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Understanding the Development Challenges Associated with Emerging Non-Traditional Antibiotics

JW Marriott • Washington, DC
June 14, 2018

Deverick Anderson is an Associate Professor with tenure in the Division of Infectious Diseases and Department of Medicine at Duke University. He is currently Director of the Duke Center for Antimicrobial Stewardship and Infection Prevention (https://dcasip.medicine.duke.edu). With training in internal medicine, infectious diseases, and epidemiology, Dr. Anderson assesses medical problems at both the population and individual patient levels. Over the past decade, Dr. Anderson's work has led to improvements in the quality and safety of care in multiple areas of healthcare, including Duke University Hospital and more than 45 community hospitals in the southeastern U.S. through the Center's outreach networks, the Duke Infection Control Outreach Network (DICON) and the Duke Antimicrobial Stewardship Outreach Network (DASON). Dr. Anderson is recognized as an international expert in healthcare epidemiology and multidrug-resistant pathogens. He is currently a Fellow of the Infectious Disease Society of America (IDSA) and a Fellow of the Society for Healthcare Epidemiology of America (SHEA). He is the Director of the Duke Program for Infection Prevention for the National Football League (NFL). Dr. Anderson has authored over 160 peer-reviewed articles related to quality of care, patient safety, healthcare epidemiology, antimicrobial stewardship, and multidrug-resistant pathogens. Dr. Anderson has received research funding from the NIH, the AHRQ, and the CDC and is currently the Principal Investigator of the Duke-UNC Prevention Epicenter Program, one of 11 prestigious Epicenter Programs funded by the CDC. In addition, he is a member of the Steering Committee for the NIH's Antibacterial Resistance Leadership Group.

Michael Bevilacqua has 30+ years' experience as a medical scientist, inventor, and executive. After completing his MD, PhD training at SUNY Downstate in 1982, he became a resident, fellow, and then faculty member of the Department of Pathology at Brigham and Women's Hospital and Harvard Medical School. There, Dr. Bevilacqua led a successful research laboratory focused on endothelial biology and inflammation. His work included the discovery of two endothelial-leukocyte adhesion molecules and naming the family of carbohydrate-binding adhesion proteins known as "Selectins". He was chosen as PEW scholar. Dr. Bevilacqua then moved to the West Coast, invited to become a Howard Hughes Investigator and tenured faculty member of the Department of Pathology at UCSD. He expanded his studies to include protein-carbohydrate interactions and mechanisms of tumor metastasis. In 1993, he was recruited to be Vice President of Inflammation and Chemistry at Amgen. He built a division for the development of therapeutics targeting inflammatory and immunological diseases, including rheumatoid arthritis, undertook substantial work on IL-1 and TNF inhibitors, and expanded the company's operations in Colorado. In 1998, he founded the company Source Precision Medicine to develop high-precision gene analysis systems for monitoring disease progression and therapeutic effectiveness. He went on to consult for small and large biopharmaceutical corporations before launching Amicrobe in 2011. Since that time, Dr. Bevilacqua has led the company's

efforts as CEO and CSO in the development of purpose-built antimicrobials, especially for the fields of surgery and trauma.

Cara Cassino has over 20 years of experience as a clinician and executive in healthcare, including extensive experience in pharmaceutical product development with 20+ successful regulatory submissions/approvals in the US and globally. Dr. Cassino joined ContraFect Corporation in 2015 and currently serves as Executive Vice President of Research and Development, and Chief Medical Officer. Prior to joining ContraFect, Dr. Cassino served as Senior Vice President of Global Clinical Development at Forest Laboratories, Inc (acquired by Actavis plc, now Allergan plc), where she oversaw across four therapeutic areas, including Antiinfectives. While at Forest, she was responsible for clinical development for a portfolio of 35+ compounds, and clinical due diligence for M&A, including closure of several multibillion dollar deals (e.g. acquisition of Aptalis Pharma and Furiex Pharmaceuticals). Prior to this, Dr. Cassino held senior executive positions at Pfizer, including Global Medical Team Leader of Pfizer's antibacterial franchise and Medical Development Group VP for Pulmonary Vascular Disease and Rare Diseases. Dr. Cassino also served as Executive Medical Director for the late stage US respiratory franchise at Boehringer-Ingelheim Pharmaceuticals, Inc, saw Spriva through US NDA submission, approval, launch and post-marketing activities. Prior to joining industry, Dr. Cassino was a member of the academic faculty of the Division of Pulmonary and Critical Care Medicine at New York University School of Medicine.

