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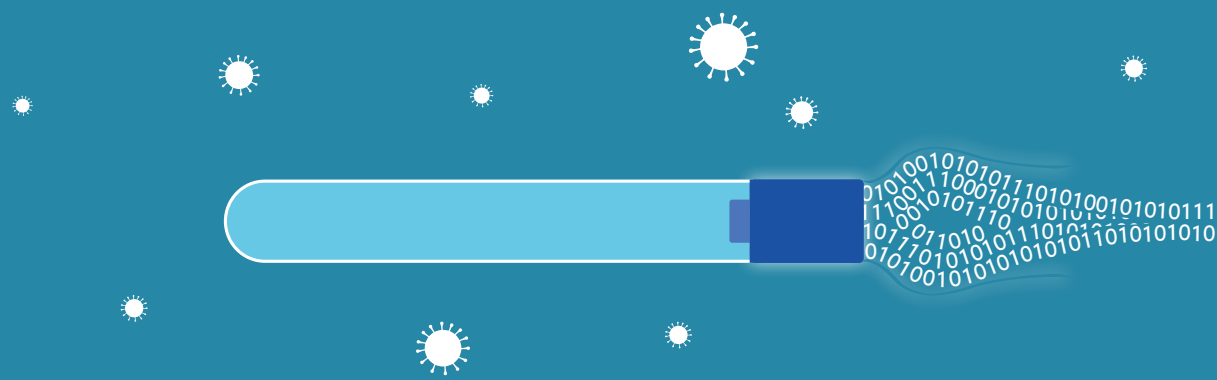
The role of covid-19 testing, data and informatics in getting back to normal

A report by The Economist Intelligence Unit



Key points:

- Testing cannot take a back seat to vaccination campaigns
- As immunity passports inch further into reality, testing will remain crucial to ensure the accuracy and validity of the passports
- No single test will be enough to combat the pandemic
- Countries need more transparency in their data processing and cloud computing tools without sacrificing privacy and security
- Technology developers, clinical practitioners and policymakers must continue to collaborate in the design and implementation of digital tools

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Background

With the advent of the covid-19 pandemic, health systems around the world have been forced to navigate through chaos and uncertainty to combat the ubiquitous virus and its damaging effects.[1] Countries are operating in a context of confusion and crisis, with the world's population experiencing lockdowns, containment measures, multiple health crises and economic shocks.[2]

To help understand the scale of infection and develop strategies to emerge from intense restrictions, covid-19 testing has been and remains an indispensable tool. Tests to detect the virus were developed within days of release of the draft genome on January 10, 2020. For many countries, widespread testing became available in a matter of months. On October 31, 2020, Slovakia became the first country in the world to test its entire population.[3,4] Following this massive undertaking in Slovakia, the prevalence rate decreased by nearly 58%, showing the world the benefits of an aggressive and wide-scale testing strategy.[5]

Throughout the pandemic, international institutions such as the WHO and the European Centre for Disease Prevention and Control (ECDC), have been collecting covid-19 testing data submitted by national governments.[6] As of mid-July 2021, there were more than 190 million total cases and more than 4 million deaths confirmed worldwide.[7]

Despite the lack of robust data in some areas, such as covid-19-related hospitalisations, testing data have effectively supported policies that contain the spread of the virus. Such policies can provide a high return on investment (future cost savings) while helping to track, trace and isolate SARS-CoV-2. Covid-19 testing is a crucial pandemic innovation and will continue to play a key role as countries adapt their strategies to meet their population's needs.

