From Research to Resilience: Preparedness Lessons from COVID-19

wellcome

Research Consulting

Contributors

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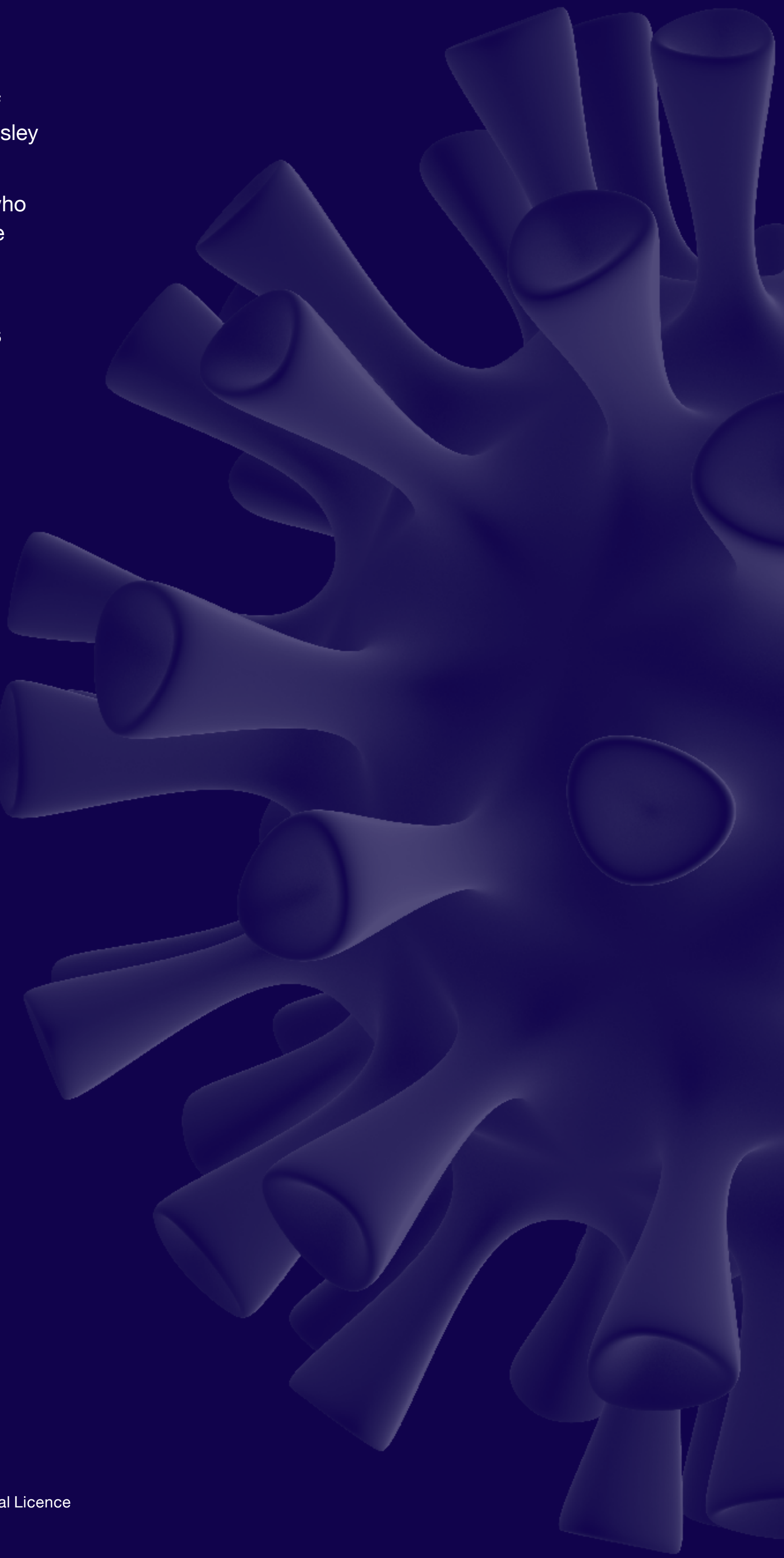

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Foreword

Pathogen genomic sequencing (PGS) has emerged as a cornerstone of national and global health systems, enabling rapid detection and response to emerging threats. Wellcome's long-standing strategic investments in genomics research and its application to public health, particularly through our emergency funding during the COVID-19 pandemic, reflects our commitment to embedding epidemic preparedness approaches into how and what research we fund.

Wellcome commissioned this review to examine how emergency research funding can be most effective in future public health emergencies. The insights gained are particularly timely as we see increasing demands for rapid, coordinated responses to emerging health threats.

In particular, Wellcome sought to understand how emergency funding can build on existing research capacity, what enables rapid deployment of scientific expertise during crises, and how different funding approaches work across varied contexts. Most crucially, we wished to explore how research findings can effectively translate into public health action.

The findings of this consultation show that effective emergency responses are built on foundations laid long before a crisis begins. Where sustained investments from Wellcome had fostered strong research infrastructure and government relationships, we saw the effective integration of genomic data into policy decisions. This was particularly evident in settings where Wellcome had previously invested in local priority pathogens like malaria, swine flu, and tuberculosis. This enabled teams to rapidly pivot their expertise to support crucial aspects of the COVID-19 response, including sample preparation, diagnostic testing, and genomic sequencing.

Looking ahead, researchers have clearly articulated the need to support comprehensive research environments, create funding mechanisms that serve diverse contexts, and strengthen connections between research institutions and policy networks. Their direct experiences and insights have been instrumental in shaping these recommendations.

We are grateful to all the researchers and partners who contributed their experiences to this valuable learning exercise. Their insights will help shape a more resilient and responsive global health research ecosystem.

Alexander Pym
Director of Infectious Disease

Executive summary

The COVID-19 pandemic marked a transformative moment for pathogen genomic surveillance. For the first time, genomic sequencing was deployed at global scale in near real-time to inform pandemic response, demonstrating both its significant potential and revealing critical gaps in global capacity. While the immediate crisis has now passed, the lessons learned from this scaling of genomic surveillance have continuing value for strengthening global health security.

This report examines how research environments enable or constrain pathogen genomic surveillance during public health emergencies. By analysing the experiences of Wellcome-funded genomic sequencing projects, this report identifies key factors that transcend the specific context of COVID-19 to inform future emergency preparedness and response capabilities.

This work reveals fundamental principles for building sustainable surveillance systems that can rapidly pivot to address new threats while maintaining scientific integrity under intense pressure. By understanding both the visible infrastructure needs and invisible support systems required, funders can strategically invest in creating resilient research environments that stand ready for future emergencies.

Wellcome commissioned Research Consulting to explore the barriers and enablers faced by genomic sequencing projects during emergency conditions. The aims of this research were to:

- **Understand** the complete pathway from sample collection to policy uptake, identifying critical junctures where strategic support can maximise impact
- **Uncover** hidden processes and pressures that affect research teams during emergencies but often remain unacknowledged in traditional evaluations
- **Identify** practical solutions that address context-specific challenges faced by researchers across diverse settings

Conducted between August 2023 and January 2025, this study engaged with eight Wellcome-funded projects through interviews, focus groups and surveys. These projects spanned multiple regions including Africa, Asia, Latin America, and the Middle East, providing a global perspective on pathogen surveillance challenges and solutions.

This consultation revealed distinct barriers and enablers across the genomic sequencing pipeline and looked beyond the technical workflows to examine the broader context in which sequencing activities occurred.

Based on this consultation, this report identifies five key themes that influence all stages of genomic surveillance:

- Funding design and grant award
- Enabling infrastructure
- Research team capacity
- Data management and sharing
- Research uptake and community engagement

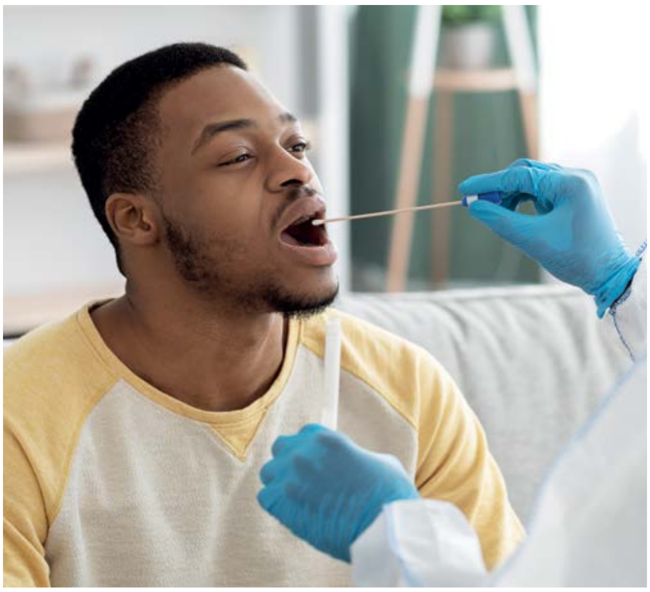
Funding design and grant award

Long-term investments in local genomic surveillance capacity create the foundation for effective emergency response. Wellcome's sustained funding relationships, particularly through its Africa and Asia Programmes, enabled researchers to rapidly redirect existing expertise toward emerging threats. When institutions have established pathogen genomics capabilities and collaborative networks before emergencies arise, they can mobilise quickly and maintain operations under pressure.

The review found the following key findings and potential actions relating to funding design and grant award:

Table ES1. Key findings relating to funding design and grant award

Key findings	Potential actions for research funders
Existing Wellcome grantees could receive funds quickly, while new partners faced significant delays due to mandatory due diligence processes (Main report, Section 3.1)	Develop context-sensitive due diligence frameworks for emergency response
Wellcome's reimbursement-based funding model caused friction with national regulations (Main report, Section 3.2)	Continue to review funding mechanisms as national regulatory requirements evolve
Projects led by institutions with existing partnerships were able to rapidly overcome roadblocks to delivery (Main report, Section 3.3)	Use dedicated sections in application form to identify existing partnerships and understand how applicants are integrated into local research and policy networks
Communication challenges delayed project initiation, particularly for newly-established funding partnerships (Main report, Section 3.4)	Create clear communication tools (like "one-pagers") for new partners explaining key processes, timelines, and explicitly inviting questions
	Continue to engage regularly with funded teams to support communication and explicitly communicate that questions are welcome from award holders
Community engagement (CE) funding supported core sequencing awards (Main report, Section 3.5)	Continue to provide ring-fenced funding for community engagement in line with findings from the supporting review of CE grants



Enabling infrastructure

Robust physical and technical infrastructure provides the essential foundation for genomic surveillance. During emergencies, even well-resourced institutions face challenges with cold chain infrastructure, reagent supply chains, and equipment maintenance. However, teams that developed innovative resource management strategies and leveraged local support networks were able to maintain operations despite these constraints.

The review found the following key findings and potential actions relating to enabling infrastructure:

Table ES2. Key findings relating to enabling infrastructure

Key findings	Potential actions for research funders
Limited access to basic physical infrastructure affected the integrity of critical reagents and consumables (Main report, Section 4.1)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Significant supply chain disruption necessitated careful consumables planning and management (Main report, Section 4.2)	Facilitate knowledge sharing about infrastructure challenges and solutions across funded teams
High resource costs and limited availability prompted innovative approaches to consumables management (Main report, Section 4.3)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Access to cutting-edge equipment and reliable technical support is critical to ensuring continuity in genomic sequencing (Main report, Section 4.4)	Consult with other funders about approaches to equipment servicing and support in low- and middle-income countries (LMICs)
Significant data demands of disease surveillance require substantial computing resources for processing, analysis and storage (Main report, Section 4.5)	Clarify approaches to funding maintenance of equipment e.g. allowing longer-term maintenance contracts

Research team capacity

Bioinformatics expertise emerged as a critical capability for effective pathogen genomic surveillance. Organisations that had invested in developing this specialised knowledge before the emergency were better positioned to analyse and interpret sequence data. Formal training programs and informal knowledge-sharing networks proved essential for building capacity and addressing technical challenges during the response.

The review identified the following key findings and potential actions relating to research team capacity:

Table ES3. Key findings relating to research team capacity

Key findings	Potential actions for research funders
Highly capable bioinformaticians were in significant demand to meet sequencing analysis needs (Main report, Section 5.1)	Continue to consider and embed investments in bioinformatics capacity building through existing initiatives that support training and researcher network building
Funded teams provided training to enhance in-house and partner bioinformatics capabilities (Main report, Section 5.2)	
Organisations established formal and informal networks to share expertise and resources (Main report, Section 5.3)	

Data management and sharing

Effective pathogen genomic surveillance requires balanced approaches to data sharing that recognise data generators' contributions while enabling timely analysis. Organisations navigated complex tensions between national data sovereignty concerns and the need for global collaboration. Platforms that credited data generators while enabling analysis were particularly valued by researchers in low and middle-income countries (LMICs).

The review identified the following key findings and potential actions related to data management and sharing:

Table ES4. Key findings relating to data management and sharing

Key findings	Potential actions for research funders
GISAID emerged as the primary platform for sharing SARS-CoV-2 sequence data and was particularly attractive to researchers in LMICs due to its policies on crediting data generators (Main report, Section 6.1)	Support tiered data sharing that allows rapid sharing to decision-makers while working towards full public release
Interim solutions were established to enable data sharing before full public sharing was possible, including restricted sharing with key stakeholders (Main report, Section 6.3)	
Metadata quality and completeness were a significant challenge, particularly in routine healthcare facilities (Main report, Section 6.4)	Promote use of existing frameworks to support metadata collection and adherence to relevant standards

Research uptake and community engagement

Successful translation of genomic data into policy action relies on established relationships between research institutions and government agencies. Projects with local leadership and pre-existing connections to policymakers achieved greater impact through timely information sharing. Technical advisory committees and formal governance structures provided crucial pathways for evidence-informed decision-making.

The review identified the following key findings and potential actions related to research uptake and community engagement:

Table ES5. Key findings relating to research uptake and community engagement

Key findings	Potential actions for research funders
Research uptake is enabled by existing relationships between research institutions and government agencies (Main report, Section 7.1)	Compile and share examples of successful policy engagement approaches from different contexts
Robust channels for communicating complex scientific information are critical to relaying information to policymakers (Main report, Section 7.2)	
Dedicated committees and advisory groups are a vital mechanism for information sharing (Main report, Section 7.3)	
Local leadership leads to more successful policy dialogue and engagement (Main report, Section 7.4)	
Community engagement supports genomic sequencing efforts, provided that messaging is carefully crafted (Main report, Section 7.5)	Develop clear, accessible guidelines on community engagement expectations and approaches for emergency funding

While identified through a review of COVID-19 experiences, the five themes outlines above represent fundamental principles for strengthening future emergency preparedness and response capabilities. By strategically addressing these elements, funders can help build resilient research environments that stand ready to respond effectively to future public health emergencies.

Contents

1. Introduction

1. Introduction

1.1 Understanding the research environment under pressure

In order to enable the generation, sharing and uptake of **Pathogen genomic sequencing** (PGS) data and analyses in future pandemics, Wellcome recognises that it must better understand the research environments in which this information is generated.

Currently, Wellcome characterises the research environment[1] as the infrastructure, people, research design, culture and behaviours present in, and applied by, research teams.

1.2 Wellcome's approach to enabling genomic sequencing and surveillance during SARS-CoV-2

As a long-standing funder[2] of global health research, Wellcome played a key role in supporting pathogen genomic surveillance efforts during the COVID-19 pandemic. The projects reviewed in this study were funded through various funding streams which aimed to strengthen the evidence base around COVID-19, enhance research and response capacity, and build robust surveillance networks across different regions.[3]

In this context, Wellcome funded a number of international principal investigators to establish a consortium of labs that would coordinate and conduct SARS-CoV-2 pathogen genomic sequencing and surveillance. These grants aimed to strengthen the evidence base to better prevent and control coronavirus epidemics and to increase research and response capacity.

Grants were awarded through a two-phased approach:

- **Phase 1**. Wellcome approached existing grantees and partners, particularly in its Africa and Asia Programmes[4], and provided additional funding or extensions, enabling these partners to scale up pathogen genomic surveillance activities.
- **Phase 2**. Wellcome focused on expanding geographic coverage to address gaps in its portfolio. Wellcome proactively contacted potential partners in regions such as Latin America, South Asia and Southeast Asia, the Middle East and North Africa to alert them of funding opportunities.

Applications were considered by the Epidemic Technical Advisory Panel and applications were reviewed rapidly, given the emergency nature of the funding call.

1.3 Developing an evidence base to inform funders' responses to future public health emergencies

Wellcome commissioned this review to understand the immediate needs of researchers during acute phases of public health emergencies, and to identify opportunities to improve grant funding design and delivery in emergency settings. The aims of this review were to:

- **understand** the pathway between generating SARS-CoV-2 genomic sequencing data and its potential uptake in research and research policy;
- **learn** about hidden and unaccounted for processes from the diverse research community; and
- **identify** solutions to address the challenges faced by researchers in different contexts.

An international team led by Research Consulting[5] managed this review to investigate the pathway between generating SARS-CoV-2 data and to better understand its uptake in research and policy. This project was led by Wellcome's Infectious Disease[6] and Research Culture and Communities[7] teams.

1.4 Wellcome provided funding to enable pathogen genomic sequencing and surveillance for SARS-CoV-2

This research was conducted between August 2023 and January 2025 and engaged with a total of eight Wellcome-funded projects through a combination of interviews, focus groups and an online survey. The overall approach to this work was guided by a research protocol available here.

Across the eight projects in scope of this review, the amount of funding awarded for each project ranged from £0.4m to £6m, with the total funding exceeding £22m.

All projects involved the coordination and management of research across multiple countries, and many were established as a consortia of laboratories. Throughout the report, we use the term 'projects' to refer to the list of awards which is available in Appendix A.


COVID-19
CORONAVIRUS
VACCINE

2. About our findings

2. About our findings

2.1 Pathogen genomic sequencing during COVID-19

The COVID-19 pandemic marked a significant turning point[8] in the use of genomic sequencing for public health responses. For the first time, pathogen genomic sequencing was conducted at scale and in near real-time to inform pandemic decision-making, interventions and the development of vaccines.

This report explores the barriers and enablers faced by Wellcome-funded projects during the COVID-19 pandemic and the unprecedented scaling up of genomic sequencing activities.

This is achieved through the lens of six key stages that outline the pathogen genomic sequencing process. This begins with initial sample collection and ends with research uptake.

These stages were identified by building on the World Health Organization's (WHO) 2022 framework for pathogen genomic surveillance[9] and the US Centers for Disease Control and Prevention's (CDC) genomic sequencing process for SARS-CoV-2.[10] WHO's framework combines some elements into broader categories – such as 'sample collection and testing' and 'sequencing and data generation' – and the CDC process extends only as far as data submission to public repositories.

However, our consultation revealed distinct challenges and enablers at each stage of the pathogen genomic sequencing pipeline.

This more granular breakdown reflects the operational realities encountered by research teams during the pandemic response, where each stage presented unique barriers and enablers (see Figure 1).

- **Sample collection**
- **Sample testing**
- **Genomic sequencing**
- **Data sharing**
- **Data analysis**
- **Research uptake**

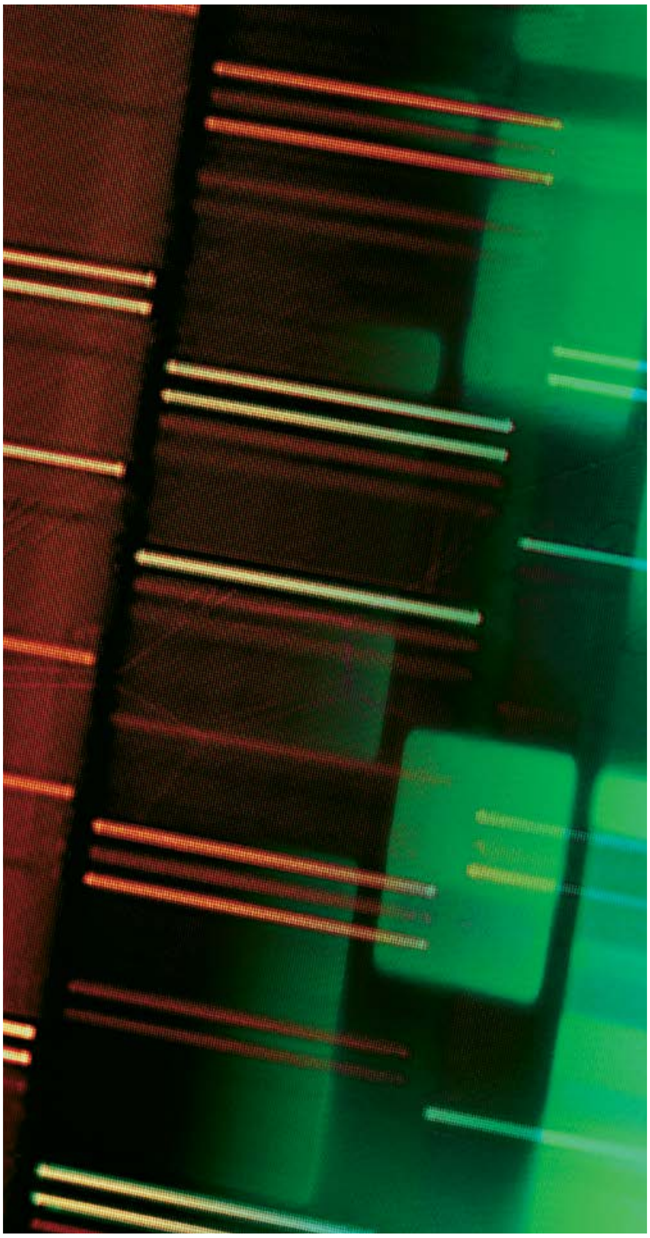
2.2 Understanding our findings

To fully understand these barriers and enablers, we looked beyond the technical sequencing workflow to examine the broader context in which these activities took place. Through our consultation with Wellcome-funded researchers, we identified five key themes that cut across all stages of the genomic sequencing process:

- **Funding design and grant award**: Covers the funding call application process and initial project administration.
- **Enabling infrastructure**: Covers the operational and logistics challenges associated with project delivery, once grants have been awarded.
- **Research team capacity**: Examines both the human resources available to project teams and the areas identified for further development or training.
- **Data management and sharing**: Focuses on data sharing as mandated by Wellcome as part of the funding conditions and as implemented by project teams.
- **Research uptake and community engagement**: Covers engagement with policy and decision makers as well as other members of local communities.

