Global Health Strategy Group: Pandemic Lessons and Future Pandemic Preparedness

First Meeting Report

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Acronyms

AI	Artificial intelligence
AMR	Antimicrobial Resistance
BRC	Biomedical Research Centre
CIOMS	Council for International Organizations of Medical Sciences
COVID-19	Coronavirus Disease 2019
ECDC	European Centre for Disease Prevention and Control
EIU	Economist Intelligence Unit
ESRC	Economic and Social Research Council
EU	European Union
IPC	Infection Prevention and Control
LMICs	Low- and middle-income countries
MPI	Multi Poverty Index
NCDs	Non-communicable Diseases
NIHR	National Institute for Health Research
NTDs	Neglected Tropical Diseases
NTI	Nuclear Threat Initiative
OHHLEP	One Health High-level Expert Panel
OiB	Oxford in Berlin
OIE	Organization for Animal Health
PREAM	Preparing for an Epidemic Analysis and Modelling
REF	Research Excellence Framework
TICO-19	Translation Initiative for COVID-19
UHC	Universal healthcare (UHC
UK	United Kingdom UK
UKRI	UK Research and Innovation
WCS	Wildlife Conservation Society
WHO	World Health Organisation

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Section 1: The First Meeting

1.1 Background

The Global Health Strategy Group for Pandemic Lessons and Future Pandemic Preparedness was set up to derive lessons that can be learnt from evidence gathered, and experience gained, in the present pandemic, and to identify key areas of policy to prevent or mitigate the impacts of future pandemics. It will do this by drawing on the extraordinary depth of knowledge and skills within its broad networks of partnerships and collaborations, and encouraging strong authentic global engagement, bringing together the global south and north in frank, open discussion.

The first meeting of the Group heard from a selection of its members about their work. This report is based on discussions during the meeting, chat messages left during the meeting, speaker presentations, feedback and insights provided before and after the meeting by members of the Group. Quotes from participants and speakers at the meeting have been included in the hope of capturing the rich discussion that took place. Subsequent meetings will hear about other activity across the Group, including that of new members. The Group will pool this experience to produce a number of focussed reports.

1.2 Key Themes Emerging

A number of key themes emerged in the first meeting:

The need to create a forum for investigating the 'science of pandemics', that dispenses with narrow disciplinary silos, embraces multi- and transdisciplinary approaches, integrates multiple method sciences (data science/data analytics; network science and computational science; public health research), biomedical innovation, social and political sciences, and multiple data sources, and applies the lessons learned by scientists and policy makers during the current pandemic.

That any new global initiatives to research, prevent, prepare for, and manage pandemics must reinforce capacity strengthening in low- and middle-income countries (LMICs), making for better adapted local responses and faster feedback, that will enable, and quickly integrate, innovation in data tools and risk analysis generated by researchers in LMICs.

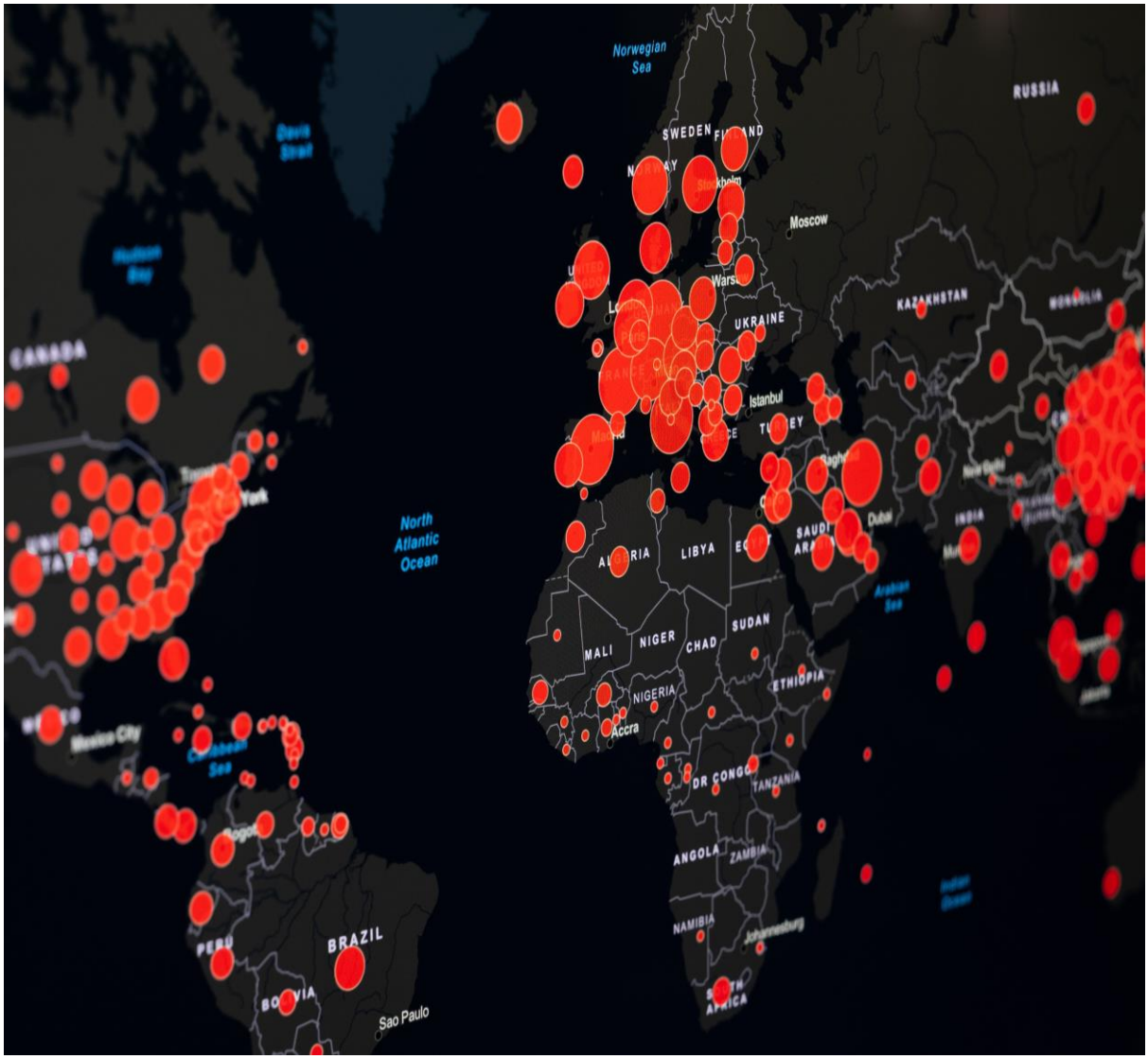
The need for permanent structural and governance changes to the way research is incentivized and rewarded so as to remove barriers to transdisciplinary work and to boost opportunities for researchers in LMICs.

The need to properly value research infrastructure and capacity ahead of epidemics and pandemics—when much of that value is a global public good and hard to see in non-pandemic years—and planetary health and One Health interventions that help prevent pandemics.

The need to improve healthcare systems resilience, including by making sure that Universal healthcare (UHC) better reflects the value of health-system resilience in health emergencies, including beyond the immediate recipients, and imbedding measures of health-system resilience in investment and funding mechanisms.

The need to derive the components, and practical workings, of a pandemic treaty to enshrine individual commitments and collective responsibility for preventing future pandemics, to support new data-sharing and data analytics tools, and for better mobilizing and coordinating future response

Section 2: Causes & Drivers of Pandemics



The Group heard from Jonathan Suk, principal expert in preparedness response at the ECDC, one of the ECDC's strategic analysts who informs their emergency activities, giving feedback to their advisory forum and director on emerging topics of importance. He also coordinates various activities and reports, such as those dealing with COVID-19 in schools. The focus of the ECDC is on recovery and ramping up approaches that all countries can use to systemically document and learn lessons and use those lessons to develop readiness plans for the future. There has been incredible innovation in public health practice as well as in science, and that good practice now needs to be safeguarded.

2.1 The Drivers of Pandemics: Risks & Ability to Handle Pandemics

To mitigate risks and improve future pandemic readiness, we first need to understand the drivers of pandemics. The ECDC worked on the main drivers of infectious disease over ten years ago, which are many, complex, have not really changed since then, and are just as relevant as ever. They were categorised under:

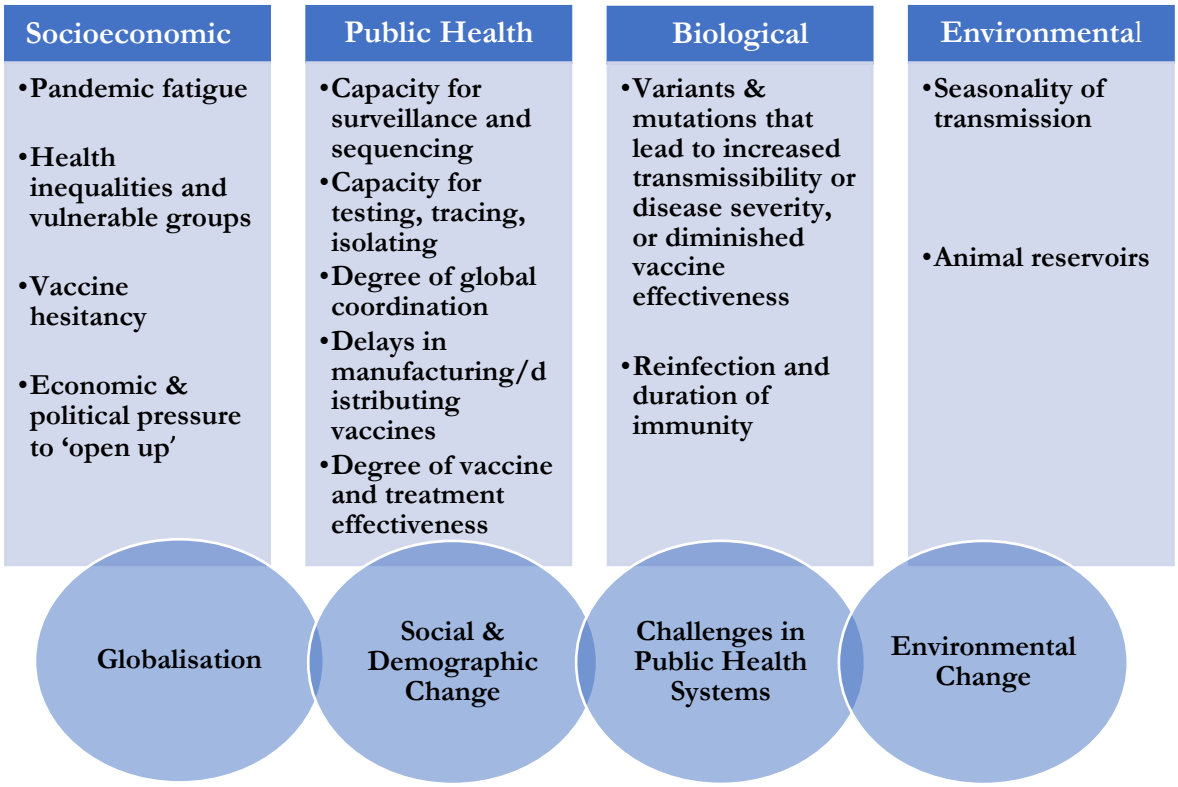


Figure 1. Drivers and Causes of Pandemics[1]

These underlying driving forces impact both the risks of pandemics happening in the first place and the ability to handle pandemics.

The ECDC preparedness response group is working ever more closely with the WHO and EU member states and accession states, as well as with partners such as Africa CDC. There is talk of appointing a liaison officer in every EU country.

Many in Brussels and various EU commissions and elsewhere are working on legislative proposals. The ECDC anticipates a union preparedness plan. It is recognised though that we are a long way from figuring out whether preparedness plans will work and how to know when preparedness is adequate and when it is not. This will need much better understanding of local realities in countries—which is hard to do in a distant centralised top-down mechanism—and a process of

[1] Adapted from Jonathan E. Suk and Jan C. Semenza, 2011: Future Infectious Disease Threats to Europe American Journal of Public Health 101, 2068_2079, https://doi.org/10.2105/AJPH.2011.300181

joint external evaluations. In resource-poor settings this will require significant local capacity strengthening and the support of external donors. This is another area for this Strategy Group to lobby for and support. The need for granular local knowledge in resource-poor settings and to empower local voices and leadership is the same need facing those seeking to tackle antimicrobial resistance, or to develop new digital health and AI tools to use in the field, or wanting to understand planetary health issues. It is why Oxford in Berlin Global Health Initiatives is building global outward-looking structures and not taking an insular Oxford/Berlin/Europe-only approach.

2.2: Learning Lessons from Pandemics

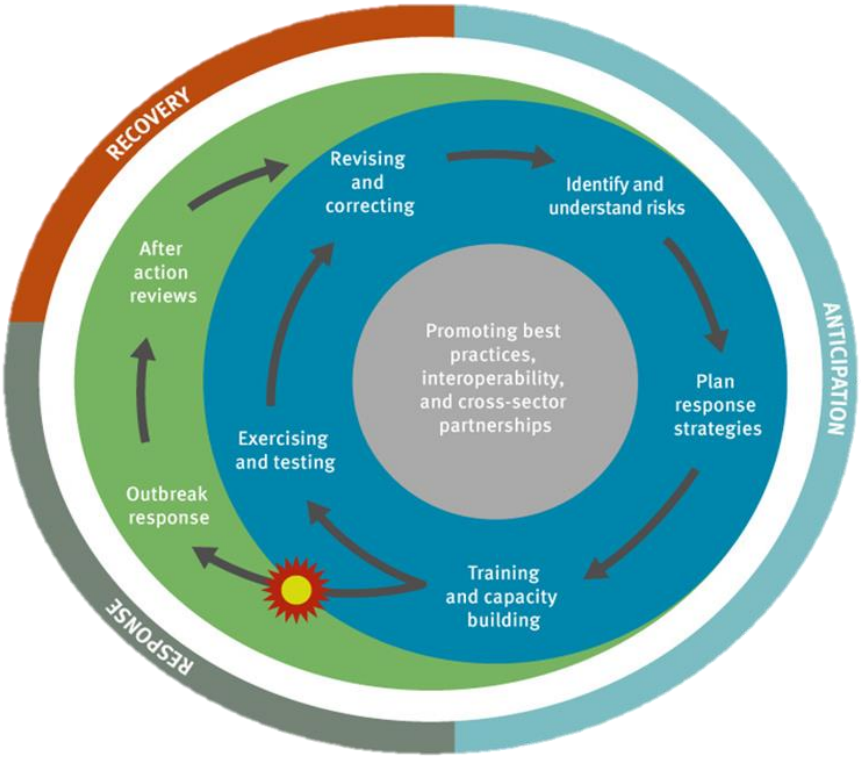


Figure 2. Preparedness and response cycle[2]

Looking backwards at what was missing or inadequate is very useful for thinking about moving forward and at what is needed. The following is a selection from the Group:

[2] Technical Report Ecdc Country PreparednessActivities 2013-2017. Available from https://www.ecdc.europa.eu/sites/default/files/documents/ECDC-country-preparedness-2013-2017.pdf

2.2.1 Infection Control

Infection control is key to tackling all pandemics, which requires focussing on the implementation of IPC (infection prevention and control) and tackling MPI (multi poverty index) issues. Much of this overlap with anti-AMR activities.

2.2.2 Testing

Speed and precision in testing, tracing, and isolation have been evolving and challenging issues. Some countries have managed it better than others.

2.2.3 Cross-Border (Mis)Communication

The spread and management of the pandemic was impacted by cross-border (mis)communication and (mis)coordination on areas ranging from travel to trade and trade barriers. Some of this (mis) communication was down to failure, some seems to have been deliberate.

