NATIONAL ACADEMIES Sciences Engineering Medicine

Toward a Common Research Agenda in Infection-Associated Chronic Illnesses

A Workshop to Examine Common, Overlapping Clinical and Biological Factors

Health and Medicine Division
Board on Global Health | Forum on Microbial Threats
Board on Health Sciences Policy | Forum on Neuroscience and Nervous System Disorders

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Workshop Briefing Book
June 29-30, 2023

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About the Forum on Microbial Threats

The Forum on Microbial Threats of the National Academies of Sciences, Engineering, and Medicine (National Academies) was created in 1996 at the request of the Centers for Disease Control and Prevention and the National Institutes of Health to provide a structured opportunity for discussion and scrutiny of critical, and possibly contentious, scientific and policy issues related to research on and the prevention, detection, surveillance, and responses to emerging and reemerging infectious diseases in humans, plants and animals as well as the microbiome in health and disease. The Forum brings together leaders from government agencies, industry, academia, and nonprofit and philanthropic organizations to facilitate cross-sector dialogue and collaboration through public debate and private consultation to stimulate original thinking about the most pressing issues across the spectrum of microbial threats.

Despite decades of progress, the need for the Forum on Microbial Threats remains. Emerging and persistent problems such as Ebola, Chikungunya, Zika, yellow fever, antibiotic resistance, and, in recent years, MERS and COVID-19 demonstrate how the issue of infectious threats is global and unrelenting. The drivers are ever more pervasive, and the consequences—human, social, and economic—loom larger than ever.

The Forum convenes several times each year to identify and discuss key problems and strategies in the area of microbial threats. To supplement the perspectives and expertise of its members, the Forum also holds public workshops to engage a wide range of experts, members of the public, and the policy community. All workshops are summarized in high quality scholarly workshop proceedings that are available for free download from the National Academies Press.

The Forum on Microbial Threats is part of the National Academies' Board on Global Health. For more information about the Forum, please visit our website: www.nationalacademies.org/microbialthreats.

Sponsors

- U.S. Agency for International Development
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The Forum greatly appreciates our sponsors that make intellectual and financial contributions to the Forum's work.

Highlights of Recent Publications

- Accelerating the Development and Uptake of Rapid Diagnostics to Address Antibiotic Resistance: Proceedings of a Workshop
- The Role of Plant Agricultural Practices on Development of Antimicrobial Resistant Fungi Affecting Human Health: Proceedings of a Workshop Series (2023)
- Toward a Post-Pandemic World: Lessons from COVID-19 for Now and the Future: Proceedings of a Workshop (2022)
- Innovations for Tackling Tuberculosis in the Time of COVID-19: Proceedings of a Workshop (2022)
- Systematizing the One Health Approach in Preparedness and Response Efforts for Infectious Disease Outbreaks: Proceedings of a Workshop (2022)
- The Critical Public Health Value of Vaccines: Tackling Issues of Access and Hesitancy: Proceedings of a Workshop (2021)
- Vaccine Access and Hesitancy: Part One of a Workshop Series: Proceedings of a Workshop—In Brief (2020)
- Exploring the Frontiers of Innovation to Tackle Microbial Threats: Proceedings of a Workshop (2020)
- The Convergence of Infectious Diseases and Noncommunicable Diseases: Proceedings of a Workshop (2019)
- Exploring Lessons Learned from a Century of Outbreaks: Readiness for 2030: Proceedings of a Workshop (2019)
- Understanding the Economics of Microbial Threats: Proceedings of a Workshop (2018)
- Urbanization and Slums: Infectious Diseases in the Built Environment: Proceedings of a Workshop (2018)

Forum's Action Collaborative – One Health

The Forum's One Health Action Collaborative (OHAC), led by Gail Hansen, D.V.M., is an ad hoc activity that engages a community of participants who are interested in contributing to ongoing exploration and information sharing related to one health topics. OHAC is committed to accelerating the implementation of a one health approach in the field to counter microbial threats. Members include a subset of forum members and a diverse range of external stakeholders from multiple sectors and disciplines such as public health, animal health, plant pathology, agriculture, environment, biotechnology, and others. Drawing from the dynamic discussions over regular conference calls, OHAC advises on one health efforts that are internal and external to the national academies, through the publication of papers and the hosting of seminars. For more info, click here.

Upcoming Events from the Forum

MITIGATING ARBOVIRAL THREATS AND STRENGTHENING PUBLIC HEALTH PREPAREDNESS: A WORKSHOP

Arthropod-borne viruses ("arboviruses"), such as those transmitted by mosquitoes and ticks, sicken billions of people around the world each year. In addition, several arboviruses are considered priority pathogens for biodefense research by the NIH. When implementing current measures to strengthen outbreak preparedness capacity, it is important to consider how these can mutually benefit from enhanced mitigation measures for arboviral diseases. This public workshop will review lessons learned from past epidemics, discuss potential actions that can be taken to understand and address emerging arboviral disease threats, and highlight priority areas for research and investment.

A planning committee of the National Academies of Sciences, Engineering, and Medicine will organize a public workshop to explore the role of arbovirus mitigation within the context of public health preparedness and capacity building. Workshop discussions will consider potential actions that can be taken to understand and mitigate arboviral disease threats and highlight priority areas for research and investment.

To receive a "Save the Date" announcement for our events, sign up for our listserv here: www.nationalacademies.org/microbialthreats

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About the Forum on Neuroscience and Nervous System Disorders

The National Academies of Sciences, Engineering, and Medicine's Forum on Neuroscience and Nervous System Disorders provides an important venue for candid discussions about emerging and critical issues among key leaders and experts, including federal agencies that serve as research sponsors and regulators; the private sector; the academic community; and the nonprofit sector, including foundations and disease advocacy groups. The Forum's activities serve to inspire new ideas and shape the field, foster relationships and collaboration, develop an improved understanding of each other's perspectives and priorities, and influence policies and programs.

The National Academies of Sciences, Engineering, and Medicine's Forum on Neuroscience and Nervous System Disorders was established in 2006 to bring together leaders from government, industry, academia, and disease advocacy organizations, as well as other interested parties. The Forum meets several times a year and provides its members with a structured, neutral venue for exchanging information, ideas, and differing perspectives. At its meetings, the Forum examines significant—and sometimes contentious—issues concerning scientific needs and opportunities, priority setting, and policies related to neuroscience and nervous system disorders research; the development, regulation, and use of interventions for the nervous system; and related ethical, legal, and social implications. The Forum also sponsors workshops for its members and the public on emerging issues, key challenges in the field, and other matters deserving scrutiny.

The Forum on Neuroscience and Nervous System Disorders is part of the National Academies' Board on Health Sciences Policy. For more information about the Forum, please visit our website: www.nas.edu/neuroforum.

Sponsors

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- National Institute of Mental Health
- National Institute of Neurological Disorders and Stroke
- National Institute on Aging
- National Institute on Alcohol Abuse and Alcoholism
- National Institute on Drug Abuse
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- Paul G. Allen Frontiers Group
- Simons Foundation
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- The University of Rhode Island
- U.S. Department of Veterans Affairs
- Wellcome Trust

The Forum greatly appreciates our sponsors that make intellectual and financial contributions to the Forum's work.

Highlights of Recent Publications

- Exploring Sleep Disturbances in Central Nervous System Disorders: Proceedings of a Workshop (2023)
- Psychedelics and Entactogens as Treatments for Psychiatric Disorders: Proceedings of a Workshop (2022)
- From Molecular Insights to Patient Stratification for Neurological and Psychiatric Disorders: Proceedings of a Workshop (2022)
- Novel Molecular Targets for Mood Disorders and Psychosis: Proceedings of a Workshop (2021)
- Evolving the Culture of Science and Training in Neuroscience to Meet a Changing World: Proceedings of a Workshop – In Brief (2021)
- Re-Envisioning Postdoctoral Training in Neuroscience: Proceedings of a Workshop (2021)
- Fostering Diversity, Equity, and Inclusion in Neuroscience Training: Proceedings of a Workshop (2021)
- Neuroscience Training in Challenging Times: An Opportunity to Address Long-Standing Problems and Move Forward: Proceedings of a Workshop (2021)

- Sex Differences in Brain Disorders: Emerging Transcriptomic Evidence: Proceedings of a Workshop (2021)
- Environmental Neuroscience: Advancing the Understanding of How Chemical Exposures Impact Brain Health and Disease: Proceedings of a Workshop (2020)

Forum's Action Collaborative – Multimodal Biomarkers

In follow-up to the recent workshop hosted by the Forum on Neuroscience and Nervous System Disorders titled Multimodal Biomarkers for Central Nervous System Disorders: Development, Integration, and Clinical Utility, the Forum has formed an action collaborative that will develop a multimodal biomarker framework for diagnosis of prodromal stages of the illness, staging, and tracking of disease progression.

Upcoming Events from the Forum

UNDERSTANDING DEEP BRAIN STIMULATION TO TREAT CENTRAL NERVOUS SYSTEM DISORDERS: A WORKSHOP

Deep brain stimulation (DBS) and its ability to intervene directly in pathological circuits has revolutionized neuroscience research and clinical care for several central nervous system (CNS) disorders. Since the U.S. Food and Drug Administration approved the use of DBS for Parkinson's disease (PD) in 2002, publications in the DBS field have rapidly increased and DBS has become the standard of care for movement disorders such as PD, tremor, and dystonia (Krauss et al., 2021; Lozano and Lipsman, 2013). Despite this growth, there remains unanswered questions about the mechanism of action and its use outside of movement disorders (e.g., psychiatry) is still limited.