These themes emerged through an iterative analysis process that considered both participant responses and Wellcome's strategic objectives. While this categorisation involves some interpretive judgment, it provides a framework that connects operational realities to desired outcomes while highlighting the systemic factors that influence success across all stages of genomic sequencing work.

The following report is structured according to the five themes above and is followed by a concluding section, summarising the potential actions for Wellcome and other key stakeholders.



Glossary terms

Key terms throughout this report are included in a Glossary and are indicated using this icon G. All glossary terms can be found here.

Barriers and enablers

Figure 1 summarises the sequencing pathway, highlighting the most significant **barriers (red)** and **enablers (green)** at each stage, as identified in our consultation. The number of unique projects affected by each barrier or enabler according to interviews and the online survey is shown in the figure.

Each project is counted only once, even if multiple participants from the same project mentioned a particular barrier or enabler. Numbers represent only explicitly mentioned instances during our consultation, and other projects may have experienced similar barriers or enablers.

Figure 1. Barriers and enablers of pathogen genomic sequencing

Sample collection

- 3 Existing relationships enabled access to samples (Section 3.3)
- 2 Geographic proximity to healthcare facilities enabled sample collection (Section 3.3)
- 2 Teams developed case report forms to share with hospitals outlining key data required (Section 7.5)

- 4 Limited cold chain storage in transit affected sample viability (Section 4.1)
- 2 Limited freezer capacity forced the prioritisation of samples (Section 4.1)

Sample testing

- 3 Batched testing strategies were implemented to save resources for testing (Section 4.3)
- 3 Sharing of reagents, other consumables and equipment took place during early stages of projects (Section 4.3)

- 5 Supply chain bottlenecks significantly impacted genomic surveillance operations (Section 4.2)
- 4 The cost of reagents was particularly high outside of Europe or the United States (Section 4.3)

Genomic sequencing

- 5 Immediate access to sequencing platforms at project initiation (Section 4.4)
- 3 Existing workforce capacity skilled in genomic sequencing (Section 5.1)
- 1 Relationships with logistics partners for sequencing equipment (Section 4.4)

- 3 Critical equipment failures complicated by limited access to technical support (Section 4.4)

Cross-cutting themes

- 3 Wellcome was regarded as a flexible research funder in comparison to others (Section 3.1)
- 3 Existing workforce capacity enabled teams to rapidly pivot to SARS-CoV-2 research (Section 3.1)
- 1 Some institutions were able to issue sub-contractors with upfront payments (Section 3.2)

- 5 Administrative bottlenecks delayed fund distribution to partner organisations (Section 3.3)
- 3 New partner organisations faced significant delays due to mandatory due diligence processes (Section 3.1)
- 3 Wellcome's reimbursement-based funding model caused friction with national regulations (Section 3.2)
- 2 Communication barriers between Wellcome and research teams delayed project initiation (Section 3.5)

1 3 5 **Barriers** Low > High

1 3 5 **Enablers** Low > High

Number of unique projects affected by barrier or enabler

Data sharing	Data analysis	Research uptake
(8) GISAID and other global databases enabled rapid and open data sharing (Section 6.1) (3) Hierarchical approaches to data sharing ensured data quality was maintained and data could be shared rapidly (Section 6.3)	(3) Teams developed bioinformatics training to upskill researchers (Section 5.2) (3) Access to high-performance servers enabled data analysis (Section 4.5) (1) Access to high-performance computing enabled data analysis (Section 4.5)	(8) Policy briefs were used to communicate critical information to policymakers (Section 7.2) (4) Technical working groups and specialised task forces were channels through which research uptake occurred (Section 7.3) (2) Engagement with policymakers was most successful where local actors led engagement (Section 7.4)
(4) Incomplete and inconsistent metadata prevented or delayed the open sharing of genomic sequences (Section 6.4) (2) Local sensitivities and approval mechanisms delayed external data sharing (Section 6.1)	(3) Limited access to in-house sequencing software constrained analysis capability (Section 4.5) (2) Bioinformatics capability was initially limited (Section 5.1)	(3) Funding for community engagement and core research not necessarily starting at the same time (Section 3.5)* (3) Difficulty in assessing policy influence and community-level impacts due to limited monitoring and evaluation frameworks for emergency funding (Section 3.5)*

* Findings from a supporting review, conducted by Research Consulting, focusing on a sub-set of Wellcome's community engagement awards designed to support genomic sequencing awards

3. Funding design and grant award

3. Funding design and grant award

Funders and research institutions typically engage in months-long grant-making processes, from strategic development of funding calls through proposal development and peer review. The COVID-19 pandemic, as with previous outbreaks like Zika and Ebola, required funders to develop more flexible mechanisms to support rapidly evolving research needs.

Key changes during the pandemic included:

- Dramatically accelerated timelines for review and funding decisions
- Simplified application processes with shorter proposals
- Streamlined reporting requirements based on trust
- Greater allowance for protocol adaptations

The following sections therefore explore the impact of these changes on institutions that received rapid response funding from Wellcome during the pandemic, with a focus on the transition from award decisions to project kick-off.

The key findings and potential actions that relate to the award decision and project kick-off phases are summarised below, with reference to the relevant sections for further reading.

Table 1. Key findings relating to funding design and grant award

Key findings	Potential actions for research funders
Existing Wellcome grantees could receive funds quickly, while new partners faced significant delays due to mandatory due diligence processes (Section 3.1)	Develop context-sensitive due diligence frameworks for emergency response
Wellcome's reimbursement-based funding model caused friction with national regulations (Section 3.2)	Continue to review funding mechanisms as national regulatory requirements evolve
Projects led by institutions with existing partnerships were able to rapidly overcome roadblocks to delivery (Section 3.3)	Use dedicated sections in application form to identify existing partnerships and understand how applicants are integrated into local research and policy networks
Communication challenges delayed project initiation, particularly for newly-established funding partnerships (Section 3.4)	Create clear communication tools (like "one-pagers") for new partners explaining key processes, timelines, and explicitly inviting questions
	Continue to engage regularly with funded teams to support communication and explicitly communicate that questions are welcome from award holders
Community engagement (CE) funding supported core sequencing awards (Section 3.5)	Continue to provide ring-fenced funding for community engagement in line with findings from the supporting review of CE grants

3.1 Existing Wellcome grantees could receive funds quickly while awards to new partners were held up by due diligence processes

During the COVID-19 pandemic, both research performing organisations and research funders had to adapt to provide and receive research funding quickly. Research funders, including Wellcome, sought to rapidly update their grant-making processes and due diligence requirements while maintaining sufficient standards of oversight and compliance.[11 12 13]

Similarly, universities and other research institutions faced internal challenges such as managing remote work transitions, staff illness and campus closures, while simultaneously trying to transform deeply embedded administrative processes in response to rapid funding calls. Their existing infrastructures – from legal departments to institutional review boards – were not designed for such accelerated timelines.[14]

This consultation validates these broader findings. In particular, conversations with **three projects revealed particular challenges linked to Wellcome's two-stage funding approach (outlined in section 1.2) during the emergency response**. While **existing Wellcome grantees could receive funds relatively quickly through grant supplements, new partner organisations faced significant delays due to mandatory due diligence processes**, even on an accelerated timeline.

When working in new regions and with new partners, tensions between rapid response and institutional compliance requirements can arise, causing bottlenecks in project initiation. This was particularly acute for organisations in regions where Wellcome had previously funded less, such as the Middle East and Latin America. Additionally, t**he timely release of funds emerged as a key factor causing stress and anxiety for team members, typically at senior levels, receiving seven mentions in the online survey (31% of respondents)**. To overcome this challenge, one institution made an exception to their standard due diligence procedures, to provide required paperwork to Wellcome, in order to be registered as a partner.

"After we were awarded funding, it turned out that nobody had ever received any funds from Wellcome in [institution]. It took a huge amount of time, energy and paperwork, but we needed to do the due diligence by providing all sorts of financial reports." - **Saudi Arabia**

3.2 Wellcome's reimbursement-based funding model was unfamiliar to new partners

Wellcome primarily operates on a reimbursement-based funding model[15], in which the funder reimburses institutions on a quarterly basis for costs that have already been incurred. In other words, institutions must first spend the money and then claim it back.

While Wellcome's standard funding model operates on a reimbursement basis, advance funding options are available when needed. However, some institutions in our study, particularly those in receipt of Wellcome funding for the first time, experienced challenges with this model. For example, institutions in India and Morocco noted that government regulations prohibit institutions from incurring expenses before receiving funds. While mechanisms for advance funding exist at Wellcome, unfamiliarity with these processes and requirements among new grantees created delays in accessing funds. These timing misalignments affected multiple aspects of project implementation, including equipment procurement, staff recruitment and retention, and the achievement of sequencing targets.

"While the preferred model for Wellcome is that you spend the money then you reimburse the money, in India, there is no concept in the government of spending money that you do not have." - **India**

For one project, the lead institution overcame this barrier by issuing sub-contractors with upfront payments, as otherwise the project could not have started. While this solution was successful in this specific instance, relying on upfront payments is not a sustainable or scalable model, as it places significant financial burden and risk on the lead institution and may not be feasible for other projects. These and similar administrative bottlenecks significantly impacted project timelines and effectiveness, with five out of eight projects reporting delayed fund distribution to partner organisations.

"Larger universities will cover their costs until they can get it in arrears, while a lot of smaller institutions can't start work until they receive the cash. Our standard practice is that we pay in arrears, and we don't pay in advance. Although we push back as much as we can, some exceptions had to be made to give upfront payments." - **Saudi Arabia**

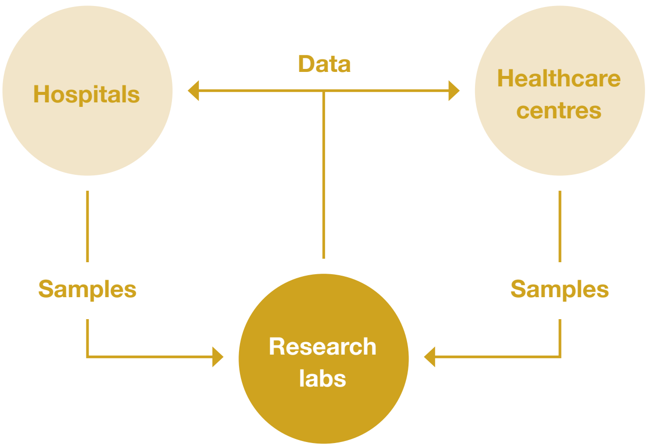
3.3 Projects led by institutions with existing partnerships were able to rapidly overcome roadblocks

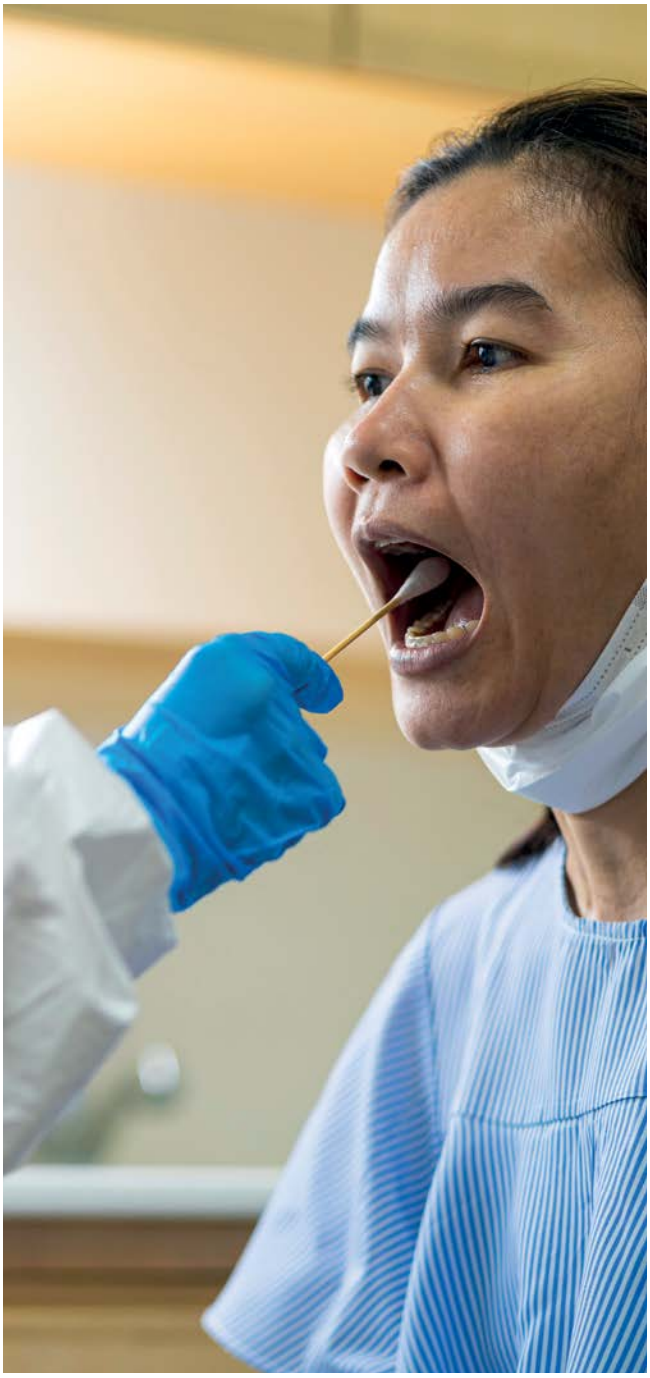
The global response to COVID-19 demonstrated the power[16] of research partnerships in addressing public health emergencies. When the pandemic struck, organisations worldwide rapidly mobilised to form collaborative networks that transcended traditional institutional and national boundaries.

In this consultation, the benefits of established partnerships were particularly evident in cases where institutions had pre-existing research networks and operational infrastructure. Organisations with established hospital relationships and sequencing platforms were able to commence work immediately, leveraging their existing systems and distributor relationships.

These benefits were further enhanced where hospitals were in close physical proximity to sequencing labs, allowing timely and consistent access to samples, as illustrated in the figure below.

Figure 2. Illustrative example of swab sample and pathogen genomic data flows





"We've been doing this for a long time already... We have all the platforms to work with the hospitals... the concept of sequencing and the relationship with distributors was already in place for years. It was relatively easy for us to get going for SARS-CoV-2." - **Vietnam**

3.4 Communication challenges delayed project initiation, particularly for newly-established funding partnerships

The COVID-19 pandemic created unprecedented demands on research funders and institutions alike as they worked to rapidly mobilise emergency response funding. Clear communication about funding decisions, project timelines and administrative processes became particularly critical during this period, enabling research teams to optimise resource allocation and maintain project momentum.

Our consultation with award holders uncovered communication barriers that affected the delivery of two projects. For example, one team reported experiencing extended delays in accessing their funds due to three key issues:

- administrative queries about portal access and claim submissions took significantly longer than usual to resolve;
- internal staff transitions at Wellcome during the pandemic response period affected some correspondence chains and were not always communicated to research teams; and
- technical issues with systems access created additional complexity for institutional registration.

While these issues were ultimately resolved through collaboration between the funder and research teams, they highlight how standard processes came under strain during the emergency response period.

"We contacted Wellcome to find out how to submit a claim for the costs we had incurred to date. We couldn't find guidance on how to use the portal, so we asked how to do it. It took a while for us to get a response back… somebody could monitor a centralised email in the future" - **Saudi Arabia**

3.5 Community engagement funding supplemented some core sequencing awards

Five projects funded by Wellcome received additional funding for community engagement (CE). Wellcome provided this funding after core sequencing projects began in order to support pathogen genomics research and surveillance in regions where this type of work was relatively unfamiliar to local populations.

Integrating CE as an optional but fully supported component of main grant applications, through a dedicated section, could streamline administrative processes and promote earlier collaboration between scientists and CE specialists. Additionally, ring-fenced funding for CE activities would crucially prevent resources from being redirected to meet other project needs.

4. Enabling infrastructure

4

4. Enabling infrastructure

In recent years, genomic sequencing and surveillance have emerged as critical tools to serve multiple public health priorities. At a national level, these technologies enable countries to monitor and respond to endemic diseases, and, more broadly, they contribute to global health security.[17] This is typically achieved through the generation of essential data for tracking pathogen evolution, transmission patterns, and variants of concern.
The literature on genomic surveillance programmes emphasises that successful implementation requires a comprehensive ecosystem[18] of technical capabilities, infrastructure, and researcher expertise.

To support genomic sequencing and surveillance effectively, research institutions require robust infrastructure and systems. The COVID-19 pandemic placed significant strain in these areas, from basic laboratory facilities to data analysis capabilities.

Key changes during the pandemic highlighted infrastructure challenges for institutions including:

- Stretched cold chain and storage capacity
- Disrupted reagent and equipment supply chains
- Increased demands on computing resources
- Limited access to technical support

The following sections therefore explore how funded institutions managed these infrastructure challenges during the pandemic, with a focus on basic requirements, consumables management, equipment needs, and computing systems.

The key findings and potential actions that relate to enabling infrastructure are summarised below, with reference to the relevant sections for further reading.

Table 2. Key findings relating to enabling infrastructure

Key findings	Potential actions for research funders
Limited access to basic physical infrastructure affected the integrity of critical reagents and consumables (Section 4.1)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Significant supply chain disruption necessitated careful consumables planning and management (Section 4.2)	Facilitate knowledge sharing about infrastructure challenges and solutions across funded teams
High resource costs and limited availability prompted innovative approaches to consumables management (Section 4.3)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Access to cutting-edge equipment and reliable technical support is critical to ensuring continuity in genomic sequencing (Section 4.4)	Consult with other funders about approaches to equipment servicing and support in low- and middle-income countries (LMICs)
Significant data demands of disease surveillance require substantial computing resources for processing, analysis and storage (Section 4.5)	Clarify approaches to funding maintenance of equipment e.g. allowing longer-term maintenance contracts

KEY

Sample collection

Sample testing

4.1 Limited access to basic physical infrastructure affected the integrity of samples

The success of genomic sequencing and surveillance programmes relies on the availability of fundamental physical infrastructure such as specialised laboratory facilities, dedicated spaces for sample preparation and processing, and robust systems for maintaining sample integrity during transit. During public health emergencies, these basic infrastructure requirements become particularly critical as they directly impact the speed, reliability, and scalability of sequencing operations.

For four projects, cold chain infrastructure emerged as a critical vulnerability in sample transportation systems, particularly affecting remote and resource-limited settings. Interviews highlighted two primary challenges: maintaining appropriate temperature conditions for RNA samples and protecting sensitive sequencing consumables during transport.

This consultation found that extensive journey times and a lack of cold chain storage meant that samples were kept at sub-optimal temperatures. Ultimately, this reduced the number of samples that were suitable for testing and sequencing.

"The roads will take about 8 to 10 hours, if not more. So we had to make sure that […], there was some chemical that was making it cold enough throughout the journey." - **Nepal**

For two projects, limited freezer capacity forced the prioritisation of sample retention. Given the scale of the pandemic, even well-established organisations with **Biosafety Level 3 (BSL-3)** laboratories were quickly overwhelmed by the volume of samples requiring storage. The challenge extended beyond space constraints to include issues of access control and biosafety considerations. To address these limitations, research teams implemented triage systems, often having to dispose of negative samples to retain the positives.

"We have one of the largest biobanks in the region. You've seen all those freezers! We have a whole freezer room and another one in another department and we just don't have space." - **Kenya**

4.2 Significant supply chain disruption necessitated careful consumables planning and management

The COVID-19 pandemic created significant challenges in managing consumables for genomic surveillance. Many of these challenges were caused by severe supply chain disruptions.[19] In these cases, institutions in low and middle-income countries were particularly affected by import delays, high import costs, inexplicably elevated costs of materials, and complex procurement processes.

Supply chain bottlenecks significantly impacted genomic surveillance operations across all funded projects. Even in non-emergency scenarios, laboratories in low- and middle-income countries face long lead times of around three months for essential reagents and other consumables such as **Flow cells**[20]. The pandemic exacerbated the impact of complex importation processes and limited local distribution networks.

"From this part of the world, on a normal day without the COVID pandemic, ordering reagents will take at least three months minimum." - **Ghana**

The rapidly evolving nature of SARS-CoV-2 created additional procurement challenges for teams all over the world. As new variants emerged, teams needed to frequently update their primer sets to maintain effective sequencing operations. However, long lead times meant that teams were constantly struggling to obtain the latest primer sets which could lead to failed or incomplete sequencing. One project reported extended lead times for primer shipping stretching beyond four months.

"The primer shipping was a challenge. The virus just kept mutating and mutating, so you had to keep changing the primers... Whether you were in London, or Cambridge, or Boston or wherever, there are still wait times." - **Malawi**

4.3 High resource costs and limited availability prompted innovative approaches to consumables management

While supply chain disruptions affected sequencing operations universally, their impact was not equally distributed. **Existing economic inequalities created additional barriers to genomic sequencing efforts** for research teams based in low- and middle-income countries.