Current testing landscape

Testing has significantly improved countries' abilities to suppress covid-19 transmission and mitigate the ongoing crisis. The speed and scale with which tests were developed was pivotal in the pandemic's trajectory. With testing data, countries can account for confirmed cases and take appropriate actions (such as impose quarantine rules or lockdown restrictions) to contain the spread of the virus.[6,8] Despite these benefits, testing continues to be limited in many countries, which means confirmed cases only represent a fraction of actual covid-19 infections, as shown in Figure 1. For instance, using serology—antibody studies of covid-19—researchers have found official cases are understated by an average of 25 to 1 in New York City (a former "hotspot" of infection in the United States).[9] For this reason, among others, numerous testing types continue to be developed and await approval around the world so that researchers can better understand the true scale and toll of this pandemic.[10]

"

The speed of covid-19 testing during the pandemic was much faster than any other laboratory test.

Dr Jameel Iqbal, Pathologist, James J. Peters Veterans Affairs Medical Center, US

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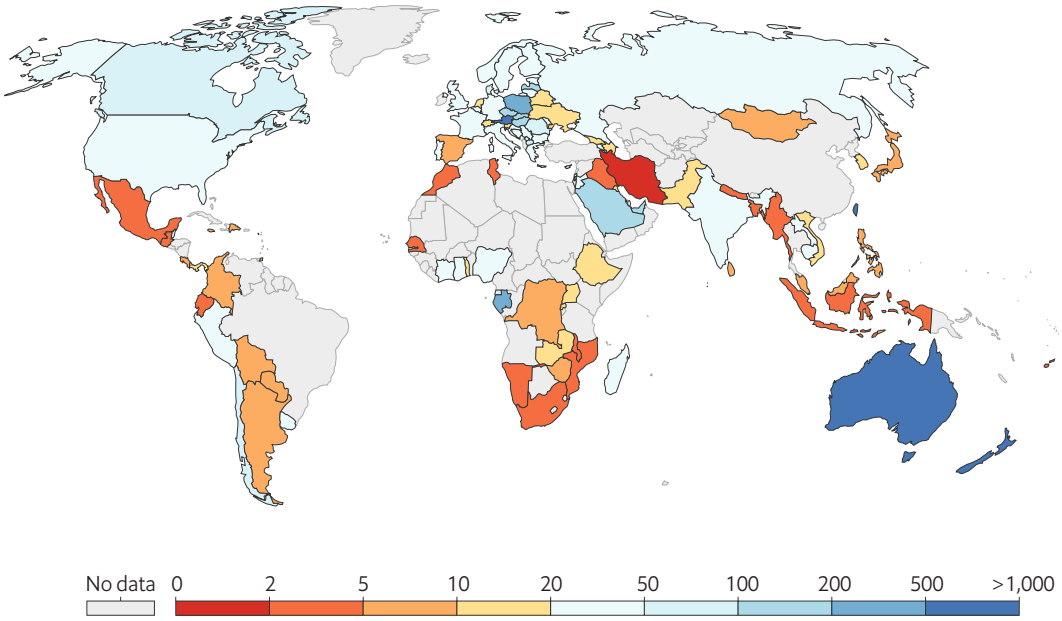
Figure 1.Tests conducted per new confirmed case of covid-19 (7-day average, as of August 6 2021)



Source: Roser M, Ritchie H, Ortiz-Ospina E, et al.[6]

Types of tests and when to use each

There are a variety of technologies for covid-19 testing that can be used in different circumstances according to their purposes, strengths and limitations. The three primary testing types used today are molecular, antigen and serologic. The reliability of each test depends on its sensitivity, meaning the probability of a test returning positive if the person is infected, and its specificity, which is the probability of a test returning negative when the person is not infected.[11]

Molecular testing (also known as RNA testing) is considered highly reliable because it uses a well-established technique that can detect viral genetic material in a respiratory tract sample. When used on a large scale, it can identify positive and negative cases of infection, including asymptomatic cases. Despite these benefits, the use of molecular testing is often limited due to the capacity limits on essential testing materials such as reagents, nasal swabs and transport issues. Numerous difficulties arise in the logistics of molecular sample collection, including transfer to a laboratory, analysis and the return of accurate results, which can lead to a high cost for countries.[11] Additional challenges arise due to inappropriate sample types based on exposure time and sampling time, along with inadequate staff experience, which can lead to false-negative results. In other words, the risk of false-negative results is high when testing occurs too early or too