2.2.4 Global Public Goods and The Pooling of Resources

There are clear challenges around access to and distribution of vaccines, and in maintaining the quality and efficacy of vaccines, but there are many other dimensions, including with regard to physicians, ICU beds, screening tools, all manner of supply chains, etc.

2.2.5 Health-System Resilience

Health system capacity and resilience is very uneven across the world for sure, but even across Europe. The issue is not only about ICUs and capacity for screening. In many parts of the world we are seeing loss of health-care worker resilience from burn-out on the front lines.

2.2.6 Health Inequalities and Vulnerable Populations

The pandemic has exposed the role of multiple existing inequalities as drivers of pandemics and as magnifiers of the damage done by pandemics. Certain groups are much more exposed than others to SARS-CoV-2 and the negative outcomes of COVID-19. SARS-CoV-2 will continue to circulate and cause harm in populations that cannot be reached with vaccines or treatments.

The spatial modelling of various members of the Group gathers information on the most disadvantaged groups and countries hit the worst. Others in the Group are working on the social determinants of health. One such work is a cross sectional study conducted in Sao Paolo Brazil by Li SL et al, with Janey Messina, of Oxford, among the researchers. Their study found that those from low-income setting and Black/Pardo communities had a higher risk for COVID-19 death due to 'differential access to quality healthcare, ability to self-isolate and increased prevalence of co-morbidities'.[3]

[3] Li SL, Pereira RHM, Prete Jr CA, et al. Higher risk of death from COVID-19 in low-income and non-White populations of São Paulo, Brazil. BMJ Global Health 2021;6:e004959. doi:10.1136/bmjgh-2021-004959.

Tackling inequalities is not just good for those whose lives are improved; it has the double benefit of reducing pandemic risks and making pandemics more manageable everywhere. If there is ever an important lesson to learn from the COVID-19 pandemic, it is that we must mitigate and not allow the same inequities post-pandemic or indeed in future pandemics. It is worth noting here some measures put forth by Paremoer L et al 'to enable a more just and sustainable world following the COVID-19 pandemic'[4]:

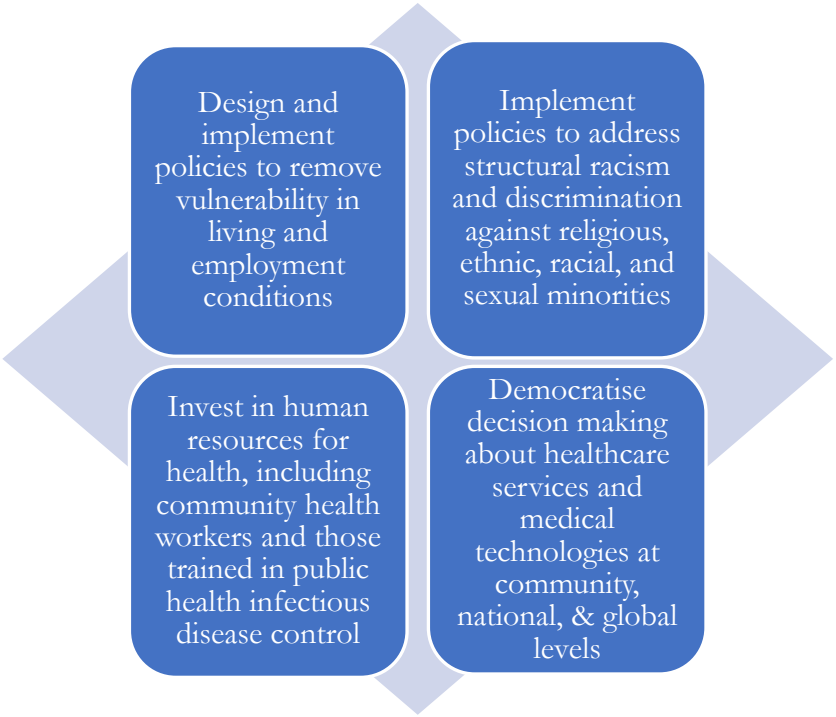


Figure 3. Measures towards a more just & sustainable post COVID-19 world proposed by Paremoer et al 2021[4]

2.2.7 Decision-Making and Political Processes

"However, mere access to models is not enough. Having leaders knowledgeable about the uncertainties in those models and able to interpret that in concrete policy action, and communicate it to society, is quite another matter."

During the pandemic, many political leaders found themselves decision-making in a continuous crisis management mode, something they were not prepared for and, in many cases, not good at. Worldwide we have seen examples of political processes that got in the way of evidence-based decision-making, be it battles in the US over public health measures such as face masks, political rallies and religious festivals in India allowed to become super spreading events, or the opening up prematurely in the UK even as vaccines had only just become available and priority should have been on vaccinating as much of the population as possible first. Politicians have often struggled to

[4] Paremoer L, Nandi S, Serag H, Baum F. Covid-19 pandemic and the social determinants of health BMJ 2021; 372 :n129 doi:10.1136/bmj.n129

identify levels of tolerable risk and to communicate this to their societies and to decide collectively what were appropriate measure and what were not. Many could not communicate uncertainty.

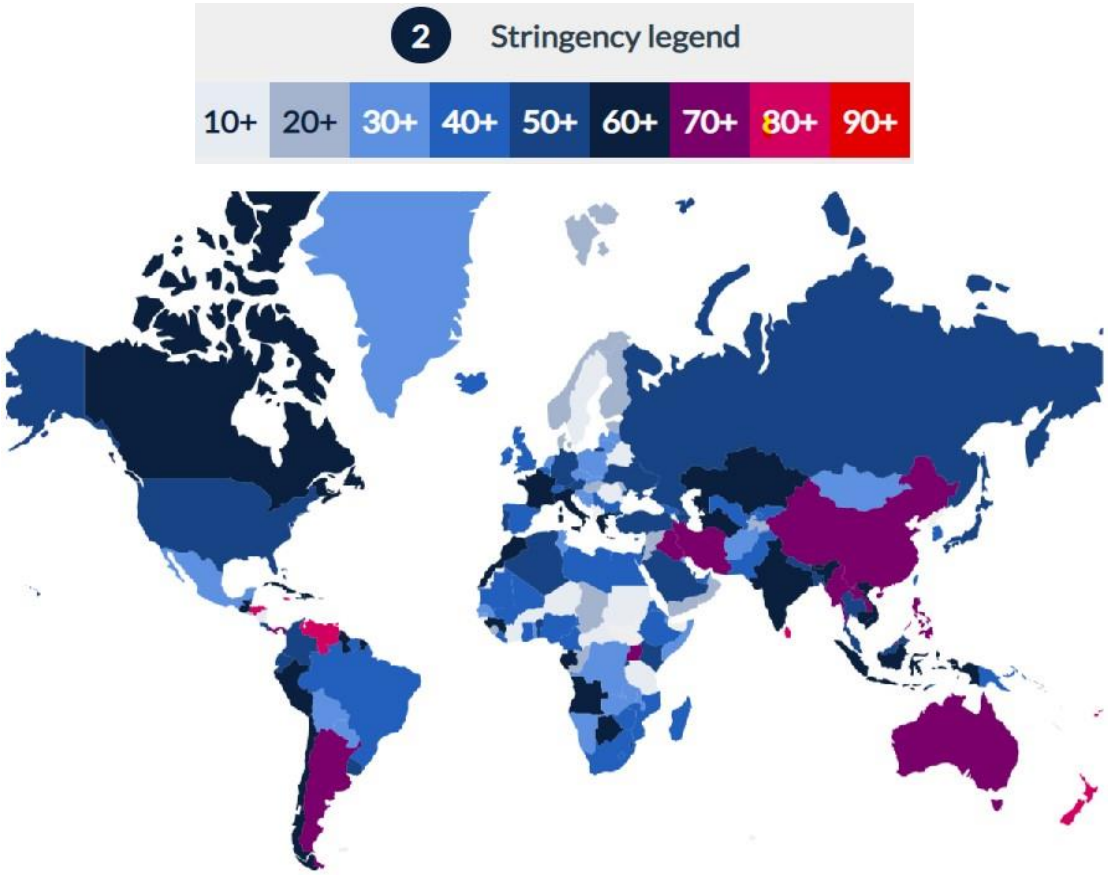


Figure 4. Relationship between COVID-19 cases and government response as of 30/11/2021[5]

2.2.8 The Need for More Social Science

The pandemic got worse in many places not for lack of understanding of the medical situation but for lack of understanding of society. It is not possible to implement public-health measures without the participation of society, and this requires understanding the incentives and motives of people. The phrase 'public health' has the word 'public' in it, yet often political and health-policy leaders failed to understand how to interact with the public. Communication needs to be based on deep social and behavioural insights and risk communication skills. As one member put it: "There is still not enough 'public' in public health."

After the HIV pandemic and after Ebola, there was more appreciation for social science informing policy responses.[6] Yet, there continues to be long-standing challenges to investing in, and incorporating into public health measures, social science perspectives and epistemology (the theory of knowledge, especially with regard to its methods, validity, and scope) and not just epidemiology.[7] Academic interests and funding-body incentives seem still overly biased towards a more

[5] https://covidtracker.bsg.ox.ac.uk/stringency-map

[6] Ripoll S.; Gercama, I.; Jones T. and Wilkinson A. (2018) Social Science Lessons Learned from Ebola Epidemics, SSHAP Lessons Learned , Kippax, Susan. "Effective HIV prevention: the indispensable role of social science." *Journal of the International AIDS Society* vol. 15,2 17357. 26 Apr. 2012, doi:10.7448/IAS.15.2.17357

[7] Bardosh, K.L., de Vries, D.H., Abramowitz, S. *et al.* Integrating the social sciences in epidemic preparedness and response: A strategic framework to strengthen capacities and improve Global Health security. *Global Health* **16,** 120 (2020). https://doi.org/10.1186/s12992-02000652-6

medicalised understanding of virus pandemics. The present pandemic has again reminded us that social science needs to be at the forefront of all epidemic/pandemic preparedness and responses.

Figure 5. Informational contribution of social science to epidemic response[7]

2.2.9 The Need for Planetary Health and One Health Approaches

The health of the planet and animal health are key to tackling the causes and drivers of pandemics.[8] Over the past 30 years, 75% of emerging/re-emerging infectious diseases and subsequent epidemics and pandemics have been zoonotic—that is, they have jumped from non-human animals to humans.[8] The main drivers of these diseases are human activities which not only affect human health but animal health and the environment. Hence, a One Health approach is now considered the most effective way to prevent and respond to these health threats.

The concept of One Health is not entirely new. However, it was during the 2003/2004 SARS outbreak at a meeting organised by the Wildlife Conservation Society (WCS) that the term "One Health" took off. Subsequently, various definitions have been employed with debates ongoing regarding the potential scope of One Health. The newly created One Health high-level expert panel (OHHLEP) describes One Health as "an integrative and systemic approach to health, grounded on the understanding that human health is closely linked to the healthiness of food, animals and the environment, and the healthy balance of their impact on the ecosystems they share, everywhere in the world".[9]

[8] https://www.unep.org/resources/report/preventing-future-zoonotic-disease-outbreaks-protecting-environment-animals-and
[9] https://www.who.int/groups/one-health-high-level-expert-panel

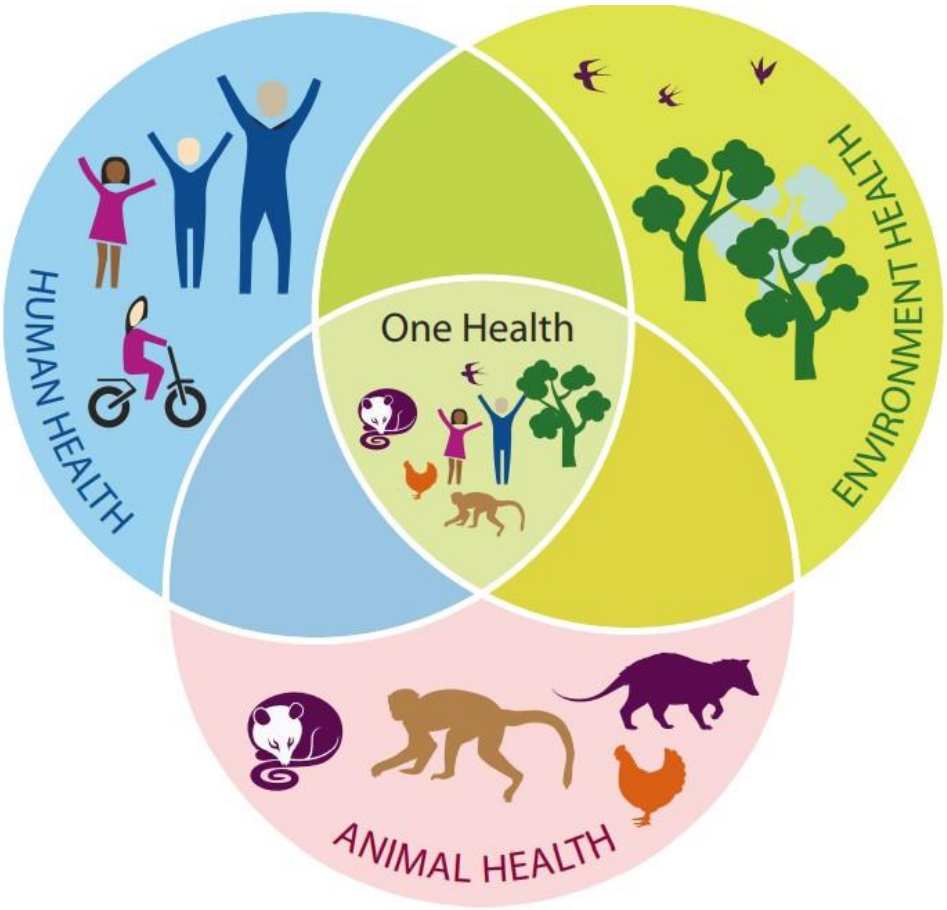


Figure 6: The One Health Approach, recognising the interdependence of human, animal, and environmental health[9]

One Health is nuanced in its multidisciplinary and cross-sectoral paradigm. It is an approach which recognises that in order to efficiently and sustainably prevent, control, and mitigate pandemics, an interdisciplinary, non-siloed collaborative approach is required.[11] This was echoed at the launch of The One Health High-Level Expert Panel by WHO Director-General, Dr Tedros Adhanom Ghebreyesus who said: "Human health does not exist in a vacuum, and nor can our efforts to protect and promote it. The close links between human, animal, and environmental health demand close collaboration, communication, and coordination between the relevant sectors…" and also by Mr Heiko Maas, Minister for Foreign Affairs of Germany who noted that "COVID-19 has painfully reminded us that the health of humans, animals, and the environment around the world is closely connected: Nobody is safe until everybody is safe. This is what we have to bear in mind to prevent future pandemics…"[10] At the 27th Tripartite Annual Executive Committee Meeting World Organization for Animal Health (OIE), the WHO Director-General reiterated the

[9] https://www.unep.org/resources/report/preventing-future-zoonotic-disease-outbreaks-protecting-environment-animals-and [11] Mackenzie JS, Jeggo M. The One Health Approach-Why Is It So Important? Trop Med Infect Dis. 2019 May 31;4(2):88. doi: 10.3390/tropicalmed4020088. PMID: 31159338; PMCID: PMC6630404. Destoumieux-Garzón D, Mavingui P, Boetsch G, Boissier J, Darriet F, Duboz P, Fritsch C, Giraudoux P, Le Roux F, Morand S, Paillard C, Pontier D, Sueur C and Voituron Y (2018) The One Health Concept: 10 Years Old and a Long Road Ahead. Front. Vet. Sci. 5:14. doi: 10.3389/fvets.2018.00014

[10] https://www.who.int/news/item/20-05-2021-new-international-expert-panel-to-address-the-emergence-and-spread-of-zoonotic-diseases

significance of One Health: "We can only prevent future pandemics with an integrated One Health approach to public health, animal health, and the environment we share…".