A planning committee of the National Academies of Sciences, Engineering, and Medicine will organize and conduct a one-day public workshop that brings together experts and key partners from academia, industry, government, philanthropic foundations, and disease-focused non-profit organizations to examine the role of deep brain stimulation (DBS) to treat central nervous system (CNS) disorders. The workshop will explore mechanisms of action; steps toward expanding clinical care, such as standardization and application of noninvasive brain stimulation; and ethical and regulatory considerations.

To receive a "Save the Date" announcement for our events, sign up for our listserv here: https://www.nationalacademies.org/our-work/forum-on-neuroscience-and-nervous-system-disorders

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About the Workshop: Toward a Common Research Agenda in Infection-Associated Chronic Illnesses

A Workshop to Examine Common, Overlapping Clinical and Biological Factors

June 29-30, 2023 | Washington, DC

PURPOSE

A planning committee of the National Academies of Sciences, Engineering, and Medicine will organize and conduct a public workshop to explore the current understanding of and future research opportunities for infection-associated chronic illnesses. The workshop will focus on long COVID, myalgic encephalomyelitis/chronic fatigue syndrome, persistent Lyme disease, and multiple sclerosis. Workshop discussions will consider the latest research and knowledge gaps in the following:

1. Overlapping clinical and biological factors underlying infection-associated chronic illnesses.
2. Current practice and novel technologies to develop urgently needed diagnostic tests for different stages of illness and/or the potential underlying infectious agent.
3. Identification of therapeutic targets and strategies to prevent or impede chronic illness progression.
4. Coordination and collaboration among various stakeholders and practitioners that will increase research and enhance care across different patient populations.

The planning committee will organize the workshop, develop the agenda, select and invite speakers and discussants, and moderate or identify moderators for the discussions. A proceedings of the presentations and discussions at the workshop will be prepared by a designated rapporteur in accordance with institutional guidelines.

This workshop is hosted by the Forum on Microbial Threats, in collaboration with the Forum on Neuroscience and Nervous System Disorders.

Workshop Agenda

June 29-30, 2023
8:30 AM – 5:00 PM ET
Virtual webcast *or* in person at the Keck Center | 500 5th St NW, Washington D.C. | Room 100

Day 1: Mechanisms underlying infection-associated chronic illnesses	
8:30-8:45 am	**Welcome remarks, workshop overview, and goals** **Welcome** Peter Daszak, EcoHealth Alliance *Chair, Forum on Microbial Threats* John Krystal, Yale University *Chair, Forum on Neuroscience and Nervous System Disorders* **Introduction and workshop overview** Tim Coetzee, National Multiple Sclerosis Society *Workshop co-chairs* **Sponsor perspectives** Lyle Petersen, US Centers for Disease Control and Prevention Ben Nemser, Steven & Alexandra Cohen Foundation
8:45-10:00 am	**Session 1: Introduction to infection-associated chronic illnesses** **Moderator:** Rafael Obregon, UNICEF **Keynote** Tim Henrich, University of California, San Francisco **Introduction and a historical perspective** Anthony Komaroff, Harvard Medical School; Brigham and Women's Hospital **Stakeholder perspectives** Joseph Breen, National Institutes of Health (NIH) RECOVER Harlan Krumholz, Yale School of Medicine Hannah Davis, Patient-Led Research Collaborative Meghan O'Rourke, Yale University *Author of* The Invisible Kingdom: Reimagining Chronic Illness **Q&A**

10:00-10:15 am	**BREAK**
10:15 am-12:00 pm	**Session 2: Common mechanistic factors of infection-associated chronic illnesses** **Host mediated factors (part 1)** **Moderator:** Peter Rowe, Johns Hopkins University *Immune Dysfunction* **Post Covid Syndrome and myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS): evidence for a role of autoantibodies and endothelial dysfunction and development of targeted therapies** Carmen Scheibenbogen, Charité University **Viral reactivation** Michael Peluso, University of California, San Francisco *Autonomic Dysfunction* **Overview of orthostatic intolerance: risk factors and treatments** Satish Raj, University of Calgary **Common underlying mechanisms of chronic illness: Lessons from postural orthostatic tachycardia syndrome (POTS), (ME/CFS), and Long COVID** Mitchell Miglis, Stanford University **Q&A**
12:00-1:00 pm	**LUNCH**
1:00 pm-3:00 pm	**Session 3: Common mechanistic factors of infection-associated chronic illnesses** **Host mediated factors (part 2)** **Moderator:** Brian Fallon, Columbia University **Impact of inflammation on the brain: significance for chronic illnesses** Andrew Miller, Emory University **Role of the microbiome in ME/CFS** Julia Oh, The Jackson Laboratory

	Pathogen mediated factors and pathogen persistence **Viral persistence and development of chronic illness: lessons from Epstein-Barr virus (EBV)** Bill Robinson, Stanford University **Pathogen distribution and persistence: learnings from SARS-CoV-2** Dan Chertow, NIH **Modeling pathogen persistence: lessons from animal studies** Monica Embers, Tulane University **Q&A**
3:00-3:15	**BREAK**
3:15-4:45	**Session 4: Future opportunities and research priorities in diagnostics** **Moderator:** Avindra Nath, National Institute of Neurological Disorders and Stroke (NINDS), NIH **Biomarkers for Lyme disease and post-treatment Lyme** John Aucott, Johns Hopkins University **Biomarkers for EBV and associations with Multiple Sclerosis (MS)** Alberto Ascherio, Harvard T.H Chan School of Public Health **Microclots as a common indicator of chronic disease** Resia Pretorius, Stellenbosch University **Next-generation / metagenomic sequencing** Charles Chiu, University of California, San Francisco **Q&A**
4:45-5:00	**Synthesis and adjourn** Amy Proal, PolyBio Research Foundation
END OF DAY 1	

Day 2: Clinical Advancements and Collaboration	
8:30-9:00 am	**Welcome remarks, review of day 1** **Welcome and introduction** Tim Endy, Coalition for Epidemic Preparedness Innovations (CEPI) *Workshop co-chair* **Keynote** Hilary Marston *Chief Medical Officer, U.S. Food and Drug Administration* **Q&A**
9:00-10:15 am	**Session 5: Patient driven research panel** **Moderator:** Liz Horn, Lyme Disease Biobank **Panel:** Lisa McCorkell, Patient-Led Research Collaborative Oved Amitay, Solve ME/CFS Lorraine Johnson, MyLymeData Liz Horn, Lyme Disease Biobank **Q&A**
10:15-10:30 am	**BREAK**
10:30 am -12:00 pm	**Session 6: Research innovation and required infrastructures** **Moderator:** Tim Endy, CEPI **Diagnostic journeys of Long COVID patients** Linda Geng, Stanford University **Ultrasensitive diagnostic assays: examples with SARS-CoV-2/ Long COVID** David Walt, Harvard University **Translating IACI research into the clinic (HIV, Long COVID, ME/CFS): repurposing** Steven Deeks, University of California, San Francisco

	Treatment approaches to post-treatment Lyme disease and a new clinical trials network Brian Fallon, Columbia University **Q&A**
12:00-1:00 pm	**LUNCH**
1:00-2:45 pm	**Session 7: Future opportunities and research priorities in therapeutics** **Moderator:** Tim Coetzee, National Multiple Sclerosis Society **Development of Oral Antiviral for COVID-19** Ravi Shankar Singh, Pfizer **Development of antivirals and combination therapies for infection-associated chronic illnesses** Sara Cherry, University of Pennsylvania **Clinical trials for multisystem inflammatory syndrome in children (MIS-C) and Long COVID** Alessio Fasano, Harvard University **Long Lyme: opportunities for prevention and treatment** Kim Lewis, Northeastern University **Clinical care for patients of various infection-associated chronic illnesses** David Putrino, Mount Sinai Health System **Q&A**
2:45-3:50 pm	**Session 8: Developing a shared research agenda: challenges and opportunities** **Moderators:** Avindra Nath, NINDS, NIH Amy Proal, PolyBio Research Foundation Lorraine Johnson, MyLymeData Peter Rowe, Johns Hopkins University **Q&A**
3:50-4:00 pm	**Synthesis and close**

	Tim Endy, CEPI Tim Coetzee, National Multiple Sclerosis Society *Workshop co-chairs*
END OF WORKSHOP	

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Planning Committee Biographies

Tim Coetzee, Ph.D., (co-chair), serves as the National MS Society's Chief Advocacy, Services and Science Officer. In this capacity, he leads the Society's work in the areas of state and federal advocacy, delivery of services and connection programs for people with MS, healthcare professional engagement and training, marketing and communications, as well as the Society's global research programs. Most recently, he served as the President of Fast Forward, a venture philanthropy of the National Multiple Sclerosis Society where he was responsible for strategic funding of biotechnology and pharmaceutical companies as well as partnerships with the financial and business communities. Prior to Fast Forward, he led the Society's global research initiatives on nervous system repair and protection in multiple sclerosis as well as the Society's fellowship and faculty award programs. He is a member of the Society's CEO Leadership team, the International Progressive MS Alliance's Scientific Steering Committee and the International Advisory Committee on Clinical Trials in MS. He also serves on the Executive Committee of the global PROMS initiative. In addition, Tim serves on the National Academy of Medicine's Forum on Neuroscience and Nervous System Disorders, and co-chairs the US National Academy of Medicine's Forum on Regenerative Medicine. Prior to joining the Society, Tim held faculty appointments at the University of Connecticut Health Sciences Center where he conduced research into the structure and function of myelin. Tim received his Ph.D. in molecular biology from Albany Medical College in 1993 and has since been involved in the field of multiple sclerosis research. He has been with the National MS Society since the fall of 2000.

