



The importance of microbiology reference laboratories and adequate funding for infectious disease surveillance

David Shaw, Raquel Abad Torreblanca, Zahin Amin-Chowdhury, Adriana Bautista, Desiree Bennett, Karen Broughton, Carlo Casanova, Eun Hwa Choi, Heike Claus, Mary Corcoran, Simon Cottrell, Robert Cunney, Lize Cuypers, Tine Dalby, Heather Davies, Linda de Gouveia, Ala-Eddine Deghmane, Stefanie Desmet, Mirian Domenech, Richard Drew, Mignon du Plessis, Carolina Duarte, Kurt Fursted, Alyssa Golden, Samanta Cristine Grassi Almeida, Desiree Henares, Birgitta Henriques-Normark, Markus Hilty, Steen Hoffmann, Hilary Humphreys, Susanne Jacobsson, Christopher Johnson, Keith A Jolley, Anibal Kawabata, Jana Kozakova, Karl G Kristinsson, Pavla Krizova, Alicja Kuch, Shamez Ladhani, Thiên-Trí Lâm, María Eugenia León Ayala, Laura Lindholm, David Litt, Martin C J Maiden, Irene Martin, Delphine Martiny, Wesley Mattheus, Noel D McCarthy, Mary Meehan, Susan Meiring, Paula Mölling, Eva Morfeldt, Julie Morgan, Robert Mulhall, Carmen Muñoz-Almagro, David Murdoch, Martin Musilek, Ludmila Novakova, Shahin Oftadeh, Amaresh Perez-Arguello, Maria Dolores Pérez-Vázquez, Monique Perrin, Benoît Prevost, Maria Roberts, Assaf Rokney, Merav Ron, Olga Marina Sanabria, Kevin J Scott, Julio Sempere, Lotta Siira, Ana Paula Silva de Lemos, Vitali Sintchenko, Anna Skoczyska, Hans-Christian Slotved, Andrew J Smith, Muhamed-Kheir Taha, Maija Toropainen, Georgina Tzanakaki, Anni Vainio, Mark P G van der Linden, Nina M van Sorge, Emmanuelle Varon, Julio Vazquez Moreno, Sandra Vohnova, Anne von Gottberg, Jose Yuste, Angela B Brueggemann

Microbiology reference laboratories perform a crucial role within public health systems. This role was especially evident during the COVID-19 pandemic. In this Viewpoint, we emphasise the importance of microbiology reference laboratories and highlight the types of digital data and expertise they provide, which benefit national and international public health. We also highlight the value of surveillance initiatives among collaborative international partners, who work together to share, analyse, and interpret data, and then disseminate their findings in a timely manner. Microbiology reference laboratories have substantial impact at regional, national, and international levels, and sustained support for these laboratories is essential for public health in both pandemic and non-pandemic times.

Introduction

In addition to its extraordinary death toll, the COVID-19 pandemic uncovered substantial fragilities in many systems and institutions around the world.^{1,2} Although the full catalogue of lessons learnt from the pandemic continues to be explored, one central feature should not escape our focus: the importance of microbiology reference laboratories and the experts working within them. Microbiology laboratories were among the first to identify cases of COVID-19 (and so-called variants of concern), monitored case numbers in real time, deployed public health responses to the pandemic, advised on policies to protect the public, and informed COVID-19 vaccination programmes.¹

Ordinarily, the functions of microbiology reference laboratories are to facilitate early detection and control of infectious diseases, including through outbreak detection, surveillance of endemic diseases, monitoring of antimicrobial resistance, and provisioning of data to monitor and assess vaccination programmes. They provide data and scientific expertise to public health authorities, support diagnostic stewardship and services in other regional laboratories, promote advocacy and linkages with patient support groups, and contribute to an overall reduction in disease burden.^{3–5}

In addition, these laboratories facilitate reference diagnostics; produce reference materials, manuals, and tools; provide (and often lead) external quality assessments; perform pathogen genome sequencing; train personnel; and conduct research projects. Reference laboratories often maintain collections of specimens and microbes with corresponding metadata, allowing future

access and characterisation as required. Reference laboratories also play crucial roles in disease risk forecasting, which improves epidemic and pandemic preparedness, and are often involved in investigating historical, neglected, or re-emerging diseases.^{6,7} The demands on microbiology reference laboratories during the COVID-19 pandemic were therefore in addition to their routine laboratory work.

The importance of infectious disease surveillance

The COVID-19 pandemic showed the public the continuing importance of local, national, and international surveillance of infectious diseases in saving lives and informing vaccination programmes. The importance of surveillance was also highlighted more recently in WHO's *Global Research and Innovation for Health Emergencies* blueprint,⁸ in which the recommendation for an improved, interconnected global laboratory capacity for pathogen surveillance was emphasised.

Many national surveillance programmes have been active for multiple decades and have made key contributions to microbiology and the control of infectious diseases both in their own countries and worldwide. Yet, despite their highly impactful work, many laboratories routinely struggle to secure ever diminishing funding for their surveillance programmes from governmental health and science budgets.⁹ The dedicated work performed by microbiology reference laboratories is often not appreciated because the science is seldom innovative and the work seems repetitive and administrative.

