatic/ asymptomatic transmission (including distinction between virus shedding and infectious transmission)
3.b	Disease severity - Identify groups at high risk of severe infection; Determine the role of different age groups in transmission
3.c	Susceptibility - Determine if children are infected, and if so, are they infectious?
3.d	Control and mitigation measures - Predict the most effective measures to reduce the peak burden on healthcare providers and other societal functions; Estimate the effects of social distancing measures and other non-pharmaceutical interventions on transmissibility
4	**Clinical characterization and management**
4.a	Prognostic factors for severe disease (Different populations - pregnancy, young children, risk groups - immunosuppressed)
4.b	Understand pathophysiology of COVID-19 infection, including understanding mild disease and the role of co-infections / infection, transmissibility, viral shedding
4.c	Optimal endpoints for clinical trials
4.d	Improve processes of care, including early diagnosis, discharge criteria; Determine interventions that improve the clinical outcome of infected patients (Steroids, High flow oxygen therapy)

4.e	Optimal adjuvant therapies for patients (and contacts)
4.f	Develop core clinical outcomes to maximize usability of data across range of trials
5	**Infection prevention and control, including health care workers' protection**
5.a	Effectiveness of restriction of movement of healthy exposed and infected persons to prevent secondary transmission (home, congregate setting, geographical restriction vs nothing)
5.b	Effectiveness of specific PPE to reduce the risk of COVID-19 transmission among HCWs, patients and individuals in the community
5.c	Effectiveness of activities to minimize the role of the environment in COVID-19 transmission
5.d	Factors and methods influencing compliance with evidence-based IPC interventions during outbreak response
6	**Candidate therapeutics R&D**
6.a	Develop in vitro and in vivo testing to identify candidates
6.b	Evaluate efficacy and safety in prophylactic use
6.c	Promote adequate supply of therapeutics showing efficacy
6.d	Evaluate efficacy and safety of therapeutics through randomised clinical trials
6.e	Investigate combination therapies
7	**Candidate vaccines R&D**
7.a	Identification of candidates for clinical evaluation in addition to the ones already prioritized.
7.b	To develop and standardize animal models to evaluate the potential for vaccine effectiveness and to understand the potential for enhanced disease after vaccination. Results from animal models are expected to be important prior to large-scale efficacy studies and prior to studies in which enhanced disease is considered a significant possibility.
7.c	To develop and standardize assays to support vaccine development, particularly to support the evaluation of immune responses and to support clinical case definition. Basic reagents should be shared to accelerate the development of international standards and reference panels that will help support the development of ELISAs, pseudovirion neutralization and PCR assays.
7.d	To develop a multi-country Master Protocol for Phase 2b/Phase 3 vaccine evaluation to determine whether candidate vaccines are safe and effective before widespread distribution, using methodologically sound and ethically acceptable vaccine trial design. Vaccine efficacy trials should be done if such are feasible to implement.
7.e	To develop potency assays and manufacturing processes to rapidly enable the production of high-quality large quantities of clinical grade and GMP materials.

8	**Ethics considerations for research**
8.a	Articulate and translate existing ethical standards to salient issues in COVID-19
8.b	Sustained education, access, and capacity building
8.c	The impact of restrictive public health measures (e.g., quarantine, isolation, cordon sanitaire)
8.d	Public health communications and the 'infodemic'; ensuring accurate and responsible communications
8.e	Ethical governance of global epidemic research
9	**Social sciences in the outbreak response**
9.a	Public Health - What are relevant, feasible, effective approaches to promote acceptance, uptake, and adherence to public health measures for COVID-19 prevention and control; and how can secondary impacts be rapidly identified and mitigated?
9.b	(Clinical) care and health Systems - What are the relevant, acceptable and feasible approaches for supporting the physical health and psychosocial needs of those providing care for COVID-19 patients?
9.c	Media and communication - How are individuals and communities communicating and making sense of COVID-19? What are the most effective ways to address the underlying drivers of fear, anxieties, rumours, stigma regarding COVID-19, and improve public knowledge, awareness, and trust during the response?
9.d	Engagement - What are the relevant, acceptable and feasible approaches for rapid engagement and good participatory practice that includes communities in the public health response.?
9.e	Sexual and reproductive health - What are the relevant, acceptable and feasible approaches to communicating uncertainty regarding mother to child transmission of COVID-19, and possible sexual transmission?
9.f	International cooperation - What international coordination mechanisms can optimize the international response to COVID-19?