Despite the importance of the One Health approach, as well as calls of action such as The Hanoi Declaration[11] and the Manhattan Principles[12] (which have been more reactionary) there are challenges in the One Health approach that are yet to be tackled. These include lack of holistic, horizontal systems, limited environmental health incorporation, and insufficient wildlife-disease monitoring particularly at national levels.[13] In addition, the pressing impacts of climate change and biodiversity loss have presented new challenges since the Manhattan Principles. To address these, an update of the Manhattan Principles, 'The Berlin Principles on One Health' were put forth in 2019 just prior to the COVID-19 outbreak.[14] These 10 principles are based on a One Health ethical framework of 'Solidarity and Environmental justice'[15] – that is, solidarity and justice at the human, plant, and environment interface and a closer look at any inequities posed by 'triple emergencies' (global health, climate change, and biodiversity loss). The inclusion of non-communicable diseases, the need for translation of evidence-based science to implemented policies, economics and global citizen participation in the Berlin Principles are welcome developments to ensure the operationalization of One Health.

Until this One Health approach is employed in every aspect of pandemic surveillance and preparedness, there will be a crack in even the strongest of walls against pandemics.

[11] Hanoi Declaration Sets Global Framework for Avian Influenza, Pandemic Readiness, Proposes National Steps to Detect Animal-Human Transmission, Control Outbreaks | Meetings Coverage and Press Releases (un.org)

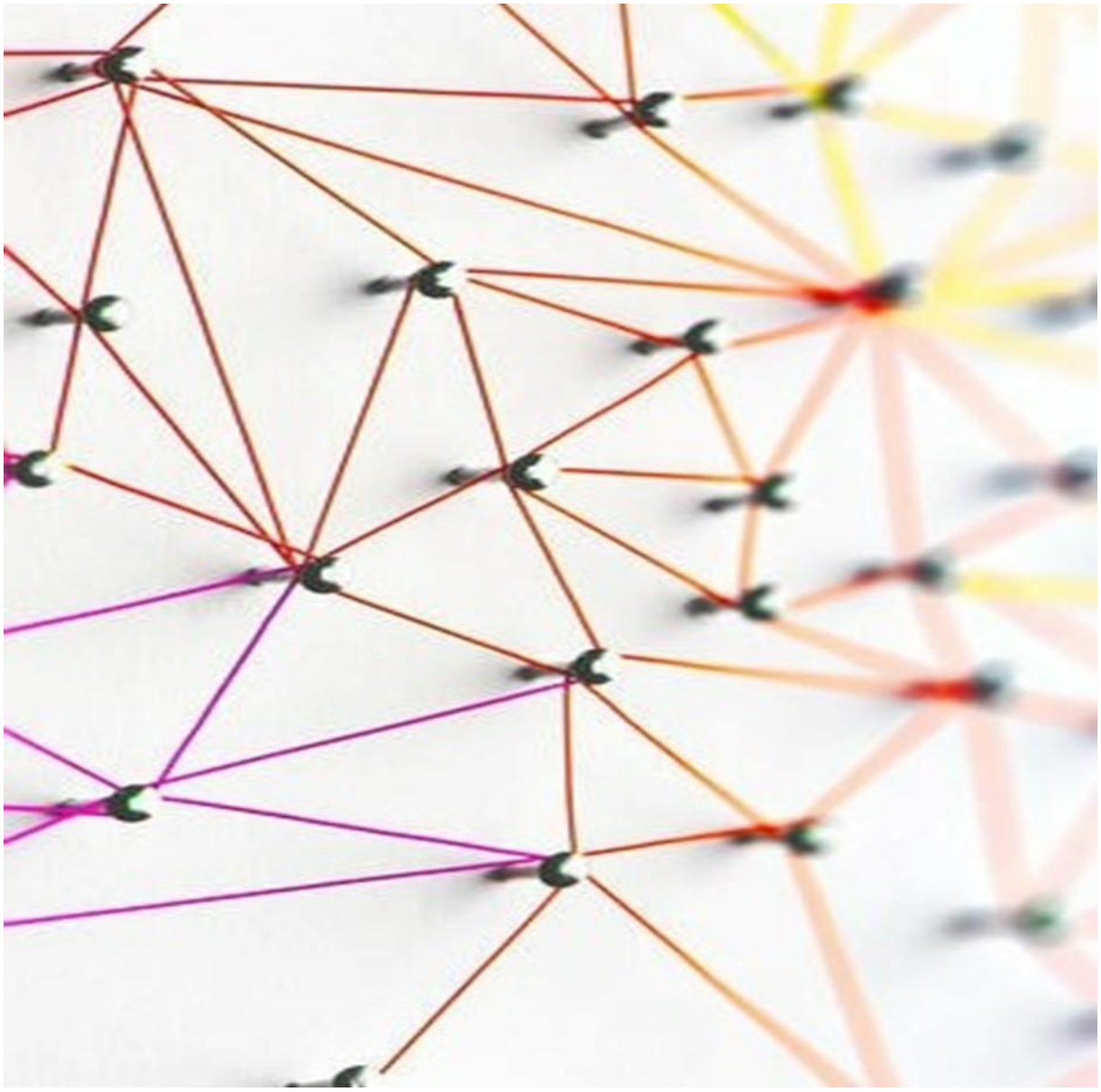
[12] Twelve Manhattan Principles Formulated (onehealthcommission.org)

[13] Acharya et al. Emerging pandemics: Lesson for one-health approach. Vet. Sci 7:1 https://doi.org/10.1002/vms3.361. Kelly et al. One Health Outlook (2020) 2:1 https://doi.org/10.1186/s42522-019-0007-9. Kelley Lee, Zabrina L. Brumme, Operationalizing the One Health approach: the global governance challenges, Health Policy and Planning, Volume 28,Issue 7, October 2013, Pages 778-785, https://doi.org/10.1093/heapol/czs127

[14] Kim Gruetzmacher, William B. Karesh, John H. Amuasi, Adnan Arshad, Andrew Farlow, Sabine Gabrysch, Jens Jetzkowitz, Susan Lieberman, Clare Palmer, Andrea S. Winkler, Chris Walzer,The Berlin principles on one health – Bridging global health and conservation,Science of The Total Environment,Volume 764,2021,142919,ISSN 0048-9697,https://doi.org/10.1016/j.scitotenv.2020.142919

[15] Lysaght, T., Capps, B., Bailey, M., et al., 2017. Justice is the missing link in one health: results of a mixed methods study in an urban city state. PLoS One 12 (1), e0170967. https://doi.org/10.1371/journal.pone.0170967

Section 3: Creating an Interdisciplinary, No-Silo Science of Pandemics



"In a pandemic, so many things come together, so many fields come together, and lots of experts come together … disease dynamics, informational components, psychological process, behavioural changes, policy, all play together."

3.1 Need for More Scientific Conversation

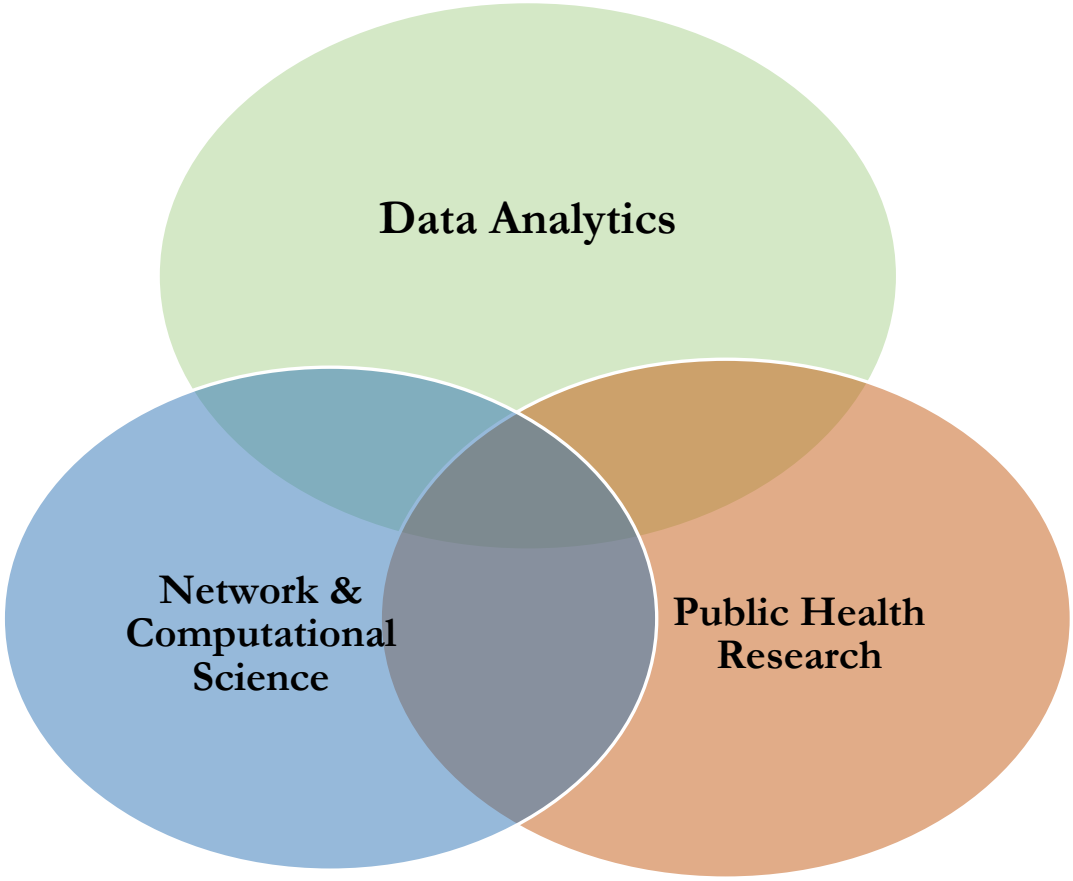
A major limitation facing those working to tackle the pandemic has been the few opportunities for genuine scientific exchange. There has been, as one member of the Group explained, "communication in journal articles and in TV talk shows" but no conferences or meetings. The creation of this Group is an opportunity to provide some missing conversation that will lead to the creation of a 'science of pandemics' and lead society towards permanent structural changes in the way we research, prevent, prepare for, and manage epidemics and pandemics. It might be the space within which key components of a global pandemic treaty can be developed.

The formation of the Global Health Strategy Group for Pandemic Lessons and Future Pandemic Preparedness is in an opportunity for several countries, and especially the UK and Germany, to explore in greater detail what they did well and what they were less successful at. For example, the lack of a domestic tradition of infectious disease modelling was identified by Berlin researchers as "a massive, massive problem in Germany." Compared to the UK, there are a handful of groups; of those, 90% started only in the last year and moved in from other fields. One back-of-the envelope calculation found about 160 times more published in this field in the UK than in Germany. Meanwhile, because of the critical importance of high-quality diagnostics in a pandemic response, the UK can learn greatly from Germany, especially from the work of the Robert Koch Institute in getting diagnostics up and running quickly. Germany also performed well compared to other countries tackling the first wave. In its second and third waves, in the words of German scientists in the Group, Germany did "no better than other countries, and there was nothing special about Germany." Both Germany and the UK have much to learn from each other and 'Oxford in Berlin' was described as "a force-field to bring us together" and share experiences and build the necessary conversations.

3.2 Integrating Multiple Method-Sciences For a Science of Pandemic

The Group heard from Dirk Brockmann, professor of physics, based in the biology department at Humboldt, working also on projects at the Robert Koch Institute. Since 2004 he has been working on infectious disease modelling, and network science. He is part of the German noCOVID initiative, a group of interdisciplinary and public health scientists developing tools and strategies for bringing about a low COVID incidence scenario in Germany.

His big lesson from the pandemic is that a 'science' of pandemics will need the integration of three 'method' sciences: data science/data analytics; network science and computational science; public health research



Yet these three things are not part of any educational agenda in the life or medical sciences. Many working in public health are from medical backgrounds and have never been exposed to these areas, they therefore end up trusting research that comes out of these areas without understanding the tools. To move away from this, change must start at the university level, by integrating these areas into university curricula. Students must have at least a basic understanding of what data science/data analytics is, the rudiments of network science, and must have programmed a computer at least once. All these need to be integrated into medical research, behavioural sciences, and life sciences, since all are part of understanding a pandemic.

"All the massive research in these areas is not known in public health research in Germany…in Germany there is a lot of room for improvement."

Two data science and computational science projects, performed by Brockmann and colleagues, were used to illustrate how to infer behavioural changes from data and so better understand the dynamics of SARS-CoV-2 and its impacts. It was noted that if we are to make any progress we need courage to do things that may fail.

3.3 Breaking Down the Silos

"We really need to get rid of this silo mentality. Expertise is important, but we really need to listen to the other people from other fields better… It is much easier if we at least understand the methods they are using. We need to get rid of disciplinary thinking in pandemics, and climate change too… There is a lot of room for improvement in transdisciplinary efforts."

Tackling pandemics is complex. Surveillance and biomedical aspects are critical components, but focusing on only highly medicalised approaches to viruses would miss the big opportunity to radically change our pandemic preparedness and, indeed, our resilience to viruses. Instead, the starting point has to embrace a very broad perspective, breaking down disciplinary silos, and viewing problems and their solutions holistically. Much more attention needs to be paid to social, political, and technological factors, and to engaging with the public. Richard Feynman was quoted: "If you are the smartest person in the room, you are in the wrong room".

The value of an independent diverse expert group was noted by many. The hallmark of all four Global Health Strategy Groups that have been put together by Oxford in Berlin is their truly interdisciplinary nature and the effort many of their members are making to break out of their own specialism-specific silos. Scientists need to speak out—disseminating sensible high-level messages to policy makers and the public—because they do have greater insight and authoritativeness than others who otherwise occupy the vacuum. The next steps for this Global Health Strategy Group may be complicated by the broad range of expertise and disciplines it contains, but the willingness to have open and deep conversations cutting across disciplines gives the Group hope.

"Much more attention needs to be paid to social, political, and technological factors, and to engaging with the public."

3.4 The Challenges in Academia of Interdisciplinary Work

Breakthrough will come only when multidisciplinary activity creates viable career paths for young researchers and is valued by publishers. We were presented with case studies of young researchers—including two who joined multidisciplinary AMR projects, funded by the ESRC precisely because they were multidisciplinary—whose careers were blighted when they tried to merge back into the normal non-multidisciplinary stream of their scholarly field based on publications coming out of the project. They had discovered the hard way that the publication model works well for well-established fields, but that interdisciplinary work is challenging to

publish. Those working in digital science and AI related to healthcare found many barriers to publishing. Cases were mentioned of publications that were interdisciplinary or transdisciplinary but counted for nothing for a discipline-specific REF (Research Excellence Framework) panel judging that discipline within very narrow bounds. It was noted "There is no panel to assess cross disciplinary research." The economists noted how academic economics gives little promotion reward to researchers for publishing in journals outside the discipline. In some subject areas, publications typically 'count' less the higher the number of authors, actively discouraging collaboration. A colleague noted that "Being a sole or joint-author on a limited-author paper is better than being sixth in a list of 10 even if it is your 'small' contribution that made the research transformational." It was noted that INTERCOVID opted against publishing in a journal that had limits on author numbers to make sure that all collaborating centres were represented.

"When it is truly interdisciplinary work, having to do with true data science, the clinicians find it often obscure or difficult to understand. And vice versa. If it is work more driven by the healthcare setting, it might not be novel enough from the data science perspective. You might say 'just write more suitably and someone will take it', but it does not work that way. If it is truly interdisciplinary, you will find barriers in understanding within journals."

"Compared to what happened in the case of the h1n1 (swine flu) virus, there has been much less inertia in the willingness to share data until results are out. This has leapt forward. What has not leapt forward are the institutional incentives and the way academic work gets rewarded. Germany, Berlin and Oxford have put together in this Group something to potentially pilot to incentivize and reward around interdisciplinary work and should use some of the modest additional funding available around this Group to try to incentivize a more progressive approach that is less siloed. That would be a really interesting step forward."

