Research across multiple disciplines to respond to health shocks

Research that spans clinical specialties and research disciplines beyond health and healthcare is a priority for planning equitable responses to manage future health shocks, argue

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Health shocks are "high consequence events that have a major disruptive effect on society,"[1] with health, social, economic, and psychological effects, and are not limited to pandemics. Whether responding to shocks related to antimicrobial resistance, climate change, or conflict, siloed research cannot deliver the science needed quickly enough at the required scale.

When science encounters new diseases and challenges, it can cross disciplinary boundaries in three complementary ways, as occurred with vaccines. "Multidisciplinary research" combines knowledge from different disciplines, each within its confines. "Interdisciplinary research" "analyses, synthesises and harmonises links between disciplines into a coordinated and coherent whole."[2] "Transdisciplinary research" "integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries."[2]

The resilience of health systems, their ability to "anticipate, absorb, adapt, and recover" from such shocks, including through research, led to favourable country level outcomes during the covid-19 pandemic.[3 4] It also accelerated the UK's vaccine development and roll-out, hailed as a major research success, which required different ways of working across disciplines.[5]

Initial vaccine development needed timely research from several distinct disciplines including genomics, virology, immunology, and physiology. Evaluation necessitated pragmatic, large scale, international clinical trials, as well as epidemiological and health economics studies. However, uptake of the covid-19 vaccine has been suboptimal, even in countries with good availability.[6] Globally, inequalities in access to vaccination have persisted,[7] potentially correctable by more coordinated, multidisciplinary research to better understand the capacity and limitations of healthcare systems. Box 1 gives examples of multidisciplinary research during the covid-19 pandemic.

Multidisciplinarity has become common, but more interdisciplinary and transdisciplinary research, from ethics and behavioural science to intellectual property law and anthropology,[8 9] could facilitate more efficient scientific strategy, progress, and translation into policy and practice. Using the "learning health system" framework to connect silos of science (what we know), evidence (how we organise what we know), and care (how we translate what we know)[10] and case examples, we investigate benefits of and barriers to multidisciplinary, interdisciplinary, and transdisciplinary research, with recommendations for research to mitigate for future shocks (box 2).

KEY MESSAGES

- Multidisciplinary health research has been beneficial in the context of shocks
- Research teams and collaborations have to look beyond multidisciplinary research and be more interdisciplinary and transdisciplinary in their strategies to increase public health impact
- Multidisciplinary, interdisciplinary, and transdisciplinary approaches are not necessarily mutually exclusive and may be overlapping and complementary in the same research question—for example, improving uptake of covid-19 vaccination
- Culture change demands that policy makers, scientists, and practitioners be connected in a "bird's eye view" of shocks instead of emphases on clinical specialty and academic discipline
- Training pathways for researchers and health professionals have been siloed and should include and encourage interdisciplinary and transdisciplinary working

Multidisciplinary research: within healthcare

Across different shocks, whether humanitarian, climatic, or health related, different parts of challenges may be better viewed

Box 1: Examples of multidisciplinary research during the covid-19 pandemic

- Sequencing of the SARS-CoV-2 genome and development of vaccines using novel technologies—genomics, immunology, virology, vaccinology
- Developing tools to measure the impact of covid-19 and disseminate this information to the public and professionals (eg, COVID-19 Dashboard in the UK)—epidemiology, statistics, public health, patient and public involvement, data science, computer science
- Rapidly developing and implementing technologies such as telemedicine, remote monitoring, and contact tracing apps—digital health, engineering, computer science, public health, operations management, patient and public involvement
- Assessing the economic impact of the pandemic and developing policies to support businesses and workers—political science, statistics, epidemiology, economics, public health
- Understanding the wider societal impact of the pandemic on areas such as mental health, education, and employment—psychology, psychiatry, educational sciences, economics, epidemiology, patient and public involvement, public health
- Developing strategies for pandemic related public communication, including vaccine hesitancy and compliance with infection control measures—behavioural science, public health, epidemiology, patient and public involvement, political science, communications
- Understanding capacity and limitations of healthcare systems—clinical specialties, healthcare management, operations management, public health, epidemiology

through the lens of different disciplines, particularly for healthcare. For example, inequalities in access to covid-19 vaccination may differ by demographic characteristics between clinical specialties to which individuals present (for example, cardiology, primary care, or general surgery). Specific contributory factors and their interplay are highlighted by considering healthcare, public health, and epidemiology (box 1).