Appendix B: COVID-19 research priorities for Africa identified in April, 2020

1. Investigations on convalescent antiserum potency as a therapeutic option
2. Environmental studies of SARS-Cov-2 including waste and sewage management practices
3. Use of m-Health technology and GIS mapping to monitor disease spread patterns
4. Studies of Leadership and decision strategies in response to the Covid Pandemic
5. Health systems strengthening and building resilience post the outbreak
6. Clinical management protocols for dual infections e.g. Covid patients with HIV TB
7. Research into water sanitation and hygiene practices in communities during the outbreak
8. Studies of community led strategies for the prevention of secondary transmission in a range of settings
9. Psychosocial issues around discrimination of persons with Covid 19 and their relatives or contact persons
10. Develop architectural designs for isolation and quarantine facilities that can be constructed using local materials and expertise within short time periods.
11. Mental health support for frontline healthcare workers
12. Identification of therapeutic candidates from traditional medicine for clinical evaluation in addition to the ones already prioritized
13. Investigate potential protective effects of standard childhood vaccines and other vaccines e.g. BCG
14. Identify resilient populations and better understand the protective determinants
15. Accelerated dissemination of research results through pre- print media
16. Investigate models for deferred consent during emergency research Determine the full impact of the Covid pandemic on
17. Maternal and Child Health including vertical transmission studies
18. Determine the load of Mental health issues arising from the outbreak measures implemented including investigations on gender-based violence
19. Determine the effect of the COVID-19 on food and nutritional security especially in relation to vulnerable groups

Appendix C: Updated COVID-19 research priorities for Africa identified in July, 2020 (outlined under the WHO research priority broad headings)

Immediate priorities
Epidemiological studies: Examine relationships to other lung diseases, e.g. Tuberculosis, Lung Cancer, Sarcoidosis, Idiopathic Pulmonary Fibrosis
Clinical management: Evolved from WHO priority 4d - Clinical guidelines for post-hospitalization home management and community rehabilitation.
Ethical considerations for research: Ethical considerations for resource allocation to LMICs
Social Sciences in the outbreak response: Understanding COVID-19 in the contexts of conflict, civil war, and refugee situations
Candidate Therapeutics: Investigate the potential role of natural / alternative /herbal/ traditional remedies and practices in treatment of COVID-19
Long-term priorities
Epidemiological studies: Research into long-term health impacts and complications of contracting COVID-19 – with emphasis on children/those with comorbidities
Clinical Management: The effects of the global response to COVID-19 on management and prevalence of other infectious diseases, such as TB/ HIV/Chikungunya
New priorities (outside WHO framework)
The **environmental impact of the response** to COVID-19 The impact of control measures on the environment including air pollution and carbon dioxide emissions. • The impact of control measures on the environment including air pollution and carbon dioxide emissions • The environmental effects of disinfectants and hand sanitizers used to control the infection. • Environmental impacts of large-scale PPE production and disposal
Preparing for the next pandemic • Ensure effective measures including community surveillance are in place to rapidly identify emerging zoonotic dis- eases by developing animal screening techniques (e.g. of bats/migrating birds) • Evaluation of governmental policies and lessons learnt in preparation for the next pandemic 18 Research & Development goals for COVID-19 in Africa

Appendix D: Six broad themes under which policy actions for the Africa research priorities were framed

Transmission dynamics, epidemiology and surveillance Priority
R&D category: diagnostics Priority
Clinical characterization of cases
Drug and vaccine clinical trials Priority
Modelling impact of COVID-19 on health systems
Social Science and Policy Research Priority

Appendix E: Ethics approval letter for this research

Oxford Tropical Research Ethics Committee

University of Oxford
Research Services, Research Governance, Ethics & Assurance
Boundary Brook House, Churchill Drive, Oxford OX3 7GB
Tel. +44 (0)1865 (2)82106
E-mail: oxtrec@admin.ox.ac.uk

Dr. Emilia Antonio
By email

27 February 2023

Dear Dr. Antonio,

Full Title of Study: An Assessment of the Funding System for the COVID-19 Health Research Response in Africa: Identifying Lessons for Future Epidemics and Pandemics

OxTREC Reference: 508-23

Thank you for your email of 20 January 2023 and minimal risk study application and documents.

I am pleased to confirm that approval has now been granted for this study. This is valid for the planned duration of the study as detailed in the application, and is subject to receiving the local ethical approval (if this approval has not yet been received).

The documents approved for this study are as follows:

Documents:	Version:	Date:
Minimal risk application form		
PIS	V1.0	Dec 2022
Email consent	V1.0	Dec 2022
Survey Information Sheet/Consent Form	V1.0	Dec 2022
Interview Guide		

Any subsequent changes to the application must be submitted to the Committee as an Amendment. This should include a letter to give the reasons for the proposed modifications and all revised documents with changes tracked.

Please ensure that you submit a completed Annual Report form on every anniversary of this approval and a final End of Study Report. The relevant forms can be found on the OxTREC website.

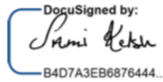
Finally, please note the following **important information**:

Data safety—all studies
It is the responsibility of the PI to ensure that all data collected during the course of the study is stored and transferred safely and securely. Further guidance and advice are available from the Research Data Team.

Only studies that will involve storing human tissue samples in Oxford
If you are planning to import the samples into England, you will need to make arrangements before the samples are transferred to store them under the governance of a Human Tissue Authority (HTA) licence. It is a legal requirement that any tissue or fluid made up of or containing human cells to be

used for the purpose of research is stored on premises licensed by the HTA unless covered by an exemption. OxTREC approval is not a recognised exemption. Further information may be found on the University's human tissue governance web pages.