Timothy Endy, M.D., M.P.H., (co-chair),), is an international expert in the field of dengue, dengue hemorrhagic fever, and emerging viral pathogens. Dr. Endy has conducted research in the field of virology, developed vaccine-field and epidemiological study sites in Southeast and Central Asia, and conducted phase I and II clinical vaccine trials. He has also served as the Principal Investigator (PI) for the US Army's Dengue Human Infection Model (DHIM), which is being developed at SUNY Upstate.

A Board Certified physician in the subspecialty of Infectious Diseases and Internal Medicine, Dr. Endy received a BS from Pennsylvania State University in University Park, PA, completed his Master's of Public Health in Epidemiology from the University of Michigan's School of Public Health in Ann Arbor, MI, and obtained his medical degree from the F. Edward Herbert School of Medicine at the Uniformed Services University in Bethesda, MD. Following this, he completed his residency and fellowship at the Walter Reed Army Medical Center in Washington, D.C. Dr. Endy served with distinction in the United States Army for 24 years and retired as a Colonel in 2006. At SUNY Upstate Medical University (UMU) Dr. Endy served as Chief of the Infectious Disease Service for 10 years then as Chair, Department of Microbiology and Immunology for 5 years. In 2021 Dr. Endy retired from UMU as a Professor Emeritus. He currently is a program leader for the Coalition for Epidemic Preparedness and Innovations (CEPI).

Dr. Endy is active in the development and management of research programs that are product-oriented towards developing vaccines, and diagnostics that meet FDA regulatory requirements. He is an NIH-funded researcher, conducting studies on dengue in Thailand. In addition, Dr. Endy is also an active reviewer for peer reviewed journals, a subject matter expert on dengue and dengue vaccine development for industry partners, and has published over 160 manuscripts and book chapters.

Brian Fallon, M.D., M.P.H., directs the Lyme & Tick-Borne Diseases Research Center and the Lyme and Tick-borne diseases Clinical Trials Network Coordinating Center at the Columbia University Irving Medical Center. As

Professor of Clinical Psychiatry at Columbia University, Dr. Fallon's research has focused on examining persistent Lyme disease using neuroimaging, neurocognitive testing, biomarker studies, and clinical trials; his other areas of expertise relate to anxiety and somatic symptom disorders. Dr. Fallon has received numerous NIH and foundation grants, served on HHS Tick-borne Diseases Working Group subcommittees, and currently serves on the Clinical Trials Steering Committee for the NIH's "Researching COVID to Enhance Recovery" (RECOVER) Initiative.

Lorraine Johnson, J.D., M.B.A., is the CEO of LymeDisease.org and the principal investigator of its patient registry, MyLymeData--which has enrolled over 17,000 patients. She has published over 50 peer reviewed articles on Lyme disease, including five big data studies on which she served as Principal Investigator. She has also published two college textbook chapters on patient registries.

She has served on five federal advisory committees related to big data, patient centered research, and patient registries and served as the Chair of the Patient Council for the Patient Centered Outcomes Research Institute's big data project PCORnet. She also sat on both the Steering Committee and the Executive Committee of PCORnet. She participated in the White House Precision Medicine Summit.

Avindra Nath, M.D., is the clinical director of the National Institute of Neurological Disorders and Stroke (NINDS) at the National Institutes of Health, where he is also chief of the Section of Infections of the Nervous System and the director of the Translational Center for Neurological Sciences. Dr. Avindra Nath is a physician–scientist who specializes in neuro-immunology and neurovirology. His research is focused on the clinical manifestations, pathophysiology and treatment of emerging neurological infections with a focus on HIV infection. In recent years, he has studied the neurological complications of endogenous retroviruses, Ebola, Zika virus and SARS-CoV-2 and conducts research on patients with undiagnosed neuroinflammatory disorders. He has served on advisory committees to the NIH, Centers for Disease Control, Food and Drug Administration and World Health Organization. The International Society of NeuroVirology gave him the Pioneer in NeuroVirology Award for his contributions to HIV neuropathogenesis and elected him as the president of the society. He received the Wybran award from the Society of Neuroimmune Pharmacology for contributions to Neurovirology. He also received the NIH Director's award for his work on SARS-CoV-2 and the Health and Human Services Secretary's award for his work on Ebola infection.

Melissa Nolan, Ph.D., M.P.H., is an Associate Professor at the University of South Carolina's Arnold School of Public Health. She serves as Director of the USC Institute for Infectious Disease Translational Research and as Deputy Director of the Southeastern Center of Excellence for Vector-borne Diseases. Dr Nolan has established expertise in infectious disease epidemiology with an emphasis on health disparities and diagnostics. She is a productive public health researcher having garnered more than $15 million in grant funding, 100 peer-reviewed publications, and 91 scientific presentations. Dr. Nolan has established domestic and international field sites, where her implementation science work focuses on designing field-deployable diagnostics with real-world efficacy.

Rafael Obregon, Ph.D., M.A., is the country representative for the United Nations Children's Fund (UNICEF) in Paraguay. He leads UNICEF´s strategic engagement with and technical support to the Government of Paraguay across several development and health issues, including to the country´s ongoing response to the COVID-19. Prior to his current role, Dr. Obregon led the UNICEF´s global team in Communication for Development through which he provided technical leadership and guidance on the development of standards, guidelines, and quality assurance for the application of risk communication and community engagement principles and strategies, including in emergency response and humanitarian action. Throughout his career, Dr. Obregon has engaged in several responses to public health emergencies and disease outbreaks such as the 2014–2015 West Africa Ebola Outbreak

and the 2016 Zika outbreak. In 2016 Dr. Obregon served as a member of the Advisory Committee to the World Health Organization's (WHO's) International Health Regulations (IHR) Emergency Committee on Zika virus and observed increase in neurological disorders and neonatal malformations. Prior to joining UNICEF, Dr. Obregon served as regional health communication adviser in Family and Community Health at the Pan American Health Organization, and served as a technical advisor, researcher, and resource/focal person for international/national cooperation agencies and government and nongovernmental organizations. His duties have focused on formative research, project design and evaluation, and capacity strengthening. Dr. Obregon has been an associate professor and guest faculty member at a number of universities, including Ohio University, the Universidad Autónoma in Barcelona, Spain, and the Universidad del Norte in Barranquilla, Colombia. Throughout his career, he has published several books, book chapters, monographs, manuals, peer-reviewed journal articles and reports on public health communication, participatory communication, and capacity development. More recently, he is co-editor of "Risk Communication and Community Engagement in Disease Outbreaks: Dealing with Rights, Culture, Complexity, and Context" (Springer). From 2017-2019 he served as the founding chair of the Global Alliance for Social and Behavior Change, and is a member of several editorial boards including the Journal of Health Communication and the Journal of Healthcare Communication. He has been a member of several scientific committees and technical advisory groups including the Global Pandemic Preparedness and Response Initiative led by the Institute for Development Studies (IDS), the Technical Advisory Group for the Social and Behavior Change Program at the University of Witwatersrand´s MPH (South Africa), the Secretariat of the International Summit on Social and Behavior Change Communication, and the Technical Advisory Group for the Global Health Communication Partnership within the Center for Communication Programs at Johns Hopkins University. Dr. Obregon earned his Ph.D. in an interdisciplinary program in mass communications, with a concentration on international health, at the College of Communications at Pennsylvania State University in 1999. He received his Master of Arts in international affairs and communication and development from Ohio University in 1994 with a minor in public health. Additionally, he obtained a diploma in education and pedagogy through the National Apprenticeship Service in Colombia in 1990.

Amy Proal, Ph.D., is a microbiologist that serves as President/CEO of PolyBio Research Foundation and directs the Organization's Long Covid Research Consortium (LCRC). Her work examines the molecular mechanisms by which viral, bacterial, and fungal pathogens dysregulate human gene expression, immunity, and metabolism. In her work with PolyBio Research Foundation and the LCRC she conceptualizes and coordinates large-scale collaborative research projects among research teams studying infection-associated chronic illnesses such as LongCovid, ME/CFS and LongLyme. She has written multiple review articles that delineate core biological drivers of both the LongCovid and ME/CFS disease processes. She holds a Bachelor of Science in biology from Georgetown University and a PhD in microbiology from Murdoch University in Australia.

Peter Rowe, M.D., is a Professor of Pediatrics in the Division of Adolescent and Young Adult Medicine at the Johns Hopkins University School of Medicine. His clinical and research interests for the last 30 years have focused on medical conditions characterized by chronic fatigue. His work has emphasized the importance of a variety of physiologic risk factors for ME/CFS, including orthostatic intolerance, joint hypermobility, allergic inflammation, and adverse biomechanical strain. He has directed the Chronic Fatigue Clinic at the Johns Hopkins Children's Center since 1996, where he is the inaugural recipient of the Sunshine Natural Wellbeing Foundation Chair in Chronic Fatigue and Related Disorders. In 2014, he received the Research Award from the International Association for CFS/ME, for outstanding research contributions to the field of CFS/ME. He is a graduate of Trinity College, University of Toronto, and the McMaster University School of Medicine, Canada. He completed his residency training in Pediatrics, General Pediatric Academic Development fellowship training, and Chief Residency at the Johns Hopkins Hospital. He was a member of the Institute of Medicine Committee on the Diagnostic Criteria for Myalgic Encephalomyelitis/Chronic Fatigue Syndrome.

