

Airborne Transmission of SARS-CoV-2: A Virtual Workshop from the Environmental Health Matters Initiative

Bios

Nicole Alexander-Scott has been the Director of the Rhode Island Department of Health (RIDOH) since April 2015. Dr. Alexander-Scott brings experience to this position from her work as a specialist in infectious diseases for children and adults, and from her time in academia as an associate professor of pediatrics, medicine, and public health (with a focus on health services, policy, and practice). Dr. Alexander-Scott is board certified in Pediatrics, Internal Medicine, Pediatric Infectious Diseases, and Adult Infectious Diseases. From 2018-2019, Dr. Alexander-Scott was President of the Association of State and Territorial Health Officials (ASTHO), the national organization for state health directors, after being elected by her peers. Her ASTHO President's Challenge focuses on "Building Healthy and Resilient Communities." In her time as Director of Health, Dr. Alexander-Scott has made it RIDOH's principal focus to give every person and every community in Rhode Island an equal opportunity to be as healthy as possible. Under her leadership, RIDOH is committed to addressing community level determinants of health, such as education, housing, transportation, and employment, so that a person's health does not depend on his or her ZIP code. Dr. Alexander-Scott has established as RIDOH's three leading priorities: (1) addressing the socioeconomic and environmental determinants of health; (2) eliminating disparities of health and promoting health equity; and (3) ensuring access to quality health services for all Rhode Islanders, including the state's vulnerable populations. For her commitment to health equity, Dr. Alexander-Scott has been recognized by numerous local and national organizations, including Grow Smart Rhode Island, the Rhode Island Chapter of the American Academy of Pediatrics, and the Kresge Foundation. Originally from Brooklyn, New York, Dr. Alexander-Scott attended Cornell University, where she majored in Human Development and Family Studies. She subsequently graduated from medical school in 2001 from SUNY Upstate Medical University at Syracuse. After completing a combined internal medicine-pediatrics residency at SUNY Stony Brook University Hospital in 2005, Dr. Alexander-Scott finished a four-year combined fellowship in adult and pediatric infectious diseases at Brown University. She obtained a Master's Degree in Public Health from Brown University in 2011.

Georges C. Benjamin, is the executive director of the American Public Health Association, the nation's oldest and largest organization of public health professionals. Formerly, he was Secretary for Health for the state of Maryland. He is board-certified in internal medicine, a Master of the American College of Physicians, a fellow of the National Academy of Public Administration, a fellow emeritus of the American College of Emergency Physicians, and a member of the National Academy of Medicine. He also serves of the National Infrastructure Advisory Council, a council that advises the President on how best to assure the security of the nation's critical infrastructure. Dr. Benjamin received his BC from Illinois Institute of Technology and his MD from University of Illinois, Chicago.

Lydia Bourouiba is an Associate Professor at the Massachusetts Institute of Technology, where she founded and directs the Fluid Dynamics of Disease Transmission Laboratory. Her research leverages advanced fluid dynamics experiments at various scales, biophysics, applied mathematics to elucidate interfacial flow and fluid fragmentation processes driving mixing, transport, and persistence of particles and microorganisms driving multiscale epidemiology and

disease transmission. Dr. Bourouiba founded the Fluids and Health Conference, to be expanded into a Gordon Research Conference that she will chair in 2022, creating an international forum for exchange on frontier research and challenges in health, where fluid dynamic concepts are at the core, including infectious diseases disease transmission and related policy. Dr. Bourouiba is the recipient of many awards, including the Tse Cheuk Ng Tai's Prize for Innovative Research in Health Sciences, the Ole Madsen Mentoring Award, and the Smith Family Foundation Odyssey Award for high-risk/high-reward basic science research. Dr. Bourouiba received her PhD from McGill University.

Pat Breysse joined the Centers for Disease Prevention and Control (CDC) in December 2014 as the Director of the National Center for Environmental Health/Agency for Toxic Substance and Disease Registry (NCEH/ATSDR). Dr. Breysse leads CDC's efforts to investigate the relationship between environmental factors and health. He came to CDC from the Johns Hopkins University where his research focused on the evaluation and control of chemical, biological, and physical factors that can affect health, with a particular concentration on risk and exposure assessment. Under Dr. Breysse's leadership, the agency has prioritized work on exposure to lead, safe drinking water, initiated new ATSDR actions to address exposure to hazardous chemicals, and has played a critical role in CDC's emergency preparedness and response to natural disasters and chemical exposures. Dr. Breysse received his PhD in environmental health engineering from Johns Hopkins University in 1985 and completed postdoctoral training at the British Institute for Occupational Medicine in Edinburgh, Scotland.

Thomas A. Burke is the Jacob I. and Irene B. Fabrikant Professor and Chair in Health Risk and Society at Johns Hopkins University Bloomberg School of Public Health, Departments of Health Policy and Management and Environmental Health Sciences and Engineering. He is also Director of the Johns Hopkins Risk Sciences and Public Policy Institute. Dr. Burke was nominated by President Barack Obama to serve as EPA Assistant Administrator for the Office of Research and Development. From January 2015 until January 2017 Dr. Burke was the EPA Science Advisor and Deputy Assistant Administrator for Research and Development. His research interests include environmental epidemiology and surveillance, population exposures to environmental pollutants, risk assessment and communication, and the application of science to public policy. Before joining the University faculty, Dr. Burke was Deputy Commissioner of Health for the State of New Jersey and Director of Science and Research for the New Jersey Department of Environmental Protection. He was Chair of the National Academy of Sciences Committee on Improving Risk Analysis that produced the report *Science and Decisions*, and currently serves as Chair of the Environmental Health Matters Initiative of the National Academies of Sciences, Engineering and Medicine. Dr. Burke received his BS from St. Peter's College, his MPH from the University of Texas and his PhD in epidemiology from the University of Pennsylvania.