As Berlin is now a hub of digital publishing,[16] the group should explore how the sort of interdisciplinary data-science-driven healthcare they propose might fit perhaps in a new journal of transdisciplinary pandemic science.

[16] https://www.businesstimes.com.sg/technology/where-the-wall-once-cut-through-berlin-a-digital-giant-rises

3.5 Institutional Collaborative Frameworks: Examples from Particle Physics, Astrophysics, and Genome-Wide Association Studies

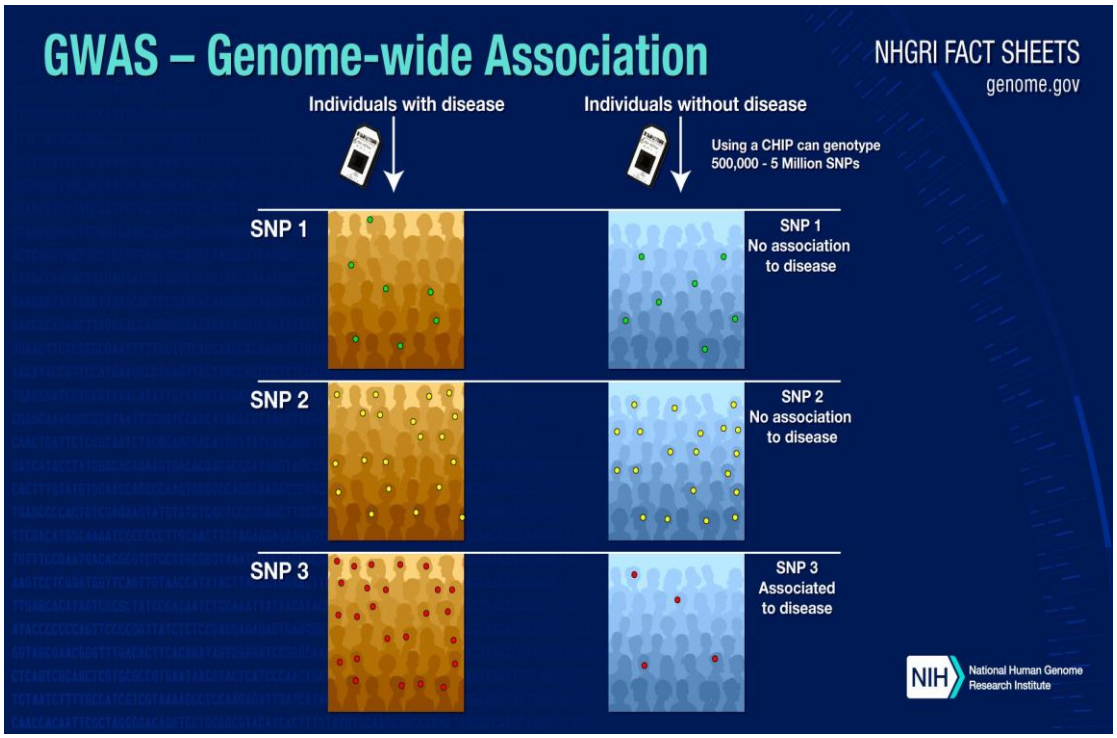


Figure 7. Genome- wide Association[17]

"In particle physics there are people who just focus on gathering the data, others writing tools to analyse the data, and experts in writing things up, with regular collaborators meetings, and all are listed as collaborators on the papers. This Group should explore how to set up collaborations like this. Instead of just making a statement now, maybe the Group should have a working collaboration and have tools ready to do this in the future."

The challenge we face is so huge and the field of pandemic science so potentially interconnected that, instead of lots of competing groups, we need to learn the lessons of large scientific projects—in particle physics, astrophysics, and genome-wide association studies, which are naturally thought of as global collaborations—and find ways to work ever more closely together. These have more collaborative publication models and have found ways to share credit and create better incentives. However, it was noted, such multi-billion-dollar endeavours—with each component a tiny cog in a massively expensive machine—are forced to structure themselves in such ways. A large global effort for tackling pandemics faces the extra complexity of appealing to a very large range of disciplines and institutions which are much more difficult to influence, and it is easy to end up with groups competing against, and cutting across, each other in efforts to divide up pockets of money.

[17] National Human Genome Research Institute

Section 4: Capacity Strengthening That is Truly Local: A Tough Journey, With Implications for 'Data Sharing'

"It is costly to do capacity building compared to what we do at the moment, and there is little or no financial incentive to build capacity beyond lip service of a week or two a year. At the moment, the convention is to train people for three years as part of a PHD programme and as part of a well-funded research group. Then, typically, capacity building comes in the form of a one-week or two-week workshop with partners in other settings. If we continue to assume that this is what capacity building is and this is all the budget there is for it, we are never going to change. The notion that this makes it a level playing field is wrong."

4.1 Epidemiological Modelling Tools at The Ready, Not a Scramble

Several members of the Group (Oxford and LSHTM) discussed their work on mathematical epidemiological modelling. Such modelling has two purposes. One is to make sense of the data being collected during outbreaks so as to better guide real-time decision-making. The second is to explore possible scenarios to guide future policy, employing close-to-data short-term forecasts. It is another side effect of funding mechanism that such models only get created during, rather than in advance of, pandemics. A common thread was the need for international capability, in the shape of many multinational hubs, virtual or real, building local capacity, and not one big central hub. It would be hard work to achieve this but the benefits would be huge.

We heard from Sebastian Funk of LSHTM who works broadly on infectious disease epidemiology using mathematical models. Much of his recent work has been on real-time forecasting of outbreaks. In past episodes of modelling for Ebola in West Africa, cholera in the Yemen, and diphtheria in Bangladesh there had been an urgent need to make sense of the real-time situation on the ground, but there was a scramble to put together the necessary modelling tools.

There is much heterogeneity in modelling capacity across Europe specifically, but also worldwide, and during the pandemic many uncoordinated efforts around the world could have benefited from generic modelling tools. Future prevention and preparedness will be greatly helped by the development and ready availability of generic tools that came out of this pandemic. Several examples of tools developed from scratch by LSHTM and colleagues during the pandemic were illustrated, including an R package, now being used by public health agencies around the world (with results represented on a website and used for various studies) and a website tracking virus reproduction numbers globally, nationally, and sub nationally. Nevertheless, while there are global dashboards, it was noted that we should be sceptical of such things even when contributing to them. Far better, if at all possible, to provide information tailored to local situations.

On Multiple Modelling Approaches

It was agreed that it is important to have multiple modelling approaches because any one model alone will not be able to give an accurate answer.

Models need to be combined, and they also need to combine multiple data sources—behavioural as well as virus-related—and to improve in real-time. In previous outbreaks, modelers did not understand how peoples' behaviours changed, what motivated such behavioural change, and how this affected the epidemiology. This made real-time modelling very difficult. Modelers had long talked about monitoring behaviour as much as clinical issues, but it took the SARS-CoV-2 pandemic to get this launched, in mid-March 2021 (by Jon Edmunds, LSHTM) as part of a European project (including the UK and Germany), comprising a weekly survey of a panel of people asking them how many people they had been in contact with, and a range of other questions. This has greatly helped inform such epidemiological models. Stephan Flasche, the new director of the LSHTM modelling centre was introduced to the Group, and there was a suggestion that a future meeting might explore the centre's work on control and other measures.

Multinational Hubs

The LSHTM modeling group have set up with the ECDC a European COVID-19 forecasting hub which tries to make short-term forecasts for 32 countries in Europe including Germany and the UK. The hub combines results from multiple models (32) and multiple modeling teams (25) from around the world. Every week, teams submit forecasts and the output is aggregated. This has multiple benefits. In particular, the accuracies of forecasts increase when multiple different forecasting approaches are combined. And it serves to create a global community.

4.2 Capacity Strengthening During the Pandemic

In March 2020, Lisa White of Oxford put together a COVID-19 modelling consortium. Modelers from all over the world joined, some of whom are very experienced and have their own hubs in South Africa, Thailand, Brazil, etc. Others were not modellers when they joined. Instead of the modelling being done in the UK for other countries to use, the concept was to help those who are modelers or capable of being modelers take charge of the work for their own countries. The role of the Oxford group was to provide resources, training, and support, and a platform for sharing ideas and developing a shared model—and freely given code—that could be accessed and modified by country teams to suit their own specific settings. The national teams would be the point of contact with decision makers, which ranged from WHO regional or national offices or ministries of health or even the PM or president of the country. They would support each other to reach out to policy makers in each country.

Though building capacity is hard, and garners little financial support, Lisa White and her group were able to achieve this as proof of principle. Now this new international network is looking beyond COVID-19. The next stage, PREAM, Preparing for an Epidemic Analysis and Modelling, will streamline the network, consolidate through training and funding, and build on this recent activity so that there will be sustainable international resources for modelling in the future.

Another part of the approach involves shifting the centre of gravity to Africa, with a new leader, Sheetal Silal, who leads an up and coming hub and group in South Africa (this, incidentally, mirrors the way the Global Health Network, (https://tghn.org) initially founded in Oxford, by Trudie Lang, is now led by three operational centres in Asia, Africa, and Latin America).

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To support this work, a new MSc in Modelling for Global Health launches this year at Oxford.

4.3 Why Is Building Global, Yet Local, Capacity Better? Modelling Case Study

First, the modelling work itself is better adapted to local situations. COVID-19 is highly age dependent. The proportion of the population at high risk varies by an order of magnitude between high- and low-income settings. Furthermore, the resources available for the sort of interventions developed for COVID-19 vary hugely between high- and low-income settings, such that the wholesale deployment of strategies that are used in high-income settings to low-income settings could have quite drastic local consequences and not be fit for purpose given that COVID-19 is such a different disease in terms of its lethality, and in comparison, with other health risks in such settings.

"In trying to understand what the issues are, one of the most important things is to pose the right questions. Without knowledge of the health system, priorities, and settings it is very hard to pose the right question to answer for an infectious disease model. It is faster to teach people to do modelling with them already in that setting and have those communications channels open than to try to understand those systems from afar quickly enough to pose and answer the right questions."

Second, because it is faster. It might seem that concentrating all the modelling in the big centers where all the expertise, experience and history is would be faster, but communicating results to policy makers, and making sure they will listen, is much less efficient. Communications from interactions with policy makers back to the modellers to support the models in tackling the 'right questions' is also much quicker with local capacity.

4.4 Barriers to Building Equitable Global Health Capacity

"We all talk about capacity building, but the basic problem is it is hard work, it's a thankless task because the ultimate results is you don't take credit for the work someone else does because you build their capacity and they used it and, third, because nobody will pay for it. It's the reason we all talk about it and it does not happen."

Many in the Group argued that the incentives created by the academic system and by research funders is "completely misaligned with the needs of meaningful capacity building". There have been repeated calls for the creation of more equitable global health research capacity. One such example is the Bamako call to action of 2008 which called for equity in global health research by pointing to the small proportion of research funding which addresses health challenges of the poor and marginalised. It also called for health research that was determined by countries, fully contextualised, and not dictated by international institutions, as well as recognising the role that civil societies play in research.[18] Yet, we continue to fall well short. Any new effort to create pandemic early warning and emergency response hubs and networks must prioritise fixing this failure first, not reinforcing the faults already in the system.

Funding

The barriers to equitable Global Health capacity are not always consciously deliberate but they do exist as "part of the status quo". It was noted that, with a few recent exceptions, funding systems are set up to maintain the status quo. Funders often reward competitive success that splits groups apart, and not collaborative success that brings them together.

Yet, the 'old model' of keeping everything to oneself, and "getting a paper out in Science" and is being replaced by "moving forward together as a group and doing something meaningful that helps people and has impact beyond or in parallel to, or—in a lot of cases— before publications appear in peer review literature."

The metrics of success, such as publication as first or senior author, also mean that funding has to be held at the institutes of principle investigators. To build up the portfolios of up-and-coming global health researchers around the world requires more established PIs to sabotage their own careers to allow others to gain what they need to get their own funding.

[18] https://wacihealth.org/wp-content/uploads/2018/05/the-bamako-call-to-action-on-research-for-health.pdf

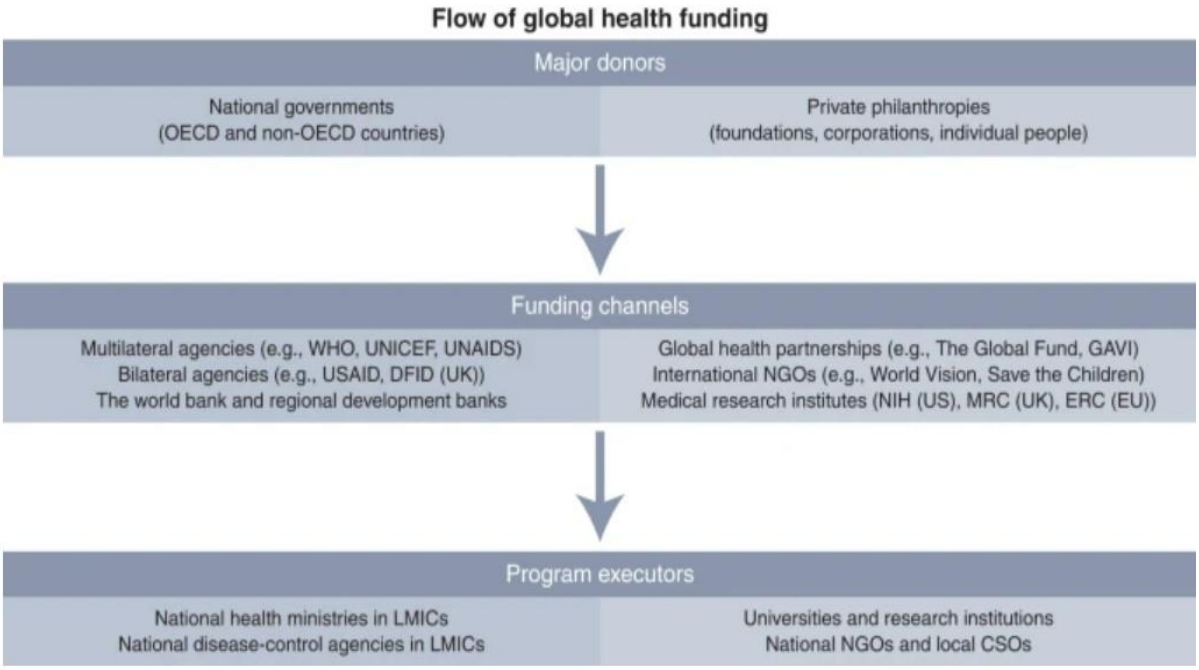

Figure 8. An overview of the funding flow for global health policies and programmes[19]

'Global North and South'

Then there is the mindset, which persists in some areas, that regards researchers from LMICs as junior partners rather than leaders or potential leaders, as laboratory technicians or data providers rather than primary investigators or potential principal investigators. It was noted that some Product Development Partnerships and some big global institute/research hubs had treated those gathering data 'on the ground' as merely another resource to support their own, usually already well-funded, enterprises. This Group strongly intends to break with this pattern. Again, any new push to create pandemic intelligence hubs or networks must fight against and not further entrench such inequality.

Prevention Centred

In previous meetings, especially the one on 'Data in Health' in June 2019, it was noted that competitive approaches to healthcare funding often de-emphasise prevention even when prevention is the most effective option overall. We saw this in the meagre flows of funding to prevent the current pandemic in comparison to what was spent fighting the pandemic. This approach de-emphasises prevention: It is a huge relief that vaccines were developed in record time but it is much easier, and more dramatic in the face of a pandemic, to show the workings of a vaccine against a virus than it is to show the benefit of interventions that would have stopped the virus in the first place. We need to find ways to make the latter into an equally salient and dramatic result for funders and publishers.

