Impact of Disaster Research on the Development of Early Career Researchers: Lessons Learned from the Wastewater Monitoring Pandemic Response Efforts

Jeseth Delgado Vela,* Jill S. McClary-Gutierrez, Mitham Al-Faliti, Vajra Allan, Peter Arts, Roberto Barbero, Cristalyne Bell, Nishita D’Souza, Kevin Bakker, Devrim Kaya, Raul Gonzalez, Katherine Harrison, Sherin Kannoly, Ishi Keenum, Lin Li, Brian Pecson, Sarah E. Philo, Rebecca Schneider, Melissa K. Schussman, Abhilasha Shrestha, Lauren B. Stadler, Krista R. Wigginton, Alexandria Boehm, Rolf U. Halden, and Kyle Bibby

KEYWORDS: disaster research, wastewater monitoring, early career researchers

The environmental science and engineering research community has repeatedly demonstrated its ability to rapidly mobilize to protect human health and the environment by performing research critical to disaster response. Recent examples include measuring pathogens exposure after hurricanes, evaluating drinking water contamination resulting from wildfires and chemical spills, investigating the cause and effects of lead contamination in Flint, Michigan, and assessing the ramifications of the Fukushima nuclear disaster. An ongoing example is the recent mobilization and rapid advancement of sewage monitoring as a tool for managing the COVID-19 pandemic. Early in the pandemic response, researchers predicted that SARS-CoV-2 genetic signals in wastewater could assist with monitoring the spread of COVID-19. Researchers not only rapidly mobilized to begin sampling, but collaborated with one another, sharing their protocols, results, and methodological pitfalls in real-time. Wastewater monitoring as a tool for managing the COVID-19 pandemic is...
now relied upon globally, with the public appreciating and benefiting from open access to data via online dashboards, demonstrating the power of coordinated research in the face of great challenges.

While the ability of researchers to respond to natural- and man-made disasters has been well demonstrated, the impact of these rapid responses on early career researchers has not yet been fully explored. Behind the COVID-19 wastewater monitoring successes are many early career investigators (undergraduate students, technicians, graduate students, postdoctoral scholars, and assistant professors). These developments have happened while early career investigators were learning how to conduct research and/or establishing their careers. Conducting research under these unprecedented circumstances has surely impacted the career trajectories and research training of these individuals. Here we explore some challenges and opportunities summarized in Table 1 from the research community as discussed at a virtual workshop hosted by the Research Coordination Network on Wastewater Surveillance held December 3, 2021.

The broad research community conducting wastewater monitoring during the pandemic has faced significant challenges in their research including changes in research direction, supply chain issues, difficulties publishing their work in a competitive environment, managing large fluxes in funding with unknown sustainability, and rapidly identifying and training personnel. We posit that early career researchers face distinct challenges. Funding for this work has typically been short-term, which may be challenging to manage for early career researchers that are looking to build a significant body of work for degree and career advancement. Across all disciplines, early career researchers may have pivoted their research early in the pandemic, for instance, to a computational project or a literature review while lab access was limited. However, researchers conducting SARS-CoV-2 wastewater monitoring have dedicated more sustained time and effort to this work, pivoting their dissertations and/or existing research programs. Publishing in this space has been challenged by the lack of established journal or conference “homes”, as well as the need for rapid results communication to advance pandemic response. Many early career researchers have faced skepticism from colleagues on the value added of this type of research; some may view the contributions we are making as service or as lacking “novelty”. However widely held these beliefs, this skepticism looms larger for early career researchers that are establishing their reputation in the field and could lead them to rethink the possible longer-term career impacts of this transition in research.

Participation by early career researchers in this field has also had advantages. For example, researchers in this space have had the benefit of participating in a quickly evolving field that is greater than the sum of its parts and have been afforded vast opportunities for collaboration. Many of the coauthors of this paper have not met outside of social media, virtual workshops, and seminars that have occurred over the past two years but have had the opportunity to learn from one another. Early career scientists have also developed new collaborations with utilities, researchers in other disciplines, and health departments, and have had the opportunity to see the impacts of their work in real time. In addition, researchers trained in this area have gained a range of technical skills that have been uniquely integrated such as understanding molecular biology in complex matrices, analyzing health surveillance data (and recognizing its pitfalls), and applying spatial data science. Additional capabilities developed include understanding sewer system dynamics, logistics, and management as well as translating research outcomes to diverse stakeholders. These experiences and connections will have long-standing impacts on how early career researchers involved in wastewater monitoring efforts will approach research—the opportunity to witness, at an accelerated pace, how collaboration can create outputs to broad audiences. Most emblematic of these opportunities is the immense weight of generating actionable data that could have immediate consequences on human health and the environment. These challenges are

