# Amanda C. Perofsky, Ph.D.

Brotman Baty Institute for Precision Medicine, University of Washington, Seattle, Washington Fogarty International Center, National Institutes of Health, Bethesda, Maryland Email: amanda.perofsky@nih.gov • Website: https://aperofsky.github.io

#### Research interests

My research focuses on the ecological, evolutionary, and behavioral drivers of respiratory virus infections, with aims to improve infectious disease surveillance and better understand and predict recurring and emerging outbreaks. I apply statistical and computational approaches to characterize respiratory virus transmission patterns and epidemiology, with a particular focus on influenza and SARS-CoV-2. I also produce operational forecasts and scenario projections of respiratory virus outbreaks.

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2018 PhD in Ecology, Evolution, and Behavior, The University of Texas at Austin, Austin, Texas

2009 B.Sc. in Ecology, B.Sc. in Biology, University of Georgia, Athens, Georgia

Summa cum laude with Highest Honors

## Research experience

2021 - Epidemiological Data Scientist (Research Scientist/Engineer 3), Brotman Baty Institute for

Precision Medicine, University of Washington (UW)

Guest Researcher, Fogarty International Center, National Institutes of Health (NIH)

Division of International Epidemiology and Population Studies

Supervisor: Cécile Viboud

2018 – 2021 **Postdoctoral Research Fellow,** Fogarty International Center, NIH

Division of International Epidemiology and Population Studies

Supervisor: Cécile Viboud

2011 – 2018 Doctoral Student, Department of Integrative Biology, The University of Texas at Austin (UT-Austin)

Dissertation: Ecological, Evolutionary, and Behavioral Determinants of Gut Microbiomes in Malagasy

Mammals

Advisor: Lauren Ancel Meyers

2010 – 2011 Postbaccalaureate IRTA Fellow, National Institute of Dental and Craniofacial Research (NIDCR), NIH

Adeno-Associated Virus Biology Section, Molecular Physiology and Therapeutics Branch

Supervisor: John Chiorini

2009 Research Assistant, Odum School of Ecology, University of Georgia (UGA)

Supervisor: Andrew Park

2007 – 2009 Honors Independent Research, Odum School of Ecology, UGA

Honors thesis: Improving abundance estimation for larval stream plethodontids

Thesis advisor: John Maerz (Warnell School of Forestry)

### Fellowships and awards

2023 Director's Individual Merit Award, For excellence in scientific research in epid	emiologica	રા modeling with
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a focus on influenza antigenic evolution and the role of human mobility in COVID-19 disease dynamics,

Fogarty International Center, NIH

2020, 2021 Director's Group Merit Award, For outstanding modeling work to support the COVID-19 pandemic

response domestically and internationally, Fogarty International Center, NIH

2020 Young Scientist Award, European Scientific Working group on Influenza (ESWI) Conference

2019 Director's Individual Merit Award, For outstanding efforts to forecast weekly influenza-like illness

activity in 27 U.S. military facilities in collaboration with DoD, Fogarty International Center, NIH

2017, 2018 Graduate School Summer Semester Continuing Fellowship, UT-Austin

2017 Network Modeling for Epidemics Course Fellowship, UW, Seattle, WA

2017	Graduate Student Professional Development Award, College of Natural Sciences, UT-Austin
2014, 2015	Summer Institute in Statistics and Modeling in Infectious Diseases (SISMID) Scholarship and Travel Award, UW, Seattle, WA
2012 – 2017	National Science Foundation (NSF) Graduate Research Fellowship
2011 – 2012	Department of Integrative Biology Graduate Recruitment Fellowship, UT-Austin
2011	Meaningful Modeling of Epidemiological Data (MMED) Clinic Scholarship and Travel Award, African Institute for Mathematical Sciences, Cape Town, South Africa
2010, 2011	Ecology and Evolution of Infectious Diseases (EEID) Conference Workshop Scholarship and Travel Award, Cornell University (2010) and University of California, Santa Barbara (2011)
2010 - 2011	NIH Postbaccalaureate Intramural Research Training Award (IRTA) Fellowship
2009	Center for Undergraduate Research (CURO) Scholar distinction, UGA
2008	Elected, Phi Beta Kappa Honors Society
2007	Honors International Scholarship, UGA Honors Program
2005 – 2009	Charter Scholarship, UGA Honors Program
2005 – 2009	National Merit Scholarship, UGA
2005 – 2009	Georgia HOPE Scholarship (full tuition)