During shocks in the UK and globally, timely access to and communication of routine and research health data are multidisciplinary problems. Near real time analysis and interpretation of hospital admission and mortality data, data from at risk groups,[11] and registry data from different specialties, became possible for covid-19. Collaboration and integration were needed among datasets (for example, disease specific registries, primary care and national administrative data), regulators (ethics panels doing rapid reviews and legislation for emergency access to data for research), disciplines (particularly for health data, including statistics, epidemiology, and data science), organisations (for example, policy makers, universities, healthcare providers), and patients and the public.[12]

The areas of communication, near real time analysis and interpretation, and collaboration need to be prioritised in shock preparedness, which has typically involved infectious disease and public health, neglecting other relevant clinical specialties (for example, primary care, intensive care, and psychiatry). Data silos in communicable and non-communicable disease disciplines have also restricted multidisciplinary working between researchers and policy makers.

Multidisciplinary research has identified two way associations between shocks and non-communicable diseases, such as cardiovascular diseases, for viral outbreaks (for example, influenza,[13] covid-19,[14] and HIV[14]), heat exposure,[15] and humanitarian crises.[16] Consideration of non-communicable diseases was essential to prepare and implement policy and guidelines, including lockdown and vaccination, for covid-19, for which older people and those with chronic diseases (for example, diabetes and heart diseases) were in high risk groups.[11] Integrating research and care in this way will be crucial before, during, and after future shocks, such as pragmatic platform trials for vaccinations or long covid clinics in England.

Despite evidence of extensive indirect effects of shocks, such as reduced rates of cardiovascular procedures during the covid-19 pandemic,[17] especially in "countries with weak health systems, inadequate preparedness, and inadequate surveillance mechanisms,"[18] research and policy related to these indirect effects are limited, partly owing to limited resources, poor availability of data, and research and care silos. The pandemic had a huge impact on non-covid care across clinical specialties owing to behaviour changes of patients, practitioners, health services, and policy makers and concomitant strain on the health system. However, for every country, disease, and procedure, separate research studies and practice and policy strategies are being developed. Unified methods and approaches across disease and specialty silos, facilitated by routine data, could reduce duplicated efforts in research and policy for shocks and the indirect effects on waiting lists for specialist health services.

Box 2: Recommendations for multidisciplinary, interdisciplinary, and transdisciplinary research for future shocks

Multidisciplinary research

Science—Collaborate and integrate across health data related disciplines, organisations, and health data for research. Governments, regulators, and funders should facilitate national level, linked electronic health record research across disciplines for future shocks.

Evidence—Avoid unnecessary communicable versus non-communicable disease dichotomies. Guideline committees and professional societies relating to shocks should consider how both communicable and non-communicable diseases can and should be incorporated.

Care—Unify methodology and approach across disciplines to tackle indirect effects of shocks. Governments should ensure representation in advisory committees by all stakeholders, including medical specialties, research disciplines, and expertise relating to different shocks to have strategies to reduce and tackle indirect effects in shock preparedness.

Interdisciplinary research

Science—Investigate long term impact of shocks on acute and long term conditions and their care. Funders should prioritise specific research calls in long term effects for shock preparedness and also during acute phases of shocks.

Evidence—Prioritise patient and public involvement in all areas of research and guideline development in relation to shocks. Mandates should involve patients and public, by academics in interdisciplinary research, and by governments and professional societies in guidelines.

Care—Recognise that population subgroups may respond differently to specific interventions, developing culturally sensitive strategies where necessary. Governments and funders should prioritise national data collection before, during, and after shocks relating to protected characteristics, including age, ethnicity, and socioeconomic status.

Transdisciplinary research

Science—Tackle social, cultural, and economic determinants of health by developing an urgent, well resourced and prioritised transdisciplinary research strategy, including focus on long term societal impact of shocks. Governments should set up a commission, involving stakeholders (including research funders and organisations) to develop a transdisciplinary research strategy for impact of shocks.

Evidence—Use large scale, representative, linked electronic health record data, managed and led by multidisciplinary teams, including public representatives. Governments and research funders should facilitate and resource linked data research across health and non-health disciplines in relation to shocks.

Care—Ensure wide angle views of health inequalities and patient/public involvement to produce effective and acceptable strategies. Funders should have specific funding calls for health inequalities during shocks to foster representative, inclusive patient and public involvement.

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Different health shocks can have very different indirect health effects, requiring different data driven research using sources from different sectors and involving different disciplines, different methods, and data with different levels of uncertainty. For example, climate change may indirectly affect health, mediated by effects on nutrition, water availability, and population displacement,[19] or it may cause natural disasters such as floods, cyclones, and disrupted weather conditions, which may not necessarily be tackled by existing multidisciplinary research strategies.

