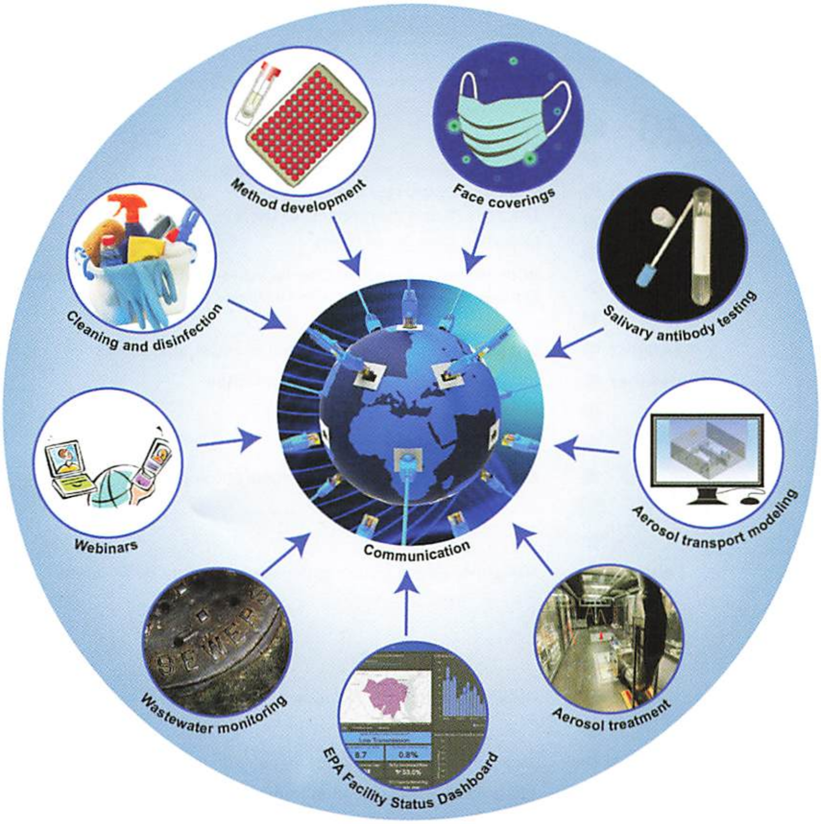
Filling Critical Science Gaps:

EPA Office of Research and Development's Response to COVID-19

by Nicolle S. Tulve , Gregory D. Sayles, Wayne E. Cascio, Lisa Baxter, Jeremy Baynes, Nichole E. Brinkman, Andrey Egorov, Aaron Ferster, Jay Garland, Shannon M. Griffin, Lahne Mattas-Curry, Sean J. Paul, Katherine M. Ratliff, Bruce Rodan, Jacky A. Rosati, Shawn Ryan, James M. Samet, Sanjiv Shah, Timothy J. Wade, and H. Christopher Frey



In this the first of a two-part series of articles, the U.S. Environmental Protection Agency's Office of Research and Development provides an in-depth look at the agency's research response to the COVID-19 pandemic. The second article, looking at the agency's COVID-19 research findings communication efforts, will appear in the fourth-quarter issue of *EM Plus*.

The early days of the COVID-19 pandemic were marked by uncertainty and social disruption. As the virus began to take hold, its main routes of transmission were largely unknown, rendering clear actions on how to attenuate its spread a mystery.

As the number of COVID-19 related deaths climbed and people moved to social isolation, the federal government looked across its scientific and public health enterprises for answers. Daily White House press briefings highlighted ongoing research efforts and the latest findings thrust federal research agencies into the spotlight. Institutions such as the Centers for Disease Control and Prevention, infectious disease experts, and prominent doctors dominated the news, some becoming household names seemingly overnight.

Outside of the immediate glare, experts from the U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD) also sprang into action. Even as its own offices were rapidly transitioning most staff to stay-at-home work, ORD took extraordinary steps to establish a COVID-19 research program. The collective capabilities of its staff, already strategically designed around diverse, multidisciplinary teams of experts from across the environmental and public health arenas, uniquely positioned ORD to tackle science gaps critical to the national response.