Edward Cox is Director of the Office of Antimicrobial Products, where he has served since 2007. As Director for the Office of Antimicrobial Products, Dr. Cox oversees the review, approval and safety of antimicrobial (antibacterial, antiviral, antifungal, and antiparasitic) drugs, and immunosuppressive agents for patients who have received solid organ transplants. Dr. Cox has worked extensively on the science and design of clinical trials for evaluating antimicrobial drugs. Dr. Cox received his M.D. from the University of North Carolina School of Medicine. He completed an internship and residency in Internal Medicine at the Hospital of the University of Pennsylvania and an Infectious Disease fellowship at the National Institute of Allergy and Infectious Diseases of the National Institutes of Health. He also holds a Masters of Public Health Degree from the Johns Hopkins School of Hygiene and Public Health. He joined FDA in 1998.

Wayne Dankner is the Chief Medical Officer for Atox Bio, a late stage biotechnology company, developing immunomodulatory therapeutics for critically ill patients with severe infections. Reltecimod, Atox Bio's lead immunomodulatory drug, is in Phase III development for necrotizing soft tissue infections and a recently initiated Phase II trial in sepsis-associated acute kidney injury in patients with intra-abdominal infection. Dr. Dankner has over 30 years' experience in clinical trials medicine and drug development through his current role as CMO and through his previous role as Global Therapeutic Area Lead for Infectious Diseases and Pediatrics at PAREXEL International and prior academic appointment as Associated Professor in Pediatrics and Pediatric Infectious Diseases at UCSD Medical Center, San Diego, CA.

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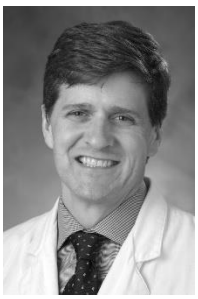
Jonathan Darrow is a faculty member at Harvard Medical School in the Program on Regulation, Therapeutics, and Law (PORTAL). He has served as Senior Law Clerk to a judge on the U.S. Court of Appeals for the Federal Circuit, taught on the faculties of four universities, worked at large law firms in New York, California, and the District of Columbia, supported the health policy work of the World Health Organization, World Trade Organization, and World Intellectual Property Organization in Geneva, Switzerland, and published dozens of articles in both the law and health policy literature. He holds a doctorate in pharmaceutical policy from Harvard and four other degrees in genetics, law, business, and intellectual property from Cornell, Duke, Boston College, and Harvard.

Dennis Dixon is Chief of the Bacteriology and Mycology Branch at the National Institute of Allergy & Infectious Disease (NIAID) at the National Institutes of Health (NIH). He serves on numerous advisory panels on dangerous pathogens such as Select Agents and Dual Use Research and also antimicrobial resistance, including the Trans-Atlantic Task Force on Antimicrobial Resistance (TATFAR) and the Presidential Advisory Committee for Combatting Antibiotic Resistant Bacteria (PACCARB). He also serves on the Joint Oversight Committee for the Combatting Antibacterial Resistance Accelerator (CARB-X). His doctorate in microbiology is from the Medical College of Virginia. He held academic positions at Loyola College in Baltimore, the University of Maryland Medical School and Albany Medical College. He was a Visiting Scientist at Hoffman LaRoche, Switzerland, and was Director for the Mycology Reference Laboratory, New York State Department of Health. He is a member of the American Academy of Microbiology. His areas of expertise and leadership oversight in addition to the preceding policy issues are: all fungal diseases of humans and many bacterial infections in humans including Lyme disease, other zoonotic diseases including biodefense pathogens, and most "hospital acquired" bacterial pathogens.