Four projects highlighted that the costs of reagents were particularly high outside of Europe or the United States and needed to be imported. Even laboratories with strong technical capabilities and established research programmes faced these economic challenges. One laboratory in a low and middle-income country reported paying up to seven times more than high-income countries would pay for the same materials due to import costs, shipping fees, and complex distribution networks.

"Vietnam is a low- to middle-income country, and it's not easy to get reagents into the country. People in the UK or Europe can talk about sequencing SARS-CoV-2 genomes at the cost of around $20 to $30 US dollars. Here, it costs six or seven times more because of the importation and shipment costs. We have to be really proactive and reach out to local distributors." - **Vietnam**

Out of necessity, institutions demonstrated resilience and ingenuity in adapting their processes. For example, **three sites implemented sample pooling strategies**[21] by allowing samples from multiple people to be analysed in one test. Similarly, labs adapted their approaches to use smaller reagent amounts than the standard procedures. **Three projects also reported sharing consumables and supplies between institutions within their consortia, particularly during times of shortage** at the earliest stages of the pandemic.

"For reagents, if you were supposed to use a millilitre of something, we would use half a millilitre... Once you know you can halve it, then you try a quarter and… if we're getting the same results in all of them, then we never needed to use the suggested standard operating procedures." - **Kenya**

The following case study, outlining the experience of researchers at KEMRI-Wellcome Trust Research Programme in Kenya, illustrates how necessity sparked inventive approaches to make efficient use of limited resources.

Maximising limited resources through pooled testing approaches, Kenya

In mid-May 2020, the KEMRI-Wellcome Trust Research Programme in Kilifi confronted a critical challenge in Kenya's COVID-19 response. While receiving over 500 samples daily, the laboratory faced a severe shortage of high-throughput RNA extraction kits.

The laboratory therefore developed and implemented a pooled testing strategy[22] in which multiple patient samples are combined into a single test, with individual retesting only performed if the pooled result is positive.

During a trial with 1,500 samples[23], the laboratory saved $4,800 by using pooled testing. Instead of testing each sample individually at $6 per test ($9,000 total), they combined samples into 250 pools of six, requiring only 700 total tests and bringing the cost down to $4,200.

The success of this approach proved particularly valuable in meeting government-mandated testing requirements during critical phases of the pandemic, helping Kenya maintain its national testing capacity of nearly 3,000 tests per day.

To enable increased efficiency within overstretched surveillance systems, other labs across Africa and Asia also implemented similar pooled approaches to great advantage

KEY

Genomic sequencing

Data analysis

4.4 Access to cutting-edge equipment and reliable technical support is critical to ensuring continuity in genomic sequencing

High-throughput sequencing machines are critical to genomic surveillance programmes. These instruments require significant financial investment and specialised expertise for day-to-day operation and maintenance. During public health emergencies, equipment maintenance becomes crucial to maintain project continuity and generate to timely data.

Prior to the pandemic, sequencing infrastructure was already in place in established surveillance centres. **Five projects had immediate access to sequencing platforms at project initiation** (typically Illumina MiSeq[24] or Oxford Nanopore GridION)[25], reflecting their long-standing roles in disease surveillance and genomics research.

However, the sustainability of this infrastructure presented significant challenges: **three projects reported critical equipment failures complicated by limited access to technical support**, particularly in regions outside of Europe without manufacturer service centres.

The absence of local Illumina offices and maintenance infrastructure in African and Middle Eastern laboratories created substantial operational barriers, even in otherwise well-resourced laboratories.

"One of the robotic arms was slightly bent. That arm was apparently available only in San Diego. So it took three months to just replace the arm. So we couldn't do anything for three months."
 - **Saudi Arabia**

In contrast, projects that were able to work with local logistics providers often benefited from more efficient equipment distribution pathways. For example, collaboration with Carramore[26], a logistics partner for Oxford Nanopore, facilitated successful initial equipment delivery to Ghana for seven sequencing laboratories. Even in this case, however, secondary distribution from core laboratories to other West African nations was delayed by customs complications, unclear equipment tracking systems, and administrative challenges in managing third-party logistics contracts.

4.5 Significant data demands of disease surveillance require substantial computing resources for processing, analysis, and storage

Modern genomic sequencing generates huge volumes of data[27] that require substantial computing resources for processing, analysis, and storage. As sequencing throughput increases, particularly during disease outbreaks, computing capabilities and storage capacity can become a significant bottleneck.

In this consultation, **data storage requirements were highlighted as a critical operational challenge for two projects, driven by the need to maintain raw sequencing data for comprehensive analysis**. Weekly data generation volumes ranged from 100 GB to 600 GB per project, necessitating considerable storage infrastructure. Additionally, the evolving nature of the pandemic demanded frequent updates to analytical algorithms, making it essential to retain raw data indefinitely rather than disposing of it after initial analysis.

Three projects highlighted that access to high-performance servers enabled timely data analysis to support the pandemic response. Of these, one project noted that they purchased the server through Wellcome funding. **Access to high performance computing clusters was also vital, as standard laptops were insufficient for analysing the large genomic datasets.** This was highlighted by one project that had access to its own high performance computing facility.

"We have a high-end server, which was very useful for analysing sequencing data within short span of time. Time is very important when you are dealing with pandemic preparedness or pandemic response." - **India**

Three projects also noted that limited in-house access to software for sequencing negatively impacted their data analysis capabilities. Typically, projects cited challenges with proprietary analysis software, requiring them to either purchase licenses or develop their own analysis pipelines from scratch, which could delay the process. One project noted that the time taken to learn how to use the proprietary software was also time consuming.

5. Research team capacity

5. Research team capacity

Research institutions faced significant workforce challenges during the rapid scaling of SARS-CoV-2 genomic sequencing, particularly in **Bioinformatics** expertise. The pandemic highlighted critical gaps in specialist skills needed for genomic surveillance, especially in low-and middle-income countries.

During the pandemic, research teams faced multiple intersecting challenges that tested both their technical capabilities and resilience. The limited availability of trained bioinformaticians created bottlenecks in data analysis, while research teams simultaneously navigated hidden pressures including increased workloads and complex institutional constraints.

However, factors that helped researchers to overcome these challenges were identified and several mitigation strategies were implemented by teams including:

- leveraging formal and informal knowledge-sharing networks;
- developing training programmes; and
- providing informal support and communication to build team morale.

The following sections therefore explore how funded institutions managed these workforce challenges during the pandemic, with a focus on training, retention, and meeting increased analytical demands.

The key findings and potential actions that relate to research team capacity are summarised below, with reference to the relevant sections for further reading.

Table 3. Key findings relating to research team capacity

Key findings	Potential actions for research funders
Highly capable bioinformaticians were in significant demand to meet sequencing analysis needs (Section 5.1)	Continue to consider and embed investments in bioinformatics capacity building through existing initiatives that support training and researcher network building
Funded teams provided training to enhance in-house and partner bioinformatics capabilities (Section 5.2)	
Organisations established formal and informal networks to share expertise and resources (Section 5.3)	

5.1 Highly capable bioinformaticians were in significant demand to meet sequencing analysis needs

This consultation found that existing expertise from prior genomic projects provided an essential foundation for COVID-19 sequencing efforts. For example, **three funded projects noted that existing workforce capacity enabled them to rapidly pivot to SARS-CoV-2 research**. Labs with researchers trained in malaria, swine flu and tuberculosis research rapidly supported many aspects of the pandemic response, including sample preparation, diagnostic testing, and genomic sequencing.

"The thing that made it [pivoting to SARS-CoV-2 research] possible was the fact that we already had a functional genomics platform that was engaged in malaria research. It was quite easy for us to shift our knowledge from sequencing malaria to handling the SARS-CoV-2 virus." - **Ghana**

Trained bioinformaticians were therefore fundamental assets to research teams. **In this consultation, three projects highlighted that having staff with bioinformatics training meant that they were able to complete timely analysis of sample sequences. These projects were those that could build on existing expertise while rapidly expanding capacity through training and collaboration**.

"Something we don't always appreciate is how important the computational part is. If you share sequencing data, you need to be able to analyse it, then share the results of that analysis. You need to build up your analysis team." - **India**

5.2 Funded teams provided training to enhance in-house and partner bioinformatics capabilities

Typically, training pathways for bioinformatics require two to three years of specialised education. However, these timelines were not compatible with meeting immediate needs during the pandemic. This led to the emergence of accelerated training programmes offered by a range of providers. For example, Wellcome Connecting Science directly delivered specialised training programmes[29] during the pandemic.

To increase bioinformatics capacity, four projects provided comprehensive training programmes that were available to funded researchers. Teams developed approaches that combined formal training with ongoing practical skill development. Training covered core technical competencies and emphasised the combination of wet lab and bioinformatics skills. The consultation showed that training included topics such as developing standard operating procedures, quality control procedures, and analytical techniques.

"This grant allowed us to conduct some [bioinformatics] training. We invited people from different reference labs… If we're lacking the technical personnel to analyse data sets… [the next pandemic] will catch us off guard." - **Ghana**

To increase bioinformatics capacity further, three teams developed training that was delivered externally. Training was delivered to a range of institutions including public health institutions and healthcare workers in local hospitals, and researchers based in other local laboratories.

5.3 Organisations engaged with formal and informal networks to share expertise, resources and troubleshoot issues

Beyond internally-developed training, researchers benefited from engaging in formal and informal networks to share expertise and resources for SARS-CoV-2 genomic surveillance. This consultation revealed that this occurred through three key channels:

1. **Regular information sharing meetings**: Structured consortium meetings (for example Africa and Asia Programmes[30] (AAPs) consortium meetings) enabled researchers to share findings, discuss emerging variants, and exchange interpretations of sequencing data.

2. **Technical support networks**: Researchers engaged in networks for troubleshooting bioinformatics challenges and sharing analytical techniques such as ARTIC[31], PulseNet[32] and COVIGEN[33].

3. **Established professional relationships**: Previous research collaborations enabled ad-hoc knowledge exchange that complemented formal knowledge sharing activities. This informal coordination proved especially valuable for addressing emerging challenges as the pandemic evolved, allowing teams to rapidly share technical insights and troubleshoot issues.

"It worked really well. We had monthly meetings, as well as ad-hoc emails, which were a useful source of technical discussions and discussions of novel things that we were seeing in the data." - **Thailand**

5.4 Hidden and unaccounted for processes

COVID-19 fundamentally altered how research was conducted and managed across institutions. These challenges extended beyond the visible disruptions to laboratory access and research protocols, revealing numerous hidden processes and pressures that significantly impacted researchers' ability to conduct their work effectively.

Wellcome's framework for understanding the research environment covers four key dimensions:

- infrastructure (both physical and technical);
- research culture and behaviour;
- stakeholder engagement; and
- research design and practice.

Each of these dimensions can be affected in both obvious and subtle ways, ranging from delayed project completions to pressure from peers conducting COVID-related research. **In emergency contexts, seemingly straightforward disruptions can cascade into complex challenges that affect multiple aspects of the research environment**.

The psychological impact on researchers in high-pressure environments is particularly noteworthy. In these settings, institutional and social support became crucial factors[34] in maintaining both mental wellbeing and scientific productivity. This aligns with Wellcome's own research[35] on research culture, which highlighted how **high expectations and competition, when combined with crisis conditions, can create significant pressure points within research environments**.

For those working directly with COVID-19 samples or in healthcare settings, additional layers of complexity can emerge. **For example, researchers faced moral distress[36] when institutional constraints prevented them from sharing critical information**. These challenges were often compounded[37] by increased workloads, project uncertainties and fears for one's own health and wellbeing.

This section examines these hidden and unaccounted for processes as revealed through our survey and interview data, organising findings according to Wellcome's definition[38] of the research environment. Figure 3 presents pressure points and pressure relievers, aiming to better understand how research environments can be strengthened to support researchers during future emergencies.

Pressures and relievers

The figure below presents the hidden and unaccounted for processes in pathogen genomic data sharing as revealed through our survey and interview data.

1 6 12 **Pressures** Low > High

1 6 12 **Relievers** Low > High

Number of unique participants affected by pressure or reliever

Figure 3. Pressures and pressure relievers identified by research teams

Infrastructure

Project resources and technologies

Pressures:

- 8 Travel restrictions and lockdowns causing researchers to spend days in labs and affecting productivity
- 4 Inability to transport and store samples, leading to wasted samples
- 4 Stress caused due to limited access to appropriate reagents, which could lead to failed or incomplete testing
- 4 Meeting the costs of reagents and equipment due to increased demand
- 4 Communication difficulties with equipment manufacturers without regional offices

Relievers:

- 3 Access to sequencing machines and relevant technologies
- 3 Innovation and resilience in approaching difficulties accessing reagents
- 2 Procurement teams working closely with teams to understand purchasing priorities

Research design and practice

Funding, grant management and research design

Pressures:

- 6 Delayed release of funding and Wellcome's model of reimbursement that clashed with local ways of working
- 4 Administrative delays to project set up and delivery
- 4 High pressure to develop skills in bioinformatics
- 3 Limited communication around extensions for application deadlines leading to job security concerns

Relievers:

- 4 Proactive management of multiple funding sources and equipment
- 4 Development of training and workshops both for increasing the amount of bioinformaticians and to train public health bodies / healthcare workers
- 1 Availability of trained researchers in bioinformatics

Culture and behaviour

Social and emotional pressures, recognition and reward

Pressures:

- 18 Fear and concern for one's health or family's health
- 18 Increased workload and exhausting working hours
- 16 Increased demand for sequencing data on a compressed timeline
- 2 Self-comparison to the productivity levels of other researchers or teams
- 1 Senior individuals felt solely responsible for the success of the project

Relievers:

- 12 Feeling sufficiently rewarded and recognised for project contributions
- 11 Activities such as sports and sharing meals to build team morale
- 5 Development of shift systems and rotas to manage lab access
- 3 Recognising that some things cannot be controlled to ease mental pressure

Stakeholder engagement

Engagement with external organisations and groups

Pressures:

- 4 Difficulty in establishing new relationships during times of crisis without existing trust
- 3 Expectations on researchers to ensure the accuracy of data for policymakers within rapid timescales
- 1 The use of researchers as translators to support hospital staff with metadata collection and reporting

Relievers:

- 22 Existing connections and established trust between research groups and policymakers or communities
- 19 Existing relationships and knowledge of stakeholders needed to enable community engagement
- 2 Informal relationships between some senior researchers and policymakers based on existing connections
- 2 Empowering local researchers to engage with policymakers rather than 'foreign' researchers

6. Data management and sharing

6

6. Data management and sharing

As the scale and urgency of the pandemic demanded a significant extent of rapid and open sharing of sequence data, this exposed a number of longstanding tensions and competing priorities such as:

- the imperative for rapid global sharing to inform variant tracking;
- concerns about equitable scientific credit;
- the protection of national interests and sovereignty over health data; and
- the need for mechanisms to ensure data quality and proper **Metadata** collection.

While platforms like **GISAID** [39] played central roles in enabling global collaboration, the combination of the above factors led to the emergence of new data sharing infrastructures and governance frameworks at both national and international levels with many countries opting to develop their own networks and national repositories for data sharing.

Funding bodies, including Wellcome, helped shape these developments through specific requirements for open and rapid data sharing. For example[40], in January 2020, Wellcome coordinated a Joint Statement[41] which called on researchers, journal publishers, and funders 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"*. This statement continued a tradition of collaborative declarations during public health emergencies, with Wellcome playing a key role in mobilising signatories alongside governments, international organisations like WHO, publishers, and other research funders. This aligns with Wellcome's longstanding expectation[42] of its researchers to manage research outputs in a way that will achieve the greatest health benefits with as few restrictions as possible.

This section demonstrates how research teams navigated these dynamics and competing interests, highlighting both the successes and challenges in building effective data sharing systems during the pandemic.

Table 4. Key findings relating to data management and sharing

Key findings	Potential actions for research funders
GISAID emerged as the primary platform for sharing SARS-CoV-2 sequence data and was particularly attractive to researchers in LMICs due to its policies on crediting data generators (Section 6.1)	Support tiered data sharing that allows rapid sharing to decision-makers while working towards full public release
Interim solutions were established to enable data sharing before full public sharing was possible, including restricted sharing with key stakeholders (Section 6.3)	
Metadata quality and completeness were a significant challenge, particularly in routine healthcare facilities (Section 6.4)	Promote use of existing frameworks to support metadata collection and adherence to relevant standards

6.1 International data sharing platforms were critical to rapidly sharing sequencing data

Previous studies[43] show that GISAID emerged as the primary platform for sharing SARS-CoV-2 sequence data during the pandemic. While the International Nucleotide Sequence Database Collaboration (INSDC) continues to serve as a comprehensive repository for genomic data across all organisms, GISAID established itself as a specialised platform of choice for SARS-CoV-2 surveillance and research.

Many data generators preferred depositing sequences in GISAID, a controlled-access repository, rather than traditional open access databases. Factors contributing to GISAID's popularity are likely to have included:

- allowing depositors to retain rights over their data and receive credit for subsequent use;
- adopting a restricted access model, requiring users to log in;
- ensuring submitted data are reviewed and curated before release; and
- harvesting data from open access repositories, making it a comprehensive data source.

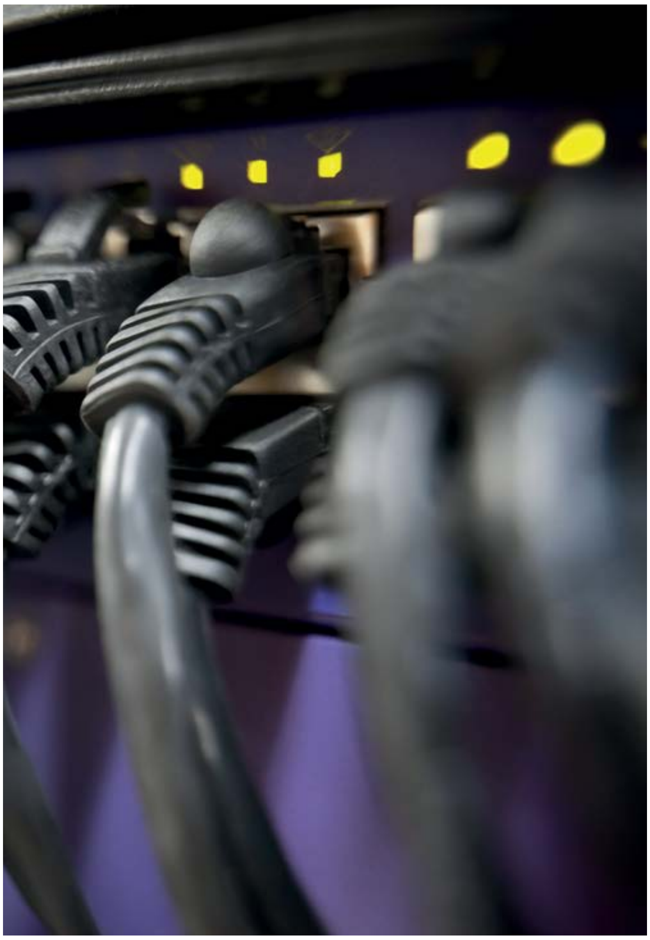
In this consultation, research teams highlighted how GISAID enabled them to rapidly share sequence data and contribute to global surveillance efforts. This was particularly the case for the rapid sharing of new variants.

Interviews across one project highlighted that GISAID's requirements around credit for data generators were particularly attractive to researchers in low- and middle-income countries, prompting submissions in this rapid context. Specifically, GISAID allowed researchers to retain their rights over their data and receive acknowledgement for subsequent reuse.

"The majority of the sequences were deposited in GISAID and INSDC has lagged behind throughout... GISAID was much more popular in LMIC settings. And I think it was because it was perceived to have protections for the academic interests of scientists based in LMIC institutions." - **Kenya**

However, **requirements imposed on data reuse through GISAID meant that scientists and public health agencies needed permission to aggregate and reanalyse sequencing data alongside other datasets**. In the context of the evolving pandemic, this led to significant delays. The navigation of multiple datasets and platforms, including GenBank, NCBI and other national repositories also created additional workload, particularly given different formatting requirements across platforms.

"Submitting data to multiple databases is tedious. You have different formatting and, despite having some standards in place, it becomes a little bit of a nightmare. You can't share data across platforms very easily." - **South Africa**



KEY

Research uptake

Data sharing

6.2 National data sharing infrastructures emerged to navigate complexity and preserve sovereignty over health data

The development of national repositories, particularly in countries with significant sequencing capacity, emerged as mechanisms to overcome the fragmented data sharing ecosystem and preserve sovereignty over health data.

In India, for example, the INSACOG network (Indian SARS-CoV-2 Consortium on Genomics) and IBDC repository (Indian Biological Data Centre) evolved to play crucial roles in coordinating national sequencing efforts. This is demonstrated in the case study below.

India's coordinated approach to developing national data infrastructure for SARS-CoV-2

Following government mandate, Indian institutions shared SARS-CoV-2 sequencing data through INSACOG, a consortium of approximately 70 institutions including research laboratories, medical institutions and government agencies.

This coordinated national infrastructure enabled India to:

- Manage data sharing across a large network of institutions
- Maintain national oversight of genomic surveillance
- Support public health interventions

Wellcome funding supported the establishment of a network of megalabs and microlabs undertaking genomic sequencing. Members of this network additionally shared SARS-CoV-2 sequence data through GISAID, fostering a balanced approach between national sovereignty and global collaboration.

6.3 Interim solutions were established to enable data sharing before full public sharing was possible

The interviews revealed tensions between national interests in controlling sensitive data and the imperative for rapid global sharing. Many countries were initially hesitant to share sequence data openly, given the potentially significant implications of this, such as national lockdowns or travel restrictions. Policymakers' views of data as nationally sensitive information created particular challenges for research teams who had to navigate between national regulations and funder requirements.