Yours sincerely,



Sami Kelsh
Research Ethics Administrator, OxTREC

for
Dr Rosemary Musesengwa
Research Ethics Manager, OxTREC

Appendix F: List of high-consequence pathogens included in the scoping review on research prioritisation

Pathogens	Global	Europe		Asia-Pacific
	WHO	**EMERGE**	**ECDC**	**ASEAN**
COVID-19 (SARS-CoV2)	X		X	X
Crimean-Congo haemorrhagic fever virus	X	X		
Ebola virus	X	X		
Marburg virus disease	X			
Lassa fever virus	X	X		
Middle East respiratory syndrome coronavirus	X			
Severe Acute Respiratory Syndrome (SARS)	X			
Nipah and henipaviral diseases	X	X		X
Rift Valley fever	X			
ZikaVirus	X			
"Disease X"	X			
Smallpox		X		
Hendra Virus		X		

Swine Influenza A (H3N2)			X	
Highly pathogenic avian influenza A (H5N1)				X
Low pathogenic avian influenza H7N9				X
Pandemic influenza A (H1N1) 2009 virus				X
Polio virus			X	
Monkey Pox			X	
West Nile Virus			X	
Brucellosis (Brucella bacteria)		X		
Q Fever (coxiella burneti)		X		
Melioidosis (Burkholderia pseudomallei)		X		
Tularaemia (Francisella tularensis)		X		
Cholera (Vibrio cholera)		X		
Plague (Yersinia pestis)		X		
Glanders (Burkholderia mallei)		X		
Anthrax (Bacillus anthracis)		X		

Appendix G: Search strategy for the scoping review on research prioritisation for preparedness and response to high-consequence pathogens

Database: Embase 1974 to present

Search Strategy:

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1 Ebola hemorrhagic fever/ or Marburg hemorrhagic fever/ or Marburg virus/ or Marburgvirus/ (8657)

2 lassa fever/ or lassa virus/ (1983)

3 Crimean Congo hemorrhagic fever/ or Crimean-Congo hemorrhagic fever virus/ (1821)

4 Rift Valley fever/ or rift valley fever virus/ (1584)

5 (ebola* or ebov or marburg* or lassa* or CCHF or CCHVF or "crimean-congo*" or "congo virus" or (crimean adj2 (hemorrhagic or haemorrhagic)) or "rift valley*" or RVF or RVFV).ti,ab,kw. (22432)

6 exp coronavirinae/ or exp Coronavirus infection/ or severe acute respiratory syndrome/ (303109)

7 ("middle east* respiratory syndr*" or MERS-CoV or "novel CoV*" or "novel betacoronavirus" or coronavirus* or covid* or ("middle east" adj3 (cov or betacoronavirus*)) or (MERS adj3 (cov or betacoronavirus*)) or "mers-coronavirus" or "mers cov" or merscov or "wuhan flu" or 2019-nCoV).tw. (308284)

8 exp West Nile virus/ (3385)

9 ("west nile" or "egypt 101").ti,ab,kw. (10079)

10 exp "influenza a virus (h1n1)"/ or "influenza a virus (h5n1)"/ or "influenza a virus (h3n2)"/ or "Influenza A virus (H7N9)"/ (9140)

11 (H1N1 or H5N1 or H3N2 or H7N9).ti,ab,kw. (35847)

12 exp henipavirus/ or exp Henipavirus infection/ (1864)

13 (nipah or hendra).tw. (1648)

14 African swine fever virus/ or African swine fever/ or ("african swine" or "ASF virus" or ASFV or "wart hog disease virus*").ti,ab,kw. (2856)

15 monkeypox/ or monkeypox virus/ (1520)

16 (monkeypox or "monkey pox").tw. (1544)

17 exp Zika virus/ or Zika fever/ (12369)

18 (zika* or zikv).ti,ab,kw. (12744)

19 ("disease x*" or "pathogen x*").ti,ab,kw. (50757)

20 exp poliomyelitis/ or polio*.ti,ab,kw. (27786)

21 smallpox/ or Smallpox virus/ (6859)

22 (smallpox* or "small pox*" or variola).ti,ab,kw. (6700)

23 exp brucellosis/ (11949)

24 (brucellosis or brucelloses or brucella).ti,ab,kw. (16567)

25 Q fever/ (5045)

26 ("q fever*" or "Coxiella burnetii" or coxiellosis or "query fever*").ti,ab,kw. (6008)

27 melioidosis/ (3205)

28 (melioidosis or pseudomallei or "whitmore* disease*" or "nightcliff gardener* disease*" or pseudoglanders or "paddy-field disease" or "paddyfield disease").ti,ab,kw. (4330)

29 tularemia/ (3429)

