

EXHIBIT 12

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**UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF LOUISIANA**

KATHLEEN MOLLER,

Plaintiff,

v.

**MARTIAN SALES, INC.; JOPEN, LLC;
JOHNSON FOODS, LLC; LP IND.,
LLC; CAG HOLDINGS, LLC; RMH
HOLDINGS, LLC; ABC INSURANCE
COMPANY and John Does 1-4,**

Defendants.

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CIVIL ACTION NO.

2:24-CV-228-WBV-DPC

THE HONORABLE WENDY B. VITTER

**MAGISTRATE JUDGE DONNA PHILLIPS
CURRAULT**

EXPERT REPORT OF EDWARD W. BOYER, MD PH.D

1. I have been asked by Kilpatrick Townsend & Stockton to review materials relevant to the medical event leading to the death of Harmony Moller on February 6, 2023, and to formulate opinions as to the cause of this event. I have therefore applied my education, training, and experience as a board-certified medical toxicologist and emergency medicine physician to address the role played by kratom, if any, in Ms. Moller's death on February 6, 2023. My fees for reviewing these materials, preparing this report, and testifying at trial are \$750/hour. My compensation is neither contingent on the outcome of this matter nor the conclusions reached in this report.

2. In preparing this report, I have relied on my personal academic and clinical expertise, some of which is described in the following paragraphs. I have attempted to highlight areas that are specific to my expertise in this case, and which permit me as a board-certified medical toxicologist to review, analyze and form the basis of my conclusions within a reasonable degree of medical certainty.

3. A copy of my current *curriculum vitae* is attached as Appendix A. A list of materials considered is attached as Appendix B.

QUALIFICATIONS

4. I am a board-