[19] Olusanya, J.O., Ubogu, O.I., Njokanma, F.O. *et al.* Transforming global health through equity-driven funding. *Nat Med* **27,** 1136–1138 (2021). https://doi.org/10.1038/s41591-021-01422-6

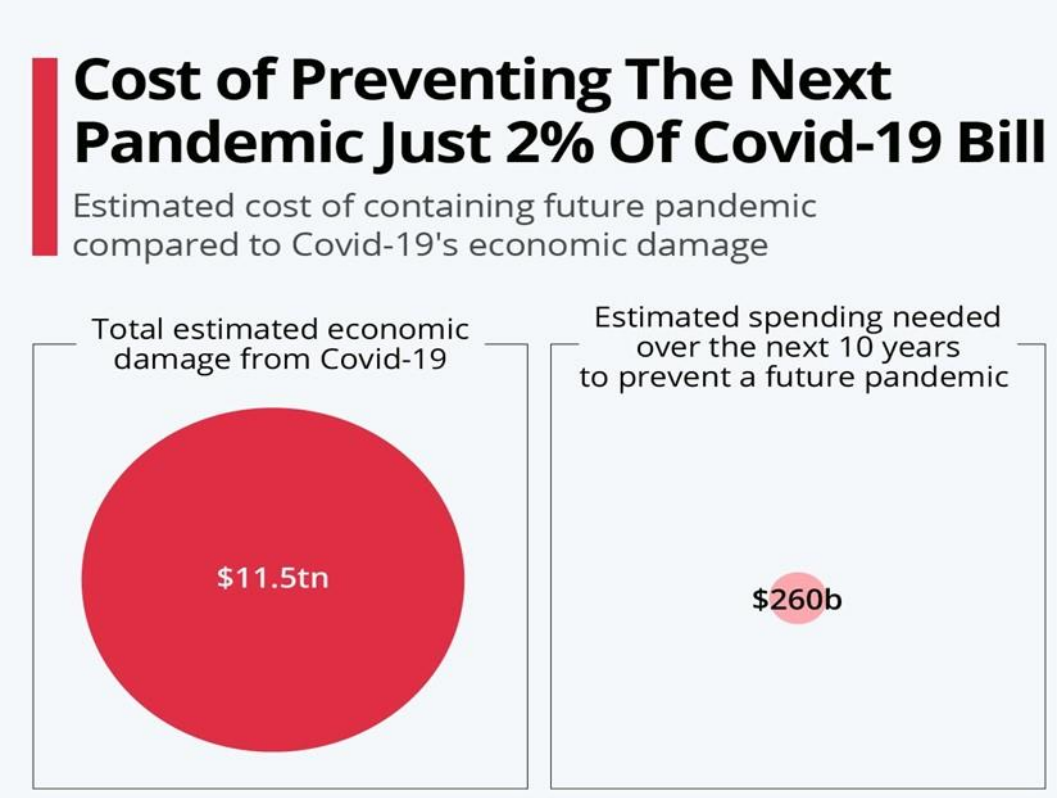

Figure 9. Estimated cost of COVID-19 versus cost of preventing next pandemic[20] Adopted from Dobson et al, Science 2020[21]

Nature of Global Health Research

Another of the many inequalities the pandemic has exposed is the way academia functions and how research is done around the world. This, like all other inequalities, tends to make pandemics more likely, and greatly worsens our ability to tackle pandemics. All the talk of global data gathering and creating 'innovations' in data tools has to be matched by an equally strong effort to tackle research inequalities, otherwise even well-meaning efforts to improve data handling will just reinforce the already existing distortions and status quo, and blunt the effort from the start.

[20] Statista

[21] Dobso A, Prim S, Hannah L et al. "Ecology and economics for pandemic prevention: Investments to prevent tropical deforestation and to limit wildlife trade will protect against future zoonosis". Science, (2020), 379-381, 369(6502)

4.5 Data Sharing

In light of the above, data sharing and innovations to increase availability and linkage of data sets have to be treated with great care. Local reasons for gathering data must be factored into the data gathering exercise from the start so that it supports, and does not weaken, local capacity strengthening. And more ways need to be found to share credit (more local PIs and new data tools, perhaps such as blockchain recording of data 'ownership' before it is forwarded for higher levels of aggregation).

"People who are collecting data in difficult circumstances with limited resources need the time and resources to analyses it as their 'own data' first. If they share their data too quickly, it is a feeding frenzy; they do all the hard work collecting all the data and someone else gets all the credit for analyzing it and putting it in a high-profile journal. This, incidentally, creates terrible incentives for the creation and maintenance of data in the first place."

Participatory Experiments

One participatory experiment—designed to infer if people have fevers or raised temperatures—asked half a million people to donate their data every day on step counts and heart rates collected on smart devices/watches. The experiment was conceived in April 2020, and went well but there were many obstacles.

Another example analysed mobility data in Germany over the past year as an indicator of how people change their behaviour. This indicated that in the first lockdown the virus was well contained because people were very afraid of the pandemic and, of their own volition, reduced their mobility and contact; here was little effect of government policies on this. When people got tired of this, it showed in the daily data.

"We have to be careful when global data-sharing ideas are put forward that they hit the target they are aiming for. If we want to achieve true diversity, then we will get better science, more appropriate science, done by the right people answering the right questions in the right places…but some of us are going to need to get out of the way… and support other people [in LMICs] to lead this work. Plenty of researchers are doing this, but they are doing it at a personal cost, to the detriment of their own career development… it is time for the people paying for the research to take away those barriers and replace them with incentives."

In this context, the Global Health Strategy Group for Pandemic Lessons and Future Pandemic Preparedness welcomes a robust discussion about a number of recently announced initiatives.

The Group is keen to explore how the WHO-German hub for pandemic and epidemic intelligence might truly be a 'global-locally-situated platform for pandemic and epidemic intelligence', 'driving innovations in data analytics' in LMICs as much as in HICs.

First off, any new 'hub' should equally prioritise data and risk analytics innovation in the spokes away from the 'hub', which means that funding has to be set up from the start to go also to the spokes on level playing-field terms. Any new hub that shifts control of data to Berlin because that is "where all the resources and money are" would be totally counter-productive and, indeed, some have noted, deeply colonial and contrary to the direction global health research has been going in recent years. Second, for what purpose, or more specifically for whose purpose, is the data gathered? Those sharing data have got to benefit too, not just at their country level but also at a personal level. How does their taking part boost their own career paths? This needs to be linked to the greater (local systems) resilience picture. Global hubs should not perversely weaken local system resilience.

Much investment is already going into surveillance, including next-generation genomic surveillance. The UK government has announced a plan to create an advanced international pathogen surveillance network to identify and track new COVID variants and emerging diseases. The notion of 'variants of concern' has highlighted the issues. It is sobering to reflect that, before the pandemic, on the Global Health Security Index—a joint project of the Nuclear Threat Initiative (NTI) the Johns Hopkins Centre for Health Security (JHU), and The Economist Intelligence Unit (EIU)—the US and UK were ranked the first and second most prepared countries in the world, in terms of their infectious disease surveillance and protection systems, but that such an accolade did not prevent them from suffering some of the worse from the pandemic.[22]

[22] Global Health Security Index, https://www.ghsindex.org/

All this new investment will be to little good if it does not go hand-in-hand with efforts to better understand society and to strengthen local research capacities. Finally, the RKI has set up a new centre for artificial intelligence and public health that will employ about 200 new personnel. Those speaking on behalf of the RKI noted that there is a long way to go with developing new tools (for example even daily reports are still done manually) and they very much hope they can learn a lot from their exchange with the Global Health Strategy Group for Pandemic Lessons and Future Preparedness and the Global Health Strategy Group for Digital Health and AI for Health.

4.5.1 Behavioural Changes from Data and Digital Tools

Due to the lag between the point of infection, being contagious, and showing symptoms, the case numbers of COVID-19 at any point in time do not represent the present occurrence of infection. This renders decision-making for politicians additionally challenging. They must rely on an analysis of current figures as well as forecasts in deciding which policies to implement. Throughout the pandemic, novel methods of modelling and forecasting have evolved, increasingly led and strengthened by a multi-sectoral collaborative approach. Facebook AI for example has partnered with academic researchers at New York University's Courant Institute of Mathematical Sciences, the Universitat Politècnica de Catalunya, the Faculty of Mathematics, and the Data Science research platform at the University of Vienna in order to develop localised COVID-19 forecasting models.[23] It is based on the Social Connectedness Index which measures the interconnectedness of two geographic areas based on Facebook friendship ties, and therefore reaches the core of the social element of social mobility, trade, and other sociological factors which contribute to the spread of disease.[26] Artificial Intelligence (AI) models are fed time-series data about the occurrence of infection with respect to county names, dates, and number of confirmed cases, amongst others. Research has suggested that "data from online social networks can be useful to epidemiologists and others hoping to forecast the spread of communicable diseases such as COVID-19".[24]

Another example is: Global.health, developed through a collaboration of institutes including the University of Oxford, Harvard, Northeastern, Boston Children's Hospital, Georgetown, University of Washington, and Johns Hopkins Center for Health Security and funding from Google, Oxford Martin School and the Rockefeller foundation. It is a pioneering data repository and visualization platform on information about anonymised COVID-19 real-time epidemiological data. The platform also provides the percentage of completeness of the data available and presented for over 130 countries in its database.

[23] Matthew Le, Mark Ibrahim, Levent Sagun, Timothee Lacroix, Maximilian Nickel (2020): Neural Relational Autoregression for HighResolutioin COVID-19 Forecasting. Facebook AI Research. [26] https://dataforgood.fb.com/tools/covid-19-forecasts/

[24] Kuchler, T., Russel, D. & Stroebel, J. The Geographic Spread of COVID-19 Correlates with the Structure of Social Networks as Measured by Facebook. J. Urban Econ., 103314 (2020).

Figure 10. Global.health map showing available COVID-19-line list cases as of 29/11/2021[25]

4.5.2 Worries About Data Sharing in the Global South

Whilst global data is an invaluable asset for the international community, it is imperative to consider the reality of researchers in different environments. In the words of Tilahun Yilma: "Any type of aid programme that does not lead eventually to self-sufficiency is actually destructive, just like welfare, and that is what has happened with many aid programmes in Africa".[26] The international community must consider this before designing and implementing programmes to strengthen data-gathering in LMICs. Serwadda, Ndebele et al. find that "studies on data sharing among LMIC researchers have found that although they are generally supportive of data sharing, there is considerably less enthusiasm for open data. There are concerns about data misuse, violations of patient privacy through reidentification, and possible humiliation and exploitation of the researchers themselves".[27]

A prominent example is that of the Minister of Health of the Republic of Indonesia H. E. DR. Dr. Siti Fadilah Supari, who voiced his outrage at the H5N1 vaccine, the development of which was enabled by samples from Indonesia's people but that once developed was not economically viable for many of the countries that had provided the samples.[28] He made the argument that since his country provided the samples that were then used to develop the vaccine, it had some form of property right in the result.[29] It is important that the international community does not neglect these concerns, and to build an environment of trust and collaboration on an equal footing.

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[25] Global.health Regional map of COVID-19 line cases [internet]. [updated 29/11/2021, Accessed:30/11/2021]. Available from https://map.covid-19.global.health/#region

[26] National, Research Council, et al. The Case for International Sharing of Scientific Data : A Focus on Developing Countries: Proceedings of a Symposium, edited by Paul F. Uhlir, and Kathie Bailey Mathae, National Academies Press, 2013. ProQuest Ebook Central,

[27] Serwadda, David, Paul Ndebele, M Kate Grabowski, Francis Bajunirwe, and Rhoda K Wanyenze. "Open Data Sharing and the Global South-

Who Benefits?" Science (New York, N.Y.)359.6376 (2018): 642-643.

[28] Elbe, Stefan, and Gemma Buckland-Merrett. "Data, Disease and Diplomacy: GISAID's Innovative Contribution to Global Health." Global Challenges 1.1 (2017): 33-46.

[29] http://www.ip-watch.org/files/Indonesia_statement_WHO.pdf

The International Ethical Guidelines for Health-related Research Involving Humans by the Council for International Organisations of Medical Sciences (CIOMS) provide guidance in achieving this goal.[30] Specifically, it states that "research conducted in low-resource settings must be responsive to the health needs or priorities of the communities or populations where the research is conducted", and products developed as well as knowledge generated should be shared with the population which was essential to their development (Guideline 2). Furthermore, "groups, communities and individuals invited to participate in research must be selected for scientific reasons and not because they are easy to recruit because of their compromised social or economic position or their ease of manipulation" (Guideline 3). Guideline 12 states that "data from low resource settings should only be collected and stored in collaboration with local health authorities". The international scientific community should engage in an active debate and carefully listen to the legitimate concerns of scientists in LMICs before conducting research and gathering data.

FAIR Principles

One of the challenges to data sharing and international comparison is the heterogeneity of approaches in gathering data. The FAIR Principles for scientific data management and stewardship outline a framework for scientists worldwide. Data should be Findable, Accessible, Interoperable, and Reusable:

1. Data should be findable via a globally unique identifier and embedded in metadata.
2. Data should be accessible via an open, free, and universally implementable protocol.
3. Data should be interoperable by using common terms.
4. Data should be reusable through a rich description of attributes.

These are the standards that would facilitate international cooperation and maximal benefit from data worldwide. The challenge for the international community is how to bring these principles to life.

4.6 Overcoming Language Barriers

Global health requires international collaboration, but language barriers remain in the way of efficient teamwork, and might hinder the effective use of data despite such data being accessible. This in turn adds to the inequities present in global health.[31] That is why initiatives are to be welcomed such as The Translation Initiative for COVID-19 (TICO-19)[32], formed through a partnership between Translators Without Borders, Google, Amazon, and others which aims to make emergency and crisis-related content available in as many languages as possible, a practice that fosters international cooperation.

[30] International Ethical Guidelines for Health-related Research Involving Humans. Geneva: Council for International Organizations of Medical Sciences (CIOMS); 2016.

https://cioms.ch/wp-content/uploads/2017/01/WEB-CIOMS-EthicalGuidelines.pdf

[31] David Flood, Peter Rohloff. 'Indigenous languages and global health' The Lancet Global Health COMMENT| VOLUME 6, ISSUE 2, E134E135, FEBRUARY 01, 2018. DOI:https://doi.org/10.1016/S2214-109X(17)30493-X

[32] https://tico-19.github.io/?fbclid=IwAR2eAU8wzMFyhNkd5LMdNWi9r4NPWIBTF9hA9yHhQ_i1SjfiigxoY-PyBWQ

Section 5: Clinical Studies

5.1 Immunological and Vaccine Studies

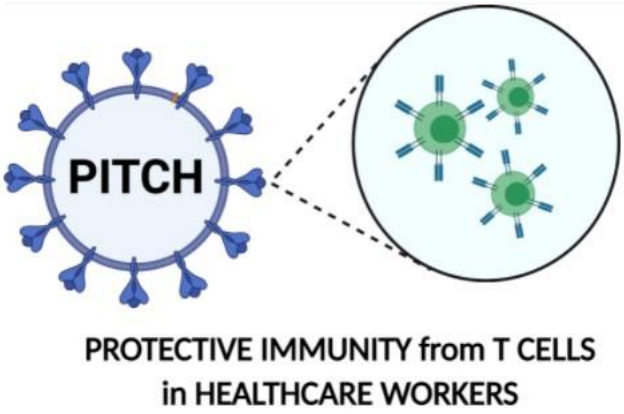


Figure 11. The PITCH study, an example of immunological study[33]

We heard from a number of members of the Group working on large clinical studies. Sussie Dunachie—an infectious disease clinician and T cell immunologist with interests in developing vaccines for tropical diseases and also in AMR—spoke about some of the Oxford immunology activity. Like many others, her activities changed dramatically following the emergence of COVID19. As her global work was affected, she went onto the wards in Oxford as an infectious diseases doctor. She has recently gone back to supporting global health and working with existing collaborators mainly through the Oxford Tropical Network, on immunology and supporting vaccines in other settings.