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late in the cycle of the virus following exposure because the viral material is present for only a short time.[12]

Antigen testing can detect viral proteins (antigens) to diagnose a current covid-19 infection. This test uses a respiratory tract sample, with results in 30 minutes, and should be performed in the first five to seven days of symptoms for the most accurate results.[13] The ease of use, lower cost and rapid results of antigen tests allow for an increased volume of testing and faster isolation, which help break the chains of transmission. However, the moderate sensitivity of rapid antigen tests (meaning higher rates of false negatives)[11] makes them less reliable than molecular tests. Despite this, the WHO's latest testing guidance (released on June 25, 2021) calls for increased uptake of reliable antigen tests to complement molecular testing and improve accessibility of testing overall.[14]

Serologic testing (also known as antibody testing) can detect the immune response to a virus by looking for the presence of disease-specific antibodies in blood. The test results show the presence of IgM antibodies (which appear in the first week of infection and may last up to three months) or IgG antibodies (which are produced 10-14 days after the infection and may last months or even years).[11] In addition, rapid antibody tests can be done at the point of care because most do not require complex instruments.[15] The role of various serologic tests for SARS-CoV-2 is being investigated, while existing research shows that antibody serology can help identify recently infected patients in whom RNA and/or antigen is no longer reliably attainable from nose and throat swabs.[11,16] Beyond supplementing antigen and/or RNA tests, serologic testing remains vital for epidemiology and continued vaccine research and implementation.[11,17] These tests are showing promising results in detecting specific vaccine responses,[18] such as spike receptor-binding domains (RBDs), representing a response to either prior covid-19 infection or a vaccine.[18]

The importance of testing

According to the OECD, large-scale testing, tracking, tracing and isolating (TTTI) strategies are essential to the public health response in this pandemic and to prevent future rebounds of infections.[11] However, testing abilities depend on a country's self-sufficiency, healthcare system capacity, fiscal conditions and the social and political environment.[8] Testing can be used in varying ways according to the strategies adopted by a region's policymakers. Different strategies can inform decisions in clinical care, evaluate cases and monitor specific population groups.[11]

A study in Spain emphasizing the cost-effectiveness of test-track quarantine (TTQ) strategies suggests that for every euro spent on TTQ, approximately €7 can be recovered from saved health resources, based on the estimation of total costs of these strategies, health gains and avoided health care costs.[19]

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Nearly every country has implemented testing policies to contain the spread of this virus and end this pandemic. Figure 2 illustrates the type of covid-19 testing policies implemented across the world. These policies primarily focus on testing anyone with covid-19 or on open public testing.[6]

Countries have also used contact tracing strategies to interrupt chains of transmission and reduce mortality associated with SARS-CoV-2. Individuals who have been identified as probable or confirmed cases of infection are instructed to quarantine to avoid further transmission.[20] For instance, South Korea and China have been tracking covid-19 data through mobile apps since the beginning of the pandemic. Western countries have experienced difficulties collecting this type of information because people are reluctant over privacy concerns or have difficulties using the application. In such cases, the responsibility for using technology can be transferred from individuals (which assumes they have the necessary technology) to businesses or governments, which can be required to have checkpoints and control that information.

There are different challenges related to data collection and processing, depending on a country's technological infrastructure and data regulations, but it is important that governments and populations worldwide understand the necessity of continued TTTI strategies. The WHO emphasised this need in their latest testing guidance by encouraging all countries to retain their capacity for covid-19 surveillance and testing during periods of low transmission to be prepared for a resurgence of cases.[14]

The biggest barrier with testing is cost. For instance, in the United States, you can walk into any clinic and get a vaccine shot for free. However, that is not the same for testing, as you still see many people paying for tests.

Dr Jameel Iqbal,
Pathologist, James J. Peters Veterans Affairs Medical Center, US

Testing, tracking, and quarantine strategies can maintain some level of economic activity open at the same time that patients are identified, treated and isolated.