This article shares the story of how urgent, public health-relevant ORD research was conceptualized, initiated, conducted, and delivered in real time during the COVID-19 pandemic. That story began in early February 2020 when EPA leaders convened an internal workgroup comprised of subject matter experts from across the agency. Its task was to report on both what was known and not known about managing viruses in the environment. The workgroup identified several knowledge gaps, including disinfection of environmental surfaces and personal protective equipment (PPE), how to assess exposures, methods to measure virus levels, and tracking changes in community infection levels by monitoring virus levels in wastewater.

In March 2020, just as states and communities across the nation began to declare public health emergencies, ORD took steps to plan and launch a COVID-19 research program to urgently address the gaps identified by the workgroup (see Figure 1).

A diverse, interdisciplinary research team of scientists, engineers, and subject matter experts was recruited from across EPA's existing research programs, supported by administrative staff, quality assurance and control personnel, contracting and purchasing specialists, communications professionals, and project and accountability managers. ORD senior leadership secured necessary financial resources.

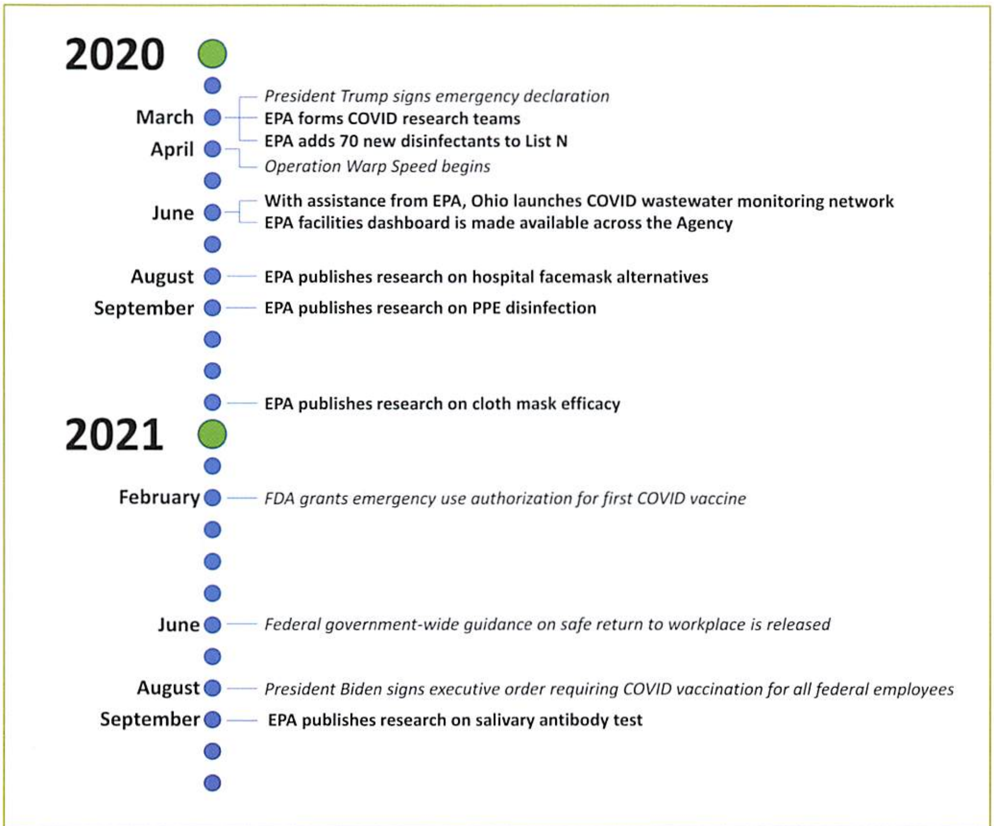


Figure 1. COVID-19 research program timeline.