Speaker Biographies

Oved Amitay, M.Sc., Ph.D., is a pharmacologist by training, a drug-developer by trade, and a patient-advocate by choice. He serves as President and Chief Executive Officer at the Solve ME/CFS Initiative- a national organization devoted to making *Myalgic Encephalomyelitis* (also known as chronic fatigue syndrome or ME/CFS) and other infection-associated diseases such as Long-Covid, understood, diagnosed and treatable. Oved has dedicated most of his professional career to the development of life-changing therapeutic options for people affected by rare genetic diseases. Oved and his organization were early to recognize the emerging concern of post SARS-CoV-2 infection condition and co-founded the Long Covid Alliance, building a network of patient-advocates to collaborate and share their collective knowledge. Prior to joining Solve, Oved held senior leadership positions at start-ups and top-tier biotech companies (Alnylam Pharmaceuticals and Genzyme Corporation, now Sanofi Genzyme).

Alberto Ascherio, M.D., Ph.D., is a Professor of Epidemiology and Nutrition at the Harvard T. H. Chan School of Public Health and a Professor of Medicine at the Harvard Medical School. Dr. Ascherio received a Doctorate in Medicine and Surgery from the University of Milan and worked for several years in medicine and public health in Latin America and Africa before obtaining a Master and Doctorate in Public Health from Harvard. Dr. Ascherio has focused much of his work over the past 25 years on discovering the causes of neurodegenerative diseases, including multiple sclerosis (MS), Parkinson disease, amyotrophic lateral sclerosis, and cognitive decline. He has conducted longitudinal studies in many populations, including, among others, the Nurses' Health Studies I and II, the Health Professionals Follow-up Study, the Cancer Prevention Study-II, the U.S Army, Navy and Air Force, the Danish MS Registry, and the Finnish Maternal Cohort. These studies have contributed to identifying several biomarkers and modifiable risk factors for MS (e.g. cigarette smoking, vitamin D insufficiency, and childhood obesity), Parkinson (pesticide exposure, low caffeine intake, low physical activity), and ALS (cigarette smoking, military service, low body mass index), and have in some cases provided the rationale for randomized trials (e.g. on physical activity in Parkinson disease). His most notable scientific contribution stems from the 20-year long investigation of over 10 million young adults that led to the recent breakthrough discovery that MS is a rare complication of infection with the Epstein-Barr virus.

Dr. Ascherio has published over 400 original research papers and reviews. His work has been recognized with several awards, including a Doctor of Medicine *honoris causa* from the University of Southern Denmark in recognition of his work on vitamin D insufficiency as a risk factor for MS.

John Aucott, M.D., is an Associate Professor of Medicine at Johns Hopkins University School of Medicine and the Director of the Johns Hopkins Lyme Disease Clinical Research Center. He is principal investigator for the SLICE studies of Lyme disease where his research interests center on the pathophysiology, diagnosis and treatment of Lyme disease associated persistent illness. He is an active clinician and educator and the program director for the Johns Hopkins Fellowship in Lyme and tickborne diseases. Dr. Aucott is the past chair of the U.S. Department of Health and Human Services Tick-Borne Disease Working Group.

Joseph Breen, Ph.D., is currently the Immunoregulation Section Chief in the Basic Immunology Branch in the Division of Allergy, Immunology and Transplantation (DAIT) at the National Institute of Allergy and Infectious Diseases (NIAID), NIH. Dr. Breen joined NIH in 2003 and assumed his current position in 2014. Dr. Breen serves on a variety of trans-NIH committees and frequently interacts with various internal and external stakeholders regarding DAIT and NIAID research priorities, including ME/CFS and COVID-19. Dr. Breen is currently the NIAID Director's delegate to the NIH RECOVER senior oversight committee and manages a portfolio containing computational immunology, immune profiling, and bioinformatics in the Basic Immunology Branch.

Sara Cherry, Ph.D., is the John W. Eckman Professor of Medical Science in the department of Pathology and Laboratory Medicine at the University of Pennsylvania, Scientific Director of the University of Pennsylvania High-Throughput Screening Core, the Director of the Program for Chemogenomic Discovery, and is leading the RNA Therapeutics Group at the Institute for RNA Innovation. Her research focuses on the interface between viruses and hosts. She has pioneered the use of high-throughput cell-based screening to study viral infections focusing on emerging RNA viruses. Her lab has discovered host proteins that promote infection and innate immune mechanisms by which cells sense and respond to infection. In addition to identifying cellular factors involved in infection, her lab is using high-throughput screening to identify antivirals active against these diverse RNA viruses. Her lab has screened more than 30,000 drugs for antiviral activity against COVID-19, identifying drugs and drug combinations that show activity in the respiratory tract. In an effort to understand potential viral reservoirs in patients with long COVID, she has extended studies to explore infection in the gastro-intestinal tract and determine how to best treat infection of this tissue type.

Dan Chertow, M.D., M.P.H., is an officer in the United States Public Health Service and a Tenure-track investigator at the National Institutes of Health (NIH). He leads the Emerging Pathogens Section of the Critical Care Medicine Department at the NIH Clinical Center and the Laboratory of Virology in the National Institute of Allergy and Infectious Diseases. Dr. Chertow's research focuses on understanding pathogenesis of severe emerging viral infections including Ebola virus and severe acute respiratory syndrome coronavirus-2. He is board certified in Critical Care Medicine and Infectious Diseases and attend in a multidisciplinary intensive care unit at the NIH Clinical Center, in Bethesda Maryland.

Charles Chiu M.D., Ph.D., is Professor of Laboratory Medicine and Medicine, Division of Infectious Diseases at University of California, San Francisco, Director of the UCSF-Abbott Viral Diagnostics and Discovery Center (VDDC), and Associate Director of the UCSF Clinical Microbiology Laboratory. Chiu currently leads a translational research laboratory focused on metagenomic next-generation sequencing assay development for infectious disease diagnostics and investigation of the pathogenesis of and immune responses to emerging pathogens, including *Borrelia burgdorferi* (Lyme disease), enterovirus D68 in acute flaccid myelitis, Zika virus, and, most recently, the SARS-CoV-2 coronavirus. He is also developing new technologies such as nanopore sequencing and RNA-Seq transcriptome profiling to develop predictive models using machine learning for host response-based diagnosis of infections. Chiu's work has been supported by funding from the National Institutes of Health (NIH), US Center for Disease Control and Prevention (CDC), Biomedical Advanced Research and Development Authority (BARDA), Abbott Laboratories, Chan-Zuckerberg Biohub, the Steven and Alexandra Cohen Foundation, and the California Initiative to Advance Precision Medicine. Dr. Chiu has authored more than 200 peer-reviewed publications (over 30 related to COVID-19), holds over 15 patents and patent applications, and is a co-founder of Delve Bio and serves on the scientific advisory board for Delve Bio, Mammoth Biosciences, Biomesense, Flightpath Bio, and Poppy Health.

Hannah Davis, M.P.S., is a co-founder of the Patient-Led Research Collaborative (PLRC), a team of Long Covid patients with research, policy, data, design, and medical backgrounds. PLRC did the first research on Long Covid in April 2020; their second paper on characterizing Long Covid is in the most viewed medical papers and was highlighted in the announcement of the $1.15 billion in Long Covid funding for the NIH. More recently, they awarded $5 million in grants for biomedical research into Long Covid and ME/CFS, launched a publication highlighting patient-generated hypotheses, created scorecards for researchers to improve their patient engagement, and co-wrote a Long Covid research review paper that has been downloaded 920,000 times. Hannah has a background in data analysis and machine learning, with a focus on tools for countering bias in machine learning datasets and on generative art & music. She has published papers on Long Covid, sanitation systems, patient-led research models, and translating novels into music.

Steven G. Deeks, M.D., is a Professor of Medicine in Residence at the University of California, San Francisco (UCSF). He is a recognized expert on the impact of viral infections on inflammation, immune function and health. Dr. Deeks has published over 600 peer-review articles, editorials and invited reviews on these and related topics. He has been the recipient of several NIH grants and is one of the principal investigators Delaney AIDS Research Enterprise (DARE), an NIH-funded international collaboratory aimed at developing therapeutic interventions to cure HIV infection. In April 2020, he leveraged his HIV research program to construct the "Long-term Impact of Infection with Novel Coronavirus (LIINC)" cohort, which is now supporting dozens of studies addressing the impact of SARS-CoV-2 on health. He is one of the UCSF Principal Investigators for RECOVER, an NIH-funded program aimed at defining the post-acute sequalae of SARS-CoV-2 infection (PASC, including "Long COVID"). Dr. Deeks has contributed to several national and international meetings on the topic and provided expert testimony on Long COVID to the US House of Representatives Subcommittee on Health on April 28, 2021. He was elected to the American Society for Clinical Investigation (ASCI) and the Association of America Physicians (AAP). He serves on the scientific advisory board for *Science Translational Medicine*.

Monica E. Embers, Ph.D., obtained her Ph.D. in the Department of Microbiology and Immunology at the Pennsylvania State University College of Medicine in Hershey, P.A., where she studied immune responses to Papillomaviruses. She made the transition to the study of bacterial pathogenesis when performing her postdoctoral research on the Lyme disease spirochete at the Tulane National Primate Research Center (TNPRC). Dr. Embers is currently an Associate Professor in the Division of Immunology and the Director of Vector-borne Disease Research at the Tulane National Primate Research Center (TNPRC). She also serves as the Director of the Education and Training Program at the TNPRC. Her research program regarding Lyme disease and its infectious cause *Borrelia burgdorferi* specializes in animal models. The research is centered around three major efforts: (1) identifying treatments that can eradicate *B. burgdorferi* infection; (2) detection of persistent Lyme disease spirochetes in human (autopsy) tissues; and (3) immunodiagnostic testing for *B. burgdorferi* infection and cure. By transmitting Lyme disease to mice and nonhuman primates by tick, and studying the natural course of infection, her group aims to attain a better understanding of the clinical quandaries of human Lyme disease, including effective diagnosis and treatment. Due to the many similarities between Bartonellosis and Lyme disease, her team has begun to develop research models for *Bartonella* infection. The goals of Bartonella research involve developing improved treatment strategies, understanding the pathophysiology of co-infection, and interrogating tick vector transmission of these pathogens.