"We are bound by policy. First, you've got a government policy that is: 'this is Kenyan data, and we can't distribute it' then you've got a funder policy saying: 'this is charity money, and these are the conditions for sharing.'" - **Kenya**

To address this tension, research teams implemented a range of solutions to ensure data was shared with priority stakeholders before it was shared via repositories, particularly to inform urgent policy decisions.

- **Restricted sharing with key stakeholders**: To enable rapid information flows, teams initially shared data with a limited circle of trusted collaborators and government officials with whom they had existing relationships.
- **Direct communication with policymakers**: Where existing relationships with policymakers were in place, direct channels to share findings before public release were leveraged, typically using **Policy briefs**.
- **Establishing formal processes for data sharing**: Teams established protocols for managing data releases. This included developing hierarchies of information flows within organisations. This helped to balance speed with protocol and ensure accurate data reached decision makers.

"First we would share all of our data with a very restricted global scientific community – our collaborators. The we would share this data with the Ministry officials... then we are able to fully release the data" - **Kenya**

6.4 Standardised metadata collection and management enables timely genomic sequencing efforts

The work of preparing data for sharing required extensive coordination across stakeholders and careful attention to data quality standards. Research teams emphasised the critical role of data quality checks prior to repository upload. **Three teams reported that they developed hierarchical approaches to ensure data quality while maintaining rapid sharing** which was particularly important in countries with significant sequencing capacity across multiple institutions.

"One reason why we went through the national repository was for quality control." - **India**

This consultation found that **the quality and completeness of sample metadata was a significant challenge across projects**. Issues arose in routine healthcare facilities rather than research settings, where staff were trained in data collection protocols. Nonetheless, these metadata challenges created delays in sequence submission to global databases, with some sequences never being shared as a result.

"Once I had assemblies and I started to submit samples to GISAID, there were so many samples for which metadata was missing. This included the sample collection date and the location of the origin of the sample, for instance. I actually had to wait for two months just to get metadata from 50 samples and I couldn't proceed with submission." - **Saudi Arabia**

Further to this, **researchers across three projects reported difficulties in linking sample data to clinical data**. The reasons cited for this included: privacy restrictions and restricted access; the need to coordinate with multiple hospitals to collect complete information; and language barriers between research teams and local hospitals. To overcome some of these barriers, one project assigned a team member to act as a translator with hospital staff and advise hospitals on the metadata required. Two projects reported developing case report forms to share with hospital staff that clearly outlined all the data required.

7. Research uptake and community engagement

7

7. Research uptake and community engagement

During public health emergencies, the rapid and effective translation of scientific evidence into policy and practice can significantly impact health outcomes. The scale and urgency of the COVID-19 pandemic not only highlighted this critical relationship between research and policy[44] but also fundamentally transformed how scientific evidence was generated[45] and communicated[46].

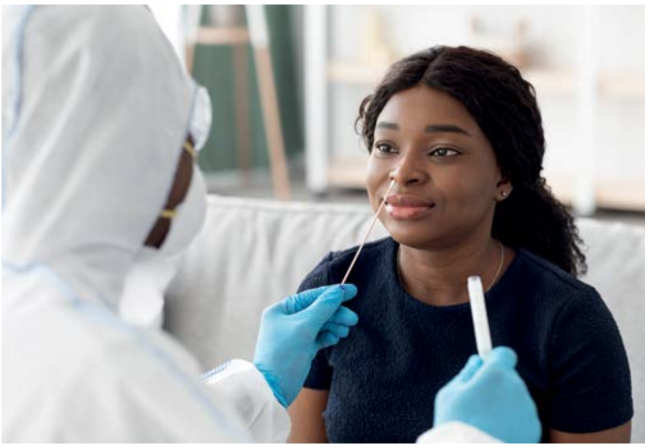
The pandemic created new imperatives for research uptake across multiple domains. Most critically, real-time genomic surveillance data was needed to inform urgent policy decisions[47] such as border controls, social distancing measures, and vaccine deployment. However, the technical complexity of genomic data, combined with intense public scrutiny and political sensitivities, demanded clear approaches to information sharing and communication.

In such emergencies, the role of credible science takes on an increased importance.[48] In this context, researchers must provide rigorous, objective data while navigating an increasingly complex and often political landscape. This includes respecting policymakers' responsibility to weigh scientific evidence alongside broader social, economic, and political factors in their decision-making processes.

This consultation confirmed that research uptake during health emergencies operates within a complex ecosystem of stakeholders and influences. Its effectiveness is significantly shaped by local contexts, including governance structures, historical experience with disease outbreak management, and the strength of existing institutional relationships between research and policy communities.

Table 5. Key findings relating to research uptake and community engagement

Key findings	Potential actions for research funders
Research uptake is enabled by existing relationships between research institutions and government agencies (Section 7.1)	Compile and share examples of successful policy engagement approaches from different contexts
Robust channels for communicating complex scientific information are critical to relaying information to policymakers (Section 7.2)	
Dedicated committees and advisory groups are a vital mechanism for information sharing (Section 7.3)	
Local leadership leads to more successful policy dialogue and engagement (Section 7.4)	
Community engagement supports genomic sequencing efforts, provided that messaging is carefully crafted (Section 7.5)	Develop clear, accessible guidelines on community engagement expectations and approaches for emergency funding



7.1 Research uptake is enabled by existing relationships between research institutions and government agencies

The ability to rapidly translate scientific evidence into policy action during health emergencies is heavily dependent on pre-existing institutional infrastructure and relationships.[49] When formal connections between research institutions and government agencies are already established, the uptake of scientific evidence can be faster and more effective. These relationships facilitate trust, enable rapid communication channels, and create shared understanding of roles and responsibilities - factors that become critical during crisis response.

Five projects engaged in this study reported that existing networks or contacts were leveraged to engage with government stakeholders. According to interviewees, these long-standing relationships enabled: information sharing; expedited approval processes for disseminating findings; and direct pathways to high-level policymakers. Ultimately, this allowed funded researchers to contribute rapidly and meaningfully to national policy decisions and stems from previous strategic investments from Wellcome and other funders to maintain this capacity.

"We had already been cultivating that relationship over time... When this pandemic happened, we had already built relationships with sponsors and funders. Even the Ministry of Health themselves were relying on us as a research institute." - **Kenya**

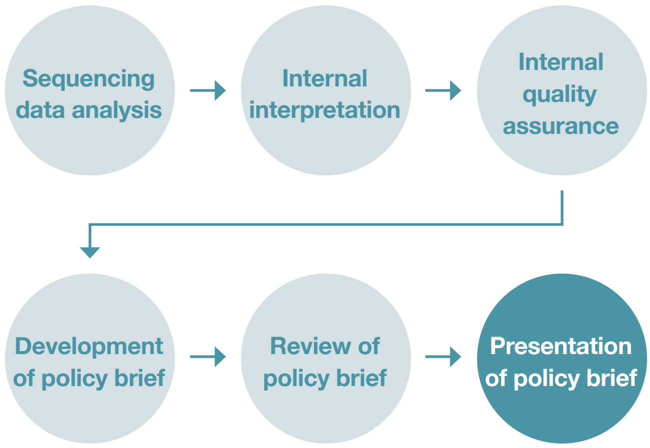
The effectiveness of research uptake varied significantly across different national contexts. Countries with long-standing experience of managing infectious disease outbreaks, such as Uganda and Vietnam, had established networks and systems that facilitated faster integration of COVID-19 surveillance data. In these cases, researchers were able to integrate COVID-19 surveillance into pre-existing emergency response frameworks that had been developed by governments through years of managing virus outbreaks.

"Uganda has a long history of virus outbreaks... There is already an established network of infectious disease personnel that monitor things happening in the country. We basically slotted into that existing system." – **Uganda**

7.2 Robust channels for communicating complex scientific information are critical to relaying information to policymakers

In this consultation, policy briefs emerged as a particularly crucial tool in this communication process, serving as a bridge between technical scientific findings and policy needs. These documents are designed to summarise complex genomic surveillance data in a format that policymakers can use to guide policy decisions, and their development and communication typically followed the process mapped out below.

Figure 4. Illustrative example of data sharing using policy briefs



All projects that participated in this study developed policy briefs as a tool to communicate critical information to policymakers. This includes sequencing data such as numbers of cases, evidence of new variants, and transmission data. Policy briefs were typically prepared in a two-page format that prioritised accessibility - featuring executive summaries and key findings.

Further to this, three projects specifically noted that policy briefs needed to be concise, non-technical, and follow established formats. Teams therefore prepared policy briefs in plain language and used diagrams, where appropriate, to convey information to policymakers.

"We spent a lot of time writing reports. So every tranche of sequence data that we generated, we tried to interpret this data, and we would write a one- or two-page report, which was then circulated to the Ministry of Health officials" - **Uganda**

Researchers were clear in interviews that their role was to provide accurate sequencing data, not to provide policymaking advice. Direct feedback on the impact and effectiveness of policy briefs was therefore limited. However, interviewees noted that their impact became evident through government press releases that quoted their policy briefs verbatim and through policy decisions such as travel 'red lists' that were implemented in response to reported variants, as illustrated in the case study below.

From analysis to action through policy briefs

Research teams across multiple countries developed standardised approaches to translate complex genomic data into actionable policy recommendations: policy briefs. Two examples demonstrate how this rapid sequencing-to-policy pipeline influenced national decision-making.

In Thailand, for example, regular genomic surveillance data sharing led to the country's removal from the UK's travel "red list", as systematic reporting of surveillance data provided evidence for policy change.

In Uganda, early sequencing data revealed that initial virus variants were closely linked to those found in international travel hubs. This evidence prompted the government to implement strict travel restrictions, including airport closure.

Several projects used policy briefs to inform national decision-making. Some common factors were critical to successful policy uptake such as clear communication channels and hierarchies, and standardised simple formats.

Given the severity of the pandemic and the policy implications, **across three projects, strict hierarchical channels for sharing information were applied**. Here, sequencing data prepared by research teams was reviewed by senior team members who were able to interpret and contextualise the data for policymakers. This data was then approved internally before sharing with policymakers.

7.3 Dedicated committees and advisory groups form part of complex information sharing networks

Existing formal governance structures can help to bridge the gap between scientific evidence and policy implementation during public health emergencies. These networks are often part of the complex picture[50] of the evidence-policy relationship during public health emergencies.

In this consultation, projects engaged with technical working groups and specialised task forces to successfully influence national pandemic policies. **Four projects noted that the communication channels created through existing working groups and tasks forces could be leveraged to facilitate dialogues between researchers and high-level policymakers**.

These government-convened bodies, which included national COVID-19 response committees and technical working groups, directly shaped critical policy decisions around genomic surveillance, epidemiological modelling, and public health communications. The committees served as authoritative platforms where scientific evidence was formally integrated into national decision-making processes.

"The data generated by the Institute was presented to the operational emergency committees, where I was directly involved with senior politicians, the cabinet, ministers and the President of the Republic. We had a window to share our data and to say what was happening in the context of all the other data generated by the health system… how many beds are occupied, how hospital occupancy is evolving, how many tests are being done per week… There was a lot of coordination." - **Costa Rica**

Technical working groups served as decisive channels for addressing specific policy questions at the national level. These formal structures established clear pathways for scientific evidence to influence government decision-making. The impact was amplified by having key researchers serve on multiple high-level committees simultaneously, allowing them to shape technical decisions while ensuring alignment with broader national policy priorities.

7.4 Local leadership leads to more successful policy dialogue and engagement

A critical success factor in working with advisory committees was having local researchers lead policy engagement efforts. **Two projects noted that having local scientists interface with policymakers was more effective than foreign researchers taking prominent roles**. This approach recognises the importance of cultural context and helps avoid perceptions of external interference in national decision-making processes.

"We keep a low profile within [national] politics. Our [local] colleagues are the ones who are much more empowered to do so. We are very aware that the foreigners amongst the group… don't want to be seen as telling [local people] what to do. It doesn't go well and it's the wrong thing to do." - **Thailand**

In particular, established relationships between local researchers and policymakers were instrumental in facilitating research uptake. This effectiveness stemmed from two key factors: the foundation of mutual trust and respect, and the ability to leverage established local networks.

"Based on my experience from the Ebola response, when I turned up and started sequencing Ebola in Sierra Leone, nobody was interested...The first time somebody became interested was when I got people who they trusted involved...I got somebody who was really well respected to bridge that connection with the government...[during COVID] we've left that all to the local partners because only they understand the connections." - **Ghana**

Notably, researchers were mindful of maintaining appropriate boundaries in their advisory roles. They emphasised their commitment to providing objective data while respecting the autonomy of local political decision-making processes.

7.5 Community engagement enables pathogen genomic sequencing efforts if messaging is carefully crafted

Community engagement is recognised in the broader literature as a crucial component[51] of effective public health interventions, particularly during disease outbreaks. The success of genomic surveillance efforts depends not only on technical capabilities but also on public understanding and cooperation.

Previous research[52] on public health emergency response has shown that, in the UK, community trust and participation are essential for collecting samples for genomics work, implementing control measures, and maintaining public support for evidence-based interventions.

Four international projects noted that increasing public awareness of key topics is critical to successful pandemic responses. Teams therefore leveraged diverse communication channels carefully selected based on local context and audience accessibility. The format and delivery of content was carefully tailored to specific audience needs and local contexts, as demonstrated in the following case study.

Approaches to community engagement in Ghana and Nepal

In Ghana, researchers worked with religious leaders and community elders, recognising their pivotal role as trusted information sources. By collaborating with interpreters to engage in local dialects, the team was able to build trust and reduce stigma around COVID-19. The Christian Health Association of Ghana (CHAG) network, comprising 374 health facilities, provided crucial links between researchers, healthcare providers, and communities.

In Nepal, researchers took a different approach, using television to reach wider audiences. The Birat Nepal Medical Trust (BNMT) and the Center for Molecular Dynamics Nepal (CMDN) organised "COVID Kurakani" (COVID Conversations) television programs which were broadcast from different provinces, bringing together academics, health officials, and laboratory staff. This format provided a platform for public dialogue about genomics and created opportunities for traditionally excluded groups to engage with health and science discussions.

8. Potential actions

8

8. Potential actions

This report has examined the outcomes and impacts of Wellcome's strategic investment in pathogen genomic sequencing and surveillance initiatives during the COVID-19 pandemic. Through extensive consultation with over 100 funded researchers and Wellcome staff involved in the funding call design, this analysis has revealed both significant contributions to the global pandemic response and important insights into the challenges of conducting genomic research during emergencies.

The research projects funded by Wellcome generated substantial impacts, advancing the scientific understanding of SARS-CoV-2 genomics through a range of channels, from data shared on public databases to policy briefs that directly informed emergency responses and public health interventions.

Drawing on these findings, this section now presents a summary of the key lessons learned that can enable research funders to enhance their support mechanisms for emergency response research. These recommendations address both immediate operational needs during acute emergency phases and longer-term strategic considerations across the genomic sequencing pipeline. The insights offered here aim to strengthen research funders' capacity to rapidly mobilise and sustain effective research responses to future public health emergencies.

8.1 Funding design and grant award

Key findings	Potential actions for research funders
Existing Wellcome grantees could receive funds quickly, while new partners faced significant delays due to mandatory due diligence processes (Section 3.1)	Develop context-sensitive due diligence frameworks for emergency response
Wellcome's reimbursement-based funding model caused friction with national regulations (Section 3.2)	Develop more flexible funding mechanisms that accommodate different national regulatory requirements
Projects led by institutions with existing partnerships were able to rapidly overcome roadblocks to delivery (Section 3.3)	Require applicants to describe their existing relationships (or proposed mechanisms to establish these) with relevant organisations, including research partners and public health agencies
Communication challenges delayed project initiation, particularly for newly-established funding partnerships (Section 3.4)	Clearly communicate timelines, expected decision points and responses to queries, recognising that new recipients of Wellcome funding may require additional guidance.
Community engagement funding supported core sequencing awards (Section 3.5)	Integrate ring-fenced funding for community engagement into core award applications

8.2 Enabling infrastructure

Key findings	Potential actions for research funders
Limited access to basic physical infrastructure affected the integrity of critical reagents and consumables (Section 4.1)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Significant supply chain disruption necessitated careful consumables planning and management (Section 4.2)	Facilitate knowledge sharing about infrastructure challenges and solutions across funded teams
High resource costs and limited availability prompted innovative approaches to consumables management (Section 4.3)	Recognise limitations in abilities to address global supply chains but consider partnerships with organisations like UNICEF to include research needs in emergency logistics planning
Access to cutting-edge equipment and reliable technical support is critical to ensuring continuity in genomic sequencing (Section 4.4)	Consult with other funders about approaches to equipment servicing and support in LMICs
Significant data demands of disease surveillance require substantial computing resources for processing, analysis and storage (Section 4.5)	Clarify approaches to funding maintenance of equipment e.g. allowing longer-term maintenance contracts

8.3 Research team capacity

Key findings	Potential actions for research funders
Highly capable bioinformaticians were in significant demand to meet sequencing analysis needs (Section 5.1)	Support the development of skilled staff, particularly in bioinformatics
Funded teams provided training to enhance in-house and partner bioinformatics capabilities (Section 5.2)	Facilitate the development of researcher networks and communities
Organisations established formal and informal networks to share expertise and resources (Section 5.3)	Support institutions to sustain relevant instrumentation and software for sequencing

8.4 Data management and sharing

Key findings	Potential actions for research funders
GISAID emerged as the primary platform for sharing SARS-CoV-2 sequence data and was particularly attractive to researchers in LMICs due to its policies on crediting data generators (Section 6.1)	Support tiered data sharing that allows rapid sharing to decision-makers while working towards full public release
Interim solutions were established to enable data sharing before full public sharing was possible, including restricted sharing with key stakeholders (Section 6.3)	
Metadata quality and completeness were a significant challenge, particularly in routine healthcare facilities (Section 6.4)	Promote use of existing frameworks to support metadata collection and adherence to relevant standards

8.5 Research uptake and community engagement

Key findings	Potential actions for research funders
Research uptake is enabled by existing relationships between research institutions and government agencies (Section 7.1)	Build researcher capacity and capability for engagement with policymakers
Dedicated committees and advisory groups are a vital mechanism for information sharing (Section 7.3)	
Local leadership leads to more successful policy dialogue and engagement (Section 7.4)	
Robust channels for communicating complex scientific information are critical to relaying information to policymakers (Section 7.2)	Raise awareness of policy briefs as a tool to communicate effectively with policymakers
Community engagement supports genomic sequencing efforts, provided that messaging is carefully crafted (Section 7.5)	Provide clear guidance on the funding requirements and objectives to ensure proposals align with Wellcome's strategic priorities and community needs

Glossary

Africa and Asia Programmes

Over the past 40 years, Wellcome has invested in five major research programmes in Africa and Asia, and these are Africa and Asia Programmes (AAPs). Each AAP is partnered with a national institution in the LMIC where it is based. The work at the AAPs is driven by the major health challenges in their regions.

Bioinformatics

Bioinformatics is an interdisciplinary field that combines biology, computer science, and data analysis to understand biological data. It involves developing and using computational tools and methods to collect, store, analyse, and visualise biological data.

Biosafety Level

Biosafety levels (BSLs) are a system of safety precautions used in laboratories to manage biological hazards. There are four biosafety levels in total. BSL-1 involves minimal precautions, while BSL-4 requires the most stringent containment measures.

Cold chain infrastructure

RNA samples must be kept between –20 °C or –80 °C to prevent degradation. However, in remote settings with limited transport infrastructure, transportation times often extended from eight hours to multiple days.

Data analysis

The process of examining and interpreting genomic sequence data to identify patterns, mutations, and relationships between different viral strains.

Data sharing

The process of sharing data that has been generated such as pathogen genomic data, or bioinformatic analyses with internal and external stakeholders.

Flow cell

A flow cell is a specialised device used in DNA sequencing that distributes DNA molecules onto a surface where they can be read, enabling the conversion of molecular DNA sequence information into digital data. Flow cells play a central role in the sequencing process.

GISAID

A global database platform specifically designed for sharing virus genetic sequences and related clinical and epidemiological data.

High-performance server

High-end servers for genomic sequencing data require substantial computational power and storage capacity to handle the massive amounts of data generated. For large-scale genomic sequencing projects, significant computing power is required, as well as large-scale storage and high-speed networking.

Metadata

Supporting information that provides context about genomic sequences, such as when and where samples were collected, patient demographics, and clinical information.

Pathogen genomic sequencing

Pathogen genomic sequencing is a laboratory technique used to determine the complete genetic code (genome) of an organism, such as a pathogen, revealing the precise order of nucleotides within its DNA or RNA molecules. During the COVID-19 pandemic, this approach was applied globally to decode the approximately 30,000 nucleotides that comprise the SARS-CoV-2 genome.

Technological advances in sequencing platforms, particularly next-generation sequencing (NGS) technologies, transformed this basic capability into a real-time surveillance tool, enabling sequence data generation within hours or days of case identification.

The capability to perform real-time surveillance proved crucial for multiple aspects of pandemic response including immediate public health responses:

- **Diagnostic test development**: Early sequencing of SARS-CoV-2 enabled the rapid development of polymerase chain reaction (PCR)-based diagnostic tests, critical for case identification.
- **Transmission tracking**: Sequence data allowed researchers and public health officials to trace transmission patterns and identify infection clusters.
- **Variant identification**: Continuous sequencing revealed emerging variants with potentially altered transmissibility, severity, or immune escape properties.
- **Vaccine development**: Understanding the viral genome was fundamental to the rapid development of COVID-19 vaccines.