Interdisciplinary research: holistic within healthcare

Interdisciplinary health research offers a more holistic and integrated view in the face of increasingly specialised healthcare and associated research disciplines in recent decades, making crucial contributions additional to multidisciplinary research. Shocks are insults to societies and countries, and politics, policy, planning, and action focus on acute and direct complications rather than on chronic determinants or effects such as socioeconomic factors. Research, whether observational or interventional studies, also emphasises acute over longer term complications, partly owing to scarce resources during crises. Worldwide, the funding and pace of trials in acute covid-19 have not been matched for long covid.

However, strong evidence indicates chronic effects among multiple organ systems after shocks including conflict, natural disasters, pandemics, and famines[16]—for example, long term, multiorgan complications and incident long term conditions in people admitted to hospital or not after covid-19.[20 21] Patients and the public have also highlighted the value of prevention and integrated care for long covid.[22] Without inclusion of knowledge, understanding, or experience of chronic conditions and their care, this aspect of shock preparedness will be overlooked. Major changes in education, culture, and practice in both research and care, co-led by patients and the public, are needed to enable movement towards the necessary longer term, interdisciplinary lens across clinical specialties, multiple disciplines, and academic training.

Despite growing patient and public involvement in health related research in recent years, it has not been prioritised in interdisciplinary research for shocks, partly as a result of perceptions that it cannot be done during acute crises.[2 23] When patients' and the public's views are ignored, research, policy, guidelines, and care cannot be holistic, patient centred, optimally designed, or fully effective. During the covid-19 pandemic, patients and the public were keen and able to participate in research, including on long covid and indirect effects.[12 17 23 24] The British Heart Foundation-NHS England CVD-COVID consortium is an exemplary platform, enabling research use of national, linked electronic health record data in which every research protocol involves review and approval by a patient and public panel.[12]

An interdisciplinary lens could be informative in public health emergencies, in which research has been difficult owing to other acute priorities, including universal access to healthcare. Populations at high risk, on the basis of age, disabilities, or low socioeconomic status, are more likely to be marginalised by lack of access to care and research.[11 17 20] Older and poorer people are more likely to be affected by climate change—for example, higher incidence and mortality risk from cardiovascular disease related to heat exposure.[15] This necessitates greater healthcare utilisation, which may be influenced by demographic, socioeconomic, and physical factors and by other health system shocks.[24]

As an example, early in the covid-19 pandemic, care home residents in the UK had very high risk of hospital admission and death.[25] People at high risk and especially vulnerable to health shocks are more likely to be in care homes or other social care settings; they are more likely to benefit from drug and non-drug interventions but less likely to receive them.[25] Multidisciplinary approaches to policy interventions (for example, on social isolation and vaccination) and their effects on patients, families, and services may lead to disjointed strategies in high risk groups, such as care home residents. An interdisciplinary approach across health and social care fosters more integrated risk reduction in future health shocks.

Transdisciplinary research: beyond healthcare

Health and healthcare are affected by social and structural determinants, requiring research contributions from many disciplines outside healthcare, particularly humanities and social sciences. These may be missed in multidisciplinary and interdisciplinary research strategies that focus on health and healthcare disciplines.

Long covid affects individual people, populations, and health systems.[22] In addition to heterogeneity in definition and challenges in management, inequities in social determinants of health introduce inequity in long covid in three ways: underlying long term conditions, such as cardiovascular disease and its risk factors; covid-19 management; and socioeconomic associations in the diagnosis, management, and prevention of long covid, such as their impact on people's employment or education.[24]

Other types of shocks show similar socioeconomic inequalities, within and across countries[15 16]; these are often neglected in existing research related to shocks or non-health domains such as education and housing. Equity and ethical considerations require extra effort, care, and resources for marginalised populations.

Moreover, as in other areas of science, long covid research must confront an extensive and corrosive flood of misinformation, which cannot be tackled without a broader approach, informed by transdisciplinary understanding beyond health and healthcare, including information management, psychology, and sociology. To ensure that research during shocks tackles socioeconomic inequity, a transdisciplinary approach is needed, with political will, urgency, resources, and prioritisation for short term and long term effects.