Brian Fallon, M.D., M.P.H., directs the Lyme & Tick-Borne Diseases Research Center and the Lyme and Tick-borne diseases Clinical Trials Network Coordinating Center at the Columbia University Irving Medical Center. As Professor of Clinical Psychiatry at Columbia University, Dr. Fallon's research has focused on examining persistent Lyme disease using neuroimaging, neurocognitive testing, biomarker studies, and clinical trials; his other areas of

expertise relate to anxiety and somatic symptom disorders. Dr. Fallon has received numerous NIH and foundation grants, served on HHS Tick-borne Diseases Working Group subcommittees, and currently serves on the Clinical Trials Steering Committee for the NIH's "Researching COVID to Enhance Recovery" (RECOVER) Initiative.

Alessio Fasano, M.D., is the W. Allan Walker Professor of Pediatrics at Mass General Brigham; Chief of the Division of Pediatric Gastroenterology and Nutrition, Vice Chair of Research, Director of both the Center for Celiac Research and Treatment and the Mucosal Immunology and Biology Research Center at Mass General for Children (MGfC); and Professor of Pediatrics at Harvard Medical School and Professor of Nutrition at the Harvard T.H. Chan School of Public Health. While maintaining a clinical practice for patients with celiac disease and other gluten-related disorders for nearly four decades, Dr. Fasano has devoted his research to studying the regulation of gut permeability by microorganisms and their bio-products and establishing the role of intestinal barrier function in chronic inflammatory diseases, including autoimmunity. His early research contributions include the discovery of several new enterotoxins involved in the diarrheal pathogenesis of Shigella, E. coli, and V. cholerae, which led to the engineering of attenuated enteric vaccines, some of them currently used in clinical practice. The discovery of zonulin, a family of proteins that regulate intestinal permeability, by Dr. Fasano and his team in 2000 opened the door leading to a new paradigm of diagnosis and possible treatment and prevention for autoimmune disorders and other diseases. Following zonulin and related discoveries, Dr. Fasano developed larazotide acetate as an adjunctive treatment for celiac disease, and clinical trials of the drug were fast tracked by the FDA. Dr. Fasano expanded his research into the mechanistic role of the gut microbiome in health and disease with a goal of primary prevention in chronic inflammatory disease, establishing two international, multi-center studies with birth cohorts at risk of celiac disease and ASD, respectively Celiac Disease, Genomic, Environmental, Microbiome and Metabolome Study and the Genome, Environment, Microbiome and Metabolome in Autism Study to investigate the complex factors, including detailed early analyses of gut microbiota, that lead to the development of these conditions in infants and children. Early in the COVID-19 pandemic, Dr. Fasano conducted research with MGfC colleagues into Multi-Inflammatory Syndrome in Children (MIS-C) that led to the observation that SARS-CoV-2 viral particles persist in the gastrointestinal tract for weeks after the initial infection, causing dysbiosis and subsequent zonulin upregulation as key steps leading to post-infection complications including MIS-C and Long COVID. Based on these observations, FDA allowed the use of larazotide acetate for clinical trials for both MIS-C and Long COVID. Dr. Fasano's long record of research in biomedicine span the fields of nutrition, gastrointestinal disorders, autoimmunity, and microbiome-related chronic inflammatory diseases, and has been continuously funded by the National Institutes of Health since 1995.

Linda Geng, M.D., Ph.D., is Clinical Associate Professor of Medicine at Stanford University. Dr. Geng co-founded and co-directs the Stanford Long COVID program that integrates multidisciplinary clinical care and research. Dr. Geng is involved in multiple research efforts in Long COVID including co-leading a clinical trial to study Paxlovid for the treatment of Long COVID. Dr. Geng's background and academic interests include consultative medicine and advancing the care of patients with complex and puzzling conditions.

Timothy J. Henrich, M.D., M.M.Sc., leads a laboratory/research group that specializes in immunmodulatory, cytoreductive chemotherapeutic and stem cell transplantation approaches to HIV-1 cure. Henrich's lab is also involved in the design and implementation of novel nanotechnologies and PET-based imaging approaches to characterize viral reservoirs and immune sequelae. Henrich is also a PI of the UCSF Long-Term Immunological Impact of Novel Coronavirus (LIINC) study which aims to understand pathogenic mechanisms of Long-COVID and chronic viral infections, and to evaluate clinical interventions.

Liz Horn, Ph.D., M.B.I., serves as PI of Lyme Disease Biobank, a resource created to provide much-needed blood, urine, and tissue samples to researchers studying Lyme disease and other tick-borne infections. More than 1200 participants (representing early Lyme, later stages of Lyme, persistent Lyme, and controls) have been enrolled. Each participant's sample donation can support up to 50 different research projects. Currently, >85 projects in academia and industry have been approved for samples. Liz earned her doctorate in molecular pharmacology and cancer therapeutics from The State University of New York at Buffalo, was a National Library of Medicine fellow in biomedical informatics, and received her MBI from Oregon Health & Science University. She has spent nearly 2 decades working with non-profit organizations to build research initiatives and collaborations with academia, other non-profits, and industry. Liz is passionate about building resources to move research forward that help people, improve lives, and reduce suffering.

Lorraine Johnson, J.D., M.B.A., is the CEO of LymeDisease.org and the principal investigator of its patient registry, MyLymeData--which has enrolled over 17,000 patients. She has published over 50 peer reviewed articles on Lyme disease, including five big data studies on which she served as Principal Investigator. She has also published two college textbook chapters on patient registries.

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Anthony L. Komaroff, M.D., is the Simcox/Clifford/Higby Distinguished Professor of Medicine at Harvard Medical School and a Senior Physician at Brigham & Women's Hospital. He has held leadership positions including as Director of the Division of General Medicine and Primary Care within the Department of Medicine at Brigham & Women's Hospital; Editor-in-Chief of the Harvard Health Publications Division of Harvard Medical School; and Founding Editor of *NEJM Journal Watch General Medicine,* a publication of the Massachusetts Medical Society/*New England Journal of Medicine*.

Dr. Komaroff has spent 45 years as a clinician and investigator, focusing his research interests primarily on myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) and, more recently, Long COVID. He has served on multiple committees of the Department of Health and Human Services, the Centers for Disease Control and Prevention, the National Institutes of Health and the National Academies of Science, Engineering and Medicine. He has served as a member of two National Advisory Neurological Disorders and Stroke Council Working Groups for ME/CFS Research.

Dr. Komaroff has published over 270 research articles, review articles/book chapters and two books, and authored a daily newspaper column syndicated by United Features Syndicate in 450 newspapers in North America. He is a Project PI on one of the NIH-funded ME/CFS Research Centers.

In recognition of his contributions, Dr. Komaroff has been elected a fellow of the American Association for the Advancement of Science and the American College of Physicians.

Harlan Krumholz, M.D., S.M., is a cardiologist and the Harold H. Hines, Jr. Professor of Medicine and the founder and Director of the Yale Center for Outcomes Research and Evaluation (CORE). He is a leading outcomes researcher and has published >1400 scientific articles, has an h-index >220 and is one of the most highly cited medical researchers. Dr. Krumholz pioneered strategies to improve healthcare quality, outcomes and health equity,

promote open science and transform research processes, support patient empowerment, and apply digital technologies and computational approaches to accelerate progress in clinical care and research. He is collaborating with Professor Akiko Iwasaki to study long COVID, vaccine injury, and associated illnesses. Dr. Krumholz co-founded the Yale University Open Data Access (YODA) Project, Hugo Health (patient-centric platform to enable a consumer-mediated health information exchange), Refactor Health, (healthcare AI-augmented data insight company), and medRxiv (non-profit preprint server for the medical and health sciences). He is a Distinguished Scientist of the American Heart Association and a member of the National Academy of Medicine, served as a member of the Advisory Committee to the Director of the National Institutes of Health and was a founding Governor of the Patient-Centered Outcomes Research Institute (PCORI) and was the Director of the Robert Wood Johnson Clinical Scholars Program at Yale. He grew up in Dayton, Ohio and graduated from Yale College, Harvard Medical School, and the Harvard School of Public Health.

Kim Lewis, Ph.D., is a University Distinguished Professor and Director, Antimicrobial Discovery Center at Northeastern University in Boston. He is a Fellow of the American Society of Microbiology, and a Fellow of the American Association for the Advancement of Science. He is a Highly Cited Researcher (Clarivate Analytics) and an Expertscape World Expert in Microbial Drug Resistance (top 0.1% of scholars in the field).

He obtained his Ph.D. in Biochemistry from Moscow University in 1980, and has been on the Faculty of MIT, University of Maryland, and Tufts University prior to coming to Northeastern.

Dr. Lewis has authored over 100 papers and is an inventor on several patents. His notable findings include the development of general methods to grow previously uncultured bacteria that make up >99% of biodiversity on the planet, the discovery of the culprit of recalcitrant biofilm infections, drug-tolerant persister cells; and several novel antibiotics, including teixobactin and darobactin.

Dr. Lewis has served as a panelist and contributor to reports on antimicrobial resistance (AMR) by National Academies Institute of Medicine, the Pew Charitable Trust, and the European Academies of Science. He is a recipient of the MIT C.E. Reed Faculty Initiative Award, the NIH Director's Transformative Award, and the American Society for Microbiology Applied Biology and Biotechnology Research Award.

Apart from his work in Academia, Dr. Lewis is a co-founder of NovoBiotic Pharmaceuticals, Arietis Pharma, Holobiome, Flightpath and Odyssey Therapeutics.