Scott Evans is a Professor of Epidemiology and Biostatistics and the Director of the George Washington Biostatistics Center. Professor Evans interests include benefit:risk assessment and the design, monitoring, analyses, and reporting of and education in clinical trials and diagnostic studies. He is the author of more than 100 peer-reviewed publications and three textbooks on clinical trials including Fundamentals for New Clinical Trialists. He is the Director of the Statistical and Data Management Center (SDMC) for the Antibacterial Resistance Leadership Group (ARLG). Professor Evans is a member of the Board of Directors for the American Statistical Association (ASA) and the Society for Clinical Trials (SCT) and is a former member of the Board for the Mu Sigma Rho, the National Honorary Society for Statistics. He is a member of an FDA Advisory Committee, the Steering Committee of the Clinical Trials Transformation Initiative (CTTI), and serves as the Chair of the Trial of the Year Committee of the SCT. Professor Evans is the Editor-in-Chief of CHANCE and Statistical Communications in Infectious Diseases (SCID), and the Co-Editor of a Special Section of Clinical Infectious Diseases (CID) entitled Innovations in Design, Education, and Analysis (IDEA). Professor Evans has served on numerous DMCs including as Chair for the Adolescent Trials Network (ATN) and a clinical

trial of microbial restoration in Clostridium difficile associated disease. Dr. Evans is a recipient of the Mosteller Statistician of the Year Award, the Robert Zackin Distinguished Collaborative Statistician Award, and is a Fellow of the ASA and the SCT.



Vance Fowler is a professor in the Departments of Medicine and Molecular Genetics & Microbiology at the Duke University Medical Center. Dr. Fowler has over 2 decades of continuous support as PI from the NIH for clinical and translational research in Staphylococcus aureus and other bacterial infections. Dr. Fowler created the S. aureus Bacteremia Group, co-founded the International Collaboration on Endocarditis, and is the Communicating PI of the Antibacterial Resistance Leadership Group.

Paul Garofolo is the Co-founder & CEO of Locus Biosciences, an emerging biotechnology company focused on the discovery and development of precision medicines using CRISPR-Cas technologies for antimicrobial and microbiome indications. Located in Research Triangle Park, North Carolina, Locus is one of the leading early-stage companies in the Triangle focused on advancing drug products into the clinic. Paul Garofolo has been a member of multiple Executive Management teams of both publicly traded multi-national corporations and successful startup opportunities. Prior to Locus Biosciences, Paul was the Chief Technology Officer for Patheon Pharmaceuticals where he led Global Operations for Patheon's Pharmaceutical Development Services Division. One of the world leaders in Contract Manufacturing Outsourcing, his teams around the world led the development of all clinical trial materials programs for their Patheon's clients. Paul also serves as Vice President of the Friends Board at the North Carolina Museum of Natural Sciences, and as a Visiting Professor at North Carolina State University's Poole College of Management. He serves as an Executive-in-Residence for the HiTEC Graduate Program, the University's Entrepreneurship Collaborative.

Marc Gitzinger is CEO and founder of BioVersys AG, a multi-award winning biopharmaceutical company focused on combatting antimicrobial resistance. Marc is co-inventor of BioVersys' technology, enabling the company to develop Transcription Regulator Inhibitory Compounds (TRICs) that can block antibiotic resistance, virulence and metabolic activities of bacteria offering a new AMR treatment paradigm. The company has an on-going collaboration with GlaxoSmithKline and raised in excess of $20 million USD in equity financing. Prior to BioVersys, Marc completed his studies in Biology at the University of Freiburg (Germany) and the University of Queensland (Australia). He holds a PhD in Biotechnology from the ETH Zurich. Marc is winner of two Venture Leaders awards (2008 and 2016) and he is Vice President of the Board of the BEAM Alliance. The BEAM Alliance—representing approximately fifty European SME that are working on projects to combat AMR—is working actively with all stakeholders involved in AMR to improve the chances of successful development and the market environment for innovative new medicines acting on AMR.