30 (Tularaemia* or tularemia* or "Francisella tularensis" or "ohara disease" or "rabbit fever").ti,ab,kw. (4440)
31 cholera/ (10547)
32 cholera*.ti,ab,kw. (31988)
33 exp plague/ (6571)
34 (plague or "black death" or "Yersinia pestis" or "Y. pestis").ti,ab,kw. (10973)
35 glanders/ (213)
36 (Glanders or "Burkholderia mallei").ti,ab,kw. (609)
37 exp anthrax/ (6574)
38 (Anthrax or "Bacillus anthracis" or "B. anthracis").ti,ab,kw. (9521)
39 ("priority pathogen*" or "potential pathogen*" or "re-emerging pathogen*" or "reemerging pathogen*" or "emerging pathogen*").ti,ab,kw. (14648)
40 epidemic/ (123502)
41 pandemic/ (139546)
42 (((health$ or disease$) adj5 (disaster$ or catastrophe$ or crises or crisis)) or epidemic* or pandemic* or outbreak* or out-break* or "public health emergenc*" or "global health emergenc*").ti,ab,kw. (426552)
43 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 (868949)
44 research priority/ (4151)
45 ((setting* adj2 priorit*) or (research* adj2 priorit*) or "research strateg*" or "prioriti?ation methodolog*" or (generat* adj2 priorit*) or (develop* adj2 priorit*) or "priority guideline*" or "agenda setting*" or (research* adj1 gap*) or (identif* adj2 priorit*) or "research question*").ti,ab,kw. (61321)
46 44 or 45 (62685)
47 (preparedness or readiness or "in advance of" or "planning for").ti,ab,kw. (385419)
48 infection control/ (96474)
49 prevention/ (288469)
50 (response or control or prevention or addressing or tackle).ti,ab,kw. (7109751)
51 47 or 48 or 49 or 50 (7582501)
52 43 and 46 and 51 (1605)

Database: Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present

Search Strategy:

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1 hemorrhagic fever, ebola/ or lassa fever/ or marburg virus disease/ or rift valley fever/ (8692)
2 exp Filoviridae/ (4399)
3 Lassa virus/ (791)
4 Hemorrhagic Fever Virus, Crimean-Congo/ or Hemorrhagic Fever, Crimean/ (1427)
5 (ebola* or ebov or marburg* or lassa* or CCHF or CCHVF or "crimean-congo*" or "congo virus" or (crimean adj2 (hemorrhagic or haemorrhagic)) or "rift valley*" or RVF or RVFV).ti,ab,kw. (18909)
6 COVID-19/ (186659)

7 middle east respiratory syndrome coronavirus/ or sars virus/ or sars-cov-2/ (141224)
8 Severe Acute Respiratory Syndrome/ or Coronavirus Infections/ (50163)
9 ("middle east* respiratory syndr*" or MERS-CoV or "novel CoV*" or "novel betacoronavirus" or coronavirus* or covid* or ("middle east" adj3 (cov or betacoronavirus*)) or (MERS adj3 (cov or betacoronavirus*)) or "mers-coronavirus" or "mers cov" or merscov or "wuhan flu" or 2019-nCoV).ti,ab,kw. (288855)
10 West Nile virus/ or West Nile Fever/ (6060)
11 ("west nile" or "egypt 101").ti,ab,kw. (8555)
12 influenza a virus, h1n1 subtype/ or influenza a virus, h3n2 subtype/ or influenza a virus, h5n1 subtype/ or influenza a virus, h7n9 subtype/ (25999)
13 (H1N1 or H5N1 or H3N2 or H7N9).ti,ab,kw. (29472)
14 exp Henipavirus/ or Henipavirus Infections/ (923)
15 (nipah or hendra).ti,ab,kw. (1447)
16 African Swine Fever/ (1334)
17 ("african swine" or "ASF virus" or ASFV or "wart hog disease virus*").ti,ab,kw. (2500)
18 Monkeypox virus/ or Monkeypox/ (939)
19 (monkeypox or "monkey pox").ti,ab,kw. (1571)
20 Zika Virus Infection/ or Zika Virus/ (7329)
21 (zika* or zikv).ti,ab,kw. (10600)
22 ("disease x*" or "pathogen x*").ti,ab,kw. (1992)
23 Smallpox/ (6050)
24 (smallpox* or "small pox*" or variola).ti,ab,kw. (9423)
25 exp Poliomyelitis/ (20474)
26 polio*.ti,ab,kw. (32735)
27 exp Brucellosis/ (13356)
28 (brucellosis or brucelloses or brucella).ti,ab,kw. (18524)
29 Q Fever/ (5157)
30 ("q fever*" or "Coxiella burnetii" or coxiellosis or "query fever*").ti,ab,kw. (6679)
31 exp Burkholderia Infections/ (3899)
32 (melioidosis or pseudomallei or "whitmore* disease*" or "nightcliff gardener* disease*" or pseudoglanders or "paddy-field disease" or "paddyfield disease").ti,ab,kw. (4072)
33 (Glanders or "Burkholderia mallei").ti,ab,kw. (672)
34 Tularemia/ (3542)
35 (Tularaemia* or tularemia* or "Francisella tularensis" or "ohara disease" or "rabbit fever").ti,ab,kw. (4995)
36 Cholera/ (9155)
37 cholera*.ti,ab,kw. (32693)
38 exp Yersinia Infections/ (9655)
39 (plague or "black death" or "Yersinia pestis" or "Y. pestis").ti,ab,kw. (11941)
40 Anthrax/ (4473)
41 (Anthrax or "Bacillus anthracis" or "B. anthracis").ti,ab,kw. (9618)
42 ("priority pathogen*" or "potential pathogen*" or "re-emerging pathogen*" or "reemerging pathogen*" or "emerging pathogen*").ti,ab,kw. (12111)
43 disease outbreaks/ or epidemics/ or pandemics/ (194530)