Hilary Marston, M.D., M.P.H., Chief Medical Officer, FDA, serves as the primary clinical advisor to the Commissioner and oversees the Office of Clinical Policy and Programs. She leads cross-cutting initiatives that support the FDA's centers in making effective, safe, and innovative medical products available for patients.

Dr. Marston previously served as the Senior Advisor for Global COVID-19 Response on the White House COVID-19 Response Team. Her previous roles also include Director for Medical Biopreparedness and Response at the U.S. National Security Council and Medical Officer and Policy Advisor for Pandemic Preparedness at the National Institute of Allergy and Infectious Diseases, National Institutes of Health. Dr. Marston also served in positions with McKinsey & Company and the Bill & Melinda Gates Foundation.

Dr. Marston trained in Internal Medicine and Global Health Equity at Brigham & Women's Hospital. She completed her M.P.H. at the Harvard T.H. Chan School of Public Health.

Lisa McCorkell, M.M.P., is a person living with Long COVID and the co-founder of the Patient-Led Research Collaborative, a group of Long COVID patients conducting research on Long COVID and advocating for better policies for disabled people. She is the co-author of several prominent Long COVID research studies, including a review in Nature Reviews Microbiology; has coordinated a patient-led biomedical research fund of $5 million toward Long COVID and associated conditions; has had dozens of speaking engagements on Long COVID including to Congress, NIH, and the White House; and has co-created scorecards that evaluate meaningful patient engagement in research. She has a masters in public policy from University of California, Berkeley, and a background in social safety net policy and labor and employment issues. She was featured as one of Nature's 10 people who shaped science in 2022.

Mitchell Miglis, M.D., received his MD from the University of Florida. After serving as a medical intern at Washington Hospital Center/Georgetown University, he completed his neurology residency New York University. He then completed two fellowships, the first in Autonomic Disorders at the Beth Israel Deaconess Medical Center of Harvard Medical school, and the second in Sleep Medicine at the Stanford Sleep Medicine Center. Dr. Miglis treats a wide variety of neurological diseases and has a special interest in Autonomic Disorders, Sleep Disorders, and the interaction between these conditions. His current interests involve biomarkers of disease progression in REM sleep behavior disorder, and mechanisms and treatment of Postural Tachycardia Syndrome and Post-Acute COVID Syndrome.

Andrew H. Miller, M.D., is William P. Timmie Professor and Vice Chair for Research in the Department of Psychiatry and Behavioral Sciences at the Emory University School of Medicine in Atlanta, Georgia. He is an internationally recognized expert in interactions between the brain and immune system as they relate to depression. His work has demonstrated that during immune activation, inflammatory cytokines can access the brain and interact with the metabolism of dopamine and glutamate, while altering neurocircuits relevant to motivation and reward as well as anxiety and alarm. Additionally, Dr. Miller and his group conducted the first clinical trial examining the efficacy of an immunotherapy (cytokine antagonist) for the treatment of depression. He has produced over 300 scholarly publications, won numerous research, teaching and mentoring awards including the Anna Monika Award for research in mood disorders. He is also an ISI highly cited researcher and is a Board-Certified Psychiatrist voted as a Top Doctor in Psychiatry.

Megan O'Boyle is the parent of a 20 year-old daughter with Phelan-McDermid Syndrome (PMS). She is also the Principal Investigator for the PMS Data Network (PMS_DN, PCORnet) and the PMS International Registry (PMSIR) and the Patient Engagement Lead at RARE-X, a collaborative platform for global data sharing and analysis in rare disease. She advocates for data sharing, collaborating with other advocacy groups, sharing resources and streamlining IRB practices and policies. As the Patient Engagement Lead for RARE-X she brings her decade of experience in advocacy to help patient groups develop and govern their new Data Collection Efforts within RARE-X. Megan knows firsthand about the challenges that patients and patient communities face collecting and sharing their data. She is passionate about the need for the rare disease community as a whole to collect standardized data (ask the same questions) to allow for cross-disease research. She believes that having data collection developed and maintained at NO COST to the patients and patient communities is imperative to removing the barriers to finding treatments and cures for rare disease. Keeping the patient at the center of all decisions and efforts of RARE-X is Megan's priority and mission. She serves as a patient advisor on the NIH Council of Councils, the Simons Foundation – SPARK project, is a former advisor to the NCATS Advisory Council, and several PCORI awards including FasterCures and Academy Health.

Julia Oh, Ph.D., received her B.A. from Harvard University, her Ph.D. in genetics from Stanford University, and postdoctoral training at the National Institutes of Health. Now an associate professor at the Jackson Laboratory, Dr. Oh is a microbiome expert with a focus on combining high-resolution computational reconstructions of the microbiome with experimental innovations to understand how host-microbiome interactions result in disease, and to use this information to develop microbiome-based therapeutics for disease prevention and treatment.

Meghan O'Rourke is the author of the *New York Times* bestseller *The Invisible Kingdom: Reimagining Chronic Illness* and *The Long Goodbye*, as well as the poetry collections *Sun In Days, Once*, and *Halflife*. Her writing has appeared in *The Atlantic Monthly, The New Yorker*, and *The New York Times*, and more. The recipient of a Guggenheim Fellowship, a Radcliffe Fellowship, and a Whiting Nonfiction Award, she resides in New Haven, where she teaches at Yale University and is the editor of *The Yale Review*.

Michael Peluso, M.D., M.Phil., M.H.S., DTM&H, is an infectious disease physician at the University of California, San Francisco. Prior to COVID, his research focus was on the chronic sequelae of HIV infection. When the SARS-CoV-2 pandemic emerged, Dr. Peluso led the efforts to implement the Long-term Impact of Infection with Novel Coronavirus (LIINC, pronounced "link") study at San Francisco General Hospital, based on the hypothesis that COVID could have a long-term impact on health and well-being. LIINC was one of the first post-COVID cohorts in the U.S. and now includes hundreds of individuals with and without Long COVID, many of whom have been followed for more than 2 years. He leads projects within LIINC aimed at understanding the biological mechanisms that drive Long COVID and is also responsible for implementation of the UCSF enrolling sites for the NIH's RECOVER initiative.

Resia Pretorius, Ph.D., M.Sc., is a distinguished professor and Chair of Physiological Science at Stellenbosch University, and an honorary professor at Liverpool University. With 309 published papers and supervision of over 70 postgraduate students, she has made significant contributions to the field of early detection of inflammatory diseases. Her research has been featured in various prominent publications, including Nature, Science, New Scientist, and The National Geographic. Resia's research has led to the filing of several patents, which are exclusively licensed to her start-up company, Biocode Technologies, she co-founded in 2019. Resia discovered that microclots in blood from patients with Long COVID could be used as a novel biomarker. The method for detection of microclots in Long COVID was subsequently patented and licensed to various international clinics and laboratories to diagnose thrombotic endothelialitis in individuals with Long COVID. Resia has also been a WHO panel member in 2021 and 2022 due to her research into diagnosing thrombotic endothelialitis in individuals with Long COVID.

David Putrino, Ph.D., is a physical therapist with a PhD in Neuroscience. He is currently the Director of Rehabilitation Innovation for the Mount Sinai Health System, and a Professor of Rehabilitation and Human Performance at the Icahn School of Medicine at Mount Sinai. He develops innovative rehabilitation solutions for adults and children in need of better healthcare accessibility, and in 2019, he was named "Global Australian of the Year" for his contributions to healthcare. Since the beginning of the COVID-19 pandemic in 2020, David has been recognized globally as a leading expert in the assessment, treatment and underlying physiology of Long COVID. His team has managed the care of over 3000 people with Long COVID and published multiple peer-reviewed scientific papers on the topic.

Satish R. Raj, M.D., M.S.C.I., is a Professor of Cardiac Sciences and the Section Chief of the Cardiac Arrhythmia Group at the University of Calgary in Canada. He also serves as the Director of Education at the Libin Cardiovascular Institute in the University of Calgary's Cumming School of Medicine.

He was recruited to the University of Calgary in 2014 from the Vanderbilt University Autonomic Dysfunction Center, and founded the Calgary Autonomic Investigation & Management Clinic. He runs an active research program in Human Autonomic Physiology. His primary research interests relate to understanding and better treating postural orthostatic tachycardia syndrome (POTS), a disorder that primarily affects women.

William H. Robinson, M.D., Ph.D., The Robinson laboratory investigates the molecular mechanisms of autoimmune and rheumatic diseases, with a focus on rheumatoid arthritis and multiple sclerosis. We pioneered development of protein arrays and high-throughput sequencing approaches to identify the targets of antibody responses, investigate mechanisms underlying disease, and to develop novel therapeutic approaches. We are using these technologies to define key roles for microbial triggers in the initial and progression of autoimmune diseases, including for EBV infection in multiple sclerosis and for oral bacterial mucosal breaks in rheumatoid arthritis.

Carmen Scheibenbogen, M.D., is an Internal Medicine physician and hematooncologist, ME/CFS doctor and Professor for Immunology and Acting Director of the Institute of Medical Immunology at the Charité Universitätsmedizin in Berlin, Germany. She is co-founder of the COST-funded European network for ME/CFS EUROMENE, the Charité Fatigue Centre (https://cfc.charite.de), and the Post COVID Network Charité (https://pcn.charite.de).