Table 1. Challenges and Opportunities for Early Career Researchers Participating in SARS-CoV-2 Wastewater Monitoring

| Challenges                                                                 | Opportunities                                                                 |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------|
| • stopping ongoing projects and/or delaying graduation                     | • access to new funding opportunities                                         |
| • learning new experimental methods at an accelerated pace with rapid developments from global collaborators and peers | • job openings across several sectors with skilled lab workers being in high demand |
| • managing supply chain issues and other resource constraints (funding and personnel) | • opportunities for outreach                                                 |
| • establishing collaborations and buy-in from diverse stakeholders (health departments and utilities) | • collaborations and connections, many through Slack WBE collaborative       |
| • securing funding and university support (e.g., lab space and access)     | • contributing to a fast-moving field with a direct impact                    |
| • limited availability of long-term funding                                | • public awareness of the research                                            |
| • publishing pace and avenues                                              | • new equipment, more space, and/or an expanded group                         |
| • fewer opportunities to present work at conferences and limited networking opportunities | • new technical and nontechnical skills                                       |
| • training new personnel while abiding with social distancing practices     | • engagement with entrepreneurship via startup ventures                       |
| • developing methods with pressures of trying to generate actionable data   | • increased adoption of preprint servers to rapidly disseminate data          |
| • caring for and/or grieving the loss of sick loved ones                    |                                                                               |
| • working in isolation                                                     |                                                                               |

*Challenges and opportunities that have a disproportionate impact on the development of early career researchers.*
worthwhile given the opportunity to conduct science with societal impacts, which notably has a disproportionate beneficial effect on retaining women and underrepresented minorities in engineering.8

We environmental engineers and scientists pride ourselves in conducting science in service of human health and environmental protection. Early career researchers conducting disaster research experience the satisfaction of performing impactful work that achieves this goal, but given the challenges faced, would benefit from additional support from more senior colleagues such as valuing the technical and nontechnical skills gained, providing opportunities to communicate research findings, and recognizing unique scientific and societal contributions. Moving forward, we encourage the broader environmental science and engineering field to weigh the impacts of disaster research on the career trajectories of early career scientists when making hiring and promotion decisions to encourage a research community that is not afraid to take risks to benefit society.

■ AUTHOR INFORMATION

Corresponding Author
Jeseth Delgado Vela – Department of Civil and Environmental Engineering, Howard University, Washington, D.C. 20059, United States; orcid.org/0000-0001-6171-4400; Phone: 202-806-6630; Email: jeseth.delgadovela@howard.edu

Authors
Jill S. McClary-Gutierrez – Department of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, Indiana 46556, United States; Present Address: Department of University Safety & Assurances, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53211, United States; orcid.org/0000-0002-6863-7281
Mitham Al-Faliti – Department of Civil and Environmental Engineering, Howard University, Washington, D.C. 20059, United States
Vajra Allan – PATH, Seattle, Washington 98121, United States
Peter Arts – Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan 48109, United States
Roberto Barbero – Ceres Nanosciences, Manassas, Virginia 20110, United States
Cristalyne Bell – Department of Family Medicine and Community Health, University of Wisconsin, Madison, Wisconsin 53715, United States
Nishita D'Souza – Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824, United States
Kevin Bakker – Department of Epidemiology, University of Michigan, Ann Arbor, Michigan 48109, United States
Devrim Kaya – School of Chemical, Biological, and Environmental Engineering, Oregon State University, Corvallis, Oregon 97331, United States; orcid.org/0000-0002-7115-0845
Raul Gonzalez – Hampton Roads Sanitation District, Virginia Beach, Virginia 23455, United States; orcid.org/0000-0002-8115-7709
Katherine Harrison – Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan 48109, United States; orcid.org/0000-0001-5799-2598
Sherin Kannoly – Queens College, City University of New York, New York, New York 11367, United States
Ishi Keenum – National Institute of Standards and Technology, Gaithersburg, Maryland 20899, United States; orcid.org/0000-0002-5441-4634
Lin Li – Department of Civil and Environmental Engineering, University of Nevada, Reno, Nevada 89557, United States
Brian Pecson – Trussell Technologies, Pasadena, California 94612, United States
Sarah E. Philo – Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, Washington 98195, United States
Rebecca Schneider – Houston Health Department, Houston, Texas 77054, United States
Melissa K. Schussman – School of Freshwater Sciences, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53204, United States
Abhilasha Shrestha – Division of Environmental and Occupational Health Sciences, School of Public Health, University of Illinois at Chicago, Chicago, Illinois 60612, United States
Lauren B. Stadler – Department of Civil & Environmental Engineering, Rice University, Houston, Texas 77005, United States; orcid.org/0000-0001-7469-1981
Krista R. Wigginton – Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan 48109, United States; orcid.org/0000-0001-6665-5112
Alexandria Boehm – Department of Civil & Environmental Engineering, Stanford University, Stanford, California 94305, United States; orcid.org/0000-0002-8162-5090
Rolf U. Halden – Biodesign Center for Environmental Health Engineering, Bodesign Institute, Arizona State University, Tempe, Arizona 85287, United States; OneWaterOneHealth, Arizona State University Foundation, Tempe, Arizona 85281, United States; AquaVitas, LLC, Scottsdale, Arizona 85260, United States; orcid.org/0000-0001-5232-7361
Kyle Bibby – Department of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, Indiana 46556, United States; orcid.org/0000-0003-3142-6090