## Preprints (†denotes co-first authorship)

- Srinivas Duddu, A.†, Elgamal, I.†, Camacho-Mateu, J.†, Holubowska, O.†, Rella, S. A.†, Bents, S. J., Viboud, C., Hansen, C. L., Pullano, G., & **Perofsky, A. C.** Modeling the effects of COVID-19 mobility disruptions on RSV transmission in Seattle, Washington. *medRxiv*, 2024.09.13.24313667. DOI
- Kostandova, N., Corgel, R., Bansal, S., Bérubé, S., Cleary, E., Hansen, C., Hitchings, M. D. T., García-Carreras, B., Gardner, L., Kraemer, M. U. G., Lai, S., Li, Y., **Perofsky, A. C.**, Pullano, G., Read, J. M., Ribeiro dos Santos, G., Salje, H., Takahashi, S., Viboud, C., Wang, J., Cummings, D. A. T., & Wesolowski, A. Data and model needs for generalizable inferences linking human mobility and infectious disease transmission. OSF Preprint
- Tran-Kiem, C., Paredes, M. I., **Perofsky, A. C.**, . . . Viboud, C., & Bedford, T. Fine-scale spatial and social patterns of SARS-CoV-2 transmission from identical pathogen sequences. *medRxiv*, 2024.05.24.24307811. DOI

## **Publications** (†denotes co-first authorship)

- Perofsky, A. C., Huddleston, J., Hansen, C., . . . Kondor, R., Wentworth, D. E., Lewis, N., . . . Sullivan, S. G., Barr, I. G., Subbarao, K., Krammer, F., Bedford, T., & Viboud, C. Antigenic drift and subtype interference shape A(H<sub>3</sub>N<sub>2</sub>) epidemic dynamics in the United States. *Elife*, 13, RP91849. DOI
- Mathis, S. M.+, Webber, A. E.+, León, T. M., . . ., **Perofsky, A. C.**, . . . Biggerstaff, M., & Borchering, R. K. Evaluation of FluSight influenza forecasting in the 2021-22 and 2022-23 seasons with a new target laboratory-confirmed influenza hospitalizations. *Nature Communications*, 15, 6289. DOI
- Perofsky, A. C., Hansen, C., Burstein, R., . . . Famulare, M., Shendure, J. Bedford, T., Chu, H. Y., Englund, J. A., Starita, L. M., & Viboud, C. Impacts of human mobility on the citywide transmission dynamics of 18 respiratory viruses in preand post-COVID-19 pandemic years. *Nature Communications*, 15, 4164. DOI
- Paredes, M. I., **Perofsky, A. C.**, Frisbie, L., . . . Müller, N. F., & Bedford, T. Local-scale phylodynamics reveal differential community impact of SARS-CoV-2 in a metropolitan U.S. county. *PLOS Pathogens*, 20(3), e1012117. DOI
- Perofsky, A. C., Tempia, S., Bingham, J., Maslo, C., Toubkin, M., Laubscher, A., Walaza, S., Pulliam, J. R. C., Viboud, C., & Cohen, C. Direct and Indirect Effects of the Coronavirus Disease 2019 Pandemic on Private Healthcare Utilization in South Africa, March 2020-September 2021. Clinical Infectious Diseases, 75(1), e1000-e1010. DOI
- Hansen, C., **Perofsky, A. C.**, Burstein, R., Famulare, M., . . . Englund, J. A., Shendure, J., Bedford, T., Chu, H. Y., Starita, L. M., & Viboud, C. Trends in Risk Factors and Symptoms Associated With SARS-CoV-2 and Rhinovirus Test Positivity in King County, Washington, June 2020 to July 2022. *JAMA Network Open*, 5(12), e2245861. DOI
- Perofsky, A. C., Meyers, L. A., Abondano, L. A., Di Fiore, A., & Lewis, R. J. Social groups constrain the spatiotemporal dynamics of wild sifaka gut microbiomes. *Molecular Ecology*, 30(24), 6759-6775. DOI
- McBride, D. S.†, **Perofsky, A. C.**†, Nolting, J. M., Nelson, M. I., & Bowman, A. S. Tracing the Source of Influenza A Virus Zoonoses in Interconnected Circuits of Swine Exhibitions. *Journal of Infectious Diseases*, 224(3), 458-468. DOI