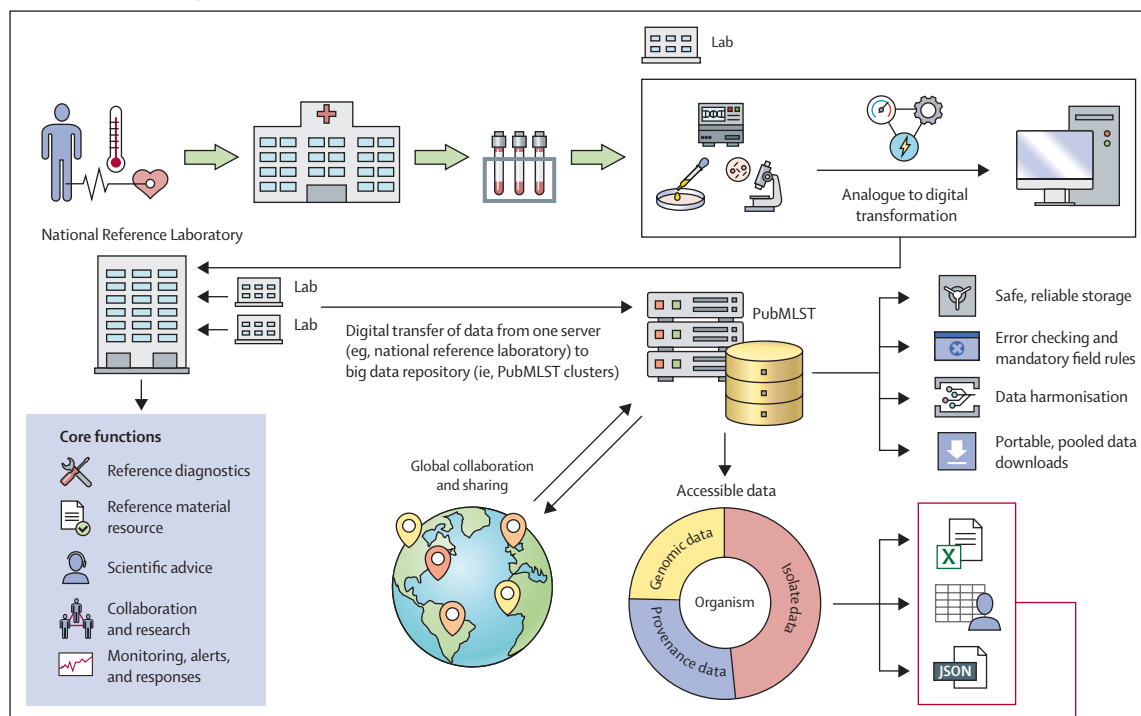
Lancet Digit Health 2024

Published Online
December 20, 2024
[https://doi.org/10.1016/S2589-7500\(24\)00241-3](https://doi.org/10.1016/S2589-7500(24)00241-3)

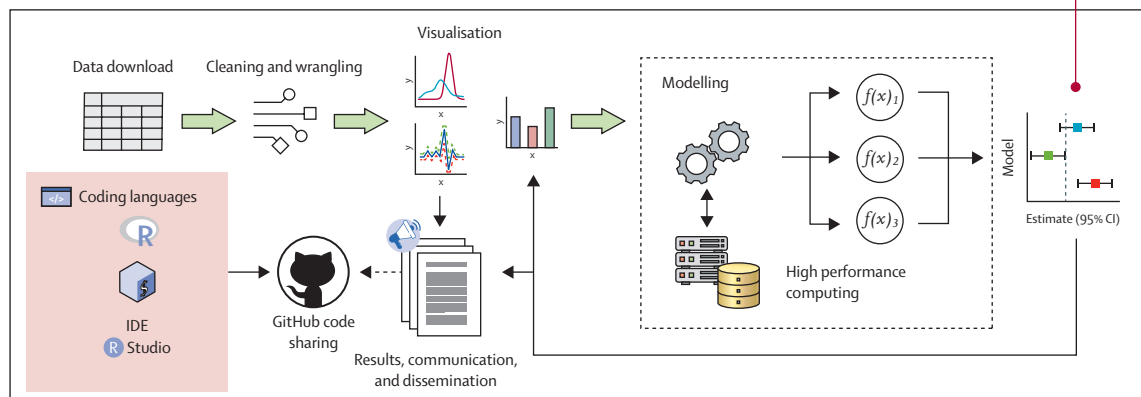
Bacterial Respiratory Infection Service, Scottish Microbiology Reference Laboratory, Glasgow, UK (K J Scott PhD, Prof A J Smith FRCPath); Division of Public Health Surveillance and Response (S Meiring PhD) and Centre for Respiratory Diseases and Meningitis (L de Gouveia NatDipMedTech, M du Plessis PhD, Prof A von Gottberg PhD), National Institute for Communicable Diseases, a Division of the National Health Laboratory Service, Johannesburg, South Africa; CIBER de Enfermedades Respiratorias, Instituto de Salud Carlos III, Madrid, Spain (M Domenech PhD, J Sempere PhD, J Yuste PhD); CIBER de Epidemiología y Salud Pública, CIBERESP, Barcelona, Spain (Prof C Muñoz-Almagro MD, D Henares PhD); Clinical Innovation Unit, Rotunda, Dublin, Ireland (Prof R Drew MD); College of Medical, Veterinary & Life Sciences, University of Glasgow, Glasgow, UK (Prof A J Smith); Department of Bacteria, Parasites & Fungi, Statens Serum Institut, Copenhagen, Denmark (K Fursted MD, S Hoffmann MD, H-C Slotved DMSc); Department of Bacteriology and Mycology, Respiratory and Meningeal Diseases Section, Laboratorio Central de Salud Pública, Asunción, Paraguay (A Kawabata BSc,