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.est.2c01583

Notes

The authors declare no competing financial interest.
Biography

Jeseth Delgado Vela is an Assistant Professor in the Civil and Environmental Engineering Department at Howard University. She received her PhD from the University of Michigan. She is a recipient of the Ford Foundation Dissertation Award, was named an Early Career Research Fellow by the Gulf Research Program in 2021, and currently serves on the Inaugural Early Career Advisory Board of *Environmental Science & Technology*.

**ACKNOWLEDGMENTS**

The workshop that prompted this work was supported by the National Science Foundation, grant 2038087. Zachary A. Marsh contributed to the workshop and this Viewpoint.

**REFERENCES**

(1) Yu, P.; Zaleski, A.; Li, Q.; He, Y.; Mapili, K.; Pruden, A.; Alvarez, P. J. J.; Studler, L. B. Elevated Levels of Pathogenic Indicator Bacteria and Antibiotic Resistance Genes after Hurricane Harvey’s Flooding in Houston. *Environ. Sci. Technol. Lett.* 2018, 5, 481.
(2) Lin, Y.; Sevillano-Rivera, M.; Jiang, T.; Li, G.; Coto, I.; Vosloo, S.; Carpenter, C. M. G.; Lares-Casanova, P.; Giese, R. W.; Helbling, D. E.; Padilla, I. Y.; Rosario-Pabón, Z.; Vélez Vega, C.; Cordero, J. F.; Alshawabkeh, A. N.; Pinto, A.; Gu, A. Z. Impact of Hurricane Maria on Drinking Water Quality in Puerto Rico. *Environ. Sci. Technol.* 2020, 54 (15), 9495–9509.
(3) Keenum, I.; Medina, M. C.; Garner, E.; Pieper, K. J.; Blair, M. F.; Milligan, E.; Pruden, A.; Ramirez-Toro, G.; Rhoads, W. J. Source-to-Tap Assessment of Microbiological Water Quality in Small Rural Drinking Water Systems in Puerto Rico Six Months after Hurricane Maria. *Environ. Sci. Technol.* 2021, 55 (6), 3775–3785.
(4) Solomon, G. M.; Hurley, S.; Carpenter, C.; Young, T. M.; English, P.; Reynolds, P. Fire and Water: Assessing Drinking Water Contamination After a Major Wildfire. *ACS ES&T Water* 2021, 1 (8), 1878–1886.
(5) Whelton, A. J.; McMillan, L.; Connell, M.; Kelley, K. M.; Gill, J. P.; White, K. D.; Gupta, R.; Dey, R.; Novy, C. Residential Tap Water Contamination Following the Freedom Industries Chemical Spill: Perceptions, Water Quality, and Health Impacts. *Environ. Sci. Technol.* 2015, 49 (2), 813–823.
(6) Pieper, K. J.; Tang, M.; Edwards, M. A. Flint Water Crisis Caused By Interrupted Corrosion Control: Investigating “Ground Zero” Home. *Environ. Sci. Technol.* 2017, 51 (4), 2007–2014.
(7) Buesseler, K.; Aoyama, M.; Fukasawa, M. Impacts of the Fukushima Nuclear Power Plants on Marine Radioactivity. *Environ. Sci. Technol.* 2011, 45 (23), 9931–9935.
(8) Davis, C. S.; Finelli, C. J. Diversity and Retention in Engineering. *New Dir. Teach. Learn.* 2007, 2007 (111), 63.