Jay C. Butler is the Deputy Director for Infectious Diseases at the Centers for Disease Control and Prevention. In this capacity, he provides leadership to the efforts of CDC's three infectious disease national centers and helps to advance the agency's cross-cutting infectious disease priorities. Dr. Butler has 30 years of experience in increasingly complex public health leadership and management positions. He is board certified in medicine, pediatrics and infectious diseases, and has served in public health positions at federal, state, and tribal government, including

completing more than 22 years in the Commissioned Corps of the US Public Health Service, from which he retired at the level of Captain (Medical Director) in 2012. From 1998-2005, Dr. Butler was Director of the Arctic Investigations Program and from June 2009 to March 2010 he directed CDC's 2009 H1N1 Pandemic Vaccine Task Force, which achieved emergency vaccination of more than 80 million Americans. Dr. Butler made critical contributions to emerging infections, including serving on the Hantavirus Task Force in CDC's Viral Special Pathogens in 1993 and 1994. He held leadership roles in multiple emergency responses, including CDC's response to bioterrorist anthrax in 2001. Dr. Butler has also held multiple leadership roles in Alaska, including Chief Medical Officer for the Alaska Department of Health and Social Services (2014-2018 and 2007-2009), State Epidemiologist (2005-2007), and Senior Director of the Division of Community Health Services for the Alaska Native Tribal Health Consortium (ANTHC)(2010-2014). He was President of the Association of State and Territorial Health Officials in 2016-2017, and has made important contributions to public health approaches to reducing harms associated with addiction. After completing CDC's Epidemic Intelligence Service in the Wisconsin Division of Health, Dr. Butler completed a preventive medicine residency with the Respiratory Diseases Branch in the National Center for Infectious Diseases, and an infectious disease fellowship at Emory University. He graduated from North Carolina State University with a BS in zoology, received his MD at the University of North Carolina, and did internship and residency training in medicine and pediatrics at Vanderbilt.

Benjamin John Cowling is currently Professor and head of the Division of Epidemiology and Biostatistics in the School of Public Health at the University of Hong Kong, and co-Director of the WHO Collaborating Centre for Infectious Disease Epidemiology and Control. He is Editor-in-Chief of *Influenza and Other Respiratory Viruses*, and an Associate Editor of the journal *Emerging Infectious Diseases*. He conducts research into the epidemiology of influenza and other respiratory viruses. His research team has characterized how easily seasonal and pandemic influenza viruses can spread in households, and the effectiveness of measures to reduce the risk of infection and transmission including vaccination and non-pharmaceutical interventions. His recent research has focused on vaccination strategies in older adults, and immune responses to repeated influenza vaccination. Since early 2020 he has conducted research on the epidemiology and control of COVID-19 including a series of highly cited publications in NEJM, Science and Nature Medicine. He has authored more than 450 peer-reviewed journal publications to date. His work is supported by grants from a number of funding agencies, including a large co-operative agreement with the US CDC on "Research on the Epidemiology, Vaccine Effectiveness and Treatment of Influenza and Other Respiratory Viruses in Southeast Asia and the Western Pacific" (US\$10m, 2016-21), and a Theme-Based Research Scheme grant from the University Grants Committee in Hong Kong entitled "Control of Influenza: Individual and Population Immunity" (US\$6m, 2020-25). After graduating with a PhD in statistics from the University of Warwick, Dr. Cowling spent a year at Imperial College London before moving to the University of Hong Kong in 2004.

Anthony S. Fauci is director of the National Institute of Allergy and Infectious Diseases (NIAID) at the U.S. National Institutes of Health, where he oversees an extensive research portfolio devoted to preventing, diagnosing, and treating infectious and immune-mediated diseases. Dr. Fauci has been a key advisor to six Presidents and their administrations on global AIDS issues, and on initiatives to bolster medical and public health preparedness against

emerging infectious disease threats such as pandemic influenza. As an HIV/AIDS researcher he has been involved in the scientific effort since AIDS was recognized in 1981, conducting pivotal studies that underpin the current understanding of the disease and efforts to develop therapies and tools of prevention. Dr. Fauci was one of the principal architects of the President's Emergency Plan for AIDS Relief (PEPFAR), which has helped save millions of lives throughout the developing world. Dr. Fauci is the long-time chief of the NIAID Laboratory of Immunoregulation. He has made many contributions to basic and clinical research on the pathogenesis and treatment of immune-mediated and infectious diseases. He helped pioneer the field of human immunoregulation by making important basic scientific observations that underpin the current understanding of the regulation of the human immune response. In addition, Dr. Fauci is widely recognized for delineating the precise mechanisms whereby immunosuppressive agents modulate the human immune response. He developed effective therapies for formerly fatal inflammatory and immune-mediated diseases such as polyarteritis nodosa, granulomatosis with polyangiitis (formerly Wegener's granulomatosis), and lymphomatoid granulomatosis. Dr. Fauci has made seminal contributions to the understanding of how HIV destroys the body's defenses leading to its susceptibility to deadly infections. Further, he has been instrumental in developing highly effective strategies for the therapy of patients living with HIV/AIDS, as well as for a vaccine to prevent HIV infection. He continues to devote much of his research time to identifying the nature of the immunopathogenic mechanisms of HIV infection and the scope of the body's immune responses to HIV. Dr. Fauci is a member of the US National Academy of Sciences and the US National Academy of Medicine, and is the recipient of numerous prestigious awards for his scientific and global health accomplishments, including the National Medal of Science, the Robert Koch Medal, the Mary Woodard Lasker Award for Public Service, the Prince Mahidol Prize, The Gairdner Canada Award for Global Health, and the Presidential Medal of Freedom. He has been awarded 45 honorary doctoral degrees and is the author, coauthor, or editor of more than 1,300 scientific publications, including several major textbooks.