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Lee Jones is Founder, President and CEO of Rebiotix Inc. and has over 30 years of experience in the medical technology industry in large and small companies and academia. She cofounded Rebiotix in 2011. Rebiotix is a clinical stage biotechnology company developing a new class of biologic drugs based on live human-derived microbes. The company was acquired by Ferring Pharmaceuticals in Apr 2018. Previously, she was Chief Administrative Officer of the Schulze Diabetes Institute at the University of Minnesota and is the former president and chief executive officer of Inlet Medical. Inlet Medical, a privately held medical device company, was sold to CooperSurgical in 2006. Prior to Inlet, she spent 14 years at Medtronic where she developed and commercialized several innovative products that opened up new markets for the company. Lee has served on several public and private boards and is currently on the board of Electromed Inc., on the University of Minnesota's Office of Technology Commercialization advisory board, and on the board of MedicalAlley, an industry association. She is a member of the Sofia Angel Investment Fund and is an advisor to several small companies. Ms. Jones has a BS in Chemical Engineering from the University of Minnesota and an Executive Management degree from the Carlson School of Management at the University of Minnesota.

Alan Joslyn is currently the CEO and President of Oragenics. He previously was a co-founder of Lazarus Pharmaceuticals. Previously, in association with Care Capital, a life sciences venture capital firm, he was Chief Executive Officer of Sentinella Pharmaceuticals, a privately held antibiotic company and CEO of Edusa Pharmaceuticals, a privately held gastroenterology company. Prior to his association with Care Capital he served as the President and Chief Executive Officer of Mt. Cook Pharma from 2007 to 2009, and as Senior Vice President of Research & Development at Penwest Pharmaceuticals a specialty pharmaceutical company from 2004 to 2007. From 1995 to 2004, Dr. Joslyn held a number of leadership drug development positions within Johnson & Johnson. Before joining Johnson & Johnson, Dr. Joslyn was engaged in gastroenterology and oncology clinical research at Glaxo from 1988 to 1995. Dr. Joslyn also sits on the board of Synergy Pharmaceuticals, a publically traded gastroenterology company. Dr. Joslyn received his B.S. in Medicinal Chemistry, B.A. in Biology and Ph.D. in Biochemical Pharmacology from the State University of New York at Buffalo.

Joe Larsen is acting Director of the Division of CBRN Medical Countermeasures within the Biomedical Advanced Research Development Authority (BARDA). In that role, he oversees a $2.8B fund for the development and procurement of medical products for use during public health emergencies. He is also the BARDA lead for the BARDA's work on combating antibiotic resistant bacteria and is an executive member of CARB-X, a novel $450M public private partnership focused on promoting innovation in antibacterial drug development. Dr. Larsen has been actively involved in discussing potential reforms to the economic incentive structures for antibacterial drug development. Previously Dr. Larsen served as Deputy Director of BARDA's CBRN Division. From 2010-2014, Joe served as Chief of the Broad Spectrum Antimicrobials program at BARDA. Dr. Larsen received

his PhD in Microbiology from the Uniformed Services University of the Health Sciences and his BA with honors from the University of Kansas.

Troy Lister is VP of Research, Head of Chemistry and Program Leader at Spero Therapeutics in Cambridge, MA. Dr. Lister leads Spero's Potentiator Franchise that has recently completed two Phase 1 assessments of lead molecule SPR741. Dr. Lister previously held roles in the Infectious Disease Therapeutic Area at AstraZeneca and Novartis, where he lead numerous programs to identify novel agents targeting bacterial and viral pathogens, including multidrug resistant Gram-negative and Gram-positive bacteria, hepatitis C virus, human rhinovirus, and respiratory syncytial virus. Dr. Lister received his PhD from Flinders University in Adelaide, Australia, and completed a post-doctoral fellowship at The Scripps Research Institute in La Jolla, California with Professor K.C. Nicolaou.

David Mantus is Chief Development Officer, and Managing Director, Arsanis Biosciences GmbH, at Arsanis, Inc., a clinical stage biotechnology company developing monoclonal antibodies to prevent and treat serious bacterial infections. He has more than 25 years of drug development experience, including clinical, regulatory and manufacturing successes for programs in endocrinology, central nervous disorders, and infectious disease. His work in infectious disease product development has included small molecules, microbiome-based therapeutics, immune globulins, monoclonal antibodies, and vaccines. Dr. Mantus has led teams responsible for all aspects of product development, from pre-IND through global commercialization and partnering. Prior to Arsanis he held leadership roles in development at Seres Health, Cubist Pharmaceuticals, Shire Biologics, and Procter & Gamble Pharmaceuticals. Dr. Mantus received his M.S. and Ph.D. in Chemistry from Cornell University and was a post-doctoral research fellow in Biomedical Engineering at the University of Washington. He was an Associate Professor of Pharmaceutical Sciences at MCPHS University, and is co-author of a book on regulatory affairs, "FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics," that is currently in its third edition.