A key component in enacting the research was safely reopening the agency's research labs. To do so, ORD established a biosafety and biosecurity committee to ensure adequate measures were in place prior to the start of any research activities. ORD's proposed COVID-19 research program was reviewed by the agency's Science Advisory Board to ensure scientific support for selected projects.[1]

With those steps in place, ORD targeted three areas where it could fill critical knowledge gaps in support of the national effort to combat the COVID-19 pandemic: (1) exposure and detection, (2) decontamination, and (3) wastewater monitoring.

As the urgency of the public health crisis has waned, ORD looked back at the research program to assess and share some of the achievements and innovations from a COVID-19 research program that moved from conception to action at unprecedented speed. Highlights of some of the results are outlined in the following sections.

About the Authors

Nicolle S. Tulve (corresponding author; tulve.nicolle@epa.gov), Research Physical Scientist, U.S. Environmental Protection Agency (EPA), Office of Research and Development, Center for Public Health and Environmental Assessment, Research Triangle Park, NC.

Gregory D. Sayles, Director, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Cincinnati, OH.

Wayne E. Cascio, Director, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Research Triangle Park, NC.

Lisa Baxter, Division Director, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Research Triangle Park, NC.

Jeremy Baynes, Computer Scientist, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Research Triangle Park, NC.

Nichole E. Brinkman, Biologist, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Cincinnati, OH.

Andrey Egorov, Research Health Scientist, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Chapel Hill, NC.

Aaron Ferster, Science Writer-Editor, EPA Office of Research and Development, Washington, DC.

Jay Garland, Water Reuse Microbial Ecologist, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Cincinnati, OH.

Shannon M. Griffin, Biologist, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Cincinnati, OH.

Lahne Mattas-Curry, Communications Director, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Washington, DC.

Sean J. Paul, Special Advisor, EPA Office of Research and Development, Washington, DC.

Katherine M. Ratliff, Physical Scientist, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Research Triangle Park, NC.

Bruce D. Rodan, Associate Director for Science, EPA Office of Research and Development, Washington, DC.

Jacky A. Rosati, Supervisory Environmental Engineer, EPA Office of Research and Development, Center for Environmental Measurement and Modeling, Research Triangle Park, NC.

Shawn Ryan, National Program Director for EPA's Homeland Security Research Program, Office of Research and Development, Center for Environmental Solutions and Emergency Response, Research Triangle Park, NC.

James M. Samet, Research Biologist, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Chapel Hill, NC.

Sanjiv R. Shah, Microbiologist, EPA Office of Research and Development, Center for Environmental Solutions and Emergency Response, Washington, DC.

Timothy J. Wade, Epidemiologist, EPA Office of Research and Development, Center for Public Health and Environmental Assessment, Chapel Hill, NC.

H. Christophe Frey, EPA Assistant Administrator for Research and Development, Office of Research and Development, Washington, DC.

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Microbial Exposure and Detection Studies

Face Coverings

Upon an urgent request from University of North Carolina at Chapel Hill (UNC) colleagues and UNC Hospitals, ORD researchers developed and conducted a testing program to evaluate face coverings under a variety of conditions that simulated real-world scenarios.[2-8] They determined the effect of facial hair on the fitted performance of various types of face coverings being used by the public,[4] informed efforts to mitigate the environmental impact of disposable face coverings by testing their durability,[2] identified the optimal level of instruction needed for wearing an N95 respirator by the public,[9] and developed a novel method to assess the containment efficiency of face coverings.[10]

Researchers successfully modified protocols and procedures to test respirators and quickly presented results to the hospital, helping professionals there make decisions on which supplies of PPE should be prioritized during emergencies.