Kevin Fennelly is a pulmonologist and Senior Research Clinician in the Division of Intramural Research, National Heart, Lung, and Blood Institute at the National Institutes of Health in Bethesda, MD. As a junior faculty member at National Jewish during the outbreaks of multidrug-resistant tuberculosis (MDR-TB) in the early 1990s, he was recruited to be a consultant to the employee health service and to direct the Personal Respiratory Protection program. His interest in protecting health care workers from MDR-TB led to the development of his research interests in TB. He collaborated with Shelly Miller from the University of Colorado to assess the effects of upper room ultraviolet germicidal irradiation (UVGI) in killing a surrogate of airborne *M. tuberculosis*. He led the first successful effort to collect, quantify, and size viable infectious aerosols directly from TB patients. He was then recruited to New Jersey where he conducted TB research in Brazil and Uganda, where cough aerosols from TB patients were shown to be the best predictor of transmission to household contacts. He has mentored younger colleagues who have replicated his cough aerosol sampling method in Brazil and South Africa. He and his collaborators have recently published the largest cohort of TB patients (500) with cough aerosol sampling to assess the effect of drug resistance. Concerned with the morbidity and mortality of health care workers during the recent pandemic, he used his quarantine and lockdown to review the literature on particle sizes of aerosols from patients with a wide range of respiratory infections, and this was recently published. Dr. Fennelly was trained in both pulmonary and

occupational-environmental medicine at the University of California, San Francisco and at the National Jewish Medical and Research Center in Denver.

Charles N. Haas is the L.D. Betz Professor of Environmental Engineering and head of the Department of Civil, Architectural and Environmental Engineering, at Drexel University, where he has been since 1991. He also has courtesy appointments in the Department of Emergency Medicine of the Drexel University College of Medicine and in the School of Public Health. He has served on the faculties of Rensselaer Polytechnic Institute and the Illinois Institute of Technology prior to joining Drexel. He co-directed the USEPA/DHS University Cooperative Center of Excellence – Center for Advancing Microbial Risk Assessment (CAMRA). He is a fellow of the International Water Association, American Academy for the Advancement of Science, the Society for Risk Analysis, the American Society of Civil Engineers the American Academy of Microbiology and the Association of Environmental Engineering and Science Professors. He is a Board Certified Environmental Engineering Member by eminence of the American Academy of Environmental Engineers. He has received the Dr. John Leal Award and the AP Black Award of the American Water Works Association and the Clarke Water Prize. Over his career, Dr. Haas has specialized in the assessment of risk from and control of human exposure to pathogenic microorganisms, and in particular the treatment of water and wastewater to minimize microbial risk to human health. Dr. Haas has served on numerous panels of the National Academies of Sciences, Engineering and Medicine. He is a past member of the Water Science and Technology Board of the National Academies, and the US EPA Board of Scientific Counselors. He received his BS (Biology) and MS (Environmental Engineering) from the Illinois Institute of Technology and his PhD in Environmental Engineering from the University of Illinois at Urbana-Champaign.

Sabra Klein is a Professor of Molecular Microbiology and Immunology at the Johns Hopkins Bloomberg School of Public Health. She is an expert on sex and gender differences in immune responses and susceptibility to infection and currently has over 130 peer-reviewed publications, authored several book chapters, and edited two books on the broad topics of sex differences in response to infection and treatments for infectious diseases. During the 2009 influenza pandemic, she was commissioned by the WHO to evaluate and publish a report on the impact of sex, gender, and pregnancy on the outcome of influenza virus infection. During the current COVID-19 pandemic, Dr. Klein has written commentaries for several journals and been interviewed by several major news media outlets about male-biased disease outcomes. She is immediate past President of the Organization for the Study of Sex Differences, PI of the Johns Hopkins Specialized Center for Research Excellence (SCORE) in sex and age differences in immunity to influenza, and co-director of the Johns Hopkins Center for Women's Health, Sex, and Gender Research.

Seema Lakdawala is an Assistant Professor at the University of Pittsburgh School of Medicine in the Department of Microbiology and Molecular Genetics and Center for Vaccine Research. She trained as a molecular virologist at the Salk Institute in San Diego, CA then moved to the NIH to study airborne transmission of emerging influenza viruses. During this time she made important discoveries regarding the presence of influenza viruses in aerosols of varying sizes, and she defined the soft palate as an important site for viral adaptation and transmission. Dr. Lakdawala started an independent laboratory at the University of Pittsburgh School of Medicine

in 2015 studying influenza virus transmission, pathogenesis, and assembly. The Lakdawala Lab has published multiple papers on the persistence of influenza viruses in aerosols and droplets and demonstrated that viruses are stable for long periods of time in small aerosols and droplets in the presence of respiratory mucus. Their research has been featured in the popular press on NPR, Gizmodo, and This Week in Virology. In addition, Dr. Lakdawala co-authored an article on non-pharmaceutical strategies to limit influenza virus transmission that was published in the Washington Post in 2018. Dr. Lakdawala recently co-authored a Perspective in Science on the animal models under development to study COVID-19 pathogenesis and SARS-CoV-2 transmission.

Yuguo Li is Chair Professor of Building Environment at Department of Mechanical Engineering and Honorary Professor of School of Public Health at the University of Hong Kong. His main research interests are on indoor air quality, city climate, and environment studies of infection. He currently serves as Editor-in-chief of Indoor Air. Since 2003, he has been studying the mechanisms of transmission by airborne and fomite routes for respiratory and enteric infection. Dr. Li received his PhD from the Royal Institute of Technology (Sweden) in Fluid Mechanics.