44 (((health$ or disease$) adj5 (disaster$ or catastrophe$ or crises or crisis)) or epidemic* or pandemic* or outbreak* or out-break* or "public health emergenc*" or "global health emergenc*").ti,ab,kw. (392003)
45 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 (748505)
46 ((setting* adj2 priorit*) or (research* adj2 priorit*) or "research strateg*" or "prioriti?ation methodolog*" or (generat* adj2 priorit*) or (develop* adj2 priorit*) or "priority guideline*" or "agenda setting*" or (research* adj1 gap*) or (identif* adj2 priorit*) or "research question*").ti,ab,kw. (49347)
47 (preparedness or readiness or "in advance of" or "planning for").ti,ab,kw. (288985)
48 exp Infection Control/ (69544)
49 exp Primary Prevention/ (174936)
50 (response or control or prevention or addressing or tackle).ti,ab,kw. (5503572)
51 47 or 48 or 49 or 50 (5885420)
52 45 and 46 and 51 (1417)

Database: Global Health <1973 to 2022 Week 36>
Search Strategy:
----
1 Ebolavirus.od. or Ebola haemorrhagic fever/ (5197)
2 Marburg virus disease/ or Marburg marburgvirus/ (87)
3 Lassa virus/ or Lassa fever/ (1041)
4 Rift Valley fever virus.od. or Rift Valley fever.sh. (1981)
5 exp crimean-congo haemorrhagic fever virus/ (1856)
6 (ebola* or ebov or marburg* or lassa* or CCHF or CCHVF or "crimean-congo*" or "congo virus" or (crimean adj2 (hemorrhagic or haemorrhagic)) or "rift valley*" or RVF or RVFV).ti,ab. (11046)
7 exp severe acute respiratory syndrome-related coronavirus/ (86613)
8 Middle East respiratory syndrome coronavirus.od. (2140)
9 ("middle east* respiratory syndr*" or MERS-CoV or "novel CoV*" or "novel betacoronavirus" or coronavirus* or covid* or ("middle east" adj3 (cov or betacoronavirus*)) or (MERS adj3 (cov or betacoronavirus*)) or "mers-coronavirus" or "mers cov" or merscov or "wuhan flu" or 2019-nCoV).ti,ab. (89257)
10 West Nile fever.sh. or West Nile virus.od. (6612)
11 ("west nile" or "egypt 101").ti,ab. (7294)
12 influenza a virus subtype h1n1/ (7289)
13 influenza a/ (14712)
14 (H1N1 or H5N1 or H3N2 or H7N9).ti,ab. (16604)
15 exp henipavirus/ (1218)
16 (nipah* or hendra* or henipavirus*).ti,ab. (1218)
17 exp african swine fever virus/ (645)
18 ("african swine" or "ASF virus" or ASFV or "wart hog disease virus*").ti,ab. (589)
19 exp monkeypox virus/ (431)
20 (monkeypox or "monkey pox").ti,ab. (501)

21 exp zika virus/ (5511)
22 (zika* or zikv).ti,ab. (6974)
23 ("disease x*" or "pathogen x*").ti,ab. (169)
24 smallpox/ (1400)
25 (smallpox* or "small pox*" or variola).ti,ab. (2041)
26 exp human poliovirus 1/ or exp human poliovirus 2/ or exp human poliovirus 3/ (5089)
27 polio*.ti,ab. (7787)
28 brucellosis/ (6497)
29 (brucellosis or brucelloses or brucella).ti,ab. (8154)
30 q fever/ (3202)
31 ("q fever*" or "Coxiella burnetii" or coxiellosis or "query fever*").ti,ab. (4545)
32 melioidosis/ (1811)
33 (melioidosis or pseudomallei or "whitmore* disease*" or "nightcliff gardener* disease*" or pseudoglanders or "paddy-field disease" or "paddyfield disease").ti,ab. (2561)
34 exp francisella tularensis/ (2979)
35 (Tularaemia* or tularemia* or "Francisella tularensis" or "ohara disease" or "rabbit fever").ti,ab. (2849)
36 cholera/ (5792)
37 cholera*.ti,ab. (12380)
38 exp yersinia pestis/ (4823)
39 (plague or "black death" or "Yersinia pestis" or "Y. pestis").ti,ab. (5642)
40 exp anthrax/ (3450)
41 (Anthrax or "Bacillus anthracis" or "B. anthracis").ti,ab. (4632)
42 emerging infectious diseases/ (6986)
43 ("priority pathogen*" or "potential pathogen*" or "re-emerging pathogen*" or "reemerging pathogen*" or "emerging pathogen*").ti,ab. (5066)
44 outbreaks/ (52091)
45 exp epidemics/ (77111)
46 (((health$ or disease$) adj5 (disaster$ or catastrophe$ or crises or crisis)) or epidemic* or pandemic* or outbreak* or out-break* or "public health emergenc*" or "global health emergenc*").ti,ab. (182052)
47 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 (296286)
48 ((setting* adj2 priorit*) or (research* adj2 priorit*) or "research strateg*" or "prioriti?ation methodolog*" or (generat* adj2 priorit*) or (develop* adj2 priorit*) or "priority guideline*" or "agenda setting*" or (research* adj1 gap*) or (identif* adj2 priorit*) or "research question*").ti,ab. (11794)
49 (preparedness or readiness or "in advance of" or "planning for").ti,ab. (51741)
50 infection control/ (13058)
51 prevention/ (29143)
52 (response or control or prevention or addressing or tackle).ti,ab. (1023753)
53 49 or 50 or 51 or 52 (1067052)
54 47 and 48 and 53 (756)