Sussie Dunachie's activity is part of a bigger immunology network across Oxford orchestrated by Paul Klenerman, whose group works on the immune response to infections, focusing on both the host and the pathogen. They set up a study to look at natural immunity in healthcare workers in Oxford, eventually enrolling about 500 participants. Successful UK funding saw the study become part of a national study of T cell immunity in healthcare workers, the PITCH Study[36] which was nested in the SIREN Study.[34]

5.2 Lessons from Clinical Studies

"It is better to surrender samples to labs that are already doing something highly expert so as to get the best results fast… let the best do it… hand over what you have got to the best people, collaborate, collaborate, and preprint…I feel sorry for people using the old model… it is not helpful in the pandemic."

Those working on clinical studies identified numerous lessons that can be taken forward to future pandemics:

[33] https://www.pitch-study.org/

[34] Victoria Jane Hall, Sarah Foulkes et al. SARS-CoV-2 infection rates of antibody-positive compared with antibody-negative health-care workers in England: a large, multicentre, prospective cohort study (SIREN). The Lancet 397,10283,2021. Available at: https://www.pitch-study.org/

Sleeping protocols

For practical work with patients and scientists, 'sleeping protocols' are a must. These are ethically approved protocols ready to go, and were vital when the SARS-CoV-2 virus started to spread.

Data

Data collection needs to be kept as simple as possible, using existing data collection forms and existing databases where possible.

Comprehensive real-time quality control of data and analysis

There is no time for data cleaning at the end of studies, which would take six months. Quality control needs to be in real-time and comprehensive. And an analysis plan has to be ready so that when the last patient is recruited, the researchers 'push a button' to get results.

Cohort design

Under pressure, research groups sometimes ended up sampling anyone. In future they would make sure there was good representation of different ethnic groups and those aged over 60 (some vaccine studies did better than others in this respect).

Importance of large support teams

One should not underestimate the usefulness of lots of project managers, researcher assistants, and administrative support. At least those doing clinical studies (it was much less reported from social science and other groups) reported that it was wonderful to see how permissions and funding could work so quickly when needs be.

Long-term relationships and capacity already in place

Long-standing global relationships can't be magic-ed up in a pandemic; they need to be there from the start, based on "people who you had already worked with, who you had already visited". Nevertheless, we also heard of colleagues who had built capacity in advance who did not have enough time for their own science, including a very talented group of immunologists who ended up running a national post office biobank service.

Pragmatic not esoteric focus

Rather than working on esoteric academically-interesting issues, immulogists had to focus on pragmatic questions such as whether one dose or two doses of a vaccine were needed and ways that would get us out of the pandemic more quickly.

Stay in lane but cross-disciplinary work

While it was important to "stay in lane"—knowing one's own expertise and being confident in what one is good at and only trying to make public statements about what one knows—this needed

to be linked up cross-disciplinarily. All agreed this is difficult, really under-recognised, and terribly under-valued.

Let the best do it

Researchers need to let go. When teams have samples that are very precious, the natural tendency is to want to do everything with those samples. There have been a few immunologists who stuck to the old model of being very secretive and not sharing and getting their papers out in 'Science'. Meanwhile, everyone else was sharing everything and informing everyone of what they were doing, putting results in pre-print as soon as possible.

Duplication is OK

Duplication should be embraced. In immunology and in modelling, researchers should not worry if other people are doing something similar. In the same way that emergency services can use three different mobile phone masts to pinpoint the location of someone, so in the UK for estimating current prevalence we have the Office for National Statistics study, the React study, and the Zoe app (https://covid.joinzoe.com) set up by Kings College London. The UK Department of Health uses all three resources to work out the current situation.

Have a science communications strategy ready in advance

The need to "communicate your science to other scientists and to the general public," requires carefully and expertly thought through communications strategies. After all, many times public opinion was more important than scientific opinion in swaying policy and achieving cooperation of the public. Many scientists found themselves facing communication roles they never expected nor were trained or prepared for. The public understanding of the work of some groups has been batted (and battered?) around in the media. Some areas of science ended up being very public and indeed very political. We heard how T cells became a very 'right-wing' topic area, with academic papers picked up "by the hard-right on Twitter saying that we are all immune after all, which was not the point we were making at all". Press releases of some vaccine results presented some scientists with difficult communication roles. Better public understanding of science might be another important function of this Global Health Strategy Group. German members of the Group argued this was just as much needed in Germany as in the UK.

At-the-ready infrastructure

The group pointed to many instances where having research infrastructure already in place paid off hugely. Such infrastructure has a huge underappreciated 'insurance'/'option' value. Several groups had built a lot of infrastructure in advance (e.g. Biobank in Oxford, INTERVCOVID, etc.), yet we still underestimated how big COVID was going to be. Researchers were able to quickly work with great collaborators they had worked with before. All in the meeting offered their networks for further collaborations.

It is hard work

Despite being built on already strong foundations, the INTERCOVID study still needed constant communication, including weekly Zoom meetings with 60-70 regularly taking part.

Section 6: The Value of Infrastructure, Research Capacity, Systems Resilience & Collaboration

"Surely, it cannot be right that when faced with a challenge like this people are expected to sacrifice their own health and that of their families? Yet, many health care workers put their own family at risk to do their job, some even have killed their own family to do their job, have gotten COVID-19 in order to do their job. Others have taken a risk in their career in doing collaborative efforts and put aside ambitions in their own fields…People have donated their health, their families, their careers, their futures, because we failed to set up robust infrastructures on all accounts"

6.1 Value of Infrastructure

The pandemic has exposed all kinds of infrastructure failings, including in academia and amongst healthcare workers and across society. One recurring message is the immense value generated by research infrastructure already in place when pandemics strike, at which time there is little 'time to-build' such capacity. Such infrastructure provides options to respond quickly. This 'option value' is part of the overall investment value, and should be incorporated, as an 'extra' value, in investment analysis of the initial decision to invest, but often it is not. The private sector, and private capital

markets, can struggle to fund this 'extra value' because any payout is rare and unpredictable, and much of the 'extra value' has public-good properties and is hard to internalise privately. Larry Roope and colleagues, who have been researching the value attributable to investment in research infrastructure (needless to say, it is huge), and analyzing the public's willingness to pay for medical research (which is currently riding high; see below), argue that strong public discourse is needed to maintain or expand future research infrastructure.[35]

While a lot of discussion in the Strategy Group focused on the value of this research infrastructure, a more general problem of 'system resilience' was repeatedly emphasised. Early in the pandemic, and still ongoing in many parts of the world, there was much talk about the lack of capacity of certain interventions such as oxygen, ventilators, PPE, and of doctors, nurses, hospital beds, and hospitals. Holding 'surge' capacity (for example to make lots of oxygen quickly, or spare ICU beds and ventilators) needs a funding stream that acts rather like an insurance premium, a yearly cost that produces low benefit most years but huge benefit when it is really needed.

The value of research infrastructure as a global public

Drawing on evidence from the pandemic, a recent commentary (Roope et al., 2021) discussed the potential scale of value attributable to biomedical research infrastructure, with particular reference to the NIHR Oxford Biomedical Research Centre (Oxford BRC). The Oxford BRC aims to translate basic scientific developments and laboratory research into clinical benefits and the clinical setting across many different research themes, one of which is vaccines. The study argued that, even considering its contributions to the development of the Oxford-AstraZeneca vaccine alone, the value of the Oxford BRC is potentially orders of magnitude more than its £114m 5-year funding. Research infrastructure such as the Oxford BRC, set up for other research projects, has been used to support development both of the Oxford-AstraZeneca vaccine and the RECOVERY trials. This has led to the development of medicines that have saved countless lives. Having such research infrastructure in place before the pandemic meant there were expert teams in place already researching related issues (including other coronaviruses)—leaving them exceptionally well placed to respond quickly and effectively. In the context of a global emergency like a pandemic, chipping even days off time lines of such activity adds enormous value. Based on IMF estimates of the fall in global output compared to the pre-pandemic path, damage has been about $15bn a day globally. Flexibility to allow research funds to be repurposed at very short notice (unlike most research funding), as happened with the Oxford vaccine, saved valuable time and allowed teams of researchers to drop other tasks immediately and focus entirely on the crisis. This further enhanced the value of the initial investment.

NIHR | National Institute for Health Research

[35] Roope, L.S.J., Candio, P., Kiparoglou, V. et al. Lessons from the pandemic on the value of research infrastructure. Health Res Policy Sys 19, 54 (2021). https://doi.org/10.1186/s12961-021-00704-2

Building more resilience into healthcare systems has an up-front cost. In resource-poor settings this cost generates immediate benefits, and the future pandemic resilience might better be seen as an extra 'externality' benefit. Perhaps Universal healthcare (UHC) might be modified to better reflect the value of this health-system resilience in health emergencies, including beyond the immediate recipients. All of this needs to be better valued when investing in UHC. At some point, a cross-cutting economics/finance/investment group will support all four Global Health Strategy Groups to properly value such elements when they appear.

The big question when we come out of the pandemic is to what extent policy-makers take messages like this on board and can make this value salient with the public. They are going to be tasked with a catastrophic fall-out from the crisis. If ever there was a time when they will think to cut budgets, it will be now. It was argued that matters could go in one of two directions. Policy makers could learn lessons, value and start to build resilience in places where we have not previously built resilience. Or, there could be so many competing demands on finance that cuts are made that reduce resilience even in places where we have had a degree of resilience before. In this context, recent cuts to UKRI funding in the UK are a worrying sign.

We need a system to regularly value such investment even if it is hard to show any payoff in the current year. Those working on climate and environmental resilience have faced similar challenges, and have found ways to value investments in long-term resilience; some similar ambition is required to develop measures of health resilience and imbed them in funding mechanisms, in much the same way as zero net carbon has been built into international agreements.

INTERCOVID: An Example of Collaboration Based on At-The Ready Infrastructure

INTERCOVID was presented by Aris Papageorghiou, a consultant and professor of obstetrics, as an example of collaboration based on at-the-ready research infrastructure. Other coronaviruses have had very bad impacts in pregnancy, so, when it became clear in February 2020 that a pandemic was underway, researchers in the INTERGROWTH project became seriously worried about the impact of the virus on pregnant women. Pregnant women had a mortality rate in SARS and MERS approaching 30% and would be at very high risk of respiratory illness from SARS-CoV-2. INERCOVID was set up as a platform to quickly gather data by taking advantage of the existing infrastructure of INTERGROWTH.

In March 2020, the team did a literature review, wrote the protocol, recruited the country members, and got ethics approval. In April 2020, they were awarded Oxford University rapid response funding, and created data-collection forms based on pre-existing data-collection forms.

It was only possible to start such a large prospective cohort study within a month because of the existing infrastructure: 43 sites across 18 countries gathering data, including from Russia to Brazil, and from the US to Nigeria. Between March and October 2020, they were able to get approval in countries, recruit patients and have real-time data monitoring. Meantime they wrote the statistical analysis plan that would allow for real-time data analysis and quality control.

Women were recruited at the same time at similar level of care, 700 with COVID-19 and 1400 without. They compared those who had had COVID-19 at any time during pregnancy (mostly lab confirmed, though early on this was not always possible) to those who did not have COVID-19 during pregnancy but who were exactly the same in all other respects. The results showed significant increase in maternal morbidity and mortality of those with COVID-19 than those

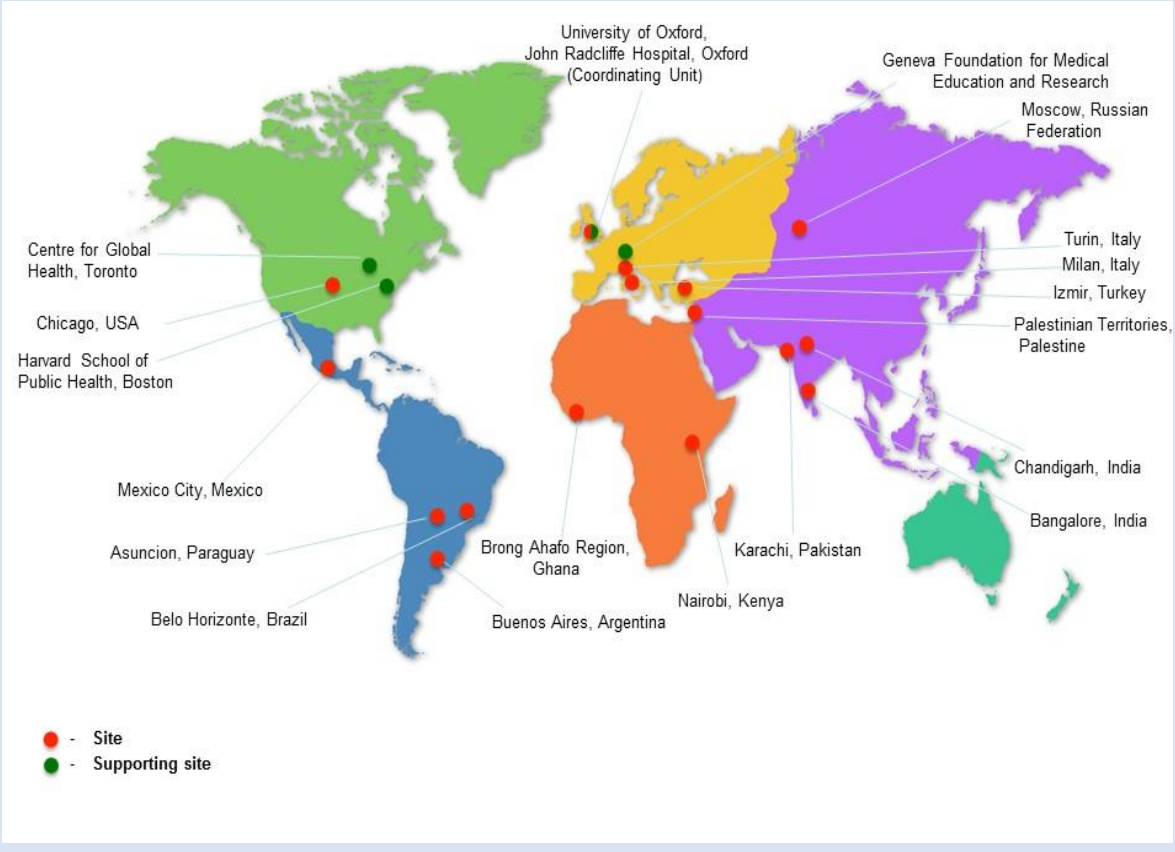
without COVID-19, concentrated in women with symptoms. There was also a three-fold increase in serious neonatal morbidly and serious perinatal morbidity and mortality, through the mechanism of premature birth and medically-indicated preterm birth due to paternal illness.

As dissemination of information is a very important part of this project, they created an e-learning course at the same time as completing the study, in collaboration with a Geneva foundation for medical education and research.

The network was presented to the Global Health Strategy Group as a fantastic resource, whose members were always open to collaboration (if funds are provided) particularly in relation to pregnancy and the pandemic.

THE INTERGROWTH CONSORTIUM

The INTERCOVID study took advantage of the intergrowth consortium which is an international grouping, coordinated out of Oxford, of about 300 researchers from 27 institutions and 18 different countries. The consortium aims at developing tools for correct pregnancy care and monitoring perinatal health, and it does this through three related projects: i) the intergrowth project aims to improve health through foetal and new-born growth standards, by monitoring foetal growth from conception right through to 5 years of age. ii) the interbio study looks at the phenotypic characterization of obstetric syndromes such as growth restriction and pre-term birth, by collecting large amounts of data from around the world. iii) Interpractice focuses on the implementation of these tools into practice to promote optimal postnatal growth of preterm infants until 6 months post-term by standardising growth measurement in babies born preterm by using the INTERGROWTH-21st international standards measurement, and by implementing evidence-based feeding recommendations based on breast feeding.
The tools for standardization and monitoring have been adopted in a large number of countries and downloaded by a large number of people.