Bill G. Lindsley is currently a research biomedical engineer at the National Institute for Occupational Safety and Health (NIOSH), which is part of the Centers for Disease Control and Prevention (CDC). Dr. Lindsley studies the role of infectious airborne particles (aerosols) in the transmission of diseases and the efficacy of measures to protect health care workers from these aerosols. He designed the NIOSH two-stage cyclone aerosol sampler which has been used to conduct aerosol sampling for a wide range of applications, including collecting airborne influenza virus and SARS-CoV-2 virus. His group has collected respiratory aerosols from influenza patients and examined the amount of virus contained in these samples. Dr. Lindsley also designed the NIOSH cough aerosol simulator, which is being used to study the efficacy of face masks and face shields as protective devices for the wearer and as source control devices to reduce the expulsion of cough-generated aerosols into the environment. Dr. Lindsley received his BS in Mechanical Engineering from the University of Maryland, College Park and his PhD in Bioengineering from the University of California, San Diego.

John-Martin Lowe is the executive director of training and education for the Global Center for Health Security, assistant vice chancellor for health security training and education, and director of research for the Nebraska Biocontainment Unit at the University of Nebraska Medical Center. At the University of Nebraska Medical Center, he leads research and training initiatives to advance environmental risk assessment, infection control and has an adjunct appointment at Indiana University. As a virologist and environmental exposure scientist, Dr. Lowe has worked extensively throughout the U.S., Africa, Asia and Europe as an educator, researcher, and in health emergency risk management related to infectious disease, infection control and emergency response. As a clinical scientist and environmental scientist, his expertise focuses on risk, specifically identification, characterization, and management of risk for patient- community- and industry-centered environments, particularly related to emerging infectious diseases. Dr. Lowe also has extensive experience in emerging pathogens and health security. He is currently co-PI for the U.S. National Emerging Special Pathogens Training and Education Center, established an international network for emerging infectious diseases, and is lead investigator for a multi-country bio-surveillance network in Africa and has experience in a broad range of health security

topics from surveillance, public health response and clinical response to health emergencies. Dr. Lowe led successful COVID-19 efforts in 2020 at the National Quarantine Unit and Nebraska Biocontainment Unit to provide monitoring and care for repatriated U.S. citizens exposed to and infected with SARS Coronavirus 2. He also led early and continued efforts to characterize the transmission dynamics of SARS Coronavirus 2 which were presented to in a joint meeting hosted by the Academy of Medicine and American Public Health Association on April 15, 2020. Dr. Lowe has co-authored numerous book chapters and scientific papers on control and response to emerging pathogens. He also provided technical consultation and participated in infection prevention and control as well as industrial hygiene in over 23 countries to a variety of industry sectors including healthcare, food production, hospitality, finance, and insurance for issues related to emerging pathogens including Ebola virus disease and COVID-19. Dr. Lowe received his PhD in Medical Science from the University of Nebraska Medical Center.

Linsey Marr is the Charles P. Lunsford Professor of Civil and Environmental Engineering at Virginia Tech. Her research group applies interdisciplinary approaches to study pollutants in indoor and outdoor air. She is especially interested in emerging or non-traditional aerosols such as engineered nanomaterials and viral pathogens. Her research on the airborne transmission of infectious disease has focused on influenza, Ebola virus disease, and Legionnaire's disease. Dr. Marr is a recipient of an NSF CAREER award and an NIH New Innovator award. In 2018, she was named a Fellow of the International Society of Indoor Air Quality and Climate. She is an Associate Editor of *Microbiome* and also serves on the editorial advisory boards of *Aerosol Science & Technology*, *Environmental Science: Processes & Impacts*, and *Environmental Science & Technology Letters*. She is a member of the National Academies' Board on Environmental Science and Toxicology and recently served on the committee on Grand Challenges in Environmental Engineering for the 21st Century. Dr. Marr received a B.S. in Engineering Science from Harvard College and a Ph.D. in Civil and Environmental Engineering from the University of California at Berkeley and completed her post-doctoral training in Earth, Atmospheric, and Planetary Sciences at the Massachusetts Institute of Technology.

John McCarthy is president of Environmental Health & Engineering, Inc. Dr. McCarthy co-founded EH&E in 1988 to provide organizations with a trusted, reliable resource for environmental and engineering consultation. He has cultivated a team of industry leading professionals who share his dedication to creating innovative solutions, based on rigorous, sound science, to resolve the most challenging environmental and human health effects questions. Dr. McCarthy specializes in the research, resolution and communication of complex environmental and occupational health risks, particularly in the built environment. He has led large interdisciplinary teams to analyze business critical issues and develop and implement effective solutions for healthcare systems, private corporations, government and non-profit organizations to improve health and safety and their operational performance. For more than three decades, Dr. McCarthy has been widely recognized as one of the nation's leading experts in exposure assessment, product evaluation, and health impacts of indoor environments. He has been the Principal-in-Charge for numerous federal studies for entities such as the U.S. Consumer Product Safety Commission, U.S. Environmental Protection Agency, U.S. Army Criminal Investigation Division, the Centers for Disease Control and Prevention and has supported the US Surgeon General's office. Often called upon to provide expert opinions, Dr. McCarthy has or currently serves as a consultant to the Department of Environmental Health at the Harvard School of Public Health, the Energy Laboratory at the Massachusetts Institute of Technology, the National

Institute for Occupational Safety and Health, the World Health Organization, and the U.S. Environmental Protection Agency. Dr. McCarthy has authored more than seventy technical papers and book chapters and co-edited the Indoor Air Quality Handbook (McGraw-Hill 2000), a comprehensive reference for building owners and managers. He received a B.S. in biology from Boston College, an M.S. in Environmental Health Sciences from Harvard University and a Sc.D. in Environmental Science and Physiology from Harvard.