SCOPUS

(((TITLE-ABS-KEY (ebola* OR ebov OR marburg* OR lassa* OR cchf OR cchvf OR "crimean-congo*" OR "congo virus" OR (crimean W/2 (hemorrhagic OR haemorrhagic)) OR "rift valley*" OR rvf OR rvfv) OR TITLE-ABS-KEY (("middle east* respiratory syndr*" OR mers-cov OR "novel CoV*" OR "novel betacoronavirus" OR coronavirus* OR covid* OR ("middle east" W/3 (cov OR betacoronavirus*)) OR (mers W/3 (cov OR betacoronavirus*)) OR "mers-coronavirus" OR "mers cov" OR merscov OR "wuhan flu" OR 2019-ncov)) OR TITLE-ABS-KEY ("west nile" OR "egypt 101" OR h1n1 OR h5n1 OR h3n2 OR h7n9 OR nipah* OR hendra* OR henipavirus* OR "african swine" OR "ASF virus" OR asfv OR "wart hog disease virus*" OR monkeypox OR "monkey pox" OR zika* OR zikv OR "disease x*" OR "pathogen x*") OR TITLE-ABS-KEY (smallpox* OR "small pox*" OR variola OR polio* OR brucellosis OR brucelloses OR brucella OR "q fever*" OR "Coxiella burnetii" OR coxiellosis OR "query fever*" OR melioidosis OR pseudomallei OR "whitmore* disease*" OR "nightcliff gardener* disease*" OR pseudoglanders OR "paddy-field disease" OR "paddyfield disease" OR tularaemia* OR tularemia* OR "Francisella tularensis" OR "ohara disease" OR "rabbit fever" OR cholera* OR plague OR "black death" OR "Yersinia pestis" OR "Y. pestis" OR anthrax OR "Bacillus anthracis" OR "B. anthracis"))) OR ((TITLE-ABS-KEY ("priority pathogen*" OR "potential pathogen*" OR "re-emerging pathogen*" OR "reemerging pathogen*" OR "emerging pathogen*") OR TITLE-ABS-KEY ((((health$ OR disease$) W/5 (disaster$ OR catastrophe$ OR crises OR crisis)) OR epidemic* OR pandemic* OR outbreak* OR out-break* OR "public health emergenc*" OR "global health emergenc*"))))) AND (TITLE-ABS-KEY (((setting* W/2 priorit*) OR (research* W/2 priorit*) OR "research strateg*" OR "prioriti?ation methodolog*" OR (generat* W/2 priorit*) OR (develop* W/2 priorit*) OR "priority guideline*" OR "agenda setting*" OR (research* W/1 gap*) OR (identif* W/2 priorit*) OR "research question*"))) AND ((TITLE-ABS-KEY (preparedness OR readiness OR "in advance of" OR "planning for") OR TITLE-ABS-KEY (response OR control OR prevention OR addressing OR tackle)))