M E León Ayala MSc; Nuffield Department of Population Health (Prof A B Brüeggemann DPhil, D Shaw MBBCh) and Department of Biology (K A Jolley PhD, Prof M C J Maiden PhD), University of Oxford, Oxford, UK; Department of Clinical Microbiology, Karolinska University Hospital, Stockholm, Sweden (Prof B Henriques-Normark MD); Department of Clinical Microbiology, Landspítali-The National University Hospital of Iceland, Reykjavik, Iceland (Prof K G Kristinsson MD); Department of Clinical Microbiology, Royal College of Surgeons in Ireland University of Medicine and Health Sciences, Dublin, Ireland (Prof H Humphreys MD); Department of Clinical Microbiology, The Royal College of Surgeons in Ireland, Dublin, Ireland (M Corcoran PhD, Prof R Cunney MB, Prof R Drew); Department of Infectious Disease Epidemiology and Prevention, Statens Serum Institut, Copenhagen, Denmark (T Dalby PhD); Department of Medical Microbiology and Infection Prevention and Netherlands Reference Laboratory for Bacterial Meningitis, Amsterdam University Medical Center, University of Amsterdam, Amsterdam, Netherlands (Prof N M van Sorge PhD); Department of Microbiology, Children's Health Ireland at Temple Street, Dublin, Ireland (Prof R Cunney); Department of Microbiology, Immunology and Transplantation, KU Leuven, Leuven, Belgium (L Cuypers PhD, S Desmet PhD); Department of Microbiology, Tumor and Cell Biology, Karolinska Institutet, Stockholm, Sweden (Prof B Henriques-Normark); Department of Pediatrics, Seoul National University College of Medicine, Seoul, South Korea (Prof E H Choi MD); Department of Public Health, Finnish Institute for Health and Welfare, Helsinki, Finland (L Lindholm MSc, L Siira PhD, M Toropainen PhD, A Vainio PhD); Grupo de Microbiología-Instituto Nacional de Salud, Bogotá, Colombia (A Bautista BSc, C Duarte MSc, O M Sanabria MPH); Faculté de Médecine et Pharmacie

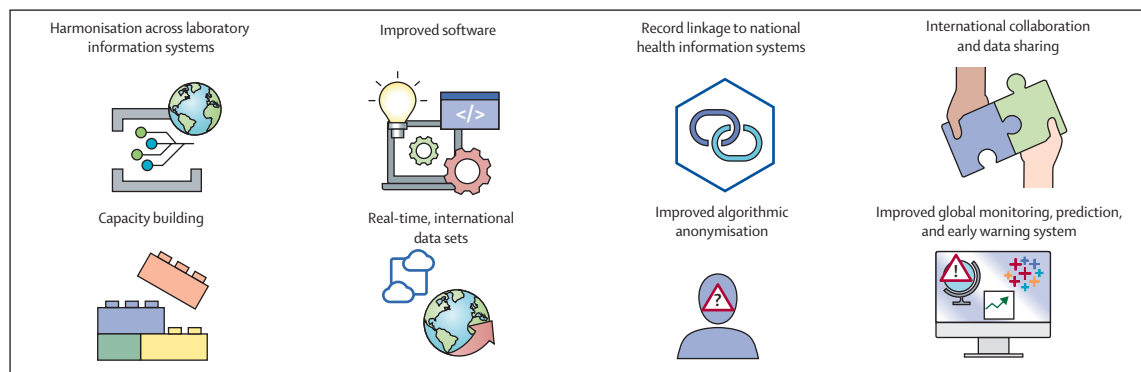
1 Data collection and storage



2 Data processing and analysis



3 Opportunities associated with digitised data



One coauthor of this Viewpoint described the work as “quiet but consistent”, which is one of the key strengths of reference laboratories: consistency in data generation and analyses, and specialist knowledge over a long period of time, allowing for the recognition of trends and any deviations from long-term trends. Similarly to the success of the polio vaccination campaign, microbiology reference laboratories suffer from the public health paradox, meaning that after a successful intervention against a specific problem, surveillance no longer seems to be required and, consequently, public and governmental institutions lose interest.¹⁰ Humans are creatures of agency—we need to see processes work to believe that they work. These laboratories are contributing tremendously to the public good and are providing crucial infrastructure, as evidenced by their impact on public health both in pandemic and non-pandemic times.

One of the most important functions of microbiology reference laboratories is the monitoring of vaccine performance through post-marketing surveillance of vaccine effectiveness and impact, disease rates, and changes in pathogen antigenic variants, in both target and non-target populations. These epidemiological data enable the assessment of national vaccination programmes and are routinely used to devise and amend vaccine policy decisions. For example, there was an invasive *Neisseria meningitidis* meningococcal disease outbreak in the Netherlands between 2015 and 2018. Through the national reference laboratory's surveillance, serogroup W meningococci were quickly identified as the cause of the outbreak, leading to the replacement of the MenC vaccine with the MenACWY vaccine in the Dutch National Immunisation Programme in 2018.¹¹ National reference laboratories, surveillance programmes, and vaccine monitoring will remain essential during the upcoming roll-out of the new *Streptococcus pneumoniae* (pneumococcal) vaccines and other vaccines in the pipeline.¹²

Investing in surveillance to promote public health

Surveillance activities help prevent disease in a population at a price, which includes personnel, equipment, consumables, information technology infrastructure, facilities, and administrative costs. Despite their indisputable value to public health, competing demands on existing funds can mean that less money is made available to some reference laboratories, sometimes

Figure 1: Illustration of the various stages and types of digital laboratory data processing in microbiology reference laboratories and the opportunities that arise with digitised data

This figure illustrates the various stages and types of digital laboratory data processing in microbiology reference laboratories (panels 1 and 2), and the opportunities that arise with digitised data (panel 3). IDE=interactive developer environment.