Vineet Menachery is an assistant professor in the Department of Microbiology and Immunology at the University of Texas Medical Branch studying coronaviruses and host immunity. His research program focuses on two related research areas: 1) emergence and infection by novel coronaviruses and 2) the role of host factors/co-morbidities in coronavirus infection and disease outcomes. Together, these research areas have the potential to produce critical insights with implications for global public health and treatment of human disease. Dr. Menachery trained as a graduate student in Immunology at Washington University in St. Louis in the laboratory of Dr. David Leib working on innate immune responses to Herpes Simplex virus. He subsequently completed post-doctoral fellowship at the University of North Carolina in the laboratory of Dr. Ralph Baric. As a researcher, Dr. Menachery has co-authored over 50 papers including 26 as first or senior author. He has been recognized as a leader in his field and won several awards including the Postdoctoral Scholars Award for Research Excellence from the University of North Carolina, the Millstein Young Investigator Award from the International Society of Interferon and Cytokine Research, and the University of Texas System Rising STARS Award. He has also been awarded T32, F32, and K99/R00 grants during his training periods. Since joining UTMB, he has also received direct NIH funding through an R01 (Coronavirus correlates for emergence) and R21 (The Host Genetics of Age-Dependent Susceptibility), participated in a large genetics based U19 (Systems Immunogenetics of SARS-CoV Infection), and recently been awarded a grant from the Chan Zuckerberg Initiative (Understanding How Age Influences Susceptibility to Coronavirus Infection).

Shelly L. Miller is a Professor of Mechanical Engineering and faculty in the Environmental Engineering Program at the University of Colorado Boulder. Dr. Miller teaches about and investigates urban air quality and works diligently to understand the impact of air pollution on public health and the environment. She is also an expert on indoor environmental quality including airborne infectious disease transmission and control and air cleaning technologies. Dr. Miller is a member of the Academy of Fellows of the International Society for Indoor Air and Climate (ISIAQ). Dr. Miller has published over 80 peer reviewed articles on air quality, authored a Chapter on Indoor Air Quality in the Environmental Engineering Handbook, is an active scientist on twitter, and publishes open access as often as possible. Dr. Miller holds an MS and PhD in Civil and Environmental Engineering from University of California, Berkeley and a BS in Applied Mathematics from Harvey Mudd College.

Donald K. Milton is a Professor of Environmental and Occupational Health at the University of Maryland School of Public Health. He is a Diplomate of the American Boards of Internal and Preventive (Occupational) Medicine and a Fellow of the International Society for Indoor Air Quality and Climate. He has served on the editorial boards of Applied Environmental Microbiology, Indoor Air, and BMC Public Health, on the NIOSH NORA Indoor Environment Team, and chaired the ACGIH Bioaerosols Committee. Dr. Milton's research focuses on

infectious disease aerobiology and exhaled breath. His work led to the recognition that influenza patients can shed infectious virus into aerosols without coughing and that surgical mask worn by infected cases can reduce the aerosol release of influenza and seasonal coronaviruses. Dr. Milton earned a B.S. in Chemistry from the University of Maryland Baltimore County, an M.D. from Johns Hopkins, and a Dr.P.H. (Environmental Health) from Harvard School of Public Health.

Lidia Morawska is a Professor at the Queensland University of Technology (QUT) in Brisbane, Australia, and the Director of the International Laboratory for Air Quality and Health (ILAQH) at QUT, which is a Collaborating Centre of the World Health Organization on Research and Training in the field of Air Quality and Health. She is also a co-director of the Australia-China Centre for Air Quality Science and Management. She conducts fundamental and applied research in the interdisciplinary field of air quality and its impact on human health and the environment, with a specific focus on science of airborne particulate matter. Dr. Morawska is an author of over eight hundred journal papers, book chapters and refereed conference papers. She has been involved at the executive level with a number of relevant national and international professional bodies, is a member of the Australian Academy of Science and a recipient of numerous scientific awards. Dr. Morawska is a physicist and received her doctorate at the Jagiellonian University, Krakow, Poland for research on radon and its progeny.

William W Nazaroff is the Daniel Tellep Distinguished Professor Emeritus from the Department of Civil and Environmental Engineering, University of California, Berkeley. He is a fellow of the International Society of Indoor Air Quality and Climate (ISIAQ) and of the American Association for Aerosol Research (AAAR). He served as Editor-in-Chief of *Indoor Air* from 2010 to 2018. He was the 2018 recipient of ISIAQ's Pettenkofer Award, "in recognition of his scientific contributions toward understanding indoor air pollutant dynamics and related occupant exposures." Dr. Nazaroff received his MEng in Electrical Engineering and Computer Science from UC Berkeley and his PhD in Environmental Engineering Science from California Institute of Technology.

Cath Noakes is a Professor of Environmental Engineering for Buildings in the School of Civil Engineering at the University of Leeds. She is a chartered mechanical engineer with a background in fluid dynamics, and significant expertise in ventilation and indoor air quality. Her research group conduct experimental and modelling based studies, with a strong focus on ventilation for health including exploring the transport of airborne pathogens and effectiveness of engineering approaches to controlling infectious disease transmission. She has been an investigator on projects funded by EPSRC, Department of Health, MRC, AHRC and CDC which have allowed her to work with researchers across a wide range of disciplines. She has over 100 peer reviewed journal and conference papers and has co-authored design guidance for CIBSE and the Department of Health. Cath is the Deputy-Director of Leeds Institute for Fluid Dynamics and the Co-Director of the EPSRC Centre for Doctoral Training in Fluid Dynamics. She currently sits on the UK government Scientific Advisory Group for Emergencies (SAGE) as part of the COVID response where she chairs the Environment and Modelling Group. Dr. Noakes received her PhD in Mechanical Engineering from the University of Leeds.