Multidisciplinary and interdisciplinary research using linked, national, electronic health record data has many benefits. Routine, real time data should also be made available to researchers in different disciplines with suitable infrastructure, including architecture and governance arrangements to link different databases, covering a range of public policy areas for future shocks. For example, DARE UK (Data and Analytics Research Environments UK) is a collaborative effort by the UK research councils to enable transdisciplinary data linkage for research, including robust governance arrangements, sophisticated technical architecture, and public involvement.

Moreover, representation of different disciplines and approaches is needed in government and international advisory panels, such as SAGE (Scientific Advisory Group for Emergencies) and NERVTAG (New and Emerging Respiratory Virus Threats Advisory Group) in the UK and the World Health Organization's SAGE (Strategic Advisory Group of Experts on

Immunization), to inform evidence based, data driven decision making.

Since early in the covid-19 pandemic, ethnic inequity in infection, hospital admission, critical care admission, and mortality have been seen.[26] When covid-19 vaccination became available in the UK and other countries, uptake was lower in ethnic minority populations, despite likely greater benefit compared with other subpopulations.[27] Even after adjustment for sociodemographic differences, lower uptake rates remained for all ethnic minority groups, compared with white British people.[27] Discovering and tackling reasons for lower uptake will involve patient, academic, clinical, and public health communities, as well as disciplines such as behavioural science and community based ethnographic approaches with patients and their families.[28 29]

Fostering transdisciplinary understanding and translating such research findings into terms useful to the public and policy makers requires specialist communicators working with public representatives. Face-to-face and online patient and public engagement occurred during the covid-19 pandemic to inform research priorities across sectors including education and health and to facilitate translation of research into policy.[22 23] The same process of patient and public involvement in identifying and tackling inequities should occur in research for other shocks. "Patient informed" is as important as "evidence based" and "data driven" agendas in practice and policy during shocks, and patients and public representatives can be involved at scale and pace in multidisciplinary, interdisciplinary, and transdisciplinary research.

Changes in culture, training, and resources

Established concepts in preparedness for shocks, such as a narrow focus on infectious disease epidemiology during pandemics, are being challenged, or will need to be challenged, to make the changes necessary for multidisciplinary, interdisciplinary, and transdisciplinary research to be encouraged and normalised. To improve the resilience of health research during shocks, changes in health research practice, culture, training, and funding are urgently needed.

Existing roles and infrastructure, including in governments and advisory committees, are specific to particular diseases and problems, and therefore to particular shocks. To be responsive to different types of shocks, multisectoral roles and infrastructure spanning disciplines (for example, new transdisciplinary centres and collaborations) are needed. For example, health system strengthening, digital methods for surveillance, and investigating associations of covid-19 with climate change represent international strategies to respond to different shocks.[30-32] Moreover, promotion of closer interaction and collaboration between research and policy, and between clinical and public health spheres, would benefit preparation for and management of shocks.

Culture in research in relation to shocks should be more open, diverse, and innovative, and the role of governments, funders, and institutions is to require these changes in behaviour where appropriate to foster cross silo working. Advisory, planning, and monitoring committees relating to shocks need adequate representation from clinical (for example, primary care and non-communicable diseases) and public health practitioners, researchers from different disciplines, policy makers, and patients and the public. Membership and records of government advisory bodies such as SAGE must be publicly available to build public understanding and trust. Research dissemination strategies also need to change. During the covid-19 pandemic, pre-publication preprints and open access publication accelerated access to emerging findings, but breaking down cross disciplinary boundaries may require new journals in new areas, such as "planetary health."

Clinical and non-clinical academic training pathways remain siloed, whether by clinical specialty (for example, infectious versus non-communicable diseases) or research discipline (for example, epidemiology at population level versus genomics and proteomics at more mechanistic and physiological levels). Developers of clinical and academic postgraduate curriculums should include multidisciplinary, interdisciplinary, and transdisciplinary methods and their advantages and disadvantages, with adoption by national specialty organisations. Undergraduate and postgraduate courses might have greater emphasis on novel, cross disciplinary frameworks such as implementation science and learning health systems, through specific, novel research training and career pathways (for example, pandemic or shock preparedness).

Without financial and human resources, focused action for multidisciplinary, interdisciplinary, and transdisciplinary research cannot happen. During shocks, poor investment in longer term implications and "business as usual" research and care unrelated to shocks may cause unintended consequences, compounding the impact of shocks themselves. Shocks can be concurrent in their impact. For example, during winter periods, influenza and covid-19 have added to pressures on UK health services. In future, climate change may combine with other natural disasters or human-made catastrophes to create new challenges for health systems. Therefore, ring fenced funding and political will, particularly for interdisciplinary and transdisciplinary research and international research partnerships, are urgently needed. Effective global responses to any future health shock must include lower income countries, which shoulder most of the global disease burden and healthcare needs before, during, and after shocks, with the least resources and the least focus in research and care. Barriers include the culture, norms, and funding in health research beyond shocks.