- 2020 Perofsky, A. C., & Nelson, M. I. Seasonal influenza: The challenges of vaccine strain selection. *Elife*, 9, e62955. DOI
- Viboud, C., Gostic, K., Nelson, M. I., Price, G. E., **Perofsky, A.**, Sun, K., Sequeira Trovao, N., Cowling, B. J., Epstein, S. L., & Spiro, D. J. Beyond clinical trials: Evolutionary and epidemiological considerations for development of a universal influenza vaccine. *PLOS Pathogens*, 16(9), e1008583. DOI
- Nelson, M. I., **Perofsky, A.**, McBride, D. S., Rambo-Martin, B. L., Wilson, M. M., Barnes, J. R., van Bakel, H., Khan, Z., Dutta, J., Nolting, J. M., & Bowman, A. S. A Heterogeneous Swine Show Circuit Drives Zoonotic Transmission of Influenza A Viruses in the United States. *Journal of Virology*, 94(24). DOI
- Perofsky, A. C., Lewis, R. J., & Meyers, L. A. Terrestriality and bacterial transfer: a comparative study of gut microbiomes in sympatric Malagasy mammals. *The ISME Journal*, 13(1), 50-63. DOI
- Rakotomalala, E. J., Rakotondraparany, F., **Perofsky, A. C.**, & Lewis, R. J. Characterization of the Tree Holes Used by *Lepilemur ruficaudatus* in the Dry, Deciduous Forest of Kirindy Mitea National Park. *Folia Primatologica*, 88(1), 28-41. DOI
- Perofsky, A. C., Lewis, R. J., Abondano, L. A., Di Fiore, A., & Meyers, L. A. Hierarchical social networks shape gut microbial composition in wild Verreaux's sifaka. *Proceedings of the Royal Society B: Biological Sciences*, 284(1868). DOI
- Berry, B. S.+, Magori, K.+, **Perofsky, A. C.**, Stallknecht, D. E., & Park, A. W. Wetland cover dynamics drive hemorrhagic disease patterns in white-tailed deer in the United States. *Journal of Wildlife Diseases*, 49(3), 501-509. DOI

## **Conference presentations**

#### Talks

- NetSci International Conference on Network Science, Québec City, Canada. *Impacts of human mobility on the citywide transmission dynamics of respiratory viruses in pre- and post-COVID-19 pandemic years.*
- Epidemics<sup>9</sup> International Conference on Infectious Disease Dynamics, Bologna, Italy. *Are changes in population mobility predictive of respiratory virus transmission? Insights from high resolution mobile phone data in the preand post-COVID-19 pandemic periods in Seattle, Washington.*
- EpiMob Satellite ("Epidemic control: from mobility data to public health"), NetSci International Conference on Network Science, Vienna, Austria. Are changes in population mobility predictive of respiratory virus transmission?

  Insights from high resolution mobile phone data in the pre- and post-COVID-19 pandemic periods in Seattle,

  Washington. \* Invited keynote speaker
- Options XI for the Control of Influenza, Belfast, Northern Ireland. *Impact of antigenic drift on influenza A/H3N2* vaccine effectiveness in the United States.
- NIH/FDA COVID-19 Research Workshop (Virtual). The impact of COVID-19 restrictions and mobility behavior on respiratory pathogen transmission in Seattle, Washington.
- NIH Modeling of Infectious Disease Agent Study (MIDAS) Annual Meeting, Bethesda, MD. *The impact of social distancing on respiratory pathogen transmission in Seattle, Washington.*
- NIH Modeling of Infectious Disease Agent Study (MIDAS) Annual Meeting (Virtual). *Impact of antigenic drift on influenza A/H3N2 vaccine effectiveness in the United States.*
- NIH NIAID Centers of Excellence for Influenza Research and Surveillance (CEIRS) Annual Meeting (Virtual). Impact of antigenic drift on influenza A/H<sub>3</sub>N<sub>2</sub> vaccine effectiveness in the United States.
- NIH/FDA COVID-19 Research Workshop (Virtual). *Utilizing Respiratory Syndromic Surveillance Data to Monitor COVID-19 Activity in South Africa.*
- 2019 Epidemics<sup>7</sup> International Conference on Infectious Disease Dynamics, Charleston, SC. *Impact of influenza antigenic evolution on disease dynamics in the United States.*
- 2019 Options X for the Control of Influenza, Singapore. *Impact of influenza antigenic evolution on disease dynamics in the United States.*
- American Association of Physical Anthropologists (AAPA) Conference, Austin, TX. *Gut microbiome diversity* across sympatric mammal populations of Madagascar reflects diet, substrate use, and host phylogeny.
- NSF BEACON Annual Congress, Michigan State University, East Lansing, MI. Social network structure shapes gut microbial communities in wild Verreaux's sifaka.