Trish M. Perl is the Jay P Sanford Professor in the Departments of Medicine (Infectious Diseases) and the Chief of the Division of Infectious Diseases and Geographic Medicine at UT Southwestern Medical Center in Dallas TX. She is the Chief of Infectious Diseases at Parkland Hospital and Health System and the Interim Associate Medical Director of Infection Prevention there. She formerly was at Johns Hopkins University School of Medicine in the Division of Infectious Diseases in the Department of Medicine, in Epidemiology at the Bloomberg School of Public Health and the Senior Epidemiologist for Johns Hopkins Health System. Dr. Perl received her Bachelor of Arts and medical degree from the University of North Carolina at Chapel Hill and a Master of Science degree from McGill University in Montreal, Canada. She completed a residency in internal medicine at McGill University and a fellowship in infectious diseases and clinical epidemiology at the University of Iowa. She was on faculty at the University of Iowa for several years before moving to Hopkins where she was the hospital epidemiologist from 1996 to 2011 and then the health system epidemiologist until 2016 when she moved to Dallas. She has extensive practical and research experience in the field of healthcare associated infections and resistant and epidemiologically significant organisms and is recognized globally for her innovation and research in healthcare associated infections, antimicrobial resistance, their transmission and prevention. An active researcher, Dr. Perl has been funded by the CDC and the Veteran's Affairs Administration over the years. She has authored or coauthored over 250 peer-reviewed articles. In addition, she has written multiple chapters and contributed to guidelines and policies relevant to healthcare associated infections at the institutional, state and federal level. She serves on NIH study sections and on IOM committees including those for Ebola. She has been asked to help with management of international outbreaks including SARS, MERS CoV, Ebola and consults with international governments on guideline development and strategies to prevent healthcare associated infections and antimicrobial resistance.

Kim Prather is distinguished professor and distinguished chair in atmospheric chemistry at Scripps Institution of Oceanography and in the Department of Chemistry and Biochemistry at the University of California, San Diego. Her work focuses on how humans are influencing the atmosphere and climate. Dr. Prather is working to understand the health and environmental impact of ocean-derived pollutants and toxins in run-off and outfalls, specifically the ocean-to-atmosphere transfer and subsequent atmospheric transport and extent of human exposure. Her research specifically focuses on measurements of the concentration of particles that are small enough to be inhaled deep into our lungs and the subsequent impact on human health. She is working collaboratively with a team of interdisciplinary scientists including in the health sciences sphere to study the potential health effects of these ocean-derived natural microbes and anthropogenic pollutants under changing climate conditions. Early in her career, Dr. Prather developed a technique known as aerosol time-of-flight mass spectrometry that is being used in atmospheric field studies worldwide to determine the sources of atmospheric aerosols. A primary focus of her research involves understanding how aerosols impact climate, with a major emphasis on their role in modifying clouds and precipitation processes. She is the founding director of the NSF Center for Aerosol Impacts on Chemistry of the Environment (CAICE), an NSF Center for Chemical Innovation. CAICE focuses on developing a better understanding of how ocean biology influences atmospheric chemistry, clouds, and climate. She also serves as co-principal investigator on a project to build the Scripps Ocean Atmosphere Research Simulator (SOARS), a new state-of-the art wind-wave channel that will mimic the ocean with unprecedented accuracy, enabling scientists to explore how the introduction of pollutants by

human activities is changing the chemistry of the ocean and atmosphere. Slated for operation in 2020, SOARS will be the only facility in the world capable of simulating future atmospheres with increasing pollution under different ocean and atmospheric conditions. She has authored over 200 publications in refereed scientific journals. Some of her more recent awards include election into the National Academy of Sciences (2020), National Academy of Engineering (2019), the 2020 American Chemical Society Frank H. Field & Joe L. Franklin Award for Outstanding Achievement in Mass Spectrometry, 2018 Chancellor's Associates Excellence Award in Research in Science and Engineering, 2015 Haagen-Smit Clean Air Award, the 2010 American Chemical Society Award for Creative Advances in Environmental Science & Technology. Dr. Prather is the first woman at UC San Diego to be elected to membership in the National Academy of Engineering (NAE) for contributions including "technologies that transformed understanding of aerosols and their impacts on air quality, climate, and human health." Dr. Prather is an elected fellow at the American Geophysical Union, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences. Dr. Prather received her PhD in physical and organic chemistry from the University of California, Davis.

Arthur Reingold is professor and head of the Division of Epidemiology at the School of Public Health at the University of California, Berkeley, having joined the faculty there in 1987. His research interests encompass the prevention and control of infectious diseases in the US and internationally, particularly infections spread via the respiratory route and vaccine preventable diseases. He has previously served on the Advisory Committee on Immunization Practices (ACIP) of the US Department of Health and Human Services and on the Strategic Advisory Group of Experts on immunizations (SAGE) of the World Health Organization. He has directed or co-directed the California Emerging Infections Program since its inception in 1994. He has published almost 300 original research papers on these subjects and teaches a wide variety of courses on related subjects at the University of California, Berkeley and at numerous other universities around the world. He was elected to membership National Academy of Medicine and the National Academy of Sciences in 2003 and has previously served on multiple NASEM committees. Dr. Reingold received his MD from the University of Chicago.

William Ristenpart is Professor of Chemical Engineering at the University of California Davis. His research focuses on complex transport phenomena in a variety of applications, including electrocoalescence of charged droplets, shear-induced deformation of red blood cells, and extraction dynamics of coffee grounds. A recipient of the NSF CAREER award for work on charged droplets, since 2014 Prof. Ristenpart has been supported by the NIH to investigate the transport of pathogens through the air, with recent results revealing the relationship between vocalization loudness and expiratory particle emission, and that influenza virus is transmissible via "aerosolized fomites." His group is currently investigating facemask efficacy as well as the potential role of dust in transmission of COVID-19. He received his Ph.D. from Princeton University and did his post-doctoral work at Harvard University.