	Location	Type	Citations (N)
National Institute for Public Health and the Environment	Netherlands	Government; research centre	4
Belgian Federal Public Services	Belgium	Government	2
Sciensano	Belgium	Government; health-care agency	2
Finnish Institute for Health and Welfare	Finland	Government; health-care agency	2
European Centre for Disease Prevention and Control	EU	Government; agency	1
Parliamentary Office for Scientific and Technological Assessment	France	Government	1
Health Protection Surveillance Centre	Ireland	Government	1
Office of the Prime Minister's Chief Science Advisor	New Zealand	Government	1
The UK Government	UK	Government	1
National Health Service Trusts	UK	Government; health-care agency	1
Centers for Disease Control and Prevention	USA	Government; health-care agency	1

Data obtained from Overton on July 9, 2024.

Table: Policy impact of the Invasive Respiratory Infection Surveillance Consortium evidenced by its citation by government, national, and international documents

requiring them to seek additional sources of financial support. Some governments deter industry funding partnerships (fearing a real or perceived conflict of interest) whereas some do not have a framework to accommodate funding from industry or other third parties. In other countries, industry funding is an appreciated source of additional financial support to their budget portfolio. These challenges exist even though cutting expenditure on public health services, including microbiology reference laboratories, is widely understood to increase health-care costs and widen health inequalities.^{13,14}

In 2016, the European Centre for Disease Control and Prevention (ECDC) commissioned a cost-benefit analysis of national reference laboratories for human pathogens.³ The ECDC's chief concern was the possible integration of disparate national reference laboratories into a centralised European Reference Laboratory, and the report detailed monetary and non-monetary costs and benefits associated with European reference laboratories. The Commission concluded that the benefits of national reference laboratories (especially of an integrated network of laboratories) exceeded the costs, both monetary and non-monetary. The Commission also acknowledged the difficulties in quantifying the work

Université de Mons (UMONS), Mons, Belgium (Prof D Martiny PhD, B Prevost PhD); German National Reference Center for Meningococci and Haemophilus influenzae, Institute for Hygiene and Microbiology, University of Würzburg, Würzburg, Germany (H Claus PhD, T-T Lâm MD); Government Central Laboratories, Ministry of Health, Jerusalem, Israel (A Rokney PhD, M Ron PhD); Institute of Clinical Pathology and Medical Research, NSW Health Pathology, NSW, Sydney, Australia (S Oftadeh MD, Prof V Sintchenko PhD); Instituto de Recerca Pediàtrica, Hospital Sant Joan de Deu, Barcelona, Spain (D Henares, Prof C Muñoz-Almagro, A Perez-Argüello MLT); Invasive Bacterial Infections Unit and National Reference Centre for Meningococci and Haemophilus influenzae, Institut Pasteur, Paris, France (A-E Deghmane PhD, M-K Taha MD); Irish Meningitis and Sepsis Reference Laboratory, Children's Health Ireland at Temple Street, Dublin, Ireland (D Bennett PhD, M Corcoran, Prof R Cunney, Prof R Drew, M Meehan PhD, R Mulhall PhD); Laboratory of Medical Biology and National Reference Centre for Pneumococci, Intercommunal Hospital of Créteil, Créteil, France (E Varon MD); Medicine Department, Universitat Internacional de Catalunya, Barcelona, Spain (Prof C Muñoz-Almagro); National Centre of Microbiology and CIBER de enfermedades infecciosas, Instituto de Salud Carlos III, Madrid, Spain (M D Pérez-Vázquez PhD); National Laboratory for Meningitis and Pneumococcal Infections, Center of Bacteriology, Instituto Adolfo Lutz, São Paulo, Brazil (S C Grassi Almeida PhD, A P Silva de Lemos PhD); National Meningitis Reference Laboratory, School of Public Health, University of West Attica, Athens, Greece (Prof G Tzanakaki PhD); National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Canada (A Golden PhD, I Martin BSc); National Reference Centre for Bacterial Meningitis, National Medicines Institute, Warsaw,