Other benefits included enabling global surveillance infrastructure and information sharing:

- **Scale and speed of implementation**. In April 2023 it was reported that over 15 million sequences of the SARS-CoV-2 genome had been shared through the GISAID platform, representing the largest viral genomic dataset ever assembled.
- **Global collaboration and data sharing**. The pandemic necessitated increased levels of international collaboration in genomic surveillance, with genomic sequencing capability increasing by 40% between February 2021 and July 2022. This fundamentally changed how data was shared globally. In this consultation, international sequencing and surveillance networks, such as ARTIC, PulseNet and COVIGEN, played a significant role in supporting global genomic surveillance efforts.
- **Evidence-based decision making**. Real-time genomic surveillance emerged as a cornerstone of evidence-based public health response during the pandemic. Public health officials relied on genomic data to provide early warnings of emerging variants of concern and assess the effectiveness of border control measures.

Policy brief

A concise document that summarizes complex scientific findings for policymakers, typically presenting key information and recommendations in an accessible format.

Primer set

Primer sets are used for amplifying specific regions of the viral genome before sequencing, and they are critical to sequencing operations because they serve as the essential starting points for DNA replication that allows us to “read” the viral genetic code.

Research uptake

The process by which research findings are communicated to and utilized by policymakers, practitioners, and other stakeholders to inform decisions.

Sample pooling

Sample pooling allows more people to be tested quickly using fewer testing resources. It does this by allowing samples from several people to be analysed in one test.

Sample testing

The process of analysing biological samples to detect the presence of pathogens or specific genetic sequences.

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KEY

- ✓ Engaged
- ⊖ Not engaged

Appendix A.

Projects in scope of this review

Award	Principal Investigator or Lead	Regions	Introductory call	Survey	Interview	Focus group
COVID-19 Genomics – MENA': towards molecular surveillance of SARS-CoV-2 genomes during the vaccination period within the Middle East and North Africa	**Arnab Pain**	Middle East, North Africa	Engaged	Engaged	Engaged	Engaged
Genomic Surveillance program for SARS-CoV-2: Consortium of India and Sri Lanka	**Anurag Agrawal, Vajira Dissanayake**	Asia	Engaged	Engaged	Engaged	Engaged
Epidemic Intelligence: Understanding how returning migrant waves drive epidemic seeding and community transmission events in the South Asian context to inform epidemic preparedness	**Maxine Caws**	Asia	Engaged	Engaged	Engaged	Engaged
Establishing genomic epidemiology hubs across Latin America	**Andrea Vicari**	Latin America	Engaged	Engaged	Engaged	Not engaged
National Covid-19 testing in South Africa, Malawi and Kenya	**Philip Bejon, Le Van Tan**	Africa, Asia	Engaged	Engaged	Engaged	Engaged
Expansion and support of SARS-CoV-2 sequencing in West and Central Africa to support the COVID-19 pandemic response	**Ian Goodfellow**	Africa	Engaged	Not engaged	Engaged	Engaged
COVID-19 intervention modelling for East Africa (CIMEA)	**James Nokes**	Africa	Engaged	Engaged	Not engaged	Not engaged
African COVID-19 preparedness (AFRICO19)	**Mathew Cotten**	Africa	Engaged	Not engaged	Not engaged	Not engaged

Appendix B.

Project contributors

The following tables list the interviewees that contributed to this research. Interviewees are presented alphabetically, by funded project.

COVID-19 Genomics – MENA': towards molecular surveillance of SARS-CoV-2 genomes during the vaccination period within the Middle East and North Africa

Interviewee	Country	Role
Abdullah Unsa	Qatar	Assistant Professor
Adeem Zafar	Saudi Arabia	Head of Post-Award Team
Aissam Hachid	Algeria	Co-Principal Investigator
Ali Alsaeed	Saudi Arabia	Infectious Disease Scientist
Amit Subudhi	Saudi Arabia	Research Specialist
Arnab Pain	**Saudi Arabia**	**Principal Investigator**
Hadi Yassine	Qatar	Assistant Professor
Hamad Ali	Kuwait	Associate Professor
Lamiae Boualla	Morocco / Saudi Arabia	Laboratory Manager
Linda Polik	Saudi Arabia	Head of Awards and Contracts
Muhammad Imara	Qatar	Associate Professor
Muhammad Shuaib	Saudi Arabia	Senior Research Scientist
Rahul Salunke	Saudi Arabia	Post Doc, Bioinformatics
Rohit Satyam	Saudi Arabia	PhD, Bioinformatics
Samir Adroub	Saudi Arabia	Research Specialist
Sara Mfarrej	Saudi Arabia	Laboratory Technician
Sarah Belkalrm	Algeria	Medical Biologist

Genomic Surveillance program for SARS-CoV-2: Consortium of India and Sri Lanka

Interviewee	Country	Role
Ajith Nagahawatte	Sri Lanka	Microlab collaborator
Anu Raghunathan	India	Coordinator for Microlab at NCL
Anurag Agrawal	**India**	**Principal Investigator**
Anusha Fernando	Sri Lanka	Virologist
Aradhita Baral	India	Project Manager
Ashwani Kumar	India	Coordinator for Microlab at IMTECH
Himani Rajapakshe	Sri Lanka	Senior Assistant Bursar
Ishara Premathilaka	Sri Lanka	Consultant Virologist
Kalamathy Muruganathan	Sri Lanka	Microlab collaborator
Karthik Bhardwaj	India	Coordinator for Megalab at CCMB
Mahesh Dharne	India	Lead for COVID surveillance in wastewater, contextual input
Manjula	Sri Lanka	Administrative Assistant
Nilaksha Neththikumara	Sri Lanka	Bioinformatician, Project Manager
Priyanki Shah	India	Collaborator for NCL, facilitation of stakeholder engagement
Rajesh Pandey	India	Coordinator for Microlab at IHBT
Sakunthala Bandaranayake	Sri Lanka	Administrative Assistant
Shobha Sanjeewani Gunathilake	Sri Lanka	Microlab collaborator
Siddik Sarkar	India	Coordinator for Microlab at IICB
Subodha Wickramasinghe	Sri Lanka	Microlab collaborator
Sumudu Suranadee	Sri Lanka	Clinical Microbiologist
Vaithehi Francis	Sri Lanka	Microlab collaborator
Vajira Dissanayake	**Sri Lanka**	**Principal Investigator**
Veranja Liyanapathirana	Sri Lanka	Microlab collaborator
Yogendra Padwad	India	Coordinator for Microlab at IHBT

Epidemic Intelligence: Understanding how returning migrant waves drive epidemic seeding and community transmission events in the South Asian context to inform epidemic preparedness

Interviewee	Country	Role
Bibha Dhungel	Nepal	Public Engagement Officer
Buddha Basnyet	Nepal	Co-Principal Investigator
Dipendra Pandey	Nepal	District Project Coordinator
Gyanendra Shrestha	Nepal	Project Manager
Kritika Dixit	Nepal	Research Manager
Maxine Caws	**Nepal**	**Principal Investigator**
Raghu Dhital	Nepal	Executive Director
Ram Koirala	Nepal	District Project Coordinator
Sameer Dixit	Nepal	Co-Principal Investigator
Swastika Shrestha	Nepal	Monitoring and Evaluation Officer

Establishing genomic epidemiology hubs across Latin America

Interviewee	Country	Role
Anamariela Tijerino	Costa Rica	Director of Regulatory Verification
Andres Castillo	Chile	Head of Infectious Agents
Barbara Parra	Chile	Laboratory Lead
Costanza Campano	Chile	Bioinformatics Engineer
Francisco Duarte	Costa Rica	Laboratory Lead
Jairo Mendez Rico	**Brazil**	**Principal Investigator**
Jorge Fernandez	Chile	Laboratory Lead
Marilda Siqueira	Brazil	Laboratory Lead
Paulo Covarrubias	Chile	Biochemist

National Covid-19 testing in South Africa, Malawi and Kenya

Interviewee	Country	Role
Agnes Mutiso	Kenya	Assistant Research Officer
An Le Duyen	Vietnam	Head of Procurement & Logistics
Carolyn Williamson	South Africa	Sequencing Lead
Charles Nyaigoti	Kenya	Investigator
Clement Lewa	Kenya	Laboratory Technologist
Cynthia Maunchon	Kenya	Head of Communications
Dorcas Okanda	Kenya	Assistant Research Officer
Elizabeth Batty	Thailand	Senior Bioinformatician
Esther Katama	Kenya	Data Manager
Frederick Mitsanze	Kenya	Procurement Manager
George Githinji	Kenya	Senior Scientist
Isabella Oyier	Kenya	Head of Biosciences
James Abuje	Kenya	Project Manager
Jennifer Musyoki	Kenya	Project Manager
Lam Anh Nguyet	Vietnam	PhD Student
Le Nguyen Truc Nhu	Vietnam	Research Assistant
Nelson Ouma	Kenya	Data Manager
Nghiem My Ngoc	Vietnam	Head of Molecular Diagnostics
Nguyen Thi Thu Hong	Vietnam	Research Assistant
Nguyen To Anh	Vietnam	Post doctoral scientist
Nguyen Van Vinh Chau	Vietnam	Vice Director
Nicholas Day	Thailand	Director
Noni Mumba	Kenya	Head of Engagement
Philip Ashton	Malawi	Lead Bioinformatician
Philip Bejon	**Kenya**	**Principal Investigator**
Rageema Joseph	South Africa	Postdoctoral Research Fellow
Robert Wilkinson	South Africa	Director
Rogier van Doorn	Vietnam	Clinical Microbiologist
Roselyne Namayi	Kenya	Media Engagement Coordinator
Tam Thi Nguyen	Vietnam	Postdoctoral Scientist
Tan Le Van	Vietnam	Co-Principal Investigator
Thanh Vu Duy	Vietnam	Public Engagement Officer
Tran Tan Thanh	Vietnam	Research Assistant

Expansion and support of SARS-CoV-2 sequencing in West and Central Africa to support the COVID-19 pandemic response

Interviewee	Country	Role
Collins Morang'a	India	Bioinformatician
Daniel Oduro-Mensah	Ghana	Field Coordinator
Francis Dzabeng	Ghana	Data Manager
Gloria Amgatcher	Ghana	Project Coordinator
Ian Goodfellow	**Ghana**	**Principal Investigator**
Kwabena Sarpong	UK	Training Coordinator
Lucas Amenga-Etigo	Ghana	Senior Research Fellow
Osbourne Quaye	Ghana	Co-Principal Investigator
Peter Quashie	Ghana	Senior Research Fellow

COVID-19 intervention modelling for East Africa (CIMEA)

Interviewee	Country	Role
James Nokes	**Kenya/UK**	**Principal Investigator**

African COVID-19 preparedness (AFRICO19)

Interviewee	Country	Role
Matt Cotten	**Uganda/UK**	**Principal Investigator**
My Phan	Uganda	Investigator

Appendix C.

Landscape maps

Africa and Asia Programmes – National COVID testing: Kenya

Funding and coordination

Africa CDC

Oversees

Governments of Ethiopia & Sudan

Wellcome

Provides funding

University of Oxford

African Pathogen Genomics Initiative

African Society for Laboratory Medicine

Sample collection

International test centres e.g. Comoros, Seychelles

National bodies e.g. Centre for Biotechnology R&D, army

Local test centres in coastal regions

Provides funding and coordination

Allocates funding

Provides coordination and reagents

Genomic sequencing

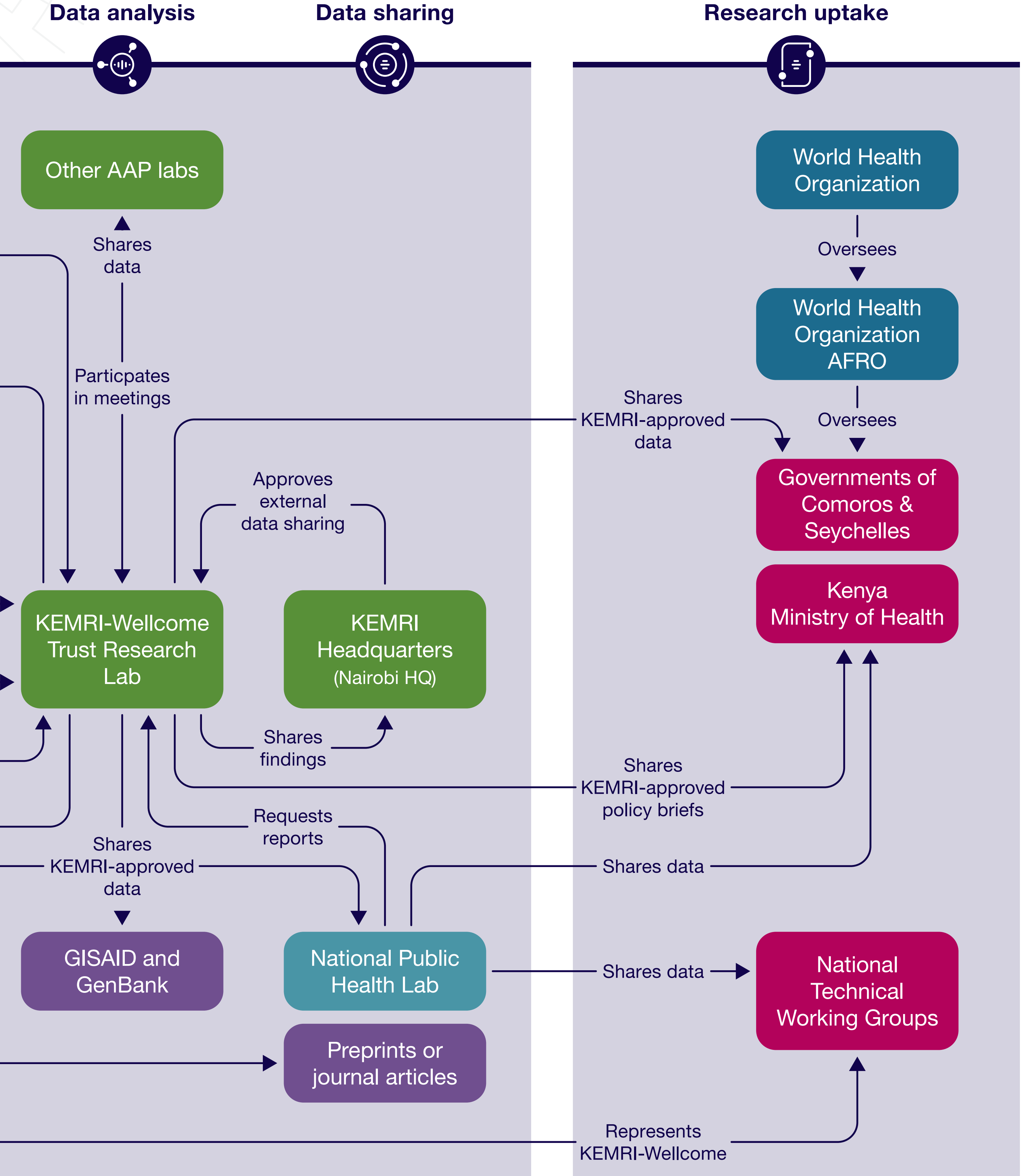
Provides samples

Provides data and reports

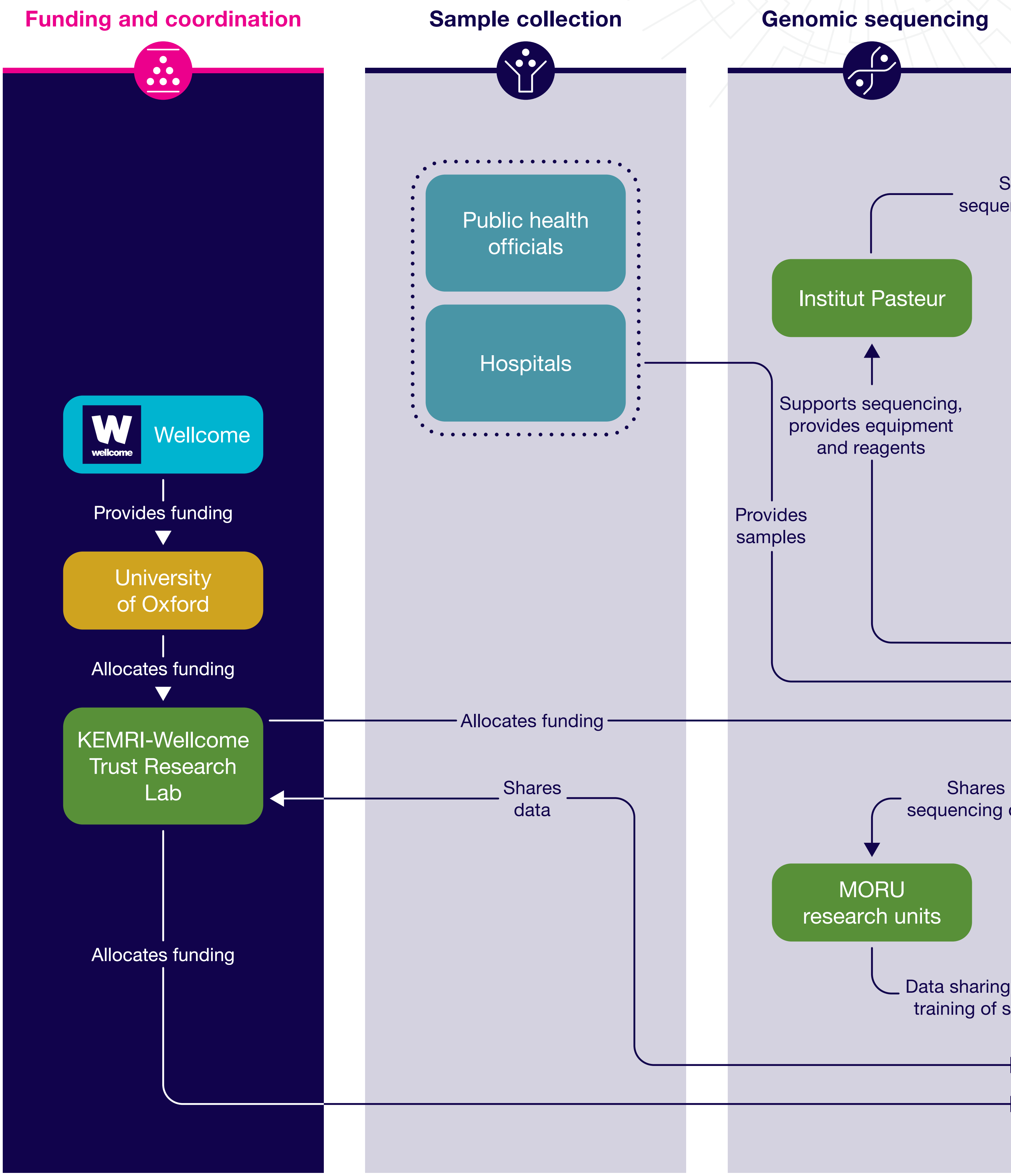
Legend

- Research funders
- Research performing organisations
- Universities
- Government
- Intergovernmantal organisations
- Public health bodies
- Public engagement
- Denotes groups of organisations

This map illustrates the key stakeholders, relationships and information flows that were captured as part of consultations with Wellcome-funded researchers. This map is illustrative only and based on the understanding and perspectives of consulted Wellcome-funded researchers at the time of engagement. It may not comprehensively represent all stakeholders or relationships in the ecosystem, and actual information flows may vary across different contexts, institutions, or research programmes.