Her research focuses on chronic fatigue syndrome (ME/CFS), Post Covid Syndrome, immune monitoring, immunodeficiencies, and immunotherapy and she has published more than 200 peer-reviewed papers. Since 2020 she has received funding from the German Government for the joint research project IMMME (immune mechanisms of ME/CFS, https://cfc.charite.de/forschung/immme/), for a German “ME/CFS patient registry and biobank”, for the interdisciplinary and intersectoral care study CFS_CARE (https://cfc.charite.de/klinische_studien/cfs_care/) and the National Clinical Study Group, a clinical trial platform for ME/CFS and Post Covid (https://cfc.charite.de/klinische_studien/nksg/).

Ravi Shankar Singh, Ph.D., is a Senior Director of Clinical Pharmacology at Pfizer. Currently, he leads development of various projects in inflammation and immunology and anti-infectives including oral protease inhibitor for COVID-19. Before joining Pfizer, he worked at Abbvie, University of Florida, Central Drug Research Institute and Dr. Reddy’s lab in India. His experience spans from discovery to late phase drug development across various organizations in various therapeutic areas including inflammation and immunology, anti-infectives, oncology and HCV.

Dr. Singh received his M. Pharm from BITS Pilani, India and PhD in pharmacokinetics at the University of Saskatchewan, Canada. He is a Fellow of American College of Clinical Pharmacology. He has published extensively and has won several awards, most recently the Pfizer Worldwide Research, Development and Medical Individual Achievement Award and visionary award from Cambridge Chamber of Commerce in 2022 for PAXLOVID Development.

David R. Walt, Ph.D., is the Hansjörg Wyss Professor of Bioinspired Engineering at Harvard Medical School, Professor of Pathology at Brigham and Women’s Hospital and Harvard Medical School, Core Faculty Member of the Wyss Institute at Harvard University, Associate Member at the Broad Institute, and is a Howard Hughes Medical Institute Professor. Walt is the Scientific Founder of Illumina Inc., Quanterix Corp., and has co-founded multiple other life sciences startups including Ultivue, Inc., Arbor Biotechnologies, Sherlock Biosciences, Vizgen, Inc., and Torus Biosciences. He has received numerous national and international awards and honors for his fundamental

and applied work in the field of optical microwell arrays and single molecules including the 2023 National Academy of Engineering's Fritz J. and Dolores H. Russ Prize and the 2021 Kabiller Prize in Nanoscience and Nanomedicine. He serves on the NASEM Committee on Emerging Infectious Diseases in the 21st Century and has been a member and chair of multiple NASEM studies. His lab's research focuses on creating and using novel technologies to solve unmet clinical diagnostics problems. He is a member of the U.S. National Academy of Engineering, the U.S. National Academy of Medicine, a Member of the American Philosophical Society, a Fellow of the American Academy of Arts and Sciences, a Fellow of the American Institute for Medical and Biological Engineering, a Fellow of the American Association for the Advancement of Science, a Fellow of the National Academy of Inventors, and is inducted in the US National Inventors Hall of Fame.

The National Academies' Statement on Preventing Discrimination, Harassment, And Bullying: Policy for Participants in NASEM Activities (Updated December 2, 2021)

The National Academies of Sciences, Engineering, and Medicine (NASEM) are committed to the principles of diversity, inclusion, integrity, civility, and respect in all of our activities. We look to you to be a partner in this commitment by helping us to maintain a professional and cordial environment. **All forms of discrimination, harassment, and bullying are prohibited in any NASEM activity.** This policy applies to all participants in all settings and locations in which NASEM work and activities are conducted, including committee meetings, workshops, conferences, and other work and social functions where employees, volunteers, sponsors, vendors, or guests are present.

Discrimination is prejudicial treatment of individuals or groups of people based on their race, ethnicity, color, national origin, sex, sexual orientation, gender identity, age, religion, disability, veteran status, or any other characteristic protected by applicable laws.

Sexual harassment is unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature that creates an intimidating, hostile, or offensive environment.

Other types of harassment include any verbal or physical conduct directed at individuals or groups of people because of their race, ethnicity, color, national origin, sex, sexual orientation, gender identity, age, religion, disability, veteran status, or any other characteristic protected by applicable laws, that creates an intimidating, hostile, or offensive environment.

Bullying is unwelcome, aggressive behavior involving the use of influence, threat, intimidation, or coercion to dominate others in the professional environment.

REPORTING AND RESOLUTION
Any violation of this policy should be reported. If you experience or witness discrimination, harassment, or bullying, you are encouraged to make your unease or disapproval known to the individual at the time the incident occurs, if you are comfortable doing so. You are also urged to report any incident by:

- Filing a complaint with the Office of Human Resources at 202-334-3400 or hrservicecenter@nas.edu, or
- Reporting the incident to an employee involved in the activity in which the member or volunteer is participating, who will then file a complaint with the Office of Human Resources.

Complaints should be filed as soon as possible after an incident. To ensure the prompt and thorough investigation of the complaint, the complainant should provide as much information as is possible, such as names, dates, locations, and steps taken. The Office of Human Resources will investigate the alleged violation

in consultation with the Office of the General Counsel.

If an investigation results in a finding that an individual has committed a violation, NASEM will take the actions necessary to protect those involved in its activities from any future discrimination, harassment, or bullying, including in appropriate circumstances **the removal of an individual from current NASEM activities and a ban on participation in future activities.**

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Information contained in a complaint is kept confidential, and information is revealed only on a need-to-know basis. NASEM will not retaliate or tolerate retaliation against anyone who makes a good faith report of discrimination, harassment, or bullying.

The National Academies' Statement on Diversity and Inclusion

The National Academies of Sciences, Engineering, and Medicine value diversity in our members, volunteers, and staff and strive for a culture of inclusion in our workplace and activities. Convening a diverse community to exchange ideas and perspectives enhances the quality of our work and increases our relevance as advisers to the nation about the most complex issues facing the nation and the world.

To promote diversity and inclusion in the sciences, engineering, and medicine, we are committed to increasing the diversity of the National Academies' staff, members, and volunteers to reflect the populations we serve. We pledge to cultivate an environment and culture that promotes inclusion and values respectful participation of all individuals who help advance the mission of the institution.

Background Reading Material

Long COVID Has Forced a Reckoning for One of Medicine's Most Neglected Diseases

Only a couple dozen doctors specialize in chronic fatigue syndrome (ME/CFS). Now their knowledge could be crucial to treating millions more patients.

By Ed Yong

SEPTEMBER 26, 2022

Kira Stoops lives in Bozeman, Montana—a beautiful mountain town where it sometimes feels like everyone regularly goes on 50-mile runs. Stoops, however, can't walk around her own block on most days. To stand for more than a few minutes, she needs a wheeled walker. She reacts so badly to most foods that her diet consists of just 12 ingredients. Her "brain fog" usually lifts for a mere two hours in the morning, during which she can sometimes work or, more rarely, see friends. Stoops has myalgic encephalomyelitis, or chronic fatigue syndrome (ME/CFS). "I'm considered a moderate patient on the mild side," she told me.

ME/CFS involves a panoply of debilitating symptoms that affect many organ systems and that get worse with exertion. The Institute of Medicine estimates that it affects 836,000 to 2.5 million people in the U.S. alone, but is so misunderstood and stigmatized that about 90 percent of people who have it have never been diagnosed. At best, most medical professionals know nothing about ME/CFS; at worst, they tell patients that their symptoms are psychosomatic, anxiety-induced, or simply signs of laziness. While ME/CFS patients, their caregivers, and the few doctors who treat them have spent years fighting for medical legitimacy, the coronavirus pandemic has now forced the issue.

A wide variety of infections can cause ME/CFS, and SARS-CoV-2, the coronavirus that causes COVID-19, is no different: Many cases of long COVID are effectively ME/CFS by another name. The exact number is hard to define, but past studies have shown that 5 to 27 percent of people infected by various pathogens, including Epstein-Barr virus and the original SARS, develop

ME/CFS. Even if that proportion is 10 times lower for SARS-CoV-2, the number of Americans with ME/CFS would still have doubled in the past three years. "We're adding an immense volume of patients to an already dysfunctional and overburdened system," Beth Pollack, a scientist at MIT who studies complex chronic illnesses, told me.

The U.S. has so few doctors who truly understand the disease and know how to treat it that when they convened in 2018 to create a formal coalition, there were only about a dozen, and the youngest was 60. Currently, the coalition's website lists just 21 names, of whom at least three have retired and one is dead, Linda Tannenbaum, the CEO and president of the Open Medicine Foundation, told me. These specialists are concentrated on the coasts; none work in the Midwest. American ME/CFS patients may outnumber the population of 15 individual states, but ME/CFS specialists couldn't fill a Major League Baseball roster. Stoops, who is 39, was formally diagnosed with ME/CFS only four years ago, and began receiving proper care from two of those specialists—Lucinda Bateman of the Bateman Horne Center and David Kaufman from the Center for Complex Diseases. Bateman told me that even before the pandemic, she could see fewer than 10 percent of the patients who asked for a consultation. "When I got into those practices, it was like I got into Harvard," Stoops told me.

ME/CFS specialists, already overwhelmed with demand for their services, now have to decide how to best use and spread their knowledge, at a time when more patients and doctors than ever could benefit from it. Kaufman recently discharged many of the more stable ME/CFS patients in his care—Stoops among them—so that he could start seeing COVID long-haulers who "were just making the circuit of doctors and getting nowhere," he told me. "I can't clone myself, and this was the only other way to" make room for new patients.

Bateman, meanwhile, is feverishly focused on educating other clinicians. The hallmark symptom of ME/CFS—post-exertional malaise, or PEM—means even light physical or mental exertion can trigger major crashes that exacerbate every other symptom. Doctors who are unfamiliar with PEM, including many now running long-COVID clinics, can unwittingly hurt their patients by encouraging them to exercise. Bateman is racing to spread that message, and better ways of treating patients, but that means she'll have to reduce her clinic hours.