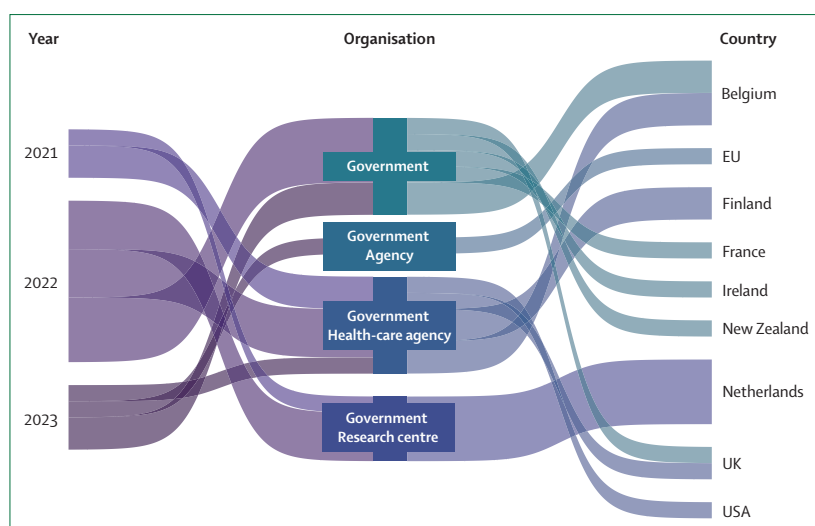


Figure 2: Sankey diagram illustrating the policy impact of the IRIS Consortium

The data visualisation depicts policy documents that have referenced IRIS papers as connections between the year of publication of the policy document, the type of organisation that published it, and the country in which the policy document originated. Data were obtained with Overton on July 9, 2024. Details of the documents can be obtained from the corresponding author. IRIS=Invasive Respiratory Infection Surveillance.

Poland (A Kuch PhD, Prof A Skoczyska PhD); **National Reference Centre for *Haemophilus influenzae*, Laboratoires des Hôpitaux Universitaires de Bruxelles–Universitaire Laboratorium Brussel, LHUB-ULB, Brussels, Belgium** (Prof D Martiny, B Prevost); **National Reference Centre for Invasive *Streptococcus pneumoniae*, University Hospitals Leuven, Leuven, Belgium** (L Cuyper, S Desmet); **National Reference Centre for *Neisseria meningitidis*, Sciensano, Brussels, Belgium** (W Mattheus PhD); **National Reference Laboratory for Meningococci** (R Abad Torrealba PhD, Prof J Vazquez Moreno PhD) and **Spanish Pneumococcal Reference Laboratory** (M Domenech, J Sempere, J Yuste), **National Centre of Microbiology, Instituto de Salud Carlos III, Madrid, Spain**; **National Reference Laboratory for *Neisseria meningitidis*, Department of Laboratory Medicine, Clinical Microbiology, Faculty of Medicine and Health, Örebro University, Örebro, Sweden** (S Jacobsson PhD, P Mölling PhD); **NRL for *Haemophilus influenzae* (L Novakova MSc), NRL for Meningococcal Infections** (P Krizova MD, M Musilek PhD), **NRL for Streptococcal Infections**

performed by these laboratories in reducing disease burden since this is influenced by many factors. The ECDC report stated that European society benefits directly along four axes: first, laboratory preparedness and the capacity for a coordinated response to outbreaks; second, more timely and accurate detection of pathogens; third, improved public health surveillance; and fourth, a reduction in disease burden and the related costs.

Although the public health microbiology network across Europe was deemed strong, the report also highlighted challenges and limitations for reference laboratories in Europe. Many of these difficulties are common among reference laboratories worldwide. For example, the need to harmonise surveillance, reporting, and operating standards; uneven country capacities and variation in the types of reference laboratory activities that are performed; political and bureaucratic limitations for sharing data, at least partly due to privacy issues; whether or not to adopt new diagnostic tools and more broadly, how to implement technological advances in the field; the implementation of standardised genomic methods for genotyping, including the prediction of phenotypes (eg, antimicrobial resistance); and how to ensure that sustainable funding is available both for routine work and when emergencies occur.

Recently, the ECDC facilitated a programme to assess where improvements to public health infrastructures might be required, and in 2019, Bajoriniene and colleagues⁴ performed a needs assessment for microbiology laboratories in western Balkan countries. They identified key areas for public health investment and concluded that these efforts enhanced health security in these countries and in Europe in general.⁴ This work

illustrated the indirect and nonlinear effects of adequate laboratory funding: not only does the country benefit by enhanced health security and disease control, but neighbouring countries and the global community benefit as well. When considered from this perspective, the price at an individual level is rather small relative to the large effect of the outcomes—similar to other public health interventions such as smoking cessation.¹⁵ A 2017 systematic review of public health expenditure in a number of high-income countries also supports the benefits and cost savings associated with population-level efforts to prevent disease.¹⁶

Similarly, a qualitative study commissioned by the Center for Global Development in 2022 examined the costs and benefits of investing in laboratory systems in Africa.¹⁷ The authors found that the wide-ranging benefits exceeded the necessary costs, and these benefits have potentially transformative impacts at the individual, population, and health-system levels.¹⁷ Discussions at the Third International Conference on Public Health in Zambia in November, 2023, resulted in pledges of support and political endorsement for national public health institutions and reference laboratories.¹⁸

The Invasive Respiratory Infection Surveillance Consortium

The Invasive Respiratory Infection Surveillance (IRIS) Consortium, with a network of microbiology reference laboratories at its centre, was established early (April–May, 2020) in the COVID-19 pandemic to track changes in the incidence of invasive bacterial disease caused by four organisms: *S pneumoniae*, *Haemophilus influenzae*, *N meningitidis*, and *S agalactiae* (group B streptococcus).¹⁹ The IRIS Consortium comprises more than 100 collaborators working in over 50 laboratories in 30 countries. The central components of the IRIS Consortium surveillance are wide population capture plus accurate, timely, and precise data—an important illustration of why setting up robust surveillance systems in every country is so pertinent.