Jonathan M. Samet is a pulmonary physician and epidemiologist and is currently Dean of the Colorado School of Public Health. Dr. Samet's research has focused on the health risks posed by inhaled pollutants and tobacco. He has served on numerous committees concerned with public health and the environment: the U.S. EPA Science Advisory Board; committees of the National

Academies, including chairing the Biological Effects of Ionizing Radiation VI Committee, the Committee on Incorporating 21st Century Science in Risk-Based Evaluations, the Committee on Research Priorities for Airborne Particulate Matter, the Committee to Review EPA's Draft Integrated Risk Information System Assessment of Formaldehyde, the Committee to Review the IRIS Process, and the Board on Environmental Studies and Toxicology, among others; and the National Cancer Advisory Board. He is a member of the National Academy of Medicine. Dr. Samet received his MD from the University of Rochester, School of Medicine and Dentistry and his master's degree in epidemiology from the Harvard T.H. Chan School of Public Health.

Joshua L. Santarpia is the Research Director for Counter WMD programs at the National Strategic Research Institute, Associate Professor of Microbiology and Pathology, and Program Director for Biodefense and Health Security Degree Program at the University of Nebraska Medical Center. He has held past positions at the Edgewood Chemical and Biological Center, the Johns Hopkins University Applied Physics Laboratory, and was most recently a distinguished staff member at the Sandia National Laboratories. His work is generally in the field of aerobiology, the study of airborne microorganisms. He has worked extensively on RDT&E and OT&E efforts for biological sensors for both DoD and DHS. He has developed building and facility sensing networks for biological detection in numerous facilities. He has developed aerosol measurement tools, including those for unmanned aerial vehicles and for biodetection/collection activities. He has worked extensively to understand optical and other signatures that can be used to detect and identify biological aerosol and studied how those signatures change over time. He has developed novel methods to study bioaerosol hazard in medical environments, and studies for private companies to determine potential aerosol hazards of medical devices in operating rooms. Dr. Santarpia is trained in aerosol physics, atmospheric chemistry and microbiology. His peer reviewed research focuses largely on the fate biological aerosols in the atmosphere, detection of biological aerosols and atmospheric chemistry of biological and anthropogenic particles. He has contributed to several books on the characterization and measurement of biological aerosols in the environment.

Robert T. Schooley is an infectious disease specialist and an expert in RNA virus infections and treatment. He currently serves as a distinguished professor in the division of infectious diseases at UC San Diego School of Medicine, where he has developed a drug discovery program for HIV, HCV and coronaviruses. As a professor of medicine, he leads the Universidade Eduardo Mondlane-UC San Diego Medical Education Partnership Initiative and supervises postdoctoral fellows. Infectious disease specialists care for patients with infections or diseases caused by viruses, bacteria, fungi and parasites. These include hepatitis viruses, tuberculosis, influenza, and HIV/AIDS, in addition to infections of the sinuses, heart, brain, lungs, gastrointestinal system, urinary tract, pelvic organs and bones. His research interests include HIV, influenza, coronaviruses, global health and international medicine, and the diagnosis and management of infections that cause death and morbidity in resource-limited settings. Dr. Schooley is particularly interested in the origin and development (pathogenesis) of HIV and HIV therapy, and was one of the first researchers to describe the humoral and cellular immune responses to HIV infection. Prior to joining UC San Diego, Dr. Schooley was head of the Division of Infectious Diseases at University of Colorado and director of the Colorado Center for AIDS Research. During his tenure at Colorado, Dr. Schooley was chair of the National Institute of Allergy and Infectious Diseases' AIDS Clinical Trials Group. Before that, he served as associate

professor of medicine at Harvard Medical School. Dr. Schooley is extensively published, having edited numerous books and authored hundreds of articles and book chapters. He serves on the editorial board of several medical journals and currently serves as Editor-in-Chief of *Clinical Infectious Diseases*. He is a fellow of the Infectious Disease Society of America and Royal Society of Medicine (UK), and member of numerous professional societies, including the American Society for Clinical Investigation, the Association of American Physicians, and the American Society of Tropical Medicine and Hygiene. In 2013, Dr. Schooley was honored with the Best Doctors in America and America's Top Doctors award. Dr. Schooley received his medical degree from Johns Hopkins School of Medicine.

Kanta Subbarao is Director of the WHO Collaborating Centre for Reference and Research on Influenza and Department of Microbiology and Immunology, The University of Melbourne at The Peter Doherty Institute for Infection and Immunity. Dr. Subbarao was appointed Director of the WHO Collaborating Centre for Reference and Research on Influenza and Honorary Professorial Fellow in the Department of Microbiology and Immunology, University of Melbourne at the Peter Doherty Institute for Infection and Immunity in 2016. Her research is focused on newly emerging viral diseases of global importance including seasonal and pandemic influenza, severe acute respiratory syndrome (SARS), Middle East Respiratory Syndrome (MERS) and now COVID-19. Her research includes the study of virus biology and pathogenesis, immune responses to infection and vaccination, development and preclinical and clinical evaluation of vaccines and evaluation of antiviral drugs. She is an internationally recognised leader in the field of emerging respiratory viruses and is an elected Fellow of the American Academy of Microbiology and the Infectious Diseases Society of America and is a member of the American Society of Microbiology, American Society for Virology and Australasian Virology Society. She serves on the Editorial Boards of *PLoS Pathogens*, *mBio* and *Cell Host and Microbe*. In response to the COVID-19 pandemic, she has been invited to serve on international panels on animal models and vaccine safety (CEPI, WHO and American Society for Microbiology). Prior to her arrival in Melbourne, she was Chief of the Emerging Respiratory Viruses Section of the Laboratory of Infectious Diseases, NIAID, National Institutes of Health (NIH) in the United States from 2002-2016 and chief of the Molecular Genetics Section of the Influenza Branch at the US CDC from 1997-2002. Dr. Subbarao is a virologist and a physician with specialty training in paediatric infectious diseases. She received her M.B.B.S. from Christian Medical College, Vellore in India and trained in pediatrics at Cardinal Glennon Children's Hospital in St Louis and pediatric infectious diseases at the University of Oklahoma Health Sciences Center, where she also completed an M.P.H. in epidemiology. She received postdoctoral training in the Laboratory of Infectious Diseases, NIAID, NIH.