6.2 Engaging the Public

While the option value of research infrastructure and health care system resilience may not be sufficiently salient to policy makers, the voting public's views on maintaining it may be. The multi-country CANDOUR[36] online survey study was established to seek the views of the general public on a wide range of pandemic-related issues, with particular focus on the allocation of COVID-19 vaccines. The first wave (15,536 individuals from 13 countries) provided evidence that, in all countries surveyed, there is overwhelming support for respondents' governments to increase or maintain medical research spending. Moreover, there is a strong willingness to pay additional taxes to fund future pandemic prevention spending.

In another study from the project (Clarke et al., 2021), among the subset of high-income countries studied (8,209 individuals from 7 countries), in each country, the number of people who supported donating vaccines to less well-off countries were at least double those who did not. Support for donating vaccines ranged from 48–56%, whilst 15–26% did not support donating vaccines and 22–28% were undecided. Of those who supported vaccine donations, most (73–81%) favoured an amount greater than or equal to 10% of their country's doses. When asked about three prioritisation principles for global vaccine distribution, the highest-ranking principle for each country was 'need', followed by 'countries unable to afford vaccines', and, last of all, whether 'the country itself had developed the vaccine'.

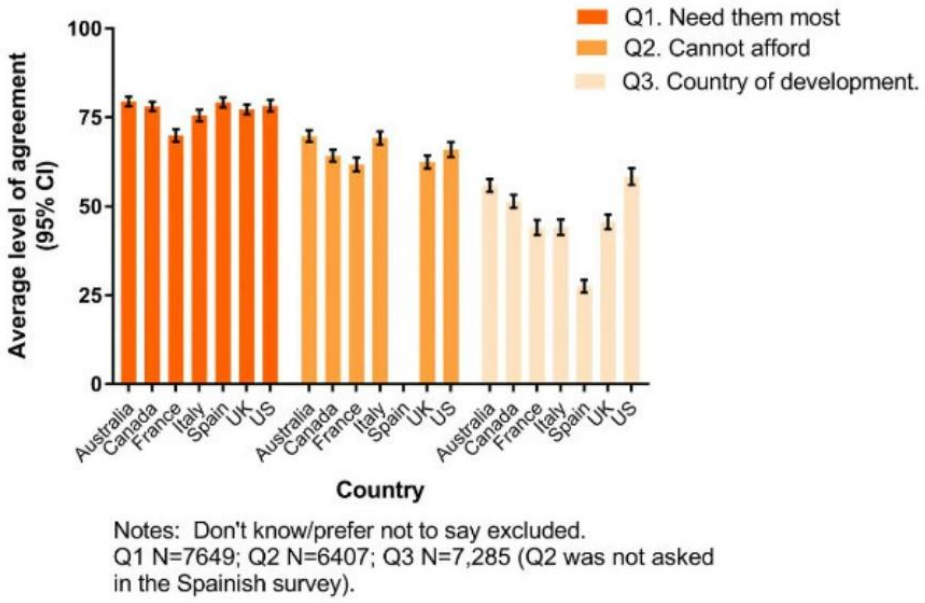


Figure 11. How vaccines should be allocated, according to the public[37]

Knowledge of the public's views on these issues should reassure policy makers of the likely political acceptability of increased investments in medical research and other measures to strengthen domestic and global health care systems. We have good evidence that the public is behind spending to address pandemics. However, we need to continue to keep an eye on what the public think, and

[36] 39 Oxford-candour.com COCID-19 vaccine preference and opinion survey [internet]. Accessed 31/11/2021. Available from https://oxfordcandour.com/

[37] Clarke, P.M., Roope, L.S.J., Loewen, P.J. *et al.* Public opinion on global rollout of COVID-19 vaccines. *Nat Med* **27,** 935–936 (2021). https://doi.org/10.1038/s41591-021-01322-9

make policy makers aware of it. Meanwhile, the CANDOUR study team face a real battle to get funding to turn this into an ongoing longitudinal study. The team is super keen to discuss collaboration on future waves of the study, and especially keen to explore funding applications.

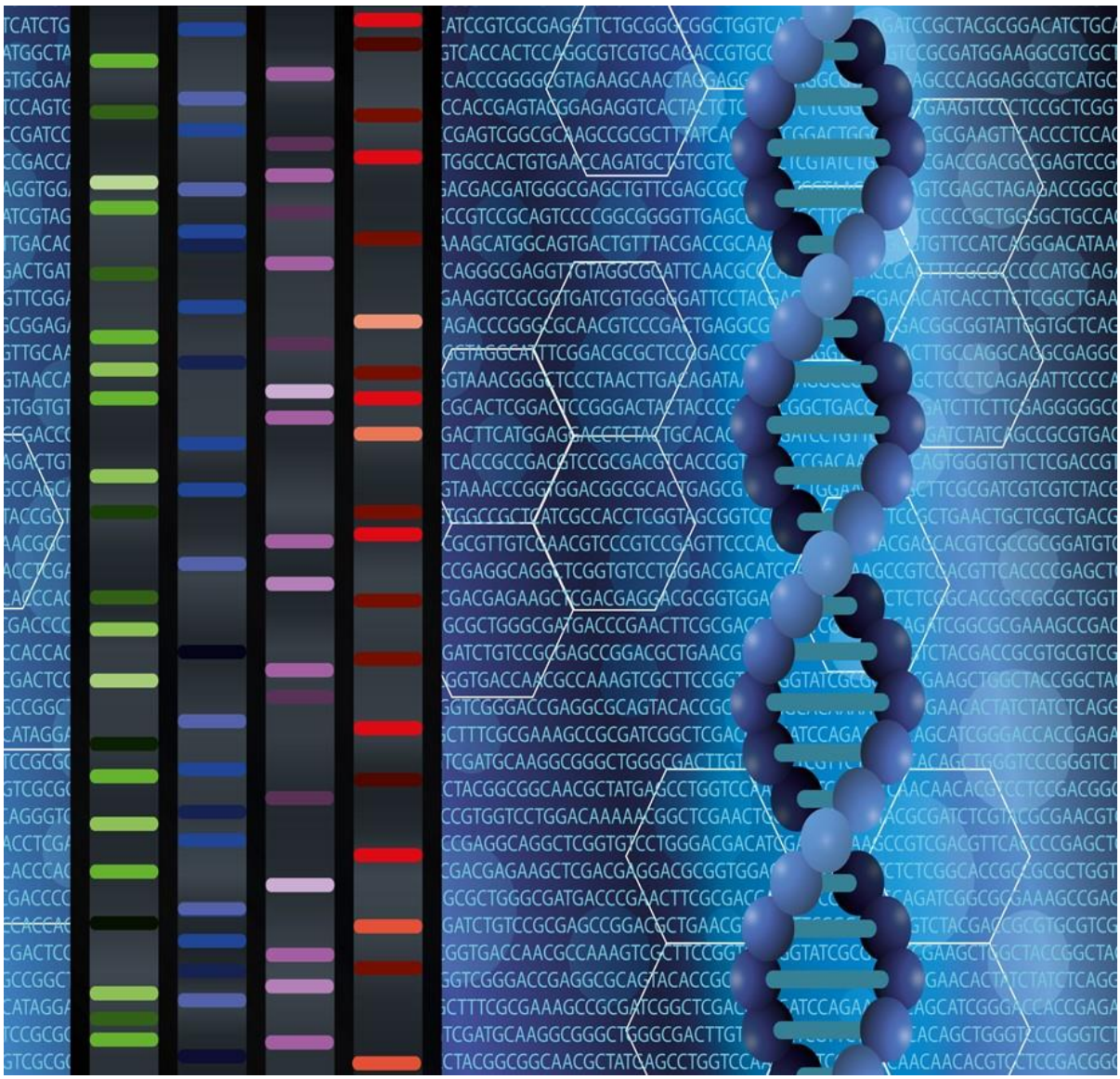
6.3 Competition Versus Collaboration

There have been good examples of research cooperation during the pandemic.[38] Yet, even in the case of vaccines—often highlighted as a model of cooperation—there has been less cooperation between developers and across countries who funded vaccine development than is sometimes supposed. Future vaccine preparedness will need to focus on creating ex-ante mechanisms of cooperation and for sharing that are set up before pandemics, including, for example, pre-agreed distribution of the fruits of research, such as vaccines and medicines.

Those working in the life sciences and medical sciences have responded well, but we are still highly vulnerable. Some in the Strategy Group argued that "We need to see this as an opportunity to reset the future state of how research & development of medicines and healthcare is to be delivered." To that end, 'Oxford in Berlin Global Health Initiatives is also fleshing out the notion of a global network of life science for global health hubs (virtual or physical) such that investment priorities, including of the private sector, can by guided by global health priorities and by treating global health as a global public good.

[38] https://storiesincorporated.com/collaboration-during-covid-19-crisis/

Section 7: Pandemic Genomics



The Group heard from Janey Messina, a geographer with a focus on spatial epidemiology, mostly related to non-communicable diseases, NTDs, and arboviruses. In about 2018 she, alongside Oliver Prybus and Angela Maclean in Oxford zoology, became one of the directors of The Oxford Martin Programme on Pandemic Genomics. This was set up to bring together mathematical epidemiology, pathogen phylodynamics, and human geography to create a new body of theory capable of co-analyzing these different sources of information. The goal was to build a prototype framework to test out on some canonical data sets, originally for Ebola. Previously, those with phylogenetic data might think how to add a spatial component, or those with a mathematical model might think how to add a spatial component to it, or vice versa. The notion was to strip back to the basic assumptions of mathematical epidemiology to build the three fields—geography/spatial epidemiology, pathogen phildynamics, and philogenetics—together as a new science.

In one early study, in May 2020, Moritz Kramer and Oliver Prybus, also part of the UK wide genomics consortium, published a paper about the genomic epidemiology of SARS-Cov-2 in

Guangdong Province China. They found that the outbreak was not caused by one large chain of transmission but by hundreds of independent introductions from outside the province.[39] This was followed by many more genomic studies. Like many speakers in the meeting, their work naturally engages many collaborators.

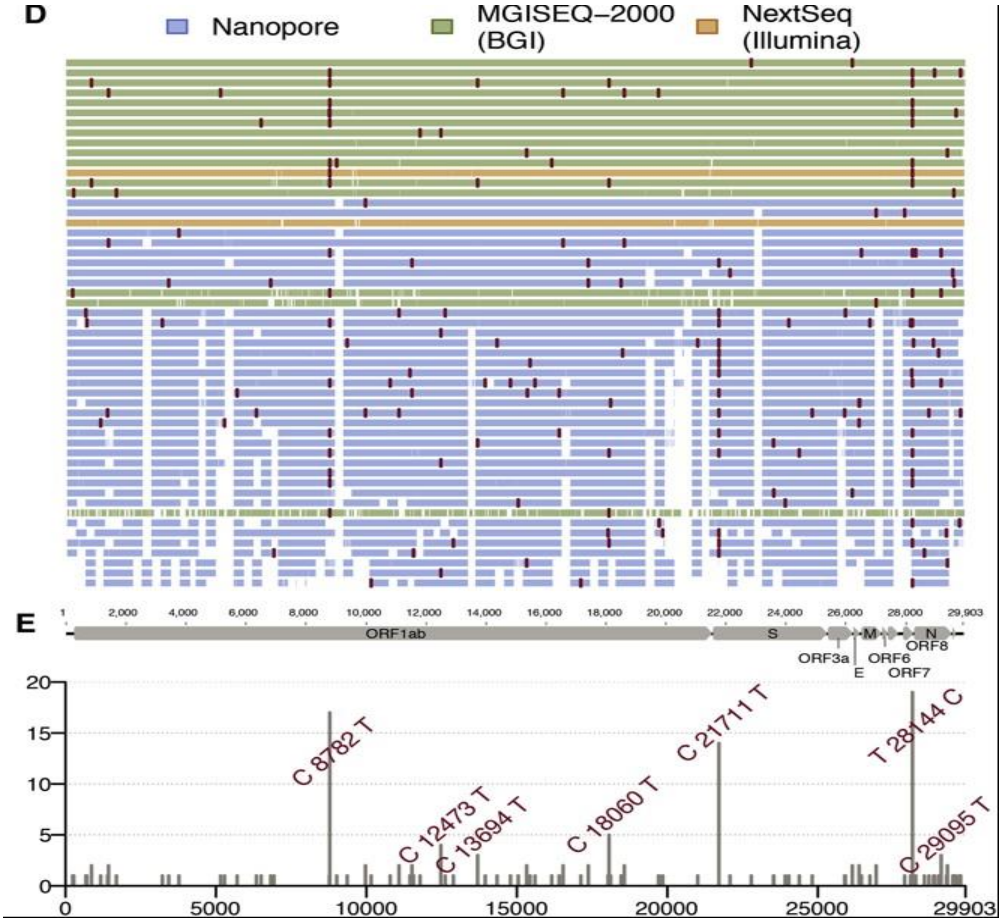


Figure 12. Profile of SARS-CoV-2 Genome Sequences from Guangdong Province, China genome coverage map (D) and genome structure (E)[44]

Working with Nuno Faria (Oxford zoology and now mostly Imperial) they helped to set up the Brazil-UK Centre for (Arbo)virus Discovery, Diagnosis, Genomics and Epidemiology.[43] As the situation deteriorated in Brazil, their funders allowed them to switch focus from arboviruses to SARS-CoV2.

The next venture that Jane Messina and Moritz Kramer hope to get funding for will be an interdisciplinary group to explore pandemic-resilient urban planning, combining sustainability with

[39] Lu J, du Plessis L, Liu Z, Hill V, Kang M, Lin H, Sun J, François S, Kraemer MUG, Faria NR, McCrone JT, Peng J, Xiong Q, Yuan R, Zeng L, Zhou P, Liang C, Yi L, Liu J, Xiao J, Hu J, Liu T, Ma W, Li W, Su J, Zheng H, Peng B, Fang S, Su W, Li K, Sun R, Bai R, Tang X, Liang M, Quick J, Song T, Rambaut A, Loman N, Raghwani J, Pybus OG, Ke C. Genomic Epidemiology of SARS-CoV-2 in Guangdong Province, China.

Cell. 2020 May 28;181(5):997-1003.e9. doi: 10.1016/j.cell.2020.04.023. Epub 2020 Apr 30. PMID: 32359424; PMCID: PMC7192124. [43] https://www.caddecentre.org/about-the-project/

urban planning. This will involve colleagues in Oxford in zoology and geography and hopefully collaborates from outside in other departments, universities, and countries.

Section 8: A Global Pandemic Treaty

"There have been many big statements and announcements about treaties. but many of those are just printed and that is it. We can't repeat that."

In the run up to, during, and after, the Global Health Strategy Group launch meeting, the notion of the Group exploring a global pandemic treaty was discussed, as was the future of global health governance. As the world claws itself out of the pandemic—and when the fires are, quite literally, still raging—willingness to explore and invest in systems of pandemic preparedness is running extremely high. Such interest will subside. It always does once crises pass. Many of the needed measures are global public goods which are easier for political leaders to coordinate upon when all their minds are focused on the same goal, but more difficult once they are distracted by the next crisis or global political turf war, and the public has moved along and lost interest. It was argued that we need to strike while the iron is hot, in a narrow window of opportunity (12-18 months).