The IRIS Consortium includes high-income and middle-income countries across the northern and southern hemispheres to rapidly monitor changes in invasive bacterial disease at a global level. The strength of the IRIS Consortium lies in the collaborative nature of this project: national and regional microbiology reference laboratories have come together to share robust and reliable data via private databases in PubMLST as a consortium of collaborating laboratories. These digital data have been (and continue to be) analysed collectively and disseminated in a timely and mutually agreed manner (figure 1).²⁰ The multidisciplinary nature of expertise within the IRIS Consortium is an additional asset, bringing together complementary fields of expertise not only in microbiology, but also in epidemiology, pathophysiology, medicine, immunology, and bioinformatics. The IRIS Consortium has produced

two papers on describing changes in the distribution of invasive bacterial disease by location, age, and serotype or serogroup before, during, and after the COVID-19 pandemic, and these papers are contributing to public health policy (table; figure 2).^{19,21}

The effects of such a collaboration are multiplicative rather than additive: in addition to performing surveillance on a global scale for four leading bacterial pathogens, we can pool data across all countries and by defined regions to generate robust estimates due to large sample sizes and increased statistical power. We can measure the impact of different prevention and control interventions among countries or regions and evaluate antimicrobial susceptibility patterns.

Surveillance in an age of digitalisation and big data

For the IRIS Consortium and other rapid surveillance systems to function efficiently and effectively, various types of digital data (often in non-standardised formats) must be shared, harmonised, stored, and analysed (figure 1). This requires laboratory information systems to manage large datasets, appropriate tools for analyses, and sufficient computing power. Data sharing is currently a major challenge for many laboratories. Human curation and expertise are also essential to place results in the correct context and check for errors. If a robust digital infrastructure is missing, gathering laboratory data and linking those data to patient information becomes more challenging, and showing the public health impact of reference laboratories becomes harder.

Although data management infrastructure is established in many laboratories, opportunities exist for further improvements. For example, digital record linkage to other national health information systems can provide richer datasets that allow risk factors, health outcomes, and interventions to be jointly investigated. Data privacy and protection are crucial when working with patient data but might restrict data linkage between different systems; however, improved algorithmic patient anonymisation could facilitate data linkage while still retaining privacy. Furthermore, digital data formats from different laboratories could be harmonised to accelerate data processing and analyses. Reference laboratories are also well positioned to show leadership in the areas of genomic surveillance and data science (including artificial intelligence), given their vital role in public health surveillance and data analytics.²² Finally, building robust data management infrastructure should be a priority when building laboratory and surveillance capabilities in countries that currently have reduced capacity.

Conclusions

Prevention is better than cure. Microbiology reference laboratories are fundamental to informing measures

that reduce mortality and minimise human suffering. Therefore, continued support for national reference laboratories is crucial to avoid the risk of hampering hard-earned scientific progress. Calls to increase investment in public health have amplified since the COVID-19 pandemic: we are specifically advocating for increased and sustained funding for microbiology reference laboratories, since sustained funding is crucial for their core work and for these networks and collaborations to develop.^{15,23} Notably, components of the core public health infrastructure such as reference laboratories deliver continuously and provide a base framework for expansion, in contrast to investment that does not build on existing core resources and established networks. As a network of international collaborators, we hope to add weight to these calls to increase investment in microbiology reference laboratories. At best, we hope this Viewpoint can be used as evidence of the need for sustained funding, but at a minimum this Viewpoint should be used to start the conversation.

Microbiology reference laboratories, along with other public health interventions, provide the protection that keeps societies safe as we navigate the health risks of our daily lives. This safety has a price and without it, the price will not just be monetary but paid for with the lives of the citizens we are supposed to protect. Public health policies and interventions have made great progress in reducing the burden of disease and increasing health and hygiene standards. Increasing the funding for microbiology reference laboratories in all countries is necessary to ensure a safe future for everyone.

Contributors

DS and ABB directly accessed and verified the underlying data reported in this Viewpoint and wrote the first draft of the manuscript. All authors made edits to and reviewed the manuscript, and approved the final version of the manuscript for submission.

Declaration of interests

EV has received research grants from the French Public Health Agency, Pfizer, and MSD (paid to Centre Hospitalier Intercommunal de Créteil). SD has received a research grant from Pfizer; and advisory board and speaker fees from Merck-MSD (paid to University Hospitals Leuven). MH and CC have received funding from the Federal Office of Public Health (paid to The Swiss National Reference Center for Invasive Pneumococci). MH has participated on a data safety monitoring board or advisory board for both Pfizer and MSD. MH also holds investigator-initiated grants from Pfizer and MSD paid to his institution. However, the sponsors had no role in the data analysis and content of this manuscript. AS and AKu have received funding from the National Science Centre, MSD, and Pfizer; and equipment from The Great Orchestra of Christmas Charity Foundation and the Clinical Microbiology Center Foundation (paid and sent to The National Medicines Institute, Warsaw). AKu has received payments from Sandoz, and Pfizer for lectures. AS has received payments from MSD and Pfizer for lectures; and from MSD, Pfizer, and Sanofi Pasteur for participation on advisory boards. LL and MT have received research funding from Pfizer (paid to The Finnish Institute for Health and Welfare). ABB has received funding from MSD for IRIS pneumococcal genome sequencing. ABB is an unpaid advisor to WHO, providing expertise related to vaccines and antimicrobial resistance. ABB is also an unpaid General Assembly member (from 2022 onwards); and was a board member from 2016 to 2022, and Secretary from 2018 to 2022 for the