Africa and Asia Programmes – National COVID testing: Thailand



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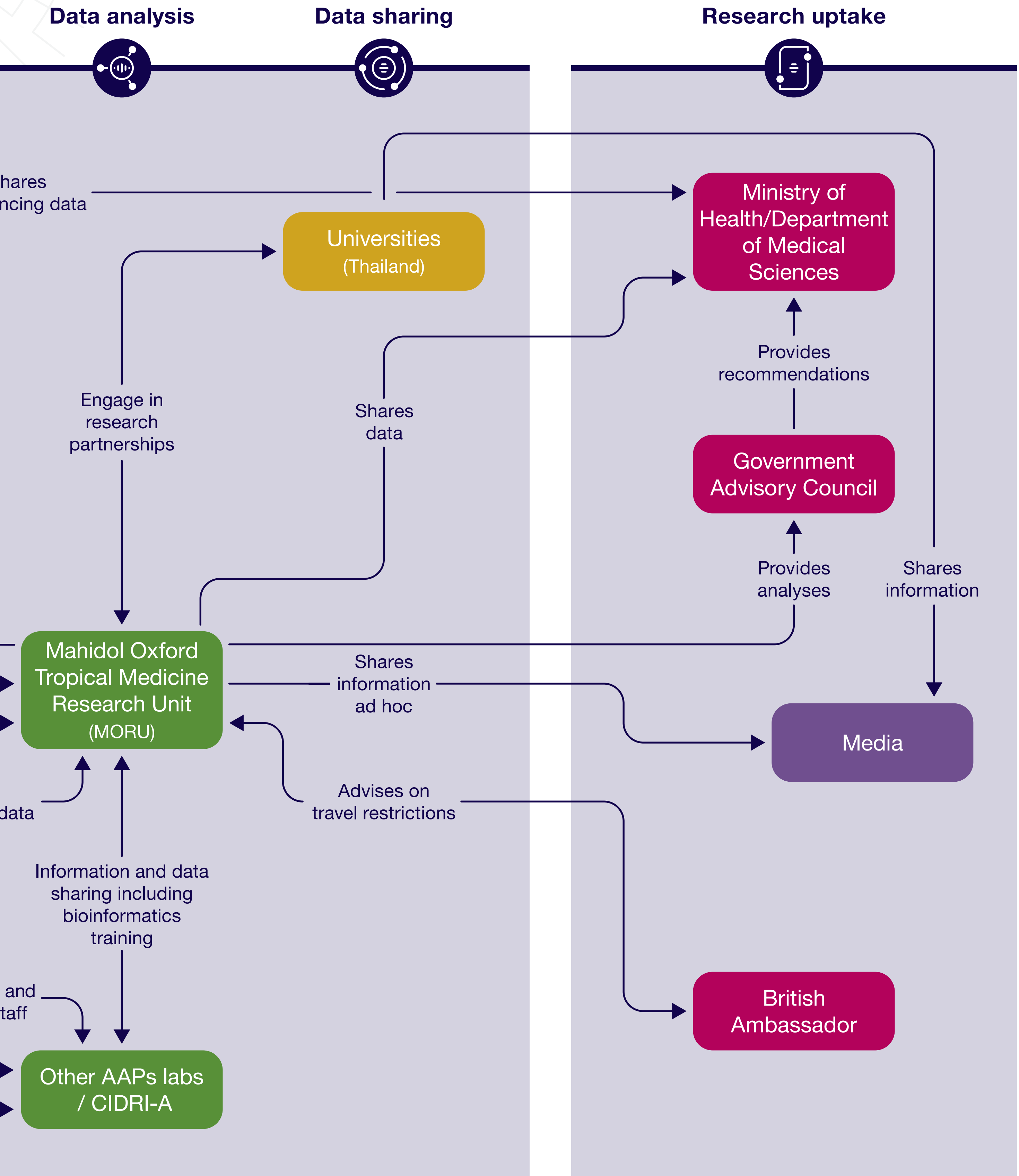
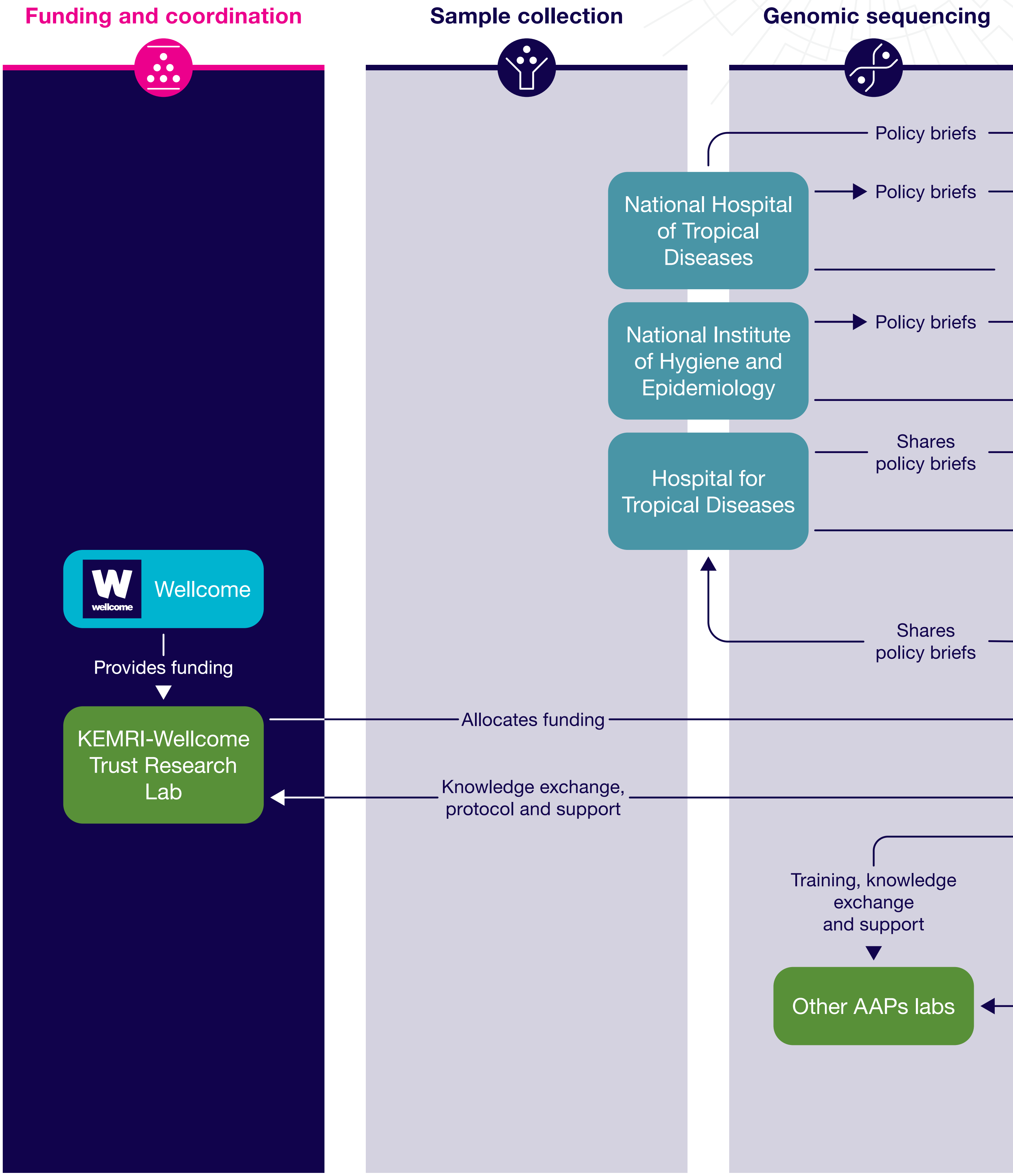


Africa and Asia Programmes – National COVID testing: Vietnam



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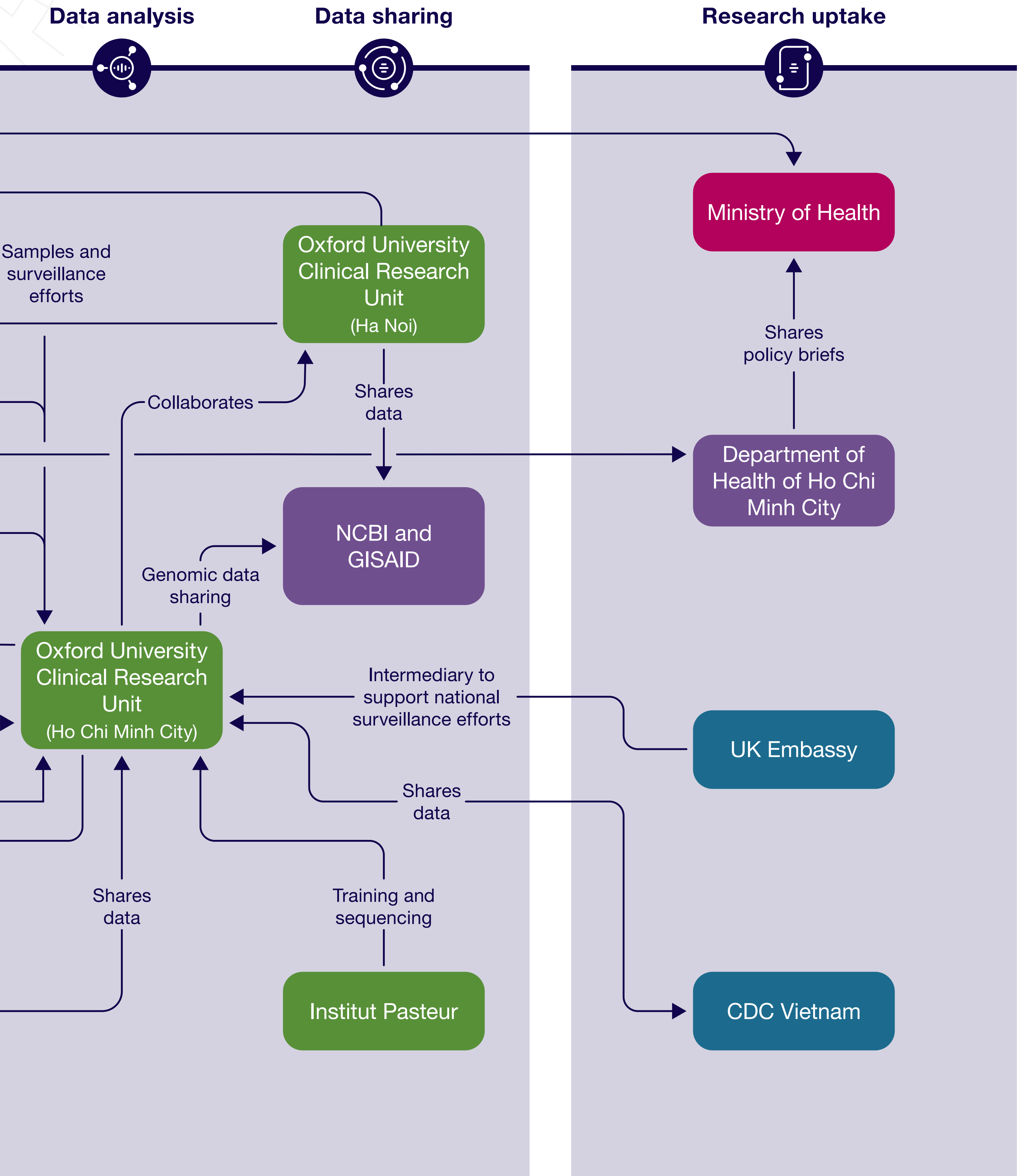
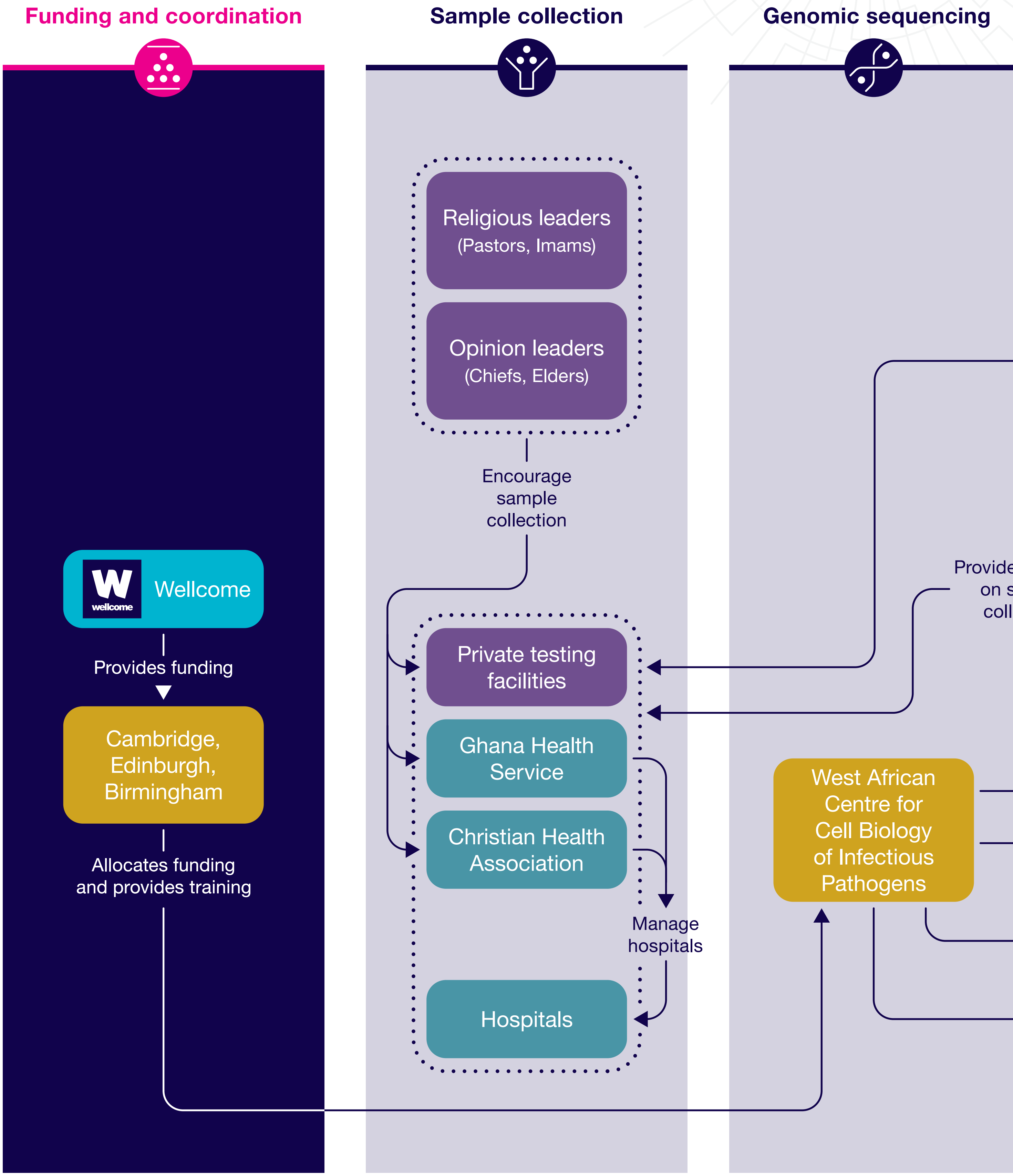


COVID-19 surveillance in West and Central Africa: Ghana



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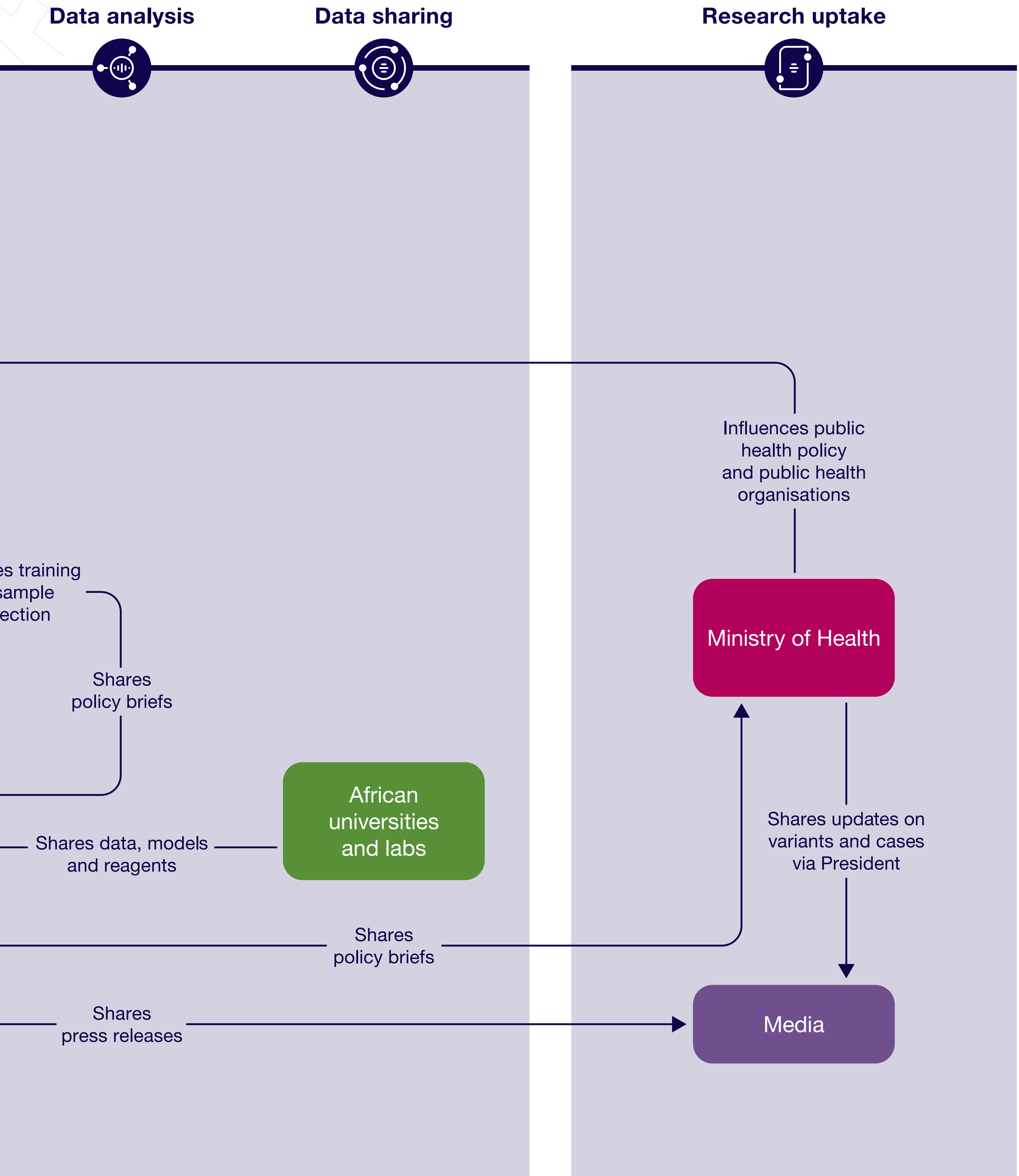
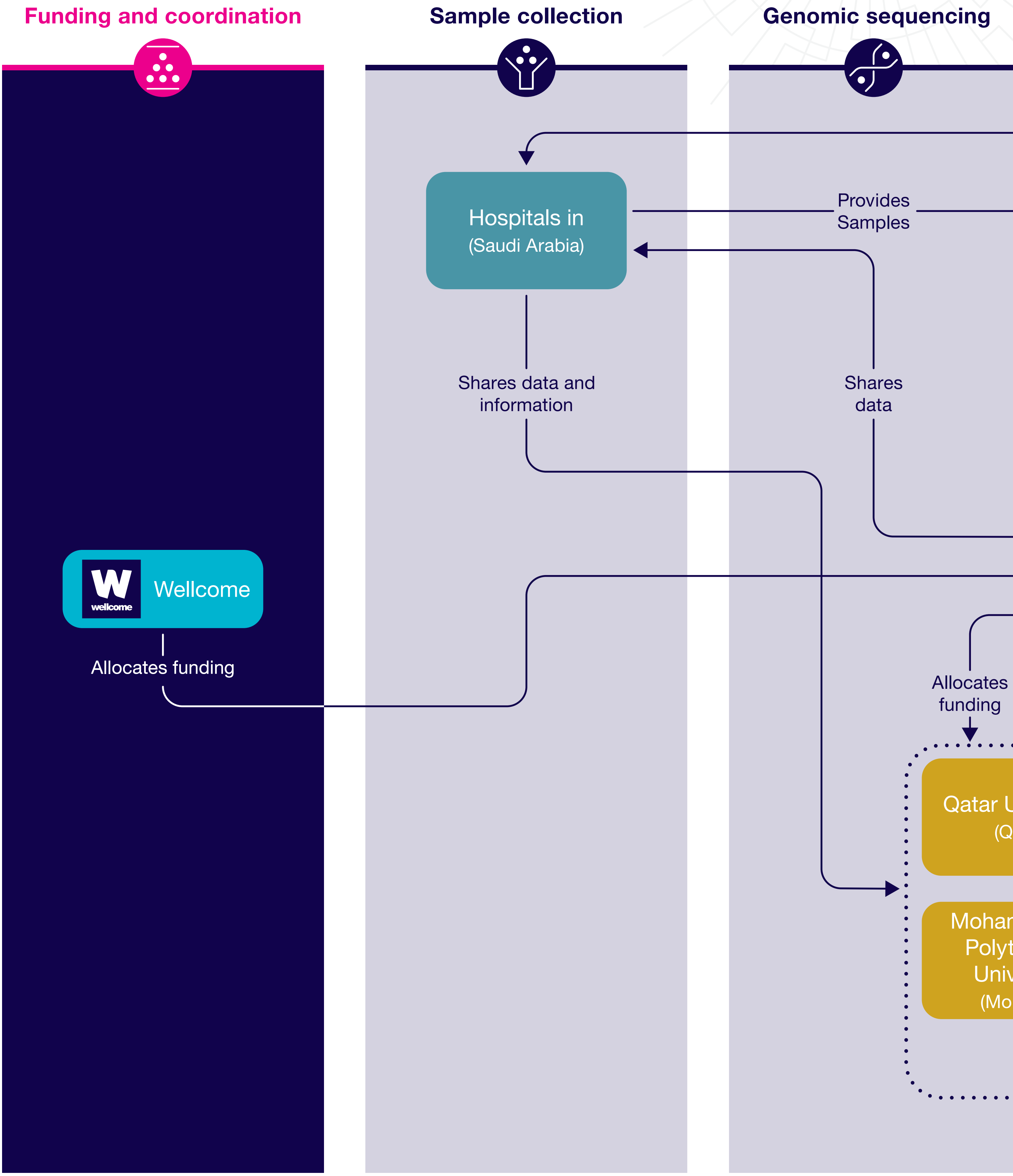