Gregory H. Symmes is the Chief Program Officer of the National Academies of Sciences, Engineering, and Medicine, where he is responsible for managing and providing overall strategic leadership of its programs. The National Academies are non-governmental, non-profit organizations that provide independent, authoritative analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. Previously he served as Executive Director of the Academies' Division on Earth and Life Studies, which carries out the Academies' mission in the broad areas of earth, life, environmental, and chemical sciences and engineering. The division's portfolio addresses some of the most critical challenges facing the nation and the world from climate change to food and

water security to environmental health. Its work has resulted in significant impacts on policy decisions at national and local levels, directions in science, and guidance on the practice of science. Before joining the Academies in 1995, Dr. Symmes served as a research assistant professor and postdoctoral associate in the Department of Earth and Space Sciences at the State University of New York at Stony Brook. He graduated with a B.A. *summa cum laude* in geology from Amherst College and received his Ph.D. in geology from the Johns Hopkins University. He received the National Academies' Individual Award for Distinguished Service in 2002.

Julian W. Tang is a Consultant Virologist and Honorary Associate Professor of Clinical Microbiology at the University Hospitals of Leicester NHS Trust/Respiratory Sciences, University of Leicester. He trained in Medicine and Zoology at Cambridge, before completing a Zoology PhD in biological fluid dynamics in Aberdeen. He then finished my medical training in Sheffield. After his general medical training, he completed my specialist clinical virology training at University College London in 2005. Later the same year, he moved to Hong Kong after the SARS 2003 outbreaks to work as an Assistant Professor, developing a clinical and research interest in respiratory viruses, particularly on influenza and its transmission. He moved to Singapore in 2008 as a Consultant/Virologist, arriving there just in time for the 2009 A/H1N1 influenza pandemic. There, he and his team built a 1 m diameter schlieren imaging system to visualise human exhaled airflows such as breathing, talking, coughing, sneezing, singing – to aid aerosol infection control guidance. After several years in Singapore, he spent a couple of years working in Edmonton, AB, Canada - where he and his team described the first imported, fatal human case of avian A/H5N1 influenza into North America in 2013. Dr. Tang returned to the UK in 2014, settling in Leicester, UK, where he has been running the diagnostic virology laboratory and advising on the clinical management and infection control of viral infections, particularly respiratory viruses, like influenza and SARS-CoV-2 that is causing the current COVID-19 pandemic.

John Volckens is a professor of Mechanical Engineering and the director of the Center for Energy Development and Health at Colorado State University (CSU). He holds affiliate appointments in Environmental Health, Biomedical Engineering, the Colorado School of Public Health, and the CSU Energy Institute. His research interests involve air quality, exposure science, and air pollution-related disease. In March of 2020, his lab at CSU was appointed as the official respirator performance testing center for Colorado Governor Jared Polis' COVID-19 Response Task Force. He is a founding member of the CSU Partnership for Air Quality, Climate, and Health – an organization that seeks to develop practical, science-vetted solutions to intertwined problems of air quality, climate, and health that we face as a society. He received postdoctoral training at the U.S. EPA's National Exposure Research Laboratory in Research Triangle Park, NC. At CSU, he has pioneered the development of several new pollution sensor technologies, which have been deployed for public health research in over 30 different countries and as far away as the International Space Station. Dr. Volckens is the recipient of the 'Best Paper' award from the American Industrial Hygiene Association (1999, 2017) and the Journal of Indoor Air (2013). He was a 2018 finalist for the NASA Earth, Space, Air Prize. He has published over 100 manuscripts related to exposure science, aerosol technology, and air pollution-related disease. He is a co-founder of Access Sensor Technologies, a company started through his research collaborations at Colorado State University and receives grant funding from

the US EPA, NIH, CDC, and NASA. Dr. Volckens received his PhD in Environmental Health Engineering from the University of North Carolina at Chapel Hill.

Emmie de Wit is the Chief of the Molecular Pathogenesis Unit in the Laboratory of Virology of NIAID, where her lab focuses on emerging respiratory viruses, aiming to combine pathogenesis studies with detailed molecular analyses to identify molecular determinants of severe respiratory tract disease within the virus and the host. In 2009, she moved to the Laboratory of Virology of NIAID in Hamilton, Montana to work in the biosafety level 4 laboratory there. Here, she focused on the pathogenesis of and countermeasures against Nipah virus, the Middle East Respiratory Syndrome Coronavirus and the 1918 H1N1 influenza A virus (Spanish flu). In 2014-2015, Dr. de Wit spent 4 months in a field lab in Monrovia, Liberia in charge of patient diagnostics for several Ebola Treatment Units in the area, to help contain the devastating Ebola epidemic in Liberia. Since the emergence of COVID-19, Dr. de Wit has focused her research on SARS-CoV-2, developing animal models and using those for testing of medical countermeasures and to gain a better understanding of SARS-CoV-2 pathogenesis. Dr. de Wit received her Ph.D. in virology in 2006 from Erasmus University Rotterdam, the Netherlands where her research focused on the replication, pathogenesis and transmission of influenza A virus.

Hui-Ling Yen is an Associate Professor in the division of public health laboratory sciences at the University of Hong Kong. Her research interests focus on studying the mechanisms facilitating transmission of influenza virus and other respiratory viruses, virus-host interactions that affect viral transmissibility and pathogenicity, and determinants of viral fitness under different selection pressures. Dr. Yen is a full member of the American Society of Virology and a committee member of ISIRV Antiviral Group. She serves at Editorial Board of Antiviral Research, Indoor Air, and PLOS ONE. Dr. Yen received her PhD in Epidemiological Science from The University of Michigan, Ann Arbor and postdoctoral training at St. Jude Children's Research Hospital, Memphis, TN.