8.1 The Need for a Pandemic Treaty

Global health is a public good the governance of which is a challenge which demands international collaboration. Everyone benefits from improved global health, but the problem is that individually

they face incentives not to invest as much as would be required to support global health. It is the classical scenario of a, so called, Prisoners' Dilemma. However, the outcomes are far too important for each of us, and the world cannot afford to end up in a situation where all actors "defect" to the low-investment option. This reality has led to a prominent call for different parties to commit to a global Pandemic Treaty. For example, among the recommendations of The Independent Panel for Pandemic Preparedness and Response (2021) is a pandemic treaty.[40] Previously, in December 2020, the President of the European Council called for an international pandemic treaty.[41] This was also echoed by the Global Preparedness Monitoring Board. Mr Jens Spahn, Federal Minister of Health of Germany, also reiterated Germany's support for an international treaty on pandemic preparedness and response.[42]

A similar topic in terms of efforts to coordinate global leadership are climate agreements. These efforts serve both as inspiration for designing a Pandemic Treaty and as a reminder of the deficiencies of international treaties. Countries can sign treaties but not ratify them, such as the United States and the Kyoto protocol.[47] Or they can sign and ratify them but exit them later, as has occurred with the Paris Climate Agreement. Furthermore, negotiation and ratification of a treaty can take a lot of time, such as the Framework Convention on Tobacco Control which took eight years to negotiate, three years to ratify, and even longer until specific protocols were asserted.[48] That is why some are calling for a different approach: "Agreements on global public goods are hard because individual countries have an incentive to defect, producing noncooperative, beggar-thy-neighbour outcomes."[43] William Nordhaus instead calls for a "Climate Club", whereby participation depends on fulfilling certain conditions, the non-fulfilment of which is linked to penalties. At the same time, participation should be made attractive. The difficulty with this approach is how to ensure that LMICs are not discriminated against, for example if certain technologies are not implementable due to a lack of infrastructure.

Nordhaus' approach focuses on the challenge of compliance, which is the key issue of international treaties, given often a lack of oversight mechanisms or that countries may be self-reporting. However, despite the numerous difficulties with regard to international treaties, a Pandemic Treaty might nevertheless provide a uniform document outlining a clear strategy and path. There currently is a vast literature on pandemic prevention and preparedness, and it might be useful to possess a dominant guiding principle that countries can be held accountable for, even if it is more for the sake of evaluation than punishment.

The subsequent question concerns content and structure of the treaty. Vinuales, Moon et al. propose a narrow scope, arguing that "deep prevention focuses on preventing the outbreak of the disease from occurring rather than focusing on local national, or international spread" and that the pandemic treaty should focus on this outbreak prevention.[44] The main objective would be establishing an oversight body that oversees regulatory actions of the different countries. Others advocate for a wider scope, highlighting the need for a cross-cutting focus. Kickbusch asserts such

a treaty should address the approval, production, and supply of or access to medical equipment, vaccines, diagnostics, and medicines in a country; the capacity of healthcare sectors in pandemics;

[40] https://theindependentpanel.org/wp-content/uploads/2021/05/COVID-19-Make-it-the-Last-Pandemic_final.pdf
[41] https://www.consilium.europa.eu/en/press/press-releases/2020/12/03/press-release-by-president-charles-michel-on-an-international-treatyon-pandemics/
[42] https://www.who.int/news/item/16-07-2021-germany-reinforces-its-commitment-to-support-who-s-work
[47] https://unfccc.int/resource/docs/convkp/kpeng.pdf [48] https://fctc.who.int

[43] "The Climate Club: How to Fix a Failing Global Effort" (William Nordhaus, 2020 in: Foreign Affairs, online magazine).
[44] Vinuales, Jorge, Suerie Moon, Ginevra Le Moli, and Gian-Luca Burci. "A Global Pandemic Treaty Should Aim for Deep Prevention." The Lancet (British Edition) 397.10287 (2021): 1791-792.

the international, multi-sectoral cooperation on research and technology sharing; the challenge of One Health; and the role of international movements and transport, fiscal measures, international trade, social protection, jobs, and education to mitigate the impact of a pandemic on supply chains. Furthermore, Gostin, Friedman, and Dueck suggest that a treaty should focus on a rapid alert system, data sharing, and empowering the WHO to monitor progress.

"The world needs a post-pandemic health treaty with teeth", so say Gostin, Friedman, and Dueck, but the question remains on just how to conceptualise it and bring it to life.

8.2 Engaging Political Process

Figure 13. G7 and G20[45]

The G7 and G20 provide opportunities to help shape the conversation. And it can't be left to scientists alone; it needs the engagement of institutions and politicians. Everybody agrees at the highest of levels that the way we have been doing things has got to change, but they, and their institutions, are also, as one member of the Group put it, "engrained in the long railway lines of medicine and health care and wider big global problems". It will be hard work. We should not blame people in politics, but rather find the tools to drive change.

It is clear that the WHO's International Health Regulations as a tool for pandemic preparedness have been found wanting, and will have to be revised in light of what we have learned during the pandemic. This Global Health Strategy Group, and its wider networks, might be a forum for a no-

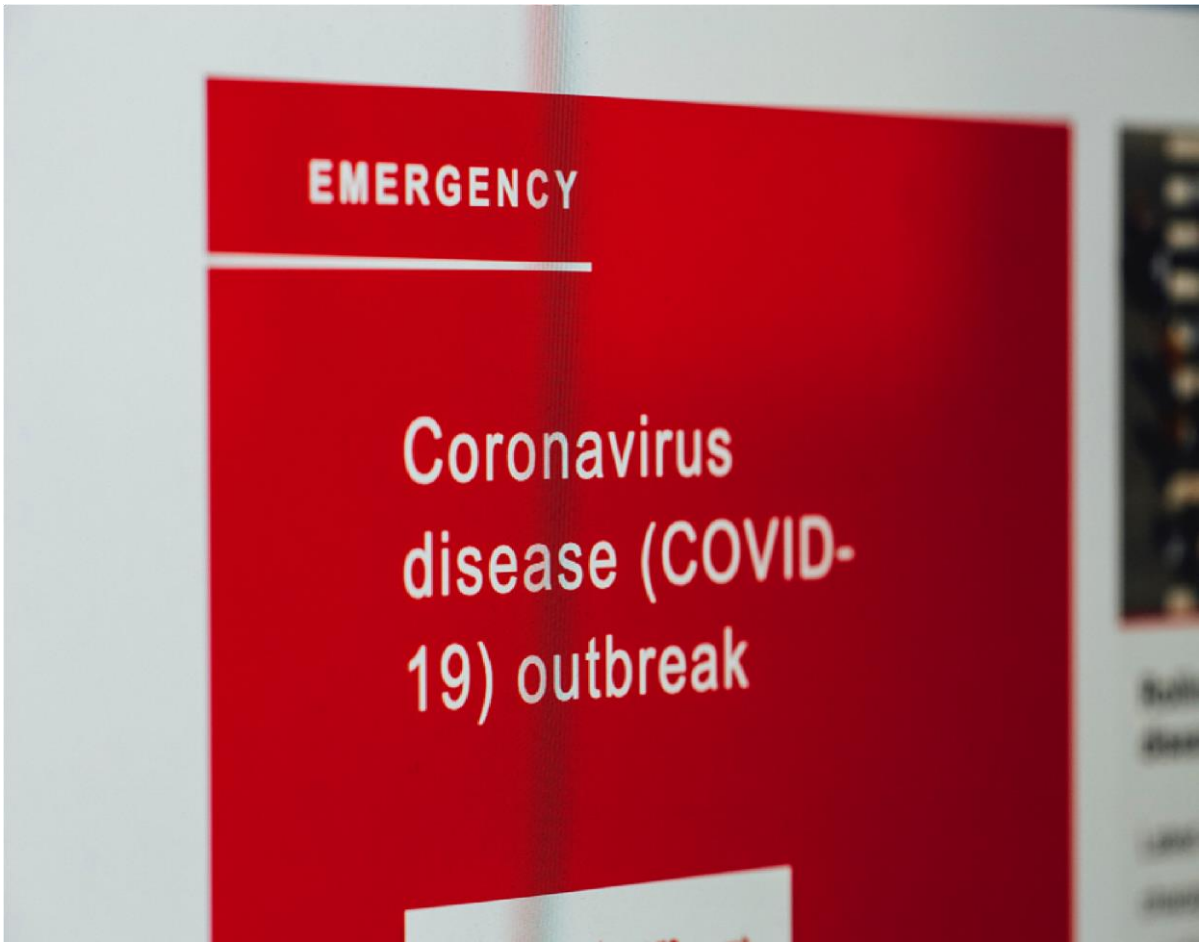
[45] https://www.boell.de/en/2016/11/30/g7-and-g20-global-governance-landscape

holds-barred discussion, based on its deep knowledge and experience built up during the pandemic, to help the WHO overhaul those rules to make them fitter for purpose.

"It is important to articulate the global value of good health, the national asset of having good health. The current paradigm of health care is about treating ill health, and we need to rise to the challenge of creating a bigger picture, and finding the right language and platform so politicians see the merits. In climate right now the debate has moved on from talking about using less carbon fuel to discussing the bigger societal values of making a fundamental change. For us, the equivalent would be a vision that is about good health and the value of good health."

It was also noted that in Germany there is little influence at the moment because of elections this year, and, it was noted, "scientists do not have a lot to say and they change what they say all the time". The RKI is the German national public health institute, and they are very close to politics in Germany, especially via the ministry of health. Some might see this as an advantage, but it is also a challenge. Politicians naturally want to use scientists and public officials. There is always pressure, for example on AMR, but they especially feel such pressure at the moment. It was proposed that as a group of public health professional, a common announcement in the autumn, after the elections, about what to do would be really worthwhile and would hopefully have impact on politics. Many in the Group argued that before then it would be important to have more international representation in the Group.

8.3 The Opportunity is Now



Improving future pandemic preparedness means working with political realities (whatever we might think of those realities and the politicians involved). The UK is currently hosting the G7, Germany will be hosting it next, and the outcomes from this year will be inherited by Germany next year. In the UK, there is great interest across government departments in developing something that will work across the G7 and beyond, giving the UK an opportunity to imprint this process while contributing to the global process. Later in the year, some of the outcomes of the G7 will feed into the G20, hosted then by Italy. Informal meetings of a few very powerful countries have no statutory authority, and trying to manage 20 countries is more difficult than 7, but at least such clustering offer opportunities to drive change. The question for this Strategy Group is: What can we build, and how can we take advantage of such political realities.

In the UK, to support the UK government in its role as Chair of the G7, the Royal Society has produced three papers on climate, biodiversity, and health, all linked together. One focuses on data and health, with health essentially meaning international health emergencies, i.e. pandemics. These are useful background papers for this Global Health Strategy Group.

8.4 Key Components of a Treaty

There is much talk by the WHO and others of a Pandemic Treaty, to enshrine individual commitments and collective responsibility for preventing future pandemics, and for better mobilizing and coordinating responses. What is less well spelled out is what would be key components of such a Treaty and how such a Treaty would work in practice. Treaties are difficult to achieve. That's why there are only really two treaties in the whole of global health. So, should we focus on the bigger picture of a pandemic treaty or focus on data in its own right (which is perhaps easier to understand than a treaty) or data as a point of entry to these bigger processes?

Those working on a pandemic treaty need to consider the following key questions:

1) What would the equivalent of nationally-determined contributions, for example to pay for stronger global surveillance as a common-pool resource?

2) How would an annual multi-stakeholder forum work to adjust contributions and invest in newly identified needs?

3) How would global collective action accommodate varying national circumstances and needs (and be evaluated, perhaps with economic tools such as cost effectiveness so that the burden of costs can be equitably shared)?

4) How would we test if preparedness plans are adequate or not, and how might processes of joint external evaluations work?

5) What about an independent scientific mechanism to take stock of progress and to inform policy makers of necessary evidence-based adjustments in line with latest best practice and understanding of pandemic risk?

6) How would an international legal agreement be structured to achieve accountability (monitoring, sanctions, enforcement) while also generating the trust and good faith also necessary to make it work?

7) How might global health governance structures work to manage such a treaty?

8) What would be the roles of digital and AI tools at patient and at population levels, including digital public goods, and how could they be used to create trustworthy and trusted systems for the equitable sharing of data?

9) What would be the roles, and responsibilities, of the private sector given its powerful systems for gathering data but often unwillingness to share?

10) What would be the agreed data standards and how might data be accessible always in real-time?

11) How would this work alongside other critical initiatives such as Universal Health Coverage—creating healthier, more resilient, populations—and all manner of public health strengthening and prevention measures (including those based on planetary health and One Health principles), so that we do not head off in the direction of yet more global health silos?

12) Should such a treaty include other major global health threats, such as AMR, which some in the Global Health Strategy Group for AMR would strongly endorse?

13) What can be developed and put in place that has lasting effect in terms of data gathering and data sharing for pandemic preparedness that is fair and equitable on all those contributing data.

14) How can such a Treaty and its operation be truly shielded from geopolitics and the power of vested interests, and truly reflect the needs of all and not just of the powerful.

15) What are the respective roles of the WHO and other international bodies and regional and country-level CDCs, and the roles of governments as well as civil societies and the general public?

The Global Health Strategy Group for Pandemic Lessons and Future Pandemic Preparedness will strive to be independent of all new proposed initiatives, hubs, and centres and to reflect the voices of many around the world interested in applying the lessons, preventing future pandemics, and being better prepared in the future.

This report has sought to demonstrate the exceptional work being carried out on various fronts during this pandemic, the lessons learnt and the immeasurable value that can be derived from synergistically working towards a larger goal of global pandemic prevention and preparedness. We know what needs to be done, the task ahead is how to get it done, to actually get it done and to carry everyone along in the process.

Appendix: Members and Observers of the Group

Members and observers of the Global Health Strategy Group for Pandemic Lessons and Future Preparedness and their host organisations arranged in alphabetical order:

Members

1	Andreas Jansen	Robert Koch Institute
2	Andrew Farlow	University of Oxford
3	Andrew Jack	UK Financial Times
4	Angelina Taylor	Robert Koch Institute
5	Aris Papageorghiou	University of Oxford
6	Chris Dye	University of Oxford
7	Christian Drosten	Charité - Universitätsmedizin Berlin
8	Colin Bennett	University of Oxford
9	Deogratias Mzurikwao	Villgro Africa
10	Dirk Brockmann	Humboldt-Universität zu Berlin
11	Esther-Maria Antao	Robert Koch Institute
12	Jacinta Nzinga	Kemri-Wellcome
13	Janey Messina	University of Oxford
14	Jennifer Cole	Royal Holloway, University of London
15	Johanna Hanefeld	London School of Hygiene and Tropical Medicine
16	Jonathan Suk	European Centre for Disease Prevention and Control
17	Karima Manji	London School of Hygiene and Tropical Medicine
18	Koen Pouwels	University of Oxford
19	Laila Harras-Pelletier	Covid-19 Clinical Resarch Coalition
20	Larry Roope	University of Oxford
21	Lisa White	University of Oxford
22	Mario Witkowski	Charité - Universitätsmedizin Berlin
23	Mirjam Jenny	Robert Koch Institute
24	Moritz Kramer	University of Oxford
25	Ole Wickmann	Robert Koch Institute
26	Philip Clarke	University of Oxford
27	Rob Beyer	Villgro Africa
28	Sebastian Funk	London School of Hygiene and Tropical Medicine
29	Sheetal Silal	University of Oxford and University of Cape Town
30	Stefan Flasche	London School of Hygiene and Tropical Medicine
31	Susie Dunachie	University of Oxford
32	Tan Le Van	OUCRU, Vietnam
33	Tim Eckmanns	Robert Koch Institute
34	Tina Fishcer	London School of Hygiene and Tropical Medicine
35	Ute Rexroth	Robert Koch Institute
36	Wilfred Njagi	Villgro Africa

37	Wilm Quentin	Technische Universität Berlin

Observers

1	Alastair Buchan	Oxford in Berlin
2	Anita Traninger	FU Berlin
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4	Darlington Akogo	co-chair Digital health and Aifor Health Strategy Group
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