Greg Mario is the President and CEO of TAXIS Pharmaceuticals, Inc. After receiving his M.B.A. in Finance and Marketing at the Fuqua School of Business, Duke University, he spent 12 years in life sciences as a sales, marketing, business development, and licensing and acquisition professional. For the past 14 years, Mr. Mario has pursued multiple entrepreneurial endeavors, including: a role as Senior VP of Business Development with Talk America, a local-long distance telecommunications provider; Partner at MFP, LP, a private equity investment entity focused on the life sciences sector that experienced multiple liquidity events during his tenure; Founder of the Brownstone Advisory Group, a real estate investment concern and; Chairman of the Board of directors at Evogen, a diagnostics start up.

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Greg Merril is CEO at Adaptive Phage Therapeutics and an experienced life-science entrepreneurial executive. He has served as founding CEO for four VC-backed fast growth health-related product companies. As founding CEO of HT Medical Systems he led the Company through a $42 million merger with Immersion Corp. Greg has delivered over fifty invited lectures and keynote addresses covering business development, virtual reality, and medical technology. He has authored numerous peer reviewed technical papers and has been awarded nineteen patents. Greg championed a Congressional appropriation funding a simulation-based medical training and certification initiative. He served as invited Guest Editor for the Proceedings of the IEEE Special Issue on Virtual and Augmented Reality in Medicine. He has served as Principal Investigator on numerous federally funded research grants and as a referee/reviewer for government-sponsored and non-profit grants related to medical informatics and virtual reality technologies. While leading Brain Sentry, Inc. Greg was recognized as a TEDMED Innovation Scholar for his work developing and commercializing head impact sensor technology. During his career Greg's product developed efforts have been recognized twice as Innovation of the Year by the Consumer Electronic Association (CEA)/ Industrial Designers Society of America (IDSA). Other awards have included the 2015 International Sports Technology Award for Best Wearable Technology, A Wall Street Journal Startup Company of the Year (2013), BusinessWeek Product Design of the Year, Popular Science "Best of What's New" winner. Greg's efforts have been recognized as a regional Ernst & Young Entrepreneur of the Year winner.

Sumathi Nambiar is Director of the Division of Anti-Infective Products, Office of Antimicrobial Products, Center for Drug Evaluation and Research, U.S. Food & Drug Administration since July 2013. Dr. Nambiar joined the Division of Anti-Infective Products in 2002. In her current role, Dr. Nambiar provides regulatory oversight for anti-infective products, including antibacterial, antifungal, and antiparasitic drugs. Dr. Nambiar is board-certified in pediatrics and pediatric infectious diseases. She completed her pediatric residency at the Inova Fairfax Hospital for Children, VA and her fellowship in pediatric infectious diseases at Children's National Medical Center, Washington DC. She received her MPH from The George Washington University School of Public Health.

Kevin Outterson teaches health care law at Boston University, where he co-directs the Health Law Program. He serves as the Executive Director and Principal Investigator for CARB-X, a $502M international public-private partnership to accelerate global antibacterial innovation. Key partners in CARB-X include the US Government (BARDA & NIAID), the Wellcome Trust, the UK Government (GAMRIF, DHSC), and the Bill & Melinda Gates Foundation. His research work focuses on the law and economics of antimicrobial resistance. He is an Associate Fellow at the Royal Institute of International Affairs (Chatham House). Professor Outterson was a founding member of the Antimicrobial Resistance Working Group at the CDC. He was a senior consultant on the Eastern Research Group study on antibiotic markets for FDA/HHS. Starting in October 2014, he joined DRIVE-AB, a three-year €9 million project on antibiotic business models sponsored by the European Union's Innovative Medicines Initiative. Professor Outterson also serves on the Advisory Panel for the Longitude Prize for an inexpensive rapid point-of-care antibiotic diagnostic. Professor Outterson was given the

2015 Leadership Award by the Alliance for the Prudent Use of Antibiotics for his research and advocacy work. He has testified before Congress, Parliamentary working groups, WHO, and several state legislatures.