Multidisciplinary research was essential to global covid-19 responses, helping scientists to develop deep understanding of the virus, effective vaccines and treatments, and public health measures. This collaborative work also helped to identify and tackle social and economic consequences, develop strategies for public communication, and prepare for future pandemics. However, multidisciplinary research is limited in scale, scope, and pace. Equitable and effective preparation and planning for future shocks demands dedicated focus on interdisciplinary and transdisciplinary working.

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1 Organisation for Economic Co-operation and Development. A systemic resilience approach to dealing with Covid-19 and future shocks. 2020. https://www.oecd-ilibrary.org/economics/a-systemic-resilience-approach-to-dealing-with-covid-19-and-future-shocks_36a5bdfb-en
2 Choi BCK, Pak AWP. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clin Invest Med* 2006;29:351-64.
3 Da'ar OB, Kalmey F. The level of countries' preparedness to health risks during Covid-19 and pre-pandemic: the differential response to health systems building blocks and socioeconomic indicators. *Health Econ Rev* 2023;13:16. doi:10.1186/s13561-023-00428-9
4 Ellis LA, Saba M, Long JC, et al, The rise of resilient healthcare research during COVID-19: scoping review of empirical research. *BMC Health Serv Res* 2023;23:833. doi:10.1186/s12913-023-09839-0
5 Majeed A, Pollock K, Hodes S, Papaluca M. Implementation of covid-19 vaccination in the United Kingdom. *BMJ* 2022;378:e070344. doi:10.1136/bmj-2022-070344
6 Gaughan CH, Razieh C, Khunti K, et al, COVID-19 vaccination uptake amongst ethnic minority communities in England: a linked study exploring the drivers of differential vaccination rates. *J Public Health (Oxf)* 2023;45:e65-74. doi:10.1093/pubmed/fdab400
7 Sachs JD, Karim SSA, Aknin L, et al, The Lancet Commission on lessons for the future from the COVID-19 pandemic. *Lancet* 2022;400:1224-80. doi:10.1016/S0140-6736(22)01585-9
8 Attwell K, Betsch C, Dubé E, et al, Increasing vaccine acceptance using evidence-based approaches and policies: Insights from research on behavioural and social determinants presented at the 7th Annual Vaccine Acceptance Meeting. *Int J Infect Dis* 2021;105:188-93. doi:10.1016/j.ijid.2021.02.007
9 Chattu VK. "Digital global health diplomacy" for climate change and human security in the Anthropocene. *Health Promot Perspect* 2022;12:277-81. doi:10.34172/hpp.2022.35
10 Mohamed MO, Banerjee A. Long COVID and cardiovascular disease: a learning health system approach. *Nat Rev Cardiol* 2022;19:287-8. doi:10.1038/s41569-022-00697-7
11 Banerjee A, Pasea L, Harris S, et al, Estimating excess 1-year mortality associated with the COVID-19 pandemic according to underlying conditions and age: a population-based cohort study. *Lancet* 2020;395:1715-25. doi:10.1016/S0140-6736(20)30854-0
12 Wood A, Denholm R, Hollings S, et al, CVD-COVID-UK consortium. Linked electronic health records for research on a nationwide cohort of more than 54 million people in England: data resource. *BMJ* 2021;373:n826. doi:10.1136/bmj.n826
13 Davidson JA, Banerjee A, Smeeth L, et al, Risk of acute respiratory infection and acute cardiovascular events following acute respiratory infection among adults with increased cardiovascular risk in England between 2008 and 2018: a retrospective, population-based cohort study. *Lancet Digit Health* 2021;3:e773-83. doi:10.1016/S2589-7500(21)00203-X
14 Casper C, Crane H, Menon M, Money D. HIV/AIDS Comorbidities: Impact on Cancer, Noncommunicable Diseases, and Reproductive Health. In: Jamison DT, Gelband H, Horton S, et al, eds. *Disease Control Priorities*. Vol 6, 3rd ed. World Bank, 2017: 45-66. doi:10.1596/978-1-4648-0524-0_ch3.
15 Liu J, Varghese BM, Hansen A, et al, Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis. *Lancet Planet Health* 2022;6:e484-95. doi:10.1016/S2542-5196(22)00117-6