#### **Posters**

2020 European Scientific Working group on Influenza (ESWI) Conference (Virtual). *Impact of influenza antigenic evolution on disease dynamics in the United States.* 

- Ecology and Evolution of Infectious Diseases (EEID) Conference, Princeton, NJ. Impact of influenza antigenic 2019 evolution on disease dynamics in the United States.
- Society of Molecular Biology and Evolution (SMBE) Conference, Austin, TX. Hierarchical social networks shape 2017 gut microbial composition in wild Verreaux's sifaka.
- Ecology and Evolution of Infectious Diseases (EEID) Conference, Isla Vista, CA. Hierarchical social networks 2017 shape gut microbial composition in wild Verreaux's sifaka.
- Epidemics<sup>5</sup> International Conference on Infectious Disease Dynamics, Clearwater Beach, FL. Social network 2015 structure shapes gut microbial communities in wild Verreaux's sifaka.

#### Seminar presentations

#### Invited talks

- Yale School of Public Health, New Haven, CT. Impacts of human mobility on the citywide transmission dynamics 2024 of respiratory viruses: Insights from the Seattle Flu Study and high-resolution mobile phone data.
- 2024 Network Science Institute, Northeastern University, Boston, MA. Impacts of human mobility on the citywide transmission dynamics of respiratory viruses in pre- and post-COVID-19 pandemic years.
- U.S. CDC Technical Outreach and Assistance to States (TOAST) Office Hours (Virtual). Are changes in 2023 population mobility predictive of respiratory virus transmission? Insights from high resolution mobile phone data in the pre- and post-COVID-19 pandemic periods in Seattle, Washington.
- Pierre Louis Institute of Epidemiology and Public Health, French National Institute of Health and Medical 2023 Research (INSERM), Paris, France. Are changes in population mobility predictive of respiratory virus transmission? Insights from high resolution mobile phone data in the pre- and post-COVID-19 pandemic periods in Seattle, Washington.
- Infectious Disease Modeling Working Group, World Health Organization (Virtual). Antigenic drift and subtype 2023 interference shape A/H<sub>3</sub>N<sub>2</sub> epidemic dynamics in the United States.
- California Department of Public Health COVID-19 Modeling Team Open House (Virtual). A time series approach 2023 for short-term forecasts and long-term scenario projections of influenza hospitalizations.
- NIH NIAID Centers of Excellence for Influenza Research and Response (CEIRR) Computational Modeling Core 2023 (Virtual). Antigenic drift and subtype interference shape A/H<sub>3</sub>N<sub>2</sub> epidemic dynamics in the United States.
- Infectious Disease Forecasting Call, organized by U.S. CDC and NIH MIDAS (Virtual). Impact of influenza 2023 antigenic evolution on A/H3N2 epidemics and vaccine effectiveness in the United States.
- Center for the Ecology of Infectious Diseases, University of Georgia (Virtual). The impact of physical distancing 2023 on respiratory pathogen transmission in Seattle, Washington.
- Influenza Research Group, National Animal Disease Center, U.S. Department of Agriculture (Virtual). Impact of 2021 influenza antigenic evolution on A/H3N2 vaccine effectiveness in the United States.
- Fogarty International Center, National Institutes of Health, Bethesda, MD. Drivers of gut microbial composition 2018 and transmission within and among wild lemur populations.
- 2016 Kirindy Mitea National Park headquarters, Belo Sur Mer, Madagascar. Bacteria transmission dynamics among wildlife in Kirindy Mitea National Park.
- Kirindy Mitea National Park headquarters, Morondava, Madagascar. Infectious disease transmission in a wild 2012 lemur population.