John H. Rex is a physician and drug developer with more than 30 years of development and policy experience focused on antimicrobial agents. He is currently CMO for F2G, Ltd. (an antifungal biotech), sits on two biotech boards (F2G Ltd, Adenium Biotech ApS), is an Expert-in-Residence for Wellcome Trust, is an operating partner with a venture capital group (Advent Life Sciences), and is a voting member on the Presidential Advisory Council on Combating Antibiotic Resistant Bacteria (PACCARB). He also blogs regularly at www.amr.solutions/blog.html. His experience (figure) includes moving compounds from early preclinical development through all development phases via academic positions (NIH, Bethesda, MD; Univ. of Texas Medical School-Houston) and VP-level roles at a multinational pharmaceutical firm (AstraZeneca). Other past activities include advancing novel regulatory paradigms for antibacterial agents,1,2 publications on novel reimbursement models for antibiotics,3 co-founding of a public-private partnership (CARB-X), co-founding of the New Drugs for Bad Bugs (ND4BB) program of Europe's Innovative Medicines Initiative (IMI), and a 4-year term as Industry Representative on the FDA Anti-Infective Drugs Advisory Committee (AIDAC, 2007–2011).

Scott Stibitz obtained his Ph.D. in 1983 at the University of Wisconsin, Madison working in the laboratories of Julian Davies and William Reznikoff on antibiotic resistance transposons. He next pursued post-doctoral studies under Stanley Falkow at Stanford University. It was there that he began studying the molecular genetics of virulence gene regulation in Bordetella pertussis. Since joining the FDA in 1987, in addition to B. pertussis, he has initiated research projects on the genetic analysis of Bacillus anthracis and Staphylococcus aureus, improved testing of live biotherapeutic products, and bacteriophage therapy. He is currently chief of the Laboratory of Mucosal Pathogens and Cellular Immunology (LMPCI/DBPAP/OVRR/CBER) and oversees its regulatory activities. The regulatory portfolio of LMPCI includes vaccines against bacterial infectious diseases and malaria, as well as live biotherapeutic products, fecal microbiota for transplantation, and bacteriophage therapy.

Vu Truong is a founder of Aridis and was elected CEO in 2014 after having served as the company's Chief Scientific Officer since 2005. He has more than 20 years of experience in biopharmaceutical drug development. Having maintained a life-long interest in infectious diseases, he has focused on researching and developing human monoclonal antibodies and vaccines designed to address life-threatening infections. Previously he worked on the development of FluMist™ vaccine and monoclonal antibody Synagis™ mAb, as well as a number of other monoclonal antibody-based therapeutics. At Aridis, he has helped to build a broad pipeline of human monoclonal antibodies against bacterial and viral targets, several of which are at pivotal clinical trials. He received his Ph.D. in Pharmacology and Molecular Sciences at the Johns Hopkins University School of Medicine.

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Duke-Margolis Moderator:

Gregory Daniel is a Clinical Professor in Duke's Fuqua School of Business and Deputy Director in the Duke-Robert J. Margolis Center for Health Policy at Duke University. Dr. Daniel directs the DC-based office of the Center and leads the Center's pharmaceutical and medical device policy portfolio which includes developing policy and data strategies for improving development and access to innovative pharmaceutical and medical device technologies. This includes post-market evidence development to support increased value, improving regulatory science and drug development tools, optimizing biomedical innovation, and supporting drug and device payment reform. Dr. Daniel is also a Senior Advisor to the Reagan-Udall Foundation for the FDA and Adjunct Associate Professor in the Division of Pharmaceutical Outcomes and Policy at the UNC Eshelman School of Pharmacy. Previously, he was Managing Director for Evidence Development & Biomedical Innovation in the Center for Health Policy and Fellow in Economic Studies at the Brookings Institution and Vice President, Government and Academic Research at HealthCore (subsidiary of Anthem, Inc). Dr. Daniel's research expertise includes utilizing electronic health data in designing research in health outcomes and pharmacoeconomics, comparative effectiveness, and drug safety and pharmacoepidemiology. Dr. Daniel received a PhD in pharmaceutical economics, policy and outcomes form the University of Arizona, as well as an MPH, MS, and BS in Pharmacy all from The Ohio State University.