16 Ngaruiya C, Bernstein R, Leff R, et al, Systematic review on chronic non-communicable disease in disaster settings. *BMC Public Health* 2022;22:1234. doi:10.1186/s12889-022-13399-z
17 Banerjee A, Sudlow C, Lawler M. Indirect effects of the pandemic: highlighting the need for data-driven policy and preparedness. *J R Soc Med* 2022;115:249-51. doi:10.1177/01410768221095245
18 Khatri RB, Endalamaw A, Erku D, et al, Preparedness, impacts, and responses of public health emergencies towards health security: qualitative synthesis of evidence. *Arch Public Health* 2023;81:208. doi:10.1186/s13690-023-01223-y
19 Myers SS, Bernstein A. The coming health crisis: indirect health effects of global climate change. *F1000 Biol Rep* 2011;3:3. doi:10.3410/B3-3
20 Ayoubkhani D, Khunti K, Nafilyan V, et al, Post-covid syndrome in individuals admitted to hospital with covid-19: retrospective cohort study. *BMJ* 2021;372:n693. doi:10.1136/bmj.n693
21 Dennis A, Cuthbertson DJ, Wootton D, et al, Multi-organ impairment and long COVID: a 1-year prospective, longitudinal cohort study. *J R Soc Med* 2023;116:97-112. doi:10.1177/01410768231154703
22 Davis HE, Assaf GS, McCorkell L, et al, Characterizing long COVID in an international cohort: 7 months of symptoms and their impact. *EClinicalMedicine* 2021;38:101019. doi:10.1016/j.eclinm.2021.101019
23 Banerjee A, Pasea L, Manohar S, et al, and members of the Health Data Research UK COVID-19 Patient and Public Involvement and Engagement Panel. 'What is the risk to me from COVID-19?': Public involvement in providing mortality risk information for people with 'high-risk' conditions for COVID-19 (OurRisk.CoV). *Clin Med (Lond)* 2021;21:e620-8. doi:10.7861/clinmed.2021-0386
24 Banerjee A. Disparities by social determinants of health: links between Long COVID and cardiovascular disease. *Can J Cardiol* 2024;40:1123-34. doi:10.1016/j.cjca.2024.02.017
25 Shrotri M, Krutikov M, Palmer T, et al, Vaccine effectiveness of the first dose of ChAdOx1 nCoV-19 and BNT162b2 against SARS-CoV-2 infection in residents of long-term care facilities in England (VIVALDI): a prospective cohort study. *Lancet Infect Dis* 2021;21:1529-38. doi:10.1016/S1473-3099(21)00289-9
26 Ayoubkhani D, Nafilyan V, White C, et al, Ethnic-minority groups in England and Wales-factors associated with the size and timing of elevated COVID-19 mortality: a retrospective cohort study linking census and death records. *Int J Epidemiol* 2021;49:1951-62. doi:10.1093/ije/dyaa208
27 Gaughan CH, Razieh C, Khunti K, et al, COVID-19 vaccination uptake amongst ethnic minority communities in England: a linked study exploring the drivers of differential vaccination rates. *J Public Health (Oxf)* 2023;45:e65-74. doi:10.1093/pubmed/fdab400
28 Huf SW, Woldmann L, Crespo RF, et al, Implementing behavioural science informed letter interventions to increase COVID-19 vaccination uptake in uncontactable London residents: a difference-in-difference study in London, UK. *Lancet* 2022;400(Suppl 1):S41. doi:10.1016/S0140-6736(22)02251-6
29 Chandok RS, Madar P, Majeed A. A qualitative study of factors influencing COVID-19 vaccine hesitancy among South Asians in London. *JRSM Open* 2022;13:20542704221123430. doi:10.1177/20542704221123430
30 Lal A, Abdalla SM, Chattu VK, et al, Pandemic preparedness and response: exploring the role of universal health coverage within the global health security architecture. *Lancet Glob Health* 2022;10:e1675-83. doi:10.1016/S2214-109X(22)00341-2
31 Kostkova P, Saigí-Rubió F, Eguia H, et al, Data and Digital Solutions to Support Surveillance Strategies in the Context of the COVID-19 Pandemic. *Front Digit Health* 2021;3:707902. doi:10.3389/fdgth.2021.707902
32 Khojasteh D, Davani E, Shamsipour A, Haghani M, Glamore W. Climate change and COVID-19: Interdisciplinary perspectives from two global crises. *Sci Total Environ* 2022;844:157142. doi:10.1016/j.scitotenv.2022.157142

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