#### Internal seminars

- Respiratory Virus Interest Group, National Institutes of Health (Virtual). The impact of influenza antigenic drift 2023 on A/H3N2 vaccine effectiveness in the United States.
- Influenza Interest Group, National Institutes of Health, Bethesda, MD. Impact of influenza antigenic evolution 2019 on disease dynamics in the United States.
- NSF BEACON weekly seminar, University of Texas at Austin, Austin, TX. Gut microbiome diversity across 2017 sympatric mammal populations of Madagascar reflects diet, substrate use, and host phylogeny.
- NSF BEACON weekly seminar, University of Texas at Austin, Austin, TX. Social networks shape the gut 2016 microbial communities of wild Verreaux's sifaka.
- Department of Integrative Biology, University of Texas at Austin, Austin, TX. Social networks shape the gut 2015 microbial communities of wild Verreaux's sifaka.

# Operational involvement in the COVID-19 pandemic response and disease predictions

2023 –	Dashboard of SARS-CoV-2 variant forecasts for Washington and other U.S. states, Seattle Flu Alliance (In collaboration with Nextstrain team)
2022 –	Contributor to U.S. CDC FluSight Forecasting Collaboration. Submitted weekly short-term forecasts of influenza hospitalizations during the 2022-23, 2023-24, and 2024-25 seasons.
2022 –	Contributor to U.S. Influenza Scenario Modeling Hub. Submitted long-term scenario projections of influenza hospitalizations during the 2022-23, 2023-24, and 2024-25 seasons.
2020 – 2022	Developed the analysis, drafted the first report, and provided technical support to South Africa's National Institute for Communicable Diseases for their COVID-19 Private Consultations Excess Respiratory Encounters Report. Biweekly and monthly reports tracked excess respiratory encounters at hospitals, emergency departments, and primary care providers across age groups and provinces.
2019 – 2022	Contributor to the U.S. Department of Defense Forecasting Collaboration. Submitted weekly short-term forecasts of influenza-like illness and COVID-like illness cases on U.S. military bases during the 2019-20, 2020-21, and 2021-22 seasons.

# Research support

2018	Research Exchange Grant, NSF Infectious Disease Evolution Across Scales Research Coordination Network, <i>How does influenza evolution impact the epidemiology of annual epidemics?</i> \$2800
2015	DBI-0939454, NSF BEACON Center for the Study of Evolution in Action, Factors that influence gut microbiota diversity and intestinal bacteria transmission dynamics in wild lemurs \$16,000 Co-PI, with Lauren Ancel Meyers and Rebecca Lewis
2015	Ecology, Evolution, and Behavior Dissertation Improvement Grant, UT-Austin \$8000
2012	Small Research Grant, American Society of Primatologists \$2000
2012	Small Research Grant, International Primatological Society \$1500
2011	Ecology, Evolution, and Behavior Startup Grant, UT-Austin \$2000
2008	NSF Research Experiences for Undergraduates (REU) Internship, NSF Coweeta Long Term Ecological Research Program, Otto, NC

## **Professional activities**

Co-organizer, EpiMob Satellite (*Epidemic control: from mobility data to public health*), NetSci International Conference on Network Science, Québec City, Canada. June 2024.

Working group on the use of human mobility data in infectious disease modeling, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD. Feb 2023.

Abstract reviewer, NIH Modeling of Infectious Disease Agent Study (MIDAS) Annual Meeting. 2022, 2023, 2024.

Coordinated and led monthly Seattle Flu Alliance Data Analysis meetings. Nov 2022 – Aug 2024.

Invited panelist, *Reflections on COVID-19*, NIH MIDAS Annual Meeting, Bethesda, MD. Sep 2022.

Poster Judge, NIH Annual Graduate Student Research Symposium, Bethesda, MD. Feb 2020.

Essay editor, Science Policy for All (policy blog with contributors from the Washington, DC area). Oct 2019 – Jul 2021. Invited Panelist, NSF BEACON Public Engagement Workshop, Austin, TX. Feb 2017.

Peer review: American Journal of Epidemiology, American Journal of Primatology, Animal Behaviour, BMJ Global Health, Ecology and Evolution, Epidemics, The ISME Journal, Molecular Ecology, Nature Communications, Nature Physics, PLOS Computational Biology, PNAS Nexus

# Teaching and mentoring experience

Tutor, Complexity 72h: Interdisciplinary workshop for young researchers in complex systems, Carlos III University of Madrid, Spain. Led and mentored a team of 5 graduate students in carrying out a research project within 3 days (i.e., 72h). Project title: "Impacts of COVID-19 restrictions on mobility networks and the spread of endemic respiratory viruses." Jun 2024.