Dr Laura Vallejo-Torres,
Researcher in health economics at Universidad de Las Palmas de Gran Canaria

Data from covid-19 tests were collected in a very traditional way, but the system needs to be improved with the use of cloud computing and big data.

Professor Hong Zhu,
Professor of computer science, School of Engineering, Computing and Mathematics, Oxford Brookes University

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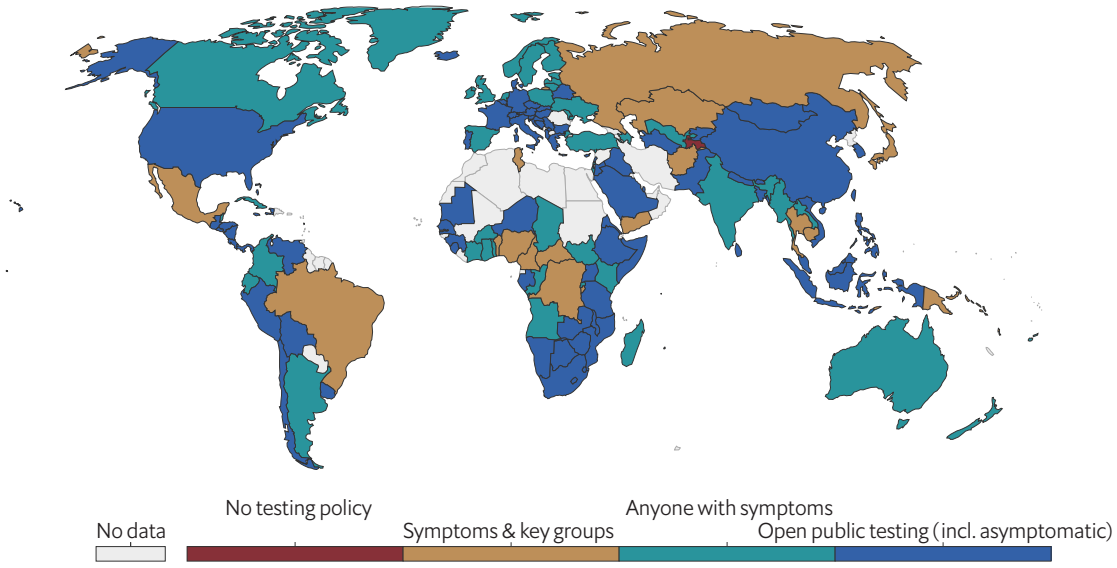
Figure 2. Covid-19 testing policies (as of August 8 2021)



Source: Roser M, Ritchie H, Ortiz-Ospina E, et al.[6]

Unanswered questions around testing

Though the benefits of effective testing strategies are apparent, many questions remain around the use of testing as we look towards the future of immunity. So-called immunity passports and the quest for herd immunity have been at the centre of many debates regarding the lifting of lockdown restrictions and return to pre-pandemic levels of activity.[21] Ethical considerations aside, the feasibility of immunity passports remains to be seen, as the duration of immunity and level of antibodies needed to achieve immunity are still to be determined.[22]

Experts believe that the virus is unlikely to go away anytime soon. With increased vaccination uptake, the virus could start to dissipate on its own, but countries may continue to grapple with future surges as a result of continued mutation of the virus. New and potentially more dangerous variants of the virus are likely to continue to emerge, and experts are not certain whether naturally derived immunity can protect against such strains.

> **The focus will shift away from antigen testing and return to antibody testing to see when a person might need to be boosted.**
>
> *Dr Rahul Batra,*
>
> *Physician and clinical innovations and disruptive technologies lead, Centre for Clinical Infection and Diagnostics Research, Guy's & St Thomas' NHS Foundation Trust*

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While there are prospects of this virus becoming endemic (such as influenza) in the long term, scientists are still apprehensive about reaching a state of herd immunity. Herd immunity means that even if a person becomes infected, there are fewer susceptible hosts to perpetuate transmission.[23] It will take time to see what the effects these novel vaccinations have at a population level and what (if any) role the booster will play moving forward. Immunity wanes over time, meaning that individuals might not get very sick, but they can still be reinfected. To address this possibility, researchers will need to identify what level of immunity is needed to protect the population, learn how long it takes to develop the specified immunity levels and how to most effectively boost immunity.[24] These unanswered questions reflect the complexities and challenges of fully transitioning out of this pandemic.

Growing curiosity around booster shots for the vaccines has spurred additional questions around the necessity of testing before receiving a booster. Can tests tell the origins of immunity (whether naturally derived or through vaccines), and is that level of data important?

> **There is good evidence of decreased covid-19 transmission with vaccinations, but we also know that people can still transmit and get the virus even though they are vaccinated.**
>
> *Dr Rahul Batra,*
> *Physician and clinical innovations and disruptive technologies lead, Centre for Clinical Infection and Diagnostics Research, Guy's & St Thomas' NHS Foundation Trust*

For that matter, do certain subpopulations need to be tested for antibodies more frequently (as identified by pre-existing condition, medication use, etc) to ensure they remain protected?[25] Though Israel has already made plans to offer booster shots beginning in October 2021, other heavily vaccinated countries such as the US and UK are more sceptical of this policy until more data are available.[26]

With the world opening up and travel restrictions easing, OECD Ministries have launched an initiative for safe international travel during the covid-19 pandemic.[27] The OECD material includes a safe-travel blueprint and temporary international cross-sectoral forum for knowledge sharing. The forum allows governments and stakeholders to share real-time information to support plans and approaches for travel.[27] Other existing international initiatives could complement this effort, such as the EU's proposed "Digital Covid-19 Certificate", digital proof that a person has either been vaccinated, received a negative test result or recovered from covid-19, which is set to begin in July 2021.[28] The International Air Transport Association is also testing a Travel Pass app that aligns governments, airlines, laboratories and travellers to provide both clarity and safety for crossing borders.[29] With rules and restrictions varying substantially by country (and even at a sub-national level), it is imperative to synchronise efforts from all stakeholders to make travel safe. A global, dedicated and digital effort to support safe travel in the face of a pandemic has never before occurred. While these initiatives will certainly raise numerous questions, they can also help answer many of the questions above if implemented in a way that is transparent and adaptable based on close monitoring and feedback.

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Role of data and informatics to support testing in pandemic response

SARS-CoV-2 testing on its own, as innovative and impressive as it is, will not be enough to eliminate this pandemic. The structures in place to collect, store, analyse and use testing data are crucial to our understanding of this disease. New and re-purposed data tools have become widespread throughout 2020 and into 2021 as countries experiment with a variety of strategies for managing novel and massive amounts of data. Table 1 offers an overview of the various technologies and their purposes throughout the pandemic.

Table 1. Digital technologies

Public-health need	Digital tool or technology	Example of use
Digital epidemiological surveillance	Machine learning	Web-based epidemic intelligence tools and online syndromic surveillance
	Survey apps and websites	Symptom reporting
	Data extraction and visualisation	Data dashboard, e.g. monitoring positivity rates or disease outbreaks
Rapid case identification	Connected diagnostic device	Point-of-care diagnosis
	Sensors including wearables	Febrile symptom checking
	Machine learning	Medical image analysis
Interruption of community transmission	Smartphone app, low-power Bluetooth technology	Digital contact tracing
	Mobile-phone location data	Mobility-pattern analysis
Public communication	Social-media platforms	Targeted communication
	Online search engine	Prioritised information
	Chat-bot	Personalised information
Clinical care	Tele-conferencing	Telemedicine, referral

Source: Budd J, Miller BS, Manning EM, et al,[30] Ministry of Health Singapore[31]

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Electronic health records

Electronic health records (EHRs) have been used with varying amounts of success during the covid-19 pandemic. The most effective EHRs have been able to streamline care and support communication between patients and healthcare providers. Experts recommend developing a standardised EHR configuration process to rapidly respond to public health emergencies. China's experience offers an example of an updated EHR configuration in which clinical informatics professionals adopted EHRs to include screening and triage processes, order tools, suspected case reports and outbreak-related information statistics.[32] Though this innovative approach has yet to take root in many countries around the world (including the US and EU), it illustrates how using new technologies is essential in epidemic prevention and control.

> **Modern EHRs can leverage data to support the implementation of new tools, algorithms and AI to assist with a patient's diagnosis and treatment.**
>
> *Dr Rahul Batra,*
> *Physician and clinical innovations and disruptive technologies lead, Centre for Clinical Infection and Diagnostics Research, Guy's & St Thomas' NHS Foundation Trust*

Substantial challenges, however, persist.[32] Such challenges include, but are certainly not limited to, outdated legal frameworks and regulations, geographical disparities in internet access, inadequate incentivisation and/or reimbursement, and system and data integration.[33] All of these components, among others, form the foundation for effective EHR use and must be addressed to ensure the efficiency and sustainability of health systems.

Challenges for implementing new and effective EHRs in particular include the need to coordinate multiple stakeholders (patients, providers, policymakers, etc), the lack of widespread interoperability and the need to adjust the tools in a quickly changing environment.[34] Therefore, EHR tools must be nimble enough to adapt to situations and processes within health systems or be supplemented with innovative yet cost-effective third-party options. To do so, institutionalised and critical enhancements of EHRs during the pandemic should be deliberately defined and developed to ensure improvements moving into the future.[35]

Artificial intelligence

Interest during the covid-19 pandemic has also intensified around artificial intelligence (AI) for its myriad uses. AI is being used at every point in the care continuum, from determining the screening results of suspected cases to identifying disease clusters and monitoring confirmed covid-19 cases. Healthcare providers have found particular utility in AI algorithms that triage patients with covid-19 and apply different levels of treatment according to their needs. AI can facilitate rapid training of health professionals, predict outbreaks, assess mortality risk and aid in disease management by resource allocation.36 The use of AI can even help to discover new drugs to treat covid-19 by speeding up trial processes like virtual screening and validation.[37]

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Though some AI algorithms have shown more accurate and faster screening results compared to the molecular tests, these algorithms do little to account for ethnic and geographic diversity, which limits efficacy in the real world.[38] During times of strained capacity and limited testing availability, AI has served as a beneficial tool to combat this pandemic. However, a gap continues to exist between those developing AI tools and those working in clinical settings, stemming in part from the mystery surrounding internal and external validation processes for these tools.[39] As AI continues to evolve and be refined, the accuracy of covid-19 testing remains an invaluable input into these algorithms.

> **In order to make AI a strong clinical tool, we need to create an appropriate regulatory environment.**
>
> *Dr Rahul Batra,*
> *Physician and clinical innovations and disruptive technologies lead, Centre for Clinical Infection and Diagnostics Research, Guy's & St Thomas' NHS Foundation Trust*

Telehealth

Telehealth has been the most direct use of technology between patient and provider throughout the pandemic. Use of various telehealth platforms sharply increased during the pandemic, enabled by structural changes in health systems.[40] Governments around the world improved reimbursement mechanisms and adapted regulations to be more supportive of telehealth. Asian telehealth platforms experienced a particular boom in large part due to government recommendation and support.[40]

Throughout the pandemic, providers have been able to practice virtual urgent care, screening and remote monitoring of covid-19 patients by linking telehealth systems and EHRs. All these uses have helped reduce the risk of exposure for the healthcare workforce and optimize the use of personal protective equipment.[41] Despite the benefits, the use of remote consultations can make it more difficult for healthcare providers to manage clinical data. Prevention efforts can be misguided when clinicians spend valuable time performing manual data entry and chart review that could instead be managed by more efficient EHR solutions.[35] With telehealth expanding rapidly, clinical guidelines are needed to support and standardise these types of services. Technology should also foster alignment between providers and EHR solutions to manage pandemic issues in real time.[35]

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Future outlook

As many countries experience declining numbers of cases and increased levels of vaccination, testing strategies and uses of various technologies will need to be adapted. Different layers of testing will be needed in the community and clinical settings. Workplaces, schools and other community-based organisations and institutions can capitalise on the proliferation of rapid "at-home" testing kits. Clinics and hospitals, in contrast, will likely use covid-19 tests in panel testing alongside other regular tests such as for influenza. Such tests are likely to produce results in minutes, but to avoid wasting resources, new strategies and policies must be developed to determine comprehensive yet efficient use. Testing in general may shift away from antigen tests and turn to antibody testing to assess whether an individual is safe to travel or if and when a vaccine booster is needed. Much is unknown about the future of testing, but keeping policies adaptable and clear will remain paramount.

The structural challenges of informatics and data management will not disappear overnight and will require an international integration and alignment of medical systems that includes AI infrastructure and applications. The development of this system must include healthcare providers, academics, the information technology industry and policymakers. In the short term, identifying successful smaller scale practices and dedicating resources to scaling them up could be an efficient use of testing data.

Conclusion

Since the beginning of the covid-19 pandemic, countries around the world have continuously adapted and pivoted their strategies to mitigate and ideally eliminate the virus. A core component of these strategies is effective and efficient testing measures and the use of those data, which will depend on tools and technologies to store, manage and analyse such crucial information. Reaching herd immunity is a perpetually moving target, but the only way to get ahead of this pandemic is to continue strategic testing measures and improve the processes for utilising this data. No country is doing a perfect job.

Testing cannot take a back seat to vaccination campaigns.

Though remaining diligent in vaccination is important, testing data are necessary to capture present realities of the pandemic as well as to measure how successful vaccination truly is over time.

As immunity passports inch further into reality, testing will remain crucial to ensure the accuracy and validity of the passports.

Without reliable evidence on long-term effectiveness of antibody-mediated immunity, it will be imperative for countries to be vigilant about learning from testing data and use it to adapt or reinforce passport strategies to avoid inadvertently increasing the risk of transmission.

No test in isolation will be enough to combat the pandemic.

Rather, all three major types of testing will continue to be essential based on the merits of

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each testing type and the various capacity issues around the world.

Countries need more transparency in their data processing and cloud computing tools without sacrificing privacy and security.

Global interoperability is not yet a widespread reality because many data management systems are confusing "black boxes" that prevent international collaboration.

Greater collaboration is needed among technology developers, clinical practitioners and policymakers in the design and implementation of digital tools.

Scaling up successful technology implementations (such as sophisticated AI algorithms) can improve communication and interaction between these often-siloed stakeholders.

There is a need for seamless integration of data into EHR systems to improve healthcare outcomes.

To reduce clinical inefficiency while prioritising patient care, EHRs in many parts of the world must be updated or supplemented with third-party innovations. Government regulation and funding mechanisms must also keep pace with the advanced technology being used throughout healthcare systems.

The innovation, scale and timeline of testing for covid-19 is unlike any scientific advancement in recent years. It is now the job of policymakers to ensure appropriate funding and resources to either reach or maintain adequate levels of testing, while enabling providers to keep covid-19 testing top of mind and routine in practice. Dr James Iqbal noted that testing must be made a higher priority because it will continue to offer invaluable information. Technology developers and implementers need continued and improved incentivisation, particularly regarding regulation, to continue developing essential and more effective tools and processes to make good use of the rich data testing offers.

While it is tempting to get lost in the details of testing and corresponding technology, testing will likely take new shape as vaccine access expands and virus variants unfold. Moving forward, maintaining focus on the broader merits of testing will be critical to help manage the pandemic.

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The EIU would like to thank the following experts for sharing their insights and experiences:

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