These agonizing decisions mean that many existing ME/CFS patients are losing access to the best care they had found so far—what for Stoops meant "the difference between being stuck at home, miserable and in pain, and actually going out once or twice a day, seeing other humans, and breathing fresh air," she told me. But painful trade-offs might be necessary to finally drag American medicine to a place where it *can* treat these kinds of complex, oft-neglected conditions. Kaufman is 75 and Bateman is 64. Although both of them told me they're not retiring anytime soon, they also won't be practicing forever. To make full use of their expertise and create more doctors like them,

the medical profession must face up to decades spent dismissing illnesses such as ME/CFS—an overdue reckoning incited by long COVID. "It's a disaster possibly wrapped up in a blessing," Stoops told me. "The system is cracking and needs to crack."

Many ME/CFS specialists have a deep knowledge of the disease because they've experienced it firsthand. Jennifer Curtin, one of the youngest doctors in the field, has two family members with the disease, and had it herself for nine years. She improved enough to make it through medical school and residency training, which showed her that ME/CFS "just isn't taught," she told me. Most curricula don't include it; most textbooks don't mention it.

Even if doctors learn about ME/CFS, America's health-care system makes it almost impossible for them to actually help patients. The insurance model pushes physicians toward shorter visits; 15 minutes might feel luxurious. "My average visit length is an hour, which doesn't include the time I spend going over the patient's 500 to 1,700 pages of records beforehand," Curtin said. "It's not a very scalable kind of care." (She works with Kaufman at the Center for Complex Diseases, which bills patients directly.) This also explains why the cohort of ME/CFS clinicians is aging out, with little young blood to refresh them. "Hospital systems want physicians to see lots of patients and they want them to follow the rules," Kaufman said. "There's less motivation for moving into areas of medicine that are more unknown and challenging."

ME/CFS is certainly challenging, not least because it's just "one face of a many-sided problem," Jaime Seltzer, the director of scientific and medical outreach at the advocacy group MEAction, told me. The condition's root causes can also lead to several distinct but interlocking illnesses, including mast cell activation syndrome, Ehlers-Danlos syndrome, fibromyalgia, dysautonomia (usually manifesting as POTS), and several autoimmune and gastrointestinal disorders. "I'm still amazed at how often patients come in with Complaint No. 1, and then I find five to seven of the other things," Kaufman said. These syndromes collectively afflict many organ systems, which can baffle doctors who've specialized in just one. Many of them disproportionately affect women, and are subject to medicine's long-standing tendency to minimize or psychologize women's pain, Pollack told me: An average woman with Ehlers-Danlos syndrome typically spends 16 years getting a diagnosis, while a man needs only four.

People with long COVID might have many of these conditions and not know about any—because their doctors don't either. Like ME/CFS, they rarely feature in medical training, and it's hard to "teach someone about all of them when they've never heard of any of them," Seltzer said. Specialists like Bateman and Kaufman matter because they understand not just ME/CFS but also the connected puzzle pieces. They can look at a patient's full array of symptoms and prioritize the ones that are most urgent or foundational. They know how to test for conditions that can be

invisible to standard medical techniques: "None of my tests came back abnormal until I saw an ME/CFS doctor, and then *all* my tests came back abnormal," said Hannah Davis of the Patient-Led Research Collaborative, who has had long COVID since March 2020.

ME/CFS specialists also know how to help, in ways that are directly applicable to cases of long COVID with overlapping symptoms. ME/CFS has no cure but can be managed, often through "simple, inexpensive interventions that can be done through primary care," Bateman told me. Over-the-counter antihistamines can help patients with inflammatory problems such as mast cell activation syndrome. Low doses of naltrexone, commonly used for addiction disorders, can help those with intense pain. A simple but rarely administered test can show if patients have orthostatic intolerance—a blood-flow problem that worsens other symptoms when people stand or sit upright. Most important, teaching patients about pacing—carefully sensing and managing your energy levels—can prevent debilitating crashes. "We don't go to an ME/CFS clinic and walk out in remission," Stoops told me. "You go to become stabilized. The ship has 1,000 holes, and doctors can patch one before the next explodes, keeping the whole thing afloat."

That's why the prospect of losing specialists is so galling. Stoops understands why her doctors might choose to focus on education or newly diagnosed COVID long-haulers, but ME/CFS patients are "just so lost already, and to lose what little we have is a really big deal," she said. Kaufman has offered to refer her to generalist physicians or talk to primary-care doctors on her behalf. But it won't be the same: "Having one appointment with him is like six to eight appointments with other practitioners," she said. He educates *her* about ME/CFS; with other doctors, it's often the other way round. "I'm going to have to work much harder to receive a similar level of care."

At least, she will for now. The ME/CFS specialists who are shifting their focus are hoping that they can use this moment of crisis to create more resources for everyone with these diseases. In a few years, Bateman hopes, "there will be 100 times more clinicians who are prepared to manage patients, and many more people with ME/CFS who have access to care."

For someone who is diagnosed with ME/CFS today, the landscape already looks very different than it did just a decade ago. In 2015, the Institute of Medicine published a landmark report redefining the diagnostic criteria for the disease. In 2017, the CDC stopped recommending exercise therapy as a treatment. In 2021, Bateman and 20 other clinicians published a comprehensive guide to the condition in the journal of the Mayo Clinic. For any mainstream disease, such events—a report, a guideline revision, a review article—would be mundane. For ME/CFS, they felt momentous. And yet, "the current state of things is simply intolerable," Julie Rehmeyer, a journalist with ME/CFS, told me. Solving the gargantuan challenge posed by complex

chronic diseases demands seismic shifts in research funding, medical training, and public attitudes. "Achieving shifts like that takes something big," Rehmeyer said. "Long COVID is big."

COVID long-haulers have proved beyond any reasonable doubt that acute viral infections can leave people chronically ill. Many health-care workers, political-decision makers, and influencers either know someone with long COVID or have it themselves. Even if they still don't know about ME/CFS, their heightened awareness of post-viral illnesses is already making a difference. Mary Dimmock's son developed ME/CFS in 2011, and before the pandemic, one doctor in 10 might take him seriously. "Now it's the flip: Only one doctor out of 10 will be a real jerk," Dimmock told me. "I attribute that to long COVID."

But being believed is the very least that ME/CFS patients deserve. They need therapeutics that target the root causes of the disease, which will require a clear understanding of those causes, which will require coordinated, well-funded research—three things ME/CFS has historically lacked. But here, too, "long COVID is going to be a catalyst," Amy Proal, the president of the Polybio Research Foundation, told me. She is leading the Long Covid Research Initiative—a group of scientists, including ME/CFS researchers, that will use state-of-the-art techniques to see exactly how the new coronavirus causes long COVID, and rapidly push potential treatments through clinical trials. The National Institutes of Health has also committed $1.15 billion to long-COVID research, and while some advocates are concerned about how that money will be spent, Rehmeyer notes that the amount is still almost 80 times greater than the paltry $15 million spent on ME/CFS every year—less than any other disease in the NIH's portfolio, relative to its societal burden. "Even if 90 percent is wasted, we'd be doing a lot better," she said.

While they wait for better treatments, patients also need the medical community to heed the lessons that they and their clinicians have learned. For example, the American Academy for Family Physicians website still wrongly recommends exercise therapy and links ME/CFS to childhood abuse. "That group of doctors is very important to these patients," Dimmock said, "so what does that say to them about what this disease is all about?"

Despite all evidence to the contrary, many clinicians and researchers still don't see ME/CFS as a legitimate illness and are quick to dismiss any connection between it and long COVID. To ensure that both groups of patients get the best possible treatments, instead of advice that might harm them, ME/CFS specialists are working to disseminate their hard-won knowledge. Bateman and her colleagues have been creating educational resources for clinicians and patients, continuing-medical-education courses, and an online lecture series. Jennifer Curtin has spent two years mapping all the decisions she makes when seeing a new patient, and is converting those into a tool that other clinicians can use. As part of her new start-up, called RTHM, she's also trying to develop better ways of testing for ME/CFS and its related syndromes, of visualizing the hefty electronic health

records that chronically ill patients accumulate, and of tracking the treatments they try and their effects. "There are a lot of things that need to be fixed for this kind of care to be scalable," Curtin told me.

Had such shifts already occurred, the medical profession might have had more to offer COVID long-haulers beyond bewilderment and dismissal. But if the profession starts listening to the ME/CFS community *now*, it will stand the best chance of helping people being disabled by COVID, and of steeling itself against future epidemics. Pathogens have been chronically disabling people for the longest time, and more pandemics are inevitable. The current one could and should be the last whose long-haulers are greeted with disbelief.

New centers that cater to ME/CFS patients are already emerging. RTHM is currently focused on COVID long-haulers but will take on some of David Kaufman's former patients in November, and will open its waiting list to the broader ME/CFS community in December. (It is currently licensed to practice in just five states but expects to expand soon.) David Putrino, who leads a long-COVID rehabilitation clinic in Mount Sinai, is trying to raise funds for a new clinic that will treat both long COVID and ME/CFS. He credits ME/CFS patients with opening his eyes to the connection between long COVID and their condition.

Every ME/CFS patient I've talked with predicted long COVID's arrival well before most doctors or even epidemiologists started catching up. They know more about complex chronic illnesses than many of the people now treating long COVID do. Despite having a condition that saps their energy, many have spent the past few years helping long-haulers navigate what for them was well-trodden terrain: "I did barely anything but work in 2020," Seltzer told me. Against the odds, they've survived. But the pandemic has created a catalytic opportunity for the odds to finally be tilted in their favor, "so that neither patients nor doctors of any complex chronic illness have to be heroes anymore," Rehmeyer said.