Completed 9-week NIH pedagogy course *Scientists Teaching Science* on best practices for teaching and learning in STEM subjects at the undergraduate level. Mar - May 2020.

Co-Instructor, Fogarty International Center-DIVERGE Training Workshop on RSV Genomics and Evolution, National Institutes of Health, Bethesda, MD. Sep 2019.

Co-Instructor, Fogarty International Center-NICD Training Workshop on Infectious Disease Dynamics and Evolution, National Institutes of Communicable Diseases, Johannesburg, South Africa. Dec 2018.

Master's student mentoring, Department of Animal Biology, University of Antananarivo. Trained Safidy Rasolonjatovo in field research techniques, data collection, and specimen preservation. Guided an independent project on sifaka scent marking behavior in Kirindy Mitea National Park, Madagascar. Jun – Jul 2016.

Graduate Teaching Assistant, Scientific Inquiry Across Disciplines, UT-Austin, Austin, TX. Fall 2016, Fall 2017.

Guest Lecture, Biological Networks and Social Network Analysis, Introduction to Biological Statistics Course, Center for Computational Biology and Bioinformatics, UT-Austin, Austin, TX. Nov 2015.

Guest Lecture, Introduction to Networks, Introduction to Biological Statistics Course, Center for Computational Biology and Bioinformatics, UT-Austin, Austin, TX. Nov 2014.

Graduate Teaching Assistant, Social Networks and Infectious Diseases, UT-Austin, Austin, TX. Spring 2013.

Master's student mentoring, Department of Animal Biology, University of Antananarivo. Trained Elvis Rakotomalala in field research techniques, data collection, and specimen preservation. Guided an independent project on Lepilemur tree hole characteristics in Kirindy Mitea National Park, Madagascar. Jun – Aug 2012.

#### Science communication and outreach

Elife podcast interview, Flu virus evolution: Combining antibody responses and genetic data can help gauge the threats posed by evolving flu strains. Apr 2024.

Science Policy for All blogpost, Can the United States achieve herd immunity? Vaccine mandates and other policies to increase COVID-19 vaccination. Jun 2021.

Science Policy for All blogpost, The Use of COVID-19 Prediction Models in Guiding Policy Decisions. May 2020.

Member, NIH Science Policy Discussion Group, Bethesda, MD. Biweekly seminar series for early-career scientists focused on the intersection of scientific research and legislative policy. Delivered science policy presentations, invited two quest speakers, and wrote and edited articles for the "Science Policy for All" blog. Oct 2019 – Jul 2021.

Selected speaker, American Association for the Advancement of Science (AAAS) Classroom Science Days, Austin, TX. Outreach lecture (Meet the Lemurs) to middle school students. Feb 2018. AAAS article

Public outreach lecture (Meet the Lemurs), Science Under the Stars, Austin, TX. Nov 2016. Daily Texan article

NSF BEACON "Researchers at Work" essay, How lemur social networks shape microbial transmission. Mar 2016.

Radio DJ and Science Talk Show Co-host, They Blinded Me with Science, KVRX 91.7FM, UT-Austin, Austin, TX. Cohosted a weekly educational talk show that interviewed UT-based and visiting researchers and reviewed science publications and news. Recruited quests, conducted interviews, and produced podcasts. Jan 2011 – May 2018.

Co-organizer and Volunteer, Science Under the Stars, Austin, TX. Monthly public outreach lecture series founded and organized by graduate students in the Department of Integrative Biology. Jan 2011 – May 2017.

#### References

- 1. Cécile Viboud, Senior Staff Scientist Fogarty International Center, National Institutes of Health Division of International Epidemiology and Population Studies Email: viboudc@mail.nih.gov
- 2. David Spiro, Division Director Fogarty International Center, National Institutes of Health Division of International Epidemiology and Population Studies Email: david.spiro@nih.gov
- Trevor Bedford, Professor Fred Hutchinson Cancer Center Vaccine and Infectious Disease, Human Biology, and Public Health Sciences Divisions Email: trevor@bedford.io