Rapid Detection Method Development (RV-RT-PCR-Based Swab Sample Analysis)

ORD researchers, in collaboration with colleagues from the U.S. Department of Energy's Lawrence Livermore National Laboratory, developed a high-throughput Rapid Viability Reverse Transcriptase Polymerase Chain Reaction (RV-RT-PCR) method, primarily aimed at testing viral contamination of surfaces, which reduced the time needed to detect infectious SARS-CoV-2 in samples from days to just hours (see Figure 2). The delivery of the new method was completed in just seven months.[11]

Salivary Antibody Testing

Agency researchers were the first to demonstrate a nationwide application of a non-invasive salivary antibody assay for SARS-CoV-2 surveillance, successfully developing an innovative method that enabled large-scale population surveys of COVID-19 by mail in a clinically-, geographically-, and demographically-diverse population[12] (see Figures 3 and 4).

Aerosol Transport Modeling

ORD researchers collaborated with researchers at Clarkson University to model the flow of SARS-CoV-2 laden air through a typical office setting. They employed Computational Fluid Dynamics (CFD) modeling to explore how factors such as ventilation rate, airflow pattern, divider height, and distance between infected individuals influenced exposure to the virus.[13,14]

Cleaning and Disinfection

Evaluating Disinfection Products and Procedures

ORD research on cleaning and disinfection was focused on disinfectants, surface types, and applications. While exposure to SARS-CoV-2 was eventually determined to be primarily via aerosol, the virus can remain infectious on surfaces for hours or longer,[15] making disinfecting surfaces an important activity in many situations.

ORD researchers evaluated the effectiveness of products on the agency's "List N" of disinfection products approved for use on surfaces to inactivate SARS-CoV-2 (see https://www.epa.gov/coronavirus/about-list-n-disinfectants-coronavirus-covid-19-0). They focused their studies on the effectiveness of such products on disinfecting surfaces of particular concern during the COVID-19 pandemic, such as the kind of hard rubber used on escalator handrails, Formica used for desktops, and fabrics used for plane and railcar seats.[16,17] Researchers also assessed the use of electrostatic sprayers (ESS) for the broad application of liquid disinfectants, evaluating parameters such as droplet size, charge, and flow rate to address effective use of ESS for disinfectant applications[18] (see Figures 5 and 6).

To inform situations where approaches other than liquid disinfectant applications are more practical, ORD researchers investigated the use and effectiveness of Ultraviolet-C (UV-C) devices,[19] steam,[20] and ozone for inactivating SARS-CoV-2.[21-23] This work included a collaborative study with the New York Metropolitan Transportation Authority and the Los Angeles County Metropolitan Transportation Authority to evaluate how effectively UV-C devices can inactivate the virus (see Figure 7).

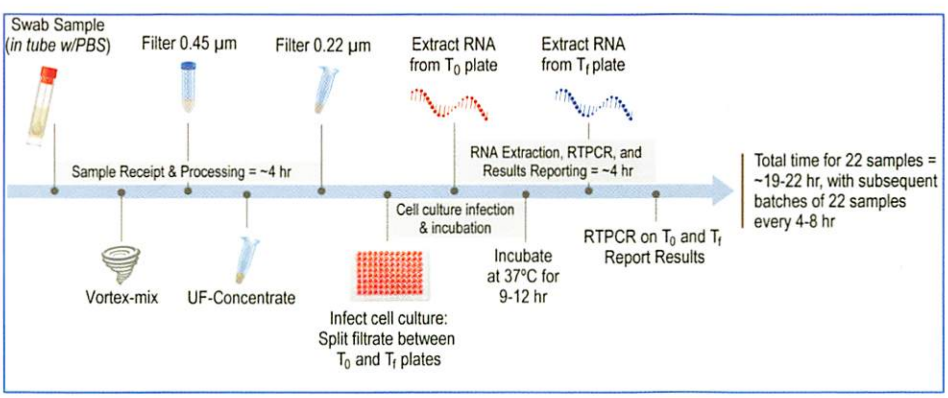

Figure 2. Estimated timeline for RV-RT-PCR-based swab sample analysis.