WHO Global Index Medicus https://pesquisa.bvsalud.org/gim/

(tw:(ebola* OR ebov OR marburg* OR lassa* OR cchf OR cchvf OR "crimean-congo*" OR "congo virus" OR (crimean AND (hemorrhagic OR haemorrhagic)) OR "rift valley*" OR rvf OR rvfv or "middle east* respiratory syndr*" OR mers-cov OR "novel CoV*" OR "novel betacoronavirus" OR coronavirus* OR covid* OR ("middle east" AND (cov OR betacoronavirus*)) OR (mers AND (cov OR betacoronavirus*)) OR "mers-coronavirus" OR "mers cov" OR merscov OR "wuhan flu" OR 2019-ncov OR "west nile" OR "egypt 101" OR h1n1 OR h5n1 OR h3n2 OR h7n9 OR nipah* OR hendra* OR henipavirus* OR "african swine" OR "ASF virus" OR asfv OR "wart hog disease virus*" OR monkeypox OR "monkey pox" OR zika* OR zikv OR "disease x*" OR "pathogen x*" OR smallpox* OR "small pox*" OR variola OR polio* OR brucellosis OR brucelloses OR brucella OR "q fever*" OR "Coxiella burnetii" OR coxiellosis OR "query fever*" OR melioidosis OR pseudomallei OR "whitmore* disease*" OR "nightcliff gardener* disease*" OR pseudoglanders OR "paddy-field disease" OR "paddyfield disease" OR tularaemia* OR tularemia* OR "Francisella tularensis" OR "ohara disease" OR "rabbit fever" OR cholera* OR plague OR "black death" OR "Yersinia pestis" OR "Y. pestis" OR anthrax OR "Bacillus anthracis" OR "B. anthracis" OR "priority pathogen*" OR "potential pathogen*" OR "re-emerging pathogen*" OR "reemerging pathogen*" OR "emerging pathogen*" OR ((health* OR disease*) AND (disaster* OR catastrophe* OR crises OR

crisis)) OR epidemic* OR pandemic* OR outbreak* OR out-break* OR "public health emergenc*" OR "global health emergenc*")) AND (tw:((setting* AND priorit*) OR (research* AND priorit*) OR "research strateg*" OR "prioritisation methodolog*" OR "prioritization methodolog*" OR (generat* AND priorit*) OR (develop* AND priorit*) OR "priority guideline*" OR "agenda setting*" OR (research* AND gap*) OR (identif* AND priorit*) OR "research question*")) AND (tw:(preparedness OR readiness OR "in advance of" OR "planning for" or response OR control OR prevention OR addressing OR tackle))

Google Scholar

(priorit*|"agenda setting"|"research gap*"|"research question*")(preparedness|readiness|"advance of"|"planning for"|response|control|prevention|addressing|tackle)(outbreak*|pandemic*|epidemic*|"public health emergenc*"|"global health emerg*")

WHO websites

https://www.google.com/search?hl=en&as_q=priority&as_epq=outbreak*&as_oq=preparedness+readiness+response+%22advance+of%22+%22planning+for%22+control+prevention+addressing&as_eq=&as_nlo=&as_nhi=&lr=&cr=&as_qdr=all&as_sitesearch=.who.int&as_occt=any&safe=images&as_filetype=&tbs=

priority preparedness OR readiness OR response OR "advance of" OR "planning for" OR control OR prevention OR addressing "outbreak*" site:.who.int

https://www.google.com/search?q=priority+preparedness+OR+readiness+OR+response+OR+%22advance+of%22+OR+%22planning+for%22+OR+control+OR+prevention+OR+addressing+%22outbreak*%22+site%3A.paho.org&lr=&safe=images&hl=en&as_qdr=all&ei=CZVCZLSOHrWYhbIP35C0yA8&ved=0ahUKEwj0toC1j7v-AhU1TEEAHV8IDfkQ4dUDCA8&uact=5&oq=priority+preparedness+OR+readiness+OR+response+OR+%22advance+of%22+OR+%22planning+for%22+OR+control+OR+prevention+OR+addressing+%22outbreak*%22+site%3A.paho.org&gs_lcp=Cgxnd3Mtd2l6LXNlcnAQAzITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCC4QjwEQ6gIQtAIQjAMQ5QIYATITCC4QjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYATITCAAQjwEQ6gIQtAIQjAMQ5QIYAUoECEEYAFAAWNbDAWDRxQFoAnAAeACAAQCIAQCSAQCYAQCgAQGgAQKwAQrAAQHaAQQIARgK&sclient=gws-wiz-serp

priority preparedness OR readiness OR response OR "advance of" OR "planning for" OR control OR prevention OR addressing "outbreak*" site:.paho.org

Appendix H: Funders of less than 10 COVID-19 research grants in Africa with their abbreviations listed