COVID-19 Genomics – MENA: Saudi Arabia



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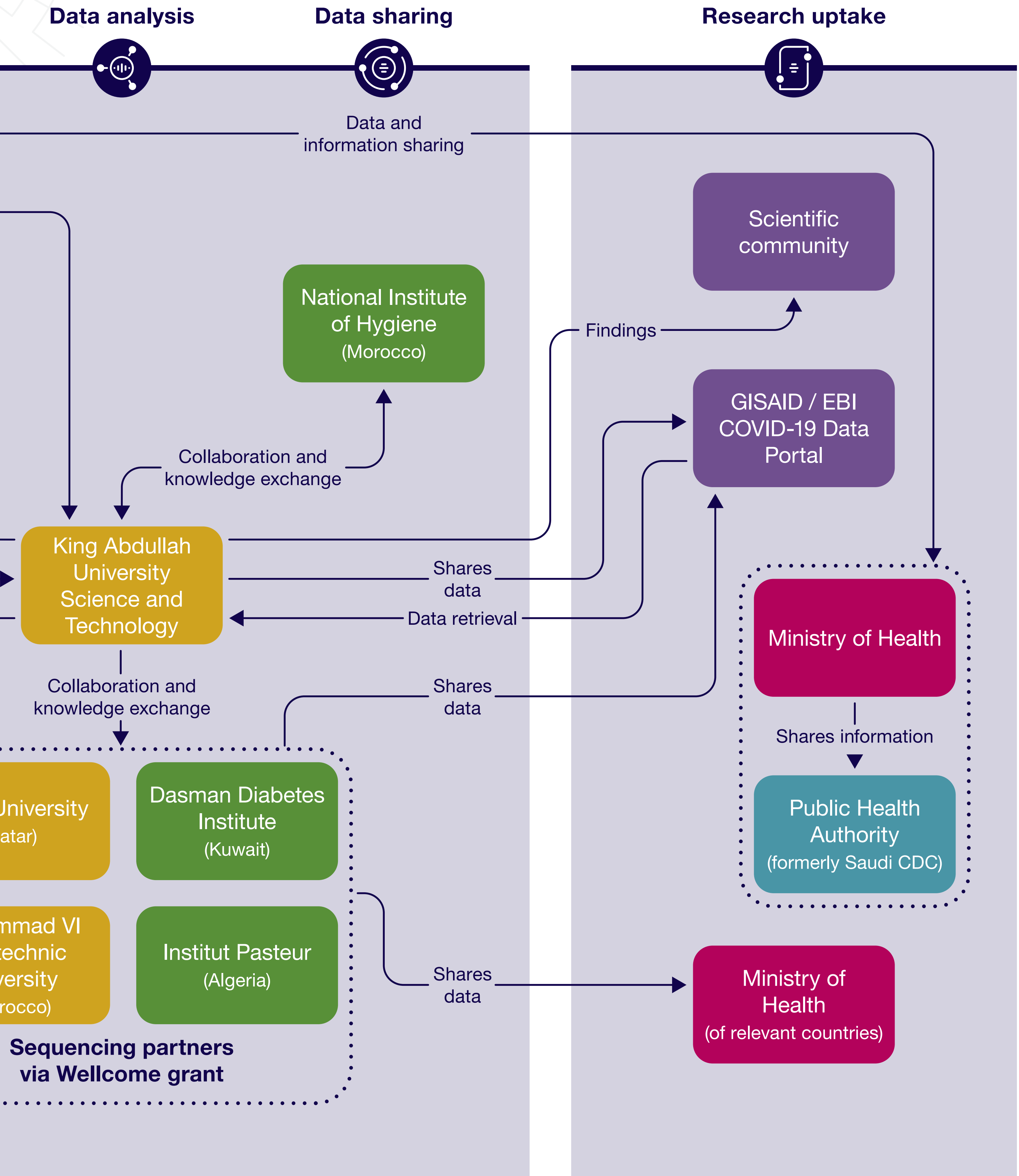
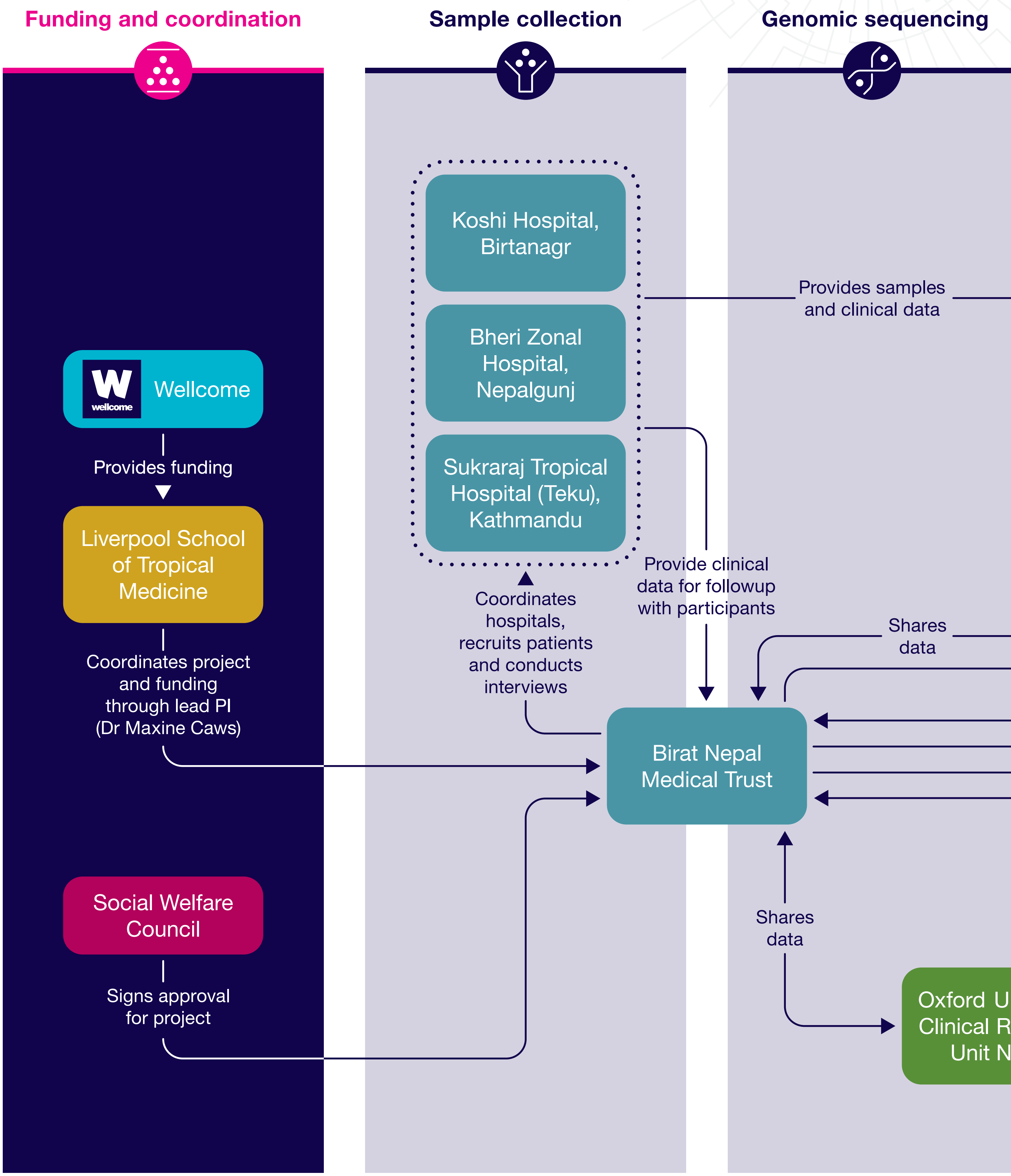


Epidemic Intelligence in South Asia: Nepal



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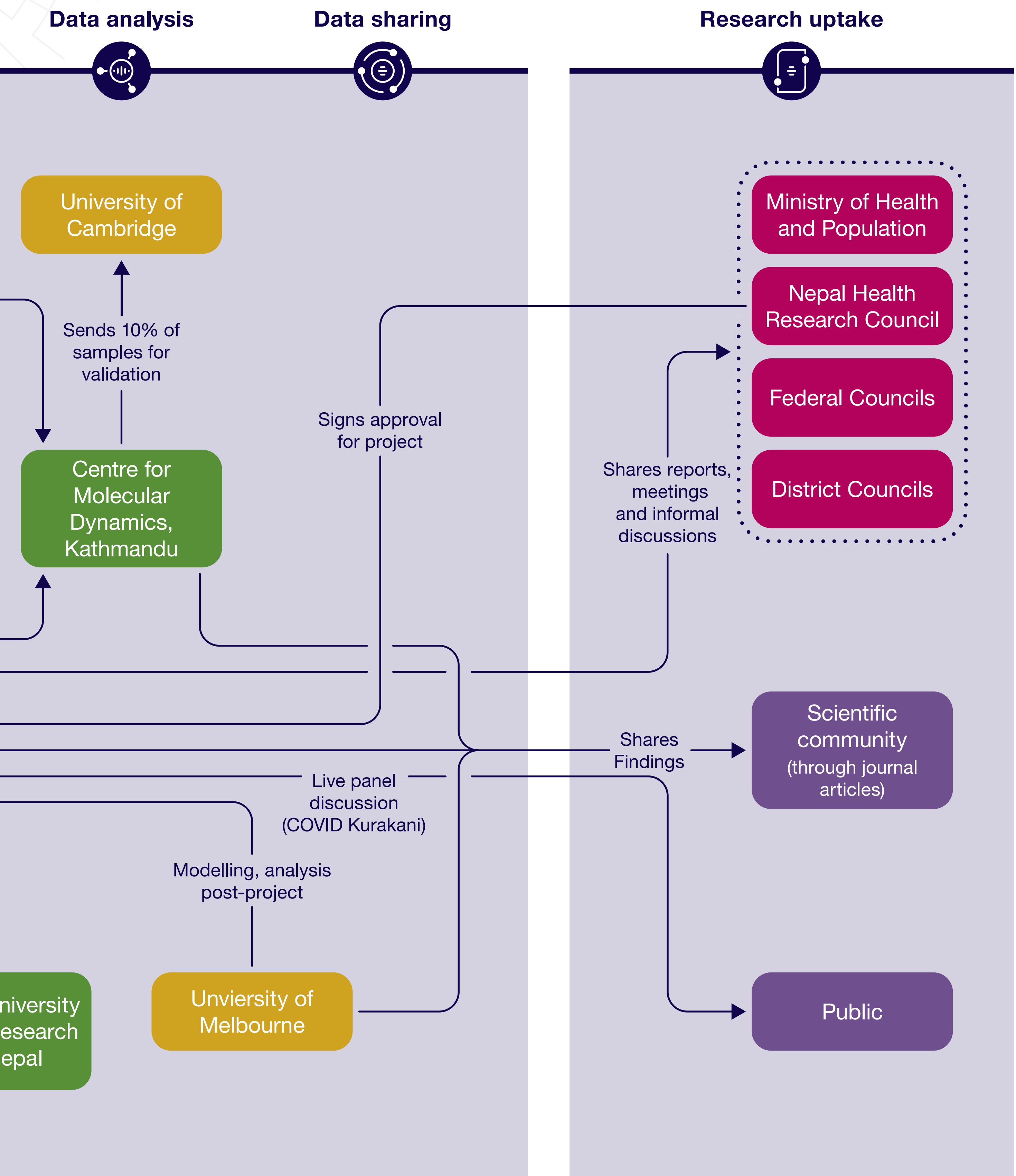
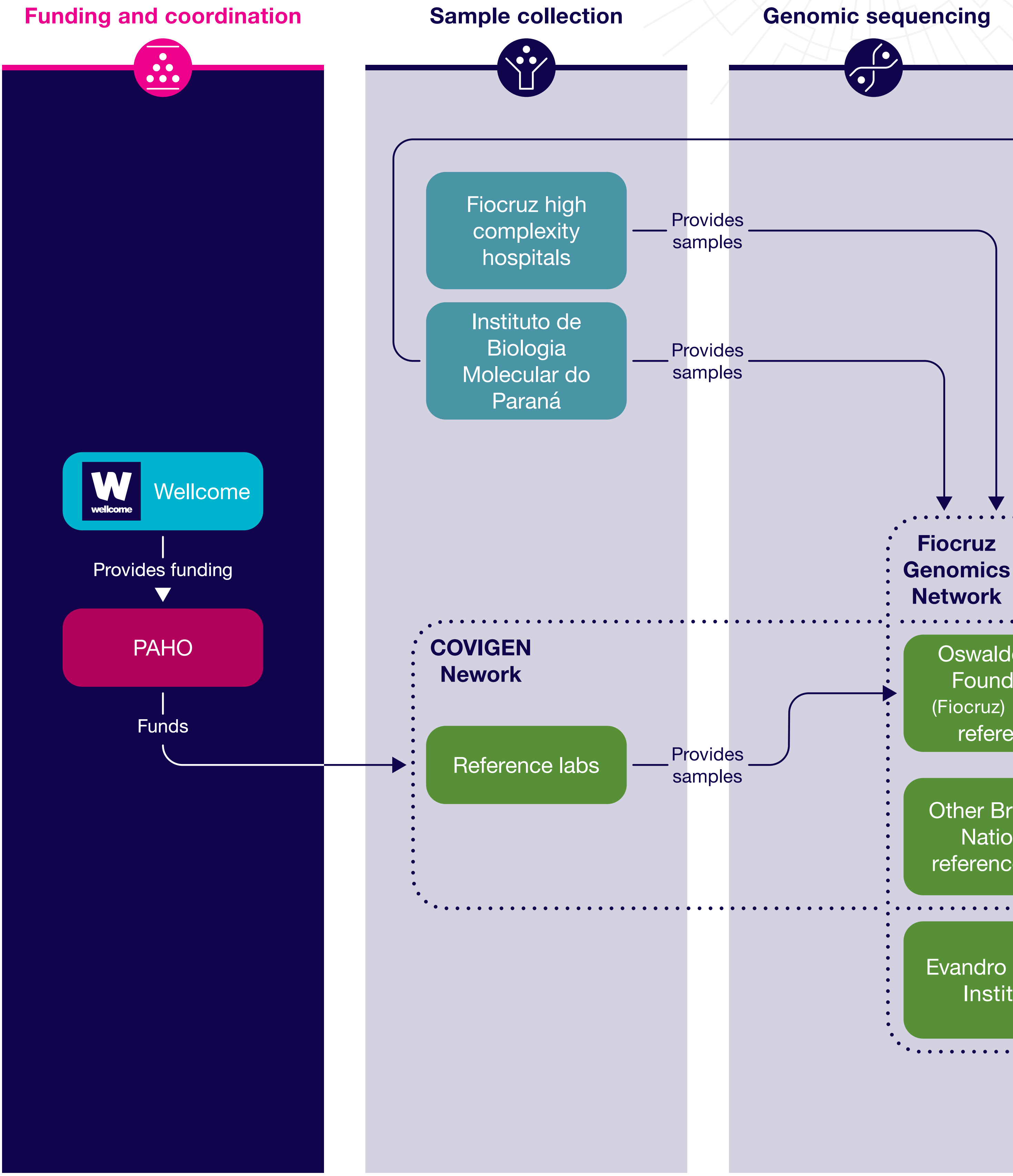


Establishing genomic epidemiology hubs across Latin America: Brazil



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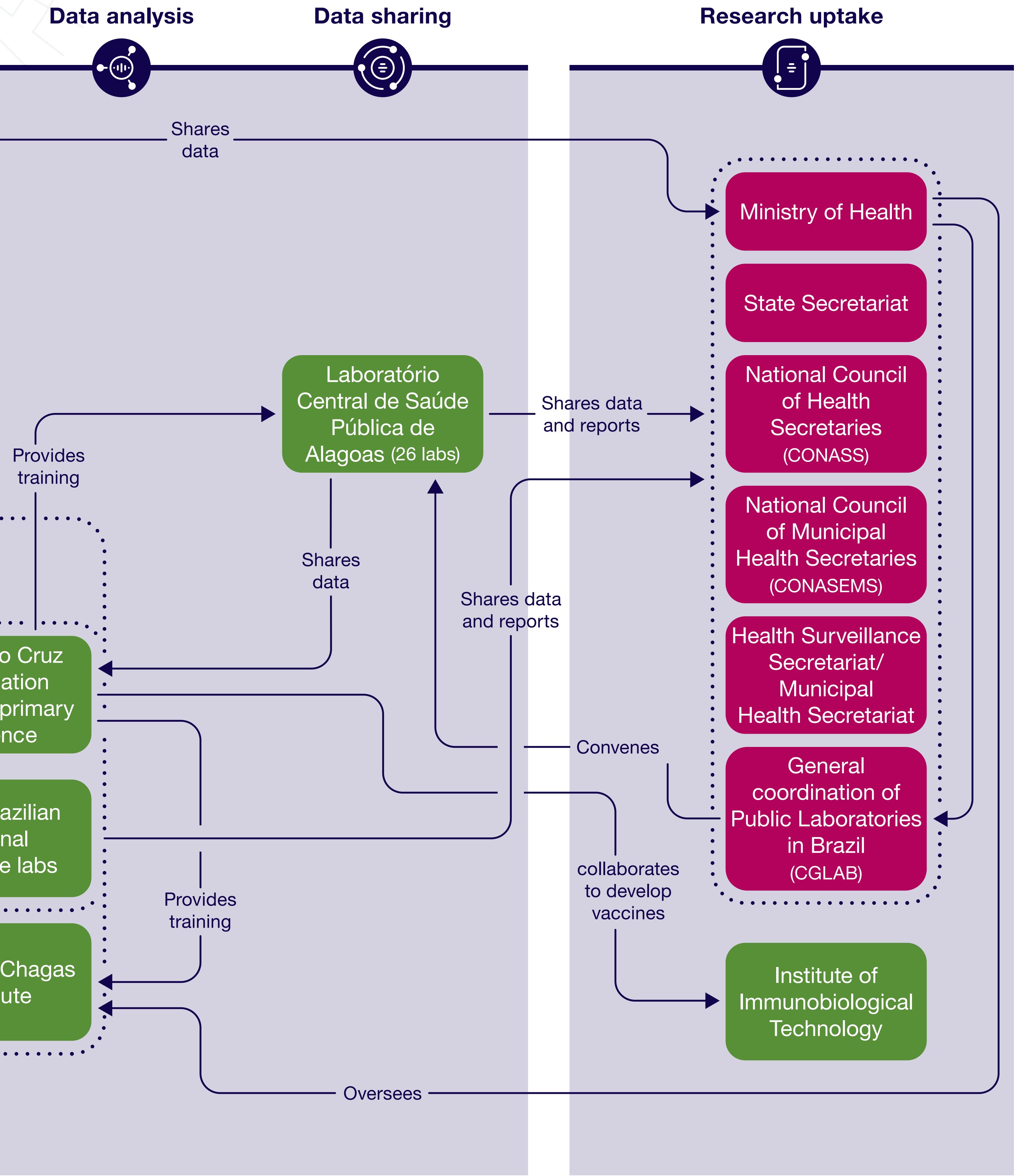
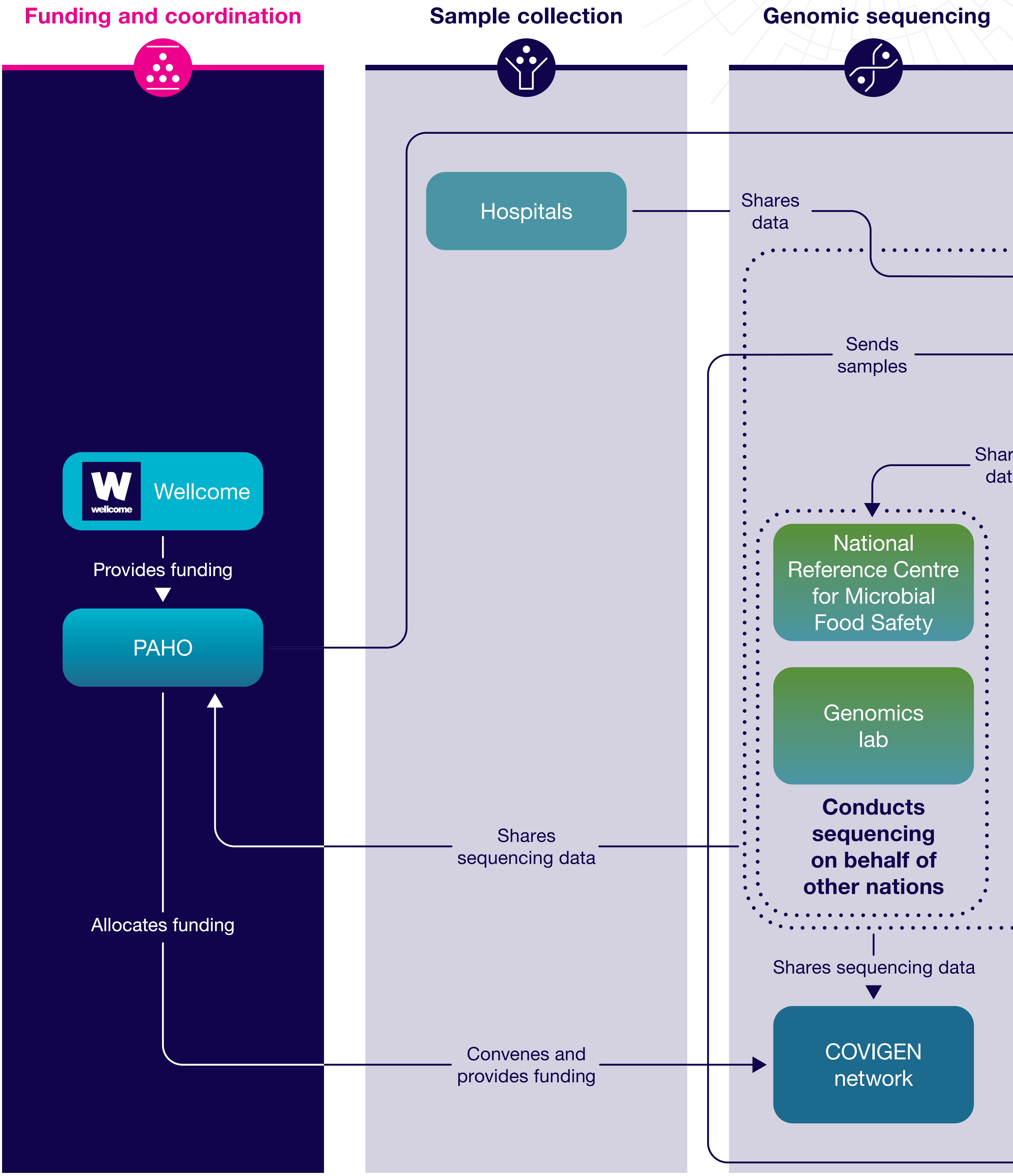