Evaluating Aerosol Treatments

As increasing evidence pointed to airborne transmission as the main route for the spread of COVID-19, agency researchers received growing calls for information on the effectiveness of technologies that remove or inactivate viruses and other pathogens in the air, including those that use ultraviolet radiation, ions, or other reactive species. To answer those calls, agency researchers established a research program using a large-scale test chamber, and implemented a systematic test methodology to assess performance at a scale that is translatable to real-world settings and comparable across different technologies. The test chamber setup and research protocols were developed in EPA's specialized bioaerosol laboratories incorporating input from experts across the agency. To date, more than 10 different air treatment technologies have been tested with results being rapidly transmitted to stakeholders and the broader scientific community.[24]

Wastewater Monitoring

ORD researchers provided critical advancements for monitoring wastewater as an indicator of community virus transmission and the emergence of new variants. Drawing on years of experience developing methods to quantify viruses in water[25,26] and monitor wastewater for enteroviruses to assess community infection dynamics,[27] the scientists identified a strong correlation between concentrations of SARS-CoV-2 gene fragments in wastewater and reported case counts.[28] In addition, their analysis of SARS-CoV-2 genetic material in wastewater reflected the emergence of the Alpha, Gamma, Delta, and Omicron variants recorded in southwest Ohio communities where monitoring was conducted (see Figure 8). This work demonstrated the utility of wastewater surveillance for monitoring SARS-CoV-2 circulation and its continued use by public health departments to monitor other pathogenic microbes.

Tying EPA's COVID-19 research program together were ambitious communications and outreach efforts designed to deliver research results and emerging information in forms that were at once timely, accurate, and accessible to wide audiences, including public health officials, state and agency officials and employees, and the public. To learn more about these important efforts, please see the companion article, "Spreading the Word: Sharing EPA Office of Research and Development's COVID-19 Research Results," which will be published in the Q4 2024 issue of *EM Plus*.

From the evaluation of face coverings to modeling virus-laden air flow through simulated workspaces and classrooms, and from the development of rapid saliva assays to wastewater testing programs, EPA's COVID-19 research program delivered under the glare

Figure 3. EPA/ORD researchers Rachel Grindstaff and Lindsay Wickersham working at the Epidemiology Branch laboratory in NC on the development of SARS-CoV-2 salivary antibody assay.

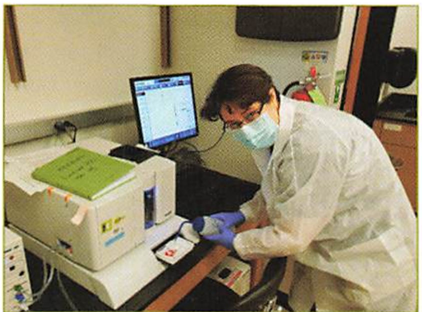

Figure 4. The Luminex LX-200 machine that was used to measure antibody responses in ORD's in-house multiplex salivary antibody assay.

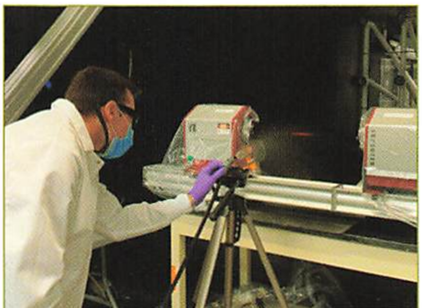

Figure 5. Droplet size formed by the electrostatic sprayer application of disinfectants.

Figure 6. Testing of spraying a cylindrical object to investigate the ability of the electrostatic sprayer to have a claimed wrap around effect.

Figure 7. Testing of LED UV-C in a subway car with LA Metro.

Figure 8. EPA's Dr. Nichole Brinkman processing a wastewater sample in ORD's enhanced Biosafety Level 2 laboratory

Tying EPA's COVID-19 research program together were ambitious communications and outreach efforts.

of an unfolding public heath crisis. That story is still unfolding as the pandemic transitions to an endemic, more data are analyzed, and results are published in the scientific literature and widely shared through other communications and outreach efforts.

Looking forward, the agency is committed to sustaining partnerships forged with public health officials, emergency response and transit agencies, states, local communities, and other stakeholders, leaving the agency better prepared to respond to ongoing and future challenges. em

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