(S Vohnova MD, J Kozakova MD), Department of Air-Borne Bacterial Infections (J Kozakova), and Centre for Epidemiology and Microbiology (J Kozakova), National Institute of Public Health, Prague, Czech Republic; Reference Laboratory for Streptococci, University Hospital RWTH Aachen, Aachen, Germany (M P G van der Linden PhD); Immunisation and Countermeasures Division (Z Amin-Chowdhury MSC, Prof S Ladhani MD) and Respiratory and Vaccine Preventable Bacteria Reference Unit (D Litt PhD), UK Health Security Agency, London, UK; Staphylococcus and Streptococcus Reference Section, AMRHAI, UK Health Security Agency, London, UK (K Broughton MSC); Meningococcal Reference Laboratory (H Davies NZCS) and Streptococcal Reference Laboratory, Institute of Environmental Science and Research Limited, Porirua, New Zealand (J Morgan HND); Swiss National Reference Centre for Invasive Pneumococci, Institute for Infectious Diseases, University of Bern, Bern, Switzerland (C Casanova PhD, M Hilty PhD); Sydney Infectious Diseases Institute, University of Sydney, Sydney, NSW, Australia (Prof V Sintchenko); Trinity College Dublin, The University of Dublin, Dublin, Ireland (Prof N D McCarthy DPhil); Laboratoire National de Sante, Dudelange, Luxembourg (M Perrin MD); Public Health Agency of Sweden, Solna, Sweden (E Morfeldt PhD); Public Health Wales, Cardiff, UK (S Cottrell PhD, C Johnson PhD, M Roberts BSc(Hons)); University of Otago, Christchurch, New Zealand (Prof D Murdoch MD)

Correspondence to: Prof Angela Brueggemann, Nuffield Department of Population Health, University of Oxford, Oxford OX3 7LF, UK angela.brueggemann@ndph.ox.ac.uk

For more on Overton see <https://www.overton.io/>

For more on PubMLST see <https://pubmlst.org>

International Society of Pneumonia and Pneumococcal Diseases. MD has received financial support from Pfizer to attend national scientific meetings. HH has received a grant from Pfizer to investigate Irish pneumococcal serotypes with whole genome sequencing. HH has received consulting fees from Bons Secours Hospital Group (Ireland). HH has received payment from the Scottish Hospitals Enquiry for expert testimony. KAJ has received personal royalties from GSK; and personal honoraria from the Wellcome Trust. T-TL has received consulting fees from the Trond Mohn Foundation. T-TL is an unpaid board member for the European Society for Meningococcal and Haemophilus influenzae disease, and the German Society for Hygiene and Microbiology (committee for microbial systematics, population genetics and infection epidemiology). H-CS has received funding from Pfizer for a pneumococcal carriage project. H-CS has received funding for consultations on a data safety monitoring board or advisory board for MSD. MPGvdL has received research funding from Pfizer and Merck (paid to the Reference Laboratory for Streptococci in Aachen, Germany); has received consulting fees from Pfizer, Merck, and GSK; payment or honoraria from Pfizer and Merck; and support for attending meetings or travel from Pfizer. AvG is the chairperson for the National Immunization Technical Advisory Group (National Advisory Group on Immunization) for South Africa. NMvS has received fees for services and consulting fees from MSD and GSK; consulting fees from Pfizer; and research funding from the Dutch Health Counsel, Argenx, Leducq Foundation, and Amsterdam UMC (all paid to their institution). NMvS holds a patent (WO 2013/020090 A3) on vaccine development against *Streptococcus pyogenes*. NMvS is an unpaid scientific advisor to the ItsME foundation, and a scientific advisor to Rapua te me ngaro ka tau (fees are paid to the University of Amsterdam). NMvS holds personal stock in Genmab and the Bank of America. JY has received payments for lectures given at scientific meetings organised by MSD and Pfizer; has received support from MSD and Pfizer to attend national and international scientific meetings; and has participated on MSD and Pfizer advisory boards. JS has participated on advisory boards for MSD. HC has received payment from Sanofi-Aventis Germany for a lecture; and is an unpaid external advisor to the German Standing Committee on Vaccination. SM is an unpaid external expert for an advisory board for enquiry into the landscape for a MenB vaccine in South Africa. JVM performs contract work for the Institute of Health Carlos III funded by GSK and Pfizer; and receives consulting fees from Pfizer and Sanofi Pasteur. MC has received an Investigator Initiated Research grant from Pfizer (W1243730; paid to their institution, Children's Health Ireland). MC is part of a working group for The National Immunisation Advisory Committee in Ireland. KGK has received funding from the European Society for Clinical Microbiology and Infectious Diseases (ESCMID) to attend the ESCMID global meeting in Barcelona as a member of the Professional Affairs Subcommittee. CM-A has received payments for invited lectures given at scientific meetings for MSD, Sanofi-Pasteur, and Pfizer. CM-A has received support from MSD and Pfizer to attend national and international scientific meetings. All other authors declare no competing interests.

Acknowledgments

The infrastructure for the IRIS Consortium is funded by a Wellcome Trust Investigator Award to ABB (grant number 206394/Z/17/Z). The IRIS databases are part of PubMLST, which is funded by a Wellcome Trust Biomedical Resource Grant awarded to MCJM, ABB, and KAJ (grant number 218205/Z/19/Z). DS received an Oxford Clarendon Scholarship covering university fees plus a stipend. This work was also partly supported by: research funding from the Polish Ministry of Health and the Polish Ministry of Science and Higher Education to the National Medicines Institute, Poland; the Robert Koch-Institute with funds of the Federal Ministry of Health (funding code 1369–237) to the National Reference Centre for Meningococci and *Haemophilus influenzae*; and research funding from Pfizer and the European Centre for Disease Prevention and Control for pneumococcal surveillance work at the Irish Meningitis and Sepsis Reference Laboratory. The funders had no role in data collection, analysis, interpretation, writing of the manuscript, or the decision to submit for publication. All authors agreed to be accountable for all aspects of the work. The corresponding author (ABB) had final responsibility for the decision to submit this work for publication.