IHU Marseille - Institut Hospitalo-Universitaire en Maladies Infectieuses de Marseille (N/A, 1 project); **York University** ($10.6k, 1 project); **IRD - L'Institut de recherche pour le développement** (N/A, 1 project); **ANRS / Expertise France** ($132k, 1 project**), IZA - Institute of Labor Economics** (N/A, 1 project), **AXA** (N/A, 1 project); **Johns Hopkins University** (N/A, 1 project); **CHEST Foundation** (N/A, 1 project); **KAKENHI** ($143k, 1 project); **DFG - Deutsche Forschungsgemeinschaft** (N/A, 1 project); **Mitacs** (N/A, 1 project); **European Commission** ($2.9m, 1 project); **National Science Center Poland** ($80.4k, 1 project); **Indian Council of Medical Research (ICMR) / National Institute for Health and Care Research / UK Research and Innovation - UKRI** ($240k, 1 project); **National Science Foundation - NSF (USA)** ($169k, 1 project); **AFD / IRD** (N/A, 1 project); **Swiss National Science Foundation - SNSF** ($53k, 1 project); **BSAC** ($22.7k, 1 project); **Solidarity Fund/Michael and Susan Dell Foundation** ($910k, 1 project); **The European Open Science Cloud - EOSC** (N/A, 1 project); **Spencer Foundation** (N/A, 1 project); **ICMR / National Institutes of Health - NIH** ($3.7k, 1 project); **Social Sciences and Humanities Research Council - SSHRC** ($712k, 1 project); **Centre de coopération internationale en recherche agronomique pour le développement - CIRAD** (N/A, 1 project); **UNITAID / Agence nationale de recherche sur le sida et les hépatites virale - ANRS** (N/A, 1 project); **ANRS-MIE** (N/A, 1 project); **UNITAID / European and Developing Countries Clinical Trials Partnership - EDCTP** (N/A, 1 project); **Foreign, Commonwealth and Development Office - FCDO/ UNICEF** (N/A, 1 project); **WHO** (N/A, 1 project); **International Science Council** (N/A, 2 projects); **Other Funders (Canada)** (N/A, 2 projects); **Royal Society of Tropical Medicine and Hygiene - RSTMH** ($13.4k, 2 projects); **Solidarity Fund** ($142k, 2 projects); **International Centre for Genetic Engineering and Biotechnology - ICGEB** (N/A, 2 projects); **Burnet Institute**

(N/A, 2 projects); **European Commission (Horizon)** ($35.8m, 2 projects); **Innovations for Poverty Action** (N/A, 2 projects); **Newton Fund** ($151k, 2 projects); **Swedish Research Council** ($977m, 2 projects); **South African Medical Research Council/Department of Science and Innovation - South Africa** ($1.1m, 3 projects); **WHO / Gabon government** (N/A, 3 projects); **Volkswagen Stiftung** (N/A, 3 projects); **Bundesministerium für Bildung und Forschung - BMBF** ($753k, 4 projects); **Agence nationale de la recherche - ANR** (N/A, 4 projects); **Wellcome / FCDO (formerly DFID)** ($5.6m, 4 projects); **COVID-19 Therapeutics Accelerator (Wellcome / Bill & Melinda Gates Foundation)** ($N/A, 4 projects); **WHO Africa** ($N/A, 4 projects); **British Academy** ($25k, 4 projects); **Duke University** (N/A, 4 projects)**; Partnership for Economic Policy** (N/A, 5 projects); **Innovations for Poverty Action/ FCDO (formerly DFID)** (N/A, 5 projects); **Mauritius Research and Innovation Council - MRIC Mauritius** ($74k, 6 projects); **Wellcome Centre for Infectious Diseases research In Africa - CIDRI-Africa** ($338k, 6 projects); **RCN Norway** ($2.3m, 6 projects); **Wellcome** ($1.4m, 6 projects); **Growth and Labour Markets in Low Income Countries Programme - G2LM|LIC** (N/A, 7 projects); **Governments of Brazil, Russia, India, China, South Africa - BRICS** (N/A, 7 projects); **UNICEF** (N/A); **L'Agence Universitaire de la Francophonie** - **AUF** (N/A, 7 projects); **FCDO (formerly DFID) / National Institute for Health and Care Research / Wellcome** ($988k, 8 projects); **Novo Nordisk Foundation** (800k, 8 projects); **Agence Française de Développement** - **AFD** ($12.6m, 8 projects); **Royal Academy of Engineering - RAENG** ($210k, 8 projects); **Social Sciences Research Council** (N/A, 9 projects); **UKRI / National Institute for Health and Care Research** ($2.3m, 9 projects); **Department of Science and Innovation - South Africa /Technology Innovation Agency** ($1.6m, 9 projects); **Canadian Institutes of Health Research - CIHR** ($3.3m, 9 projects); **Institut Pasteur** (N/A, 9 projects).

Appendix I: Interview guide for qualitative research study

Interview Guide _ Researcher

Questions

1. What discipline of COVID-19 research project(s) were you involved in?
2. Can you describe the process of applying for funding for COVID-19 research during the COVID-19 pandemic?
3. What were your experiences in identifying research funding opportunities for COVID-19 health research in Africa?
4. What were your experiences in applying for research funding for COVID-19 health research in Africa?
    a. How much time did you have to submit applications? What was your experience with the proposal review process? What were the requirements?
5. What were your experiences in receiving funds for COVID-19 health research in Africa?
    a. When did you receive funding? Could you repurpose existing research funding for COVID-19 research? How were research funds delivered?
6. What were your experiences in the M&E processes for funding received for COVID-19 health research?

Interview Guide _Grant manager

Questions

1. What role did you or your office/department play in the management of funding during the COVID-19 pandemic?
2. Did your office have a role in the grant application process? What were your experiences?
3. Were there other offices or departments in your institutions involved in grant management during the pandemic?
4. What was your experience with the awarding of grants during the pandemic?
5. What were your experiences in receiving funds for COVID-19 health research?
6. What were your experiences in the M&E processes/ reporting on funds received for COVID-19 health research?