Establishing genomic epidemiology hubs across Latin America: Costa Rica



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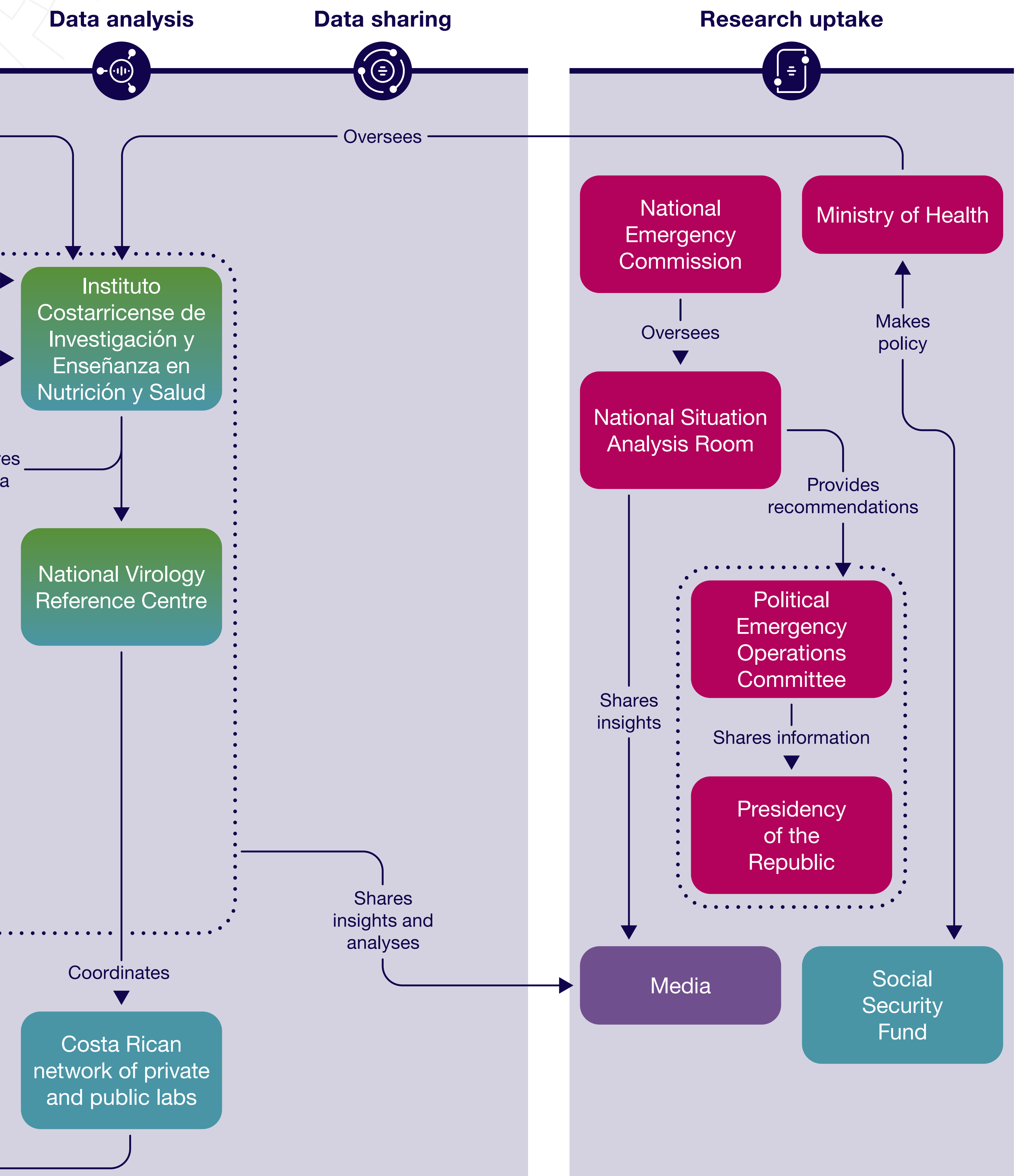
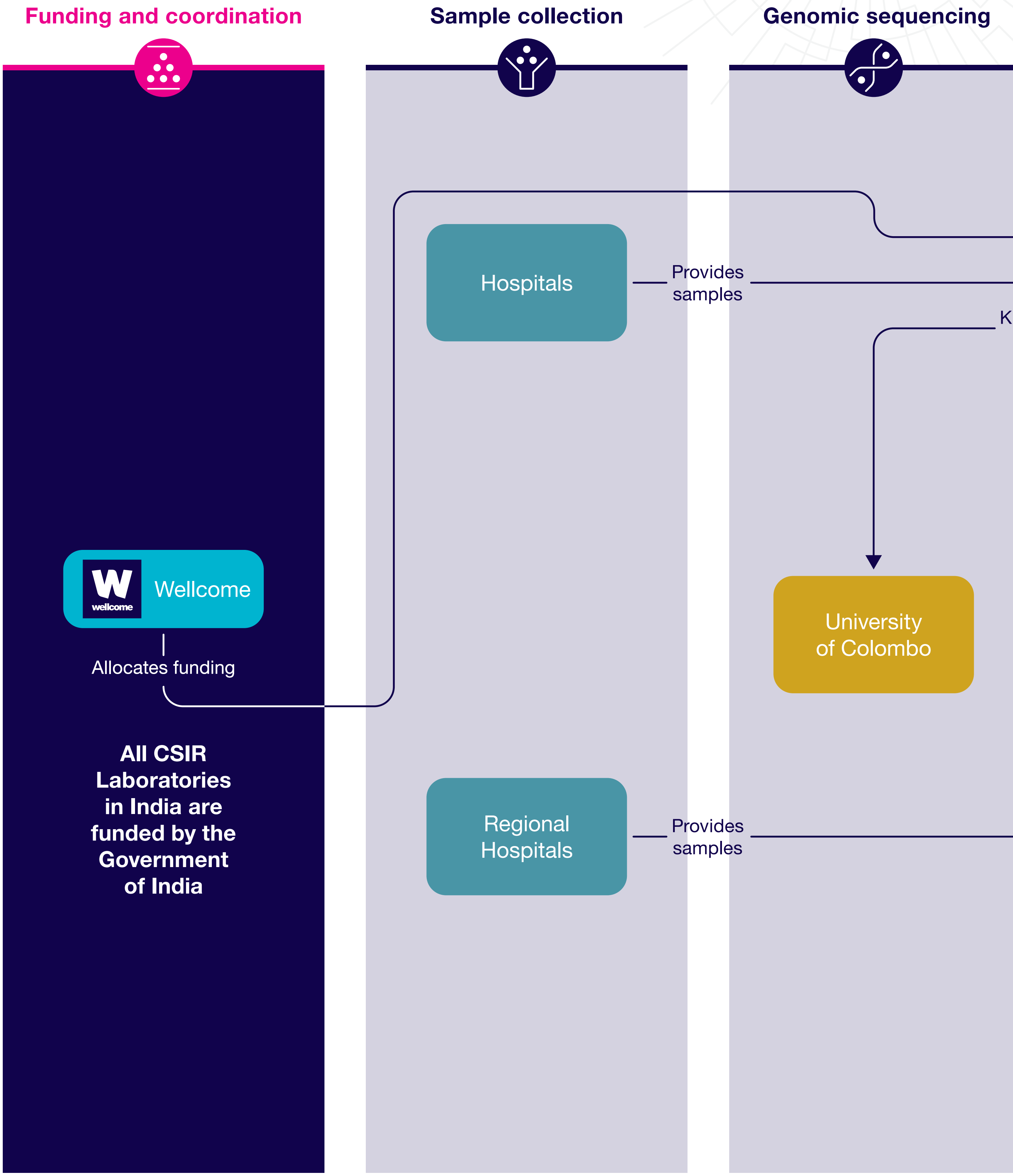


Genomic Surveillance program for SARS-CoV-2: Consortium of India and Sri Lanka: India



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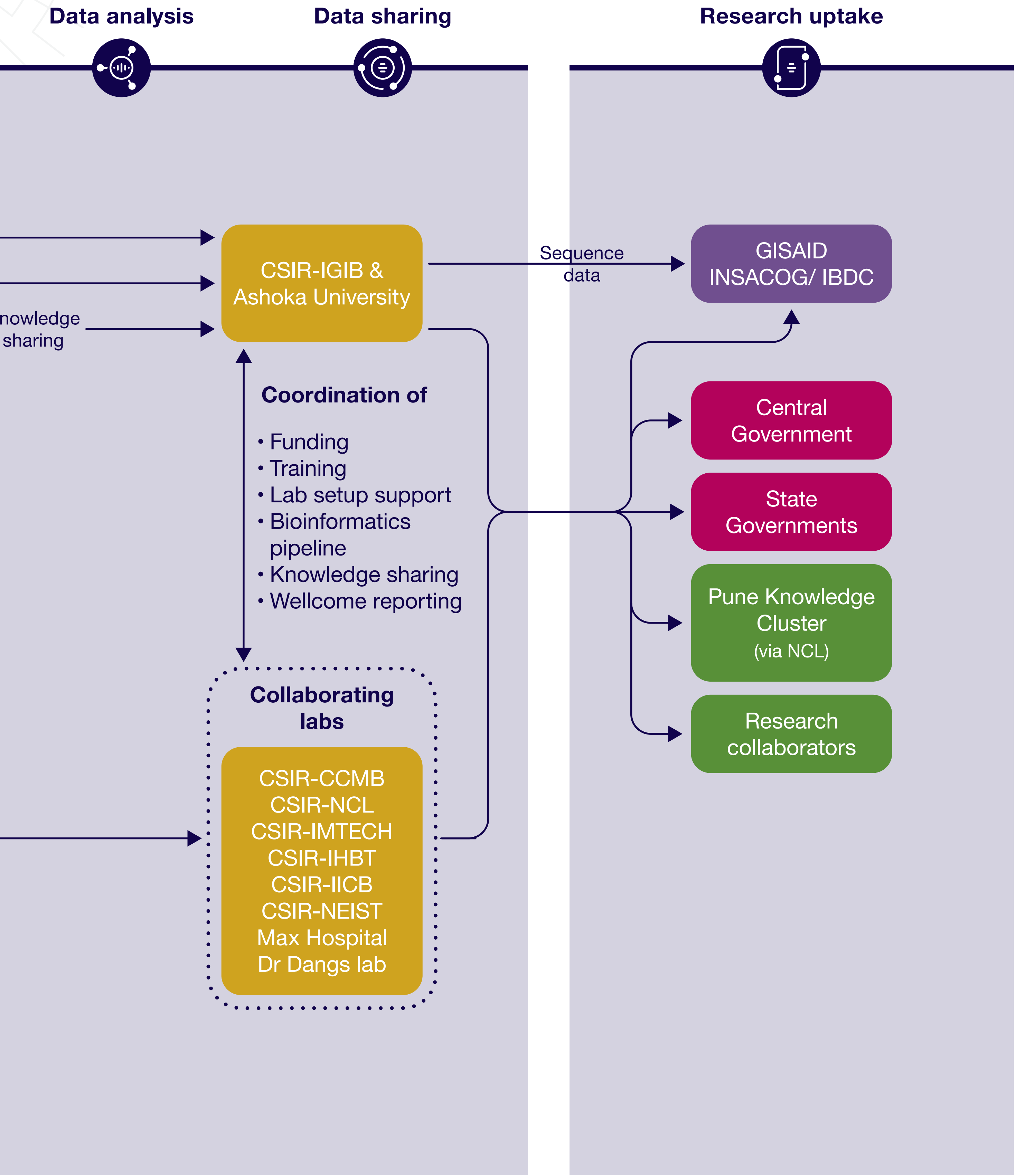
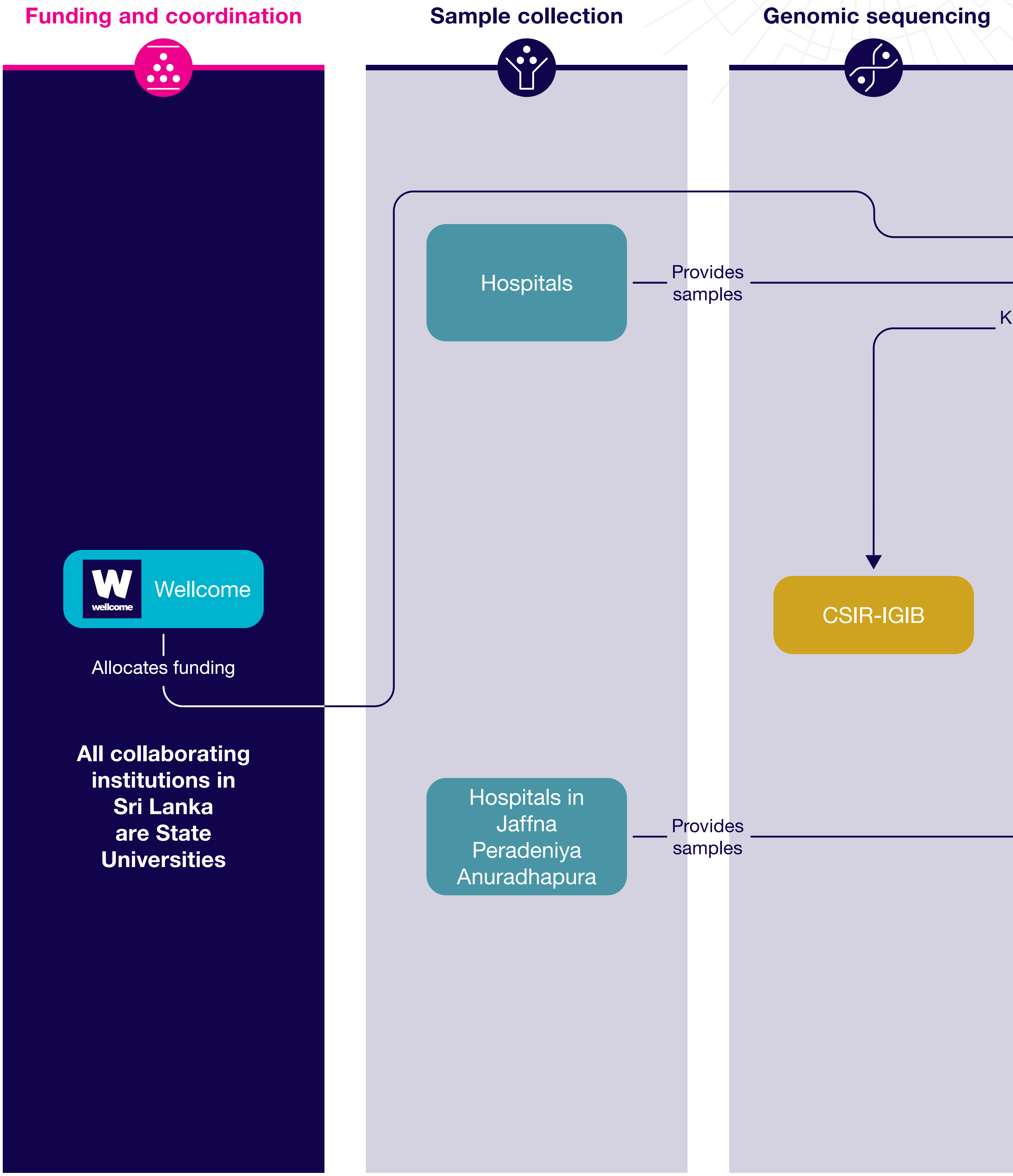


Genomic Surveillance program for SARS-CoV-2: Consortium of India and Sri Lanka: Sri Lanka



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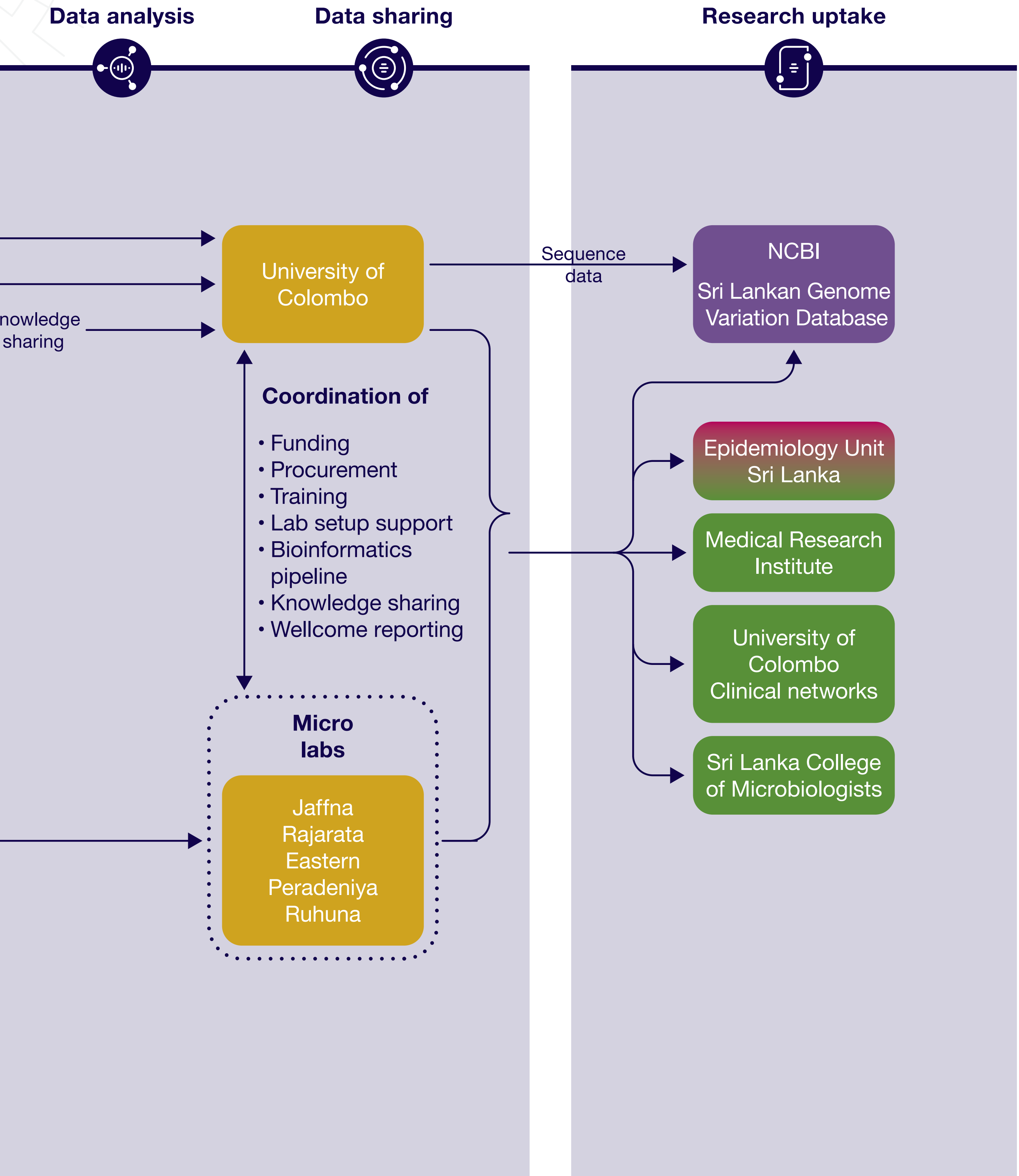
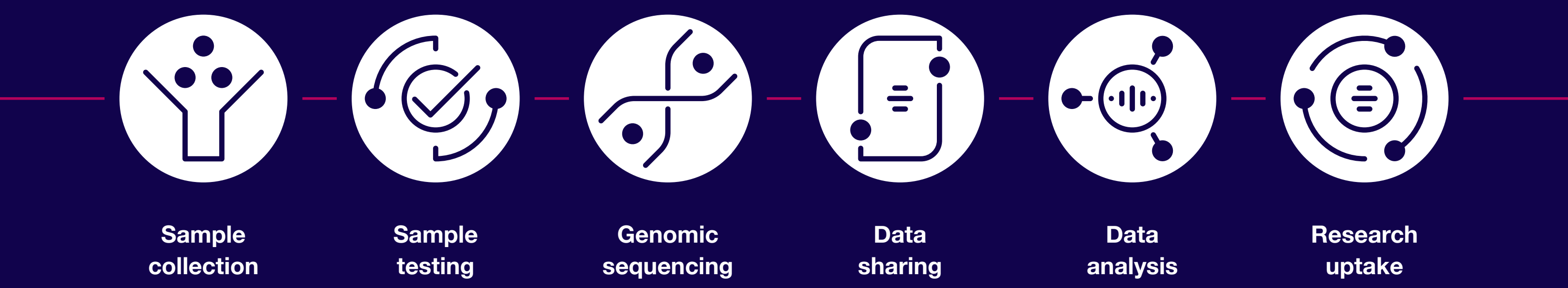


About Wellcome

Wellcome is a global charitable foundation which supports science to solve the urgent health issues facing everyone. We fund curiosity-driven research, and we're taking on three of the biggest health challenges facing humanity – climate change, infectious disease and mental health.

About Research Consulting

Research Consulting is an independent consultancy that helps solve challenges in research, scholarly communication, and knowledge exchange. We work with funders, universities, and research organisations worldwide to drive positive change in research practice and address emerging needs in the global research ecosystem.



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T +44 (0)20 7611 8888, E contact@wellcome.org, wellcome.org