References

- 1 Sachs JD, Karim SSA, Akinin L, et al. The *Lancet* Commission on lessons for the future from the COVID-19 pandemic. *Lancet* 2022; **400**: 1224–80.
- 2 WHO. WHO COVID-19 dashboard. World Health Organization, 2024. <https://data.who.int/dashboards/covid19/cases> (accessed July 9, 2024).
- 3 Consumers, Health and Food Executive Agency Unit. Study on cost-benefit analysis of reference laboratories for human pathogens—executive summary. Luxembourg: Publications Office of the European Commission, 2016.
- 4 Bajoriniene A, Leitmeyer KC, Struelens MJ, Kokki MH. Investing in public health microbiology laboratories in western Balkan countries enhances health security from communicable disease threats in Europe. *Front Public Health* 2019; **7**: 8.
- 5 WHO. Diagnostic stewardship: a guide to implementation in antimicrobial resistance surveillance sites. Geneva: World Health Organization, 2016.
- 6 Myers MF, Rogers DJ, Cox J, Flahault A, Hay SI. Forecasting disease risk for increased epidemic preparedness in public health. *Adv Parasitol* 2000; **47**: 309–30.
- 7 Ma L, Caulfield A, Dewan KK, Harvill ET. Pertactin-deficient *Bordetella pertussis*, vaccine-driven evolution, and reemergence of pertussis. *Emerg Infect Dis* 2021; **27**: 1561–66.
- 8 WHO. Global research and innovation for health emergencies. World Health Organization, 2023. <https://www.who.int/publications/m/item/global-research-and-innovation-for-health-emergencies> (accessed July 9, 2024).
- 9 Bell JA, Nuzzo JB. Global health security index: advancing collective action and accountability amid global crisis. The Global Health Security Index, 2021. <https://ghsindex.org/> (accessed July 9, 2024).
- 10 Messinger Cayetano S, Crandall L. Paradox of success and public perspective: COVID-19 and the perennial problem of prevention. *J Epidemiol Community Health* 2020; **74**: 679.
- 11 Oostdijk C, Ferreira JA, Ruijs WLM, Mollema L, Van Zoonen K. Adolescent and parental decision-making for the MenACWY vaccination: influential predictors and parental-adolescent differences among households in the Netherlands. *BMC Public Health* 2023; **23**: 947.
- 12 Largeron N, D'Agostino P, Chapman R, et al. Guiding principles for evaluating vaccines in joint health technology assessment in the European Union: preparing for the EU's regulation on HTA for vaccines. *Value Health* 2024; **27**: 1318–27.
- 13 House of Commons Health Committee. Public health post 2013, second report of session 2016–17. House of Commons, 2016. <https://publications.parliament.uk/pa/cm201617/cmselect/cmhealth/140/140.pdf> (accessed July 9, 2024).
- 14 Marmot M. Health equity in England: the Marmot review 10 years on. *BMJ* 2020; **368**: m693.
- 15 Blazer DG, Colenda CC, Applegate WB, Reifler BV. The great health paradox: a call for increasing investment in public health. *Acad Med* 2022; **97**: 484–86.
- 16 Masters R, Anwar E, Collins B, Cookson R, Capewell S. Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health* 2017; **71**: 827–34.
- 17 Fu C, Drake T, Simangolwa WM, et al. Understanding the costs and benefits of investing in laboratory systems in African countries. Center for Global Development, 2022. <https://www.cgdev.org/publication/understanding-costs-and-benefits-investing-laboratory-systems-african-countries> (accessed July 9, 2024).
- 18 Africa Centres for Disease Control and Prevention. 3rd International Conference on Public Health in Africa (CPHIA 2023). Africa Centres for Disease Control and Prevention. <https://africacdc.org/3rd-international-conference-on-public-health-in-africa-cphia-2023/> (accessed July 9, 2024).
- 19 Brueggemann AB, Jansen van Rensburg MJ, Shaw D, et al. Changes in the incidence of invasive disease due to *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis* during the COVID-19 pandemic in 26 countries and territories in the Invasive Respiratory Infection Surveillance Initiative: a prospective analysis of surveillance data. *Lancet Digit Health* 2021; **3**: e360–70.

-
- 20 Jolley KA, Maiden MC. BIGSdb: scalable analysis of bacterial genome variation at the population level. *BMC Bioinformatics* 2010; **11**: 595.
- 21 Shaw D, Abad R, Amin-Chowdhury Z, et al. Trends in invasive bacterial diseases during the first 2 years of the COVID-19 pandemic: analyses of prospective surveillance data from 30 countries and territories in the IRIS Consortium. *Lancet Digit Health* 2023; **5**: e582–93.
- 22 WHO. Global genomic surveillance strategy for pathogens with pandemic and epidemic potential, 2022–2032. World Health Organization, 2022. <https://www.who.int/publications/i/item/9789240046979> (accessed July 9, 2024).
- 23 Limb M. Public health grants in England are “far too little, far too late,” says president of directors. *BMJ* 2023; **380**: 631.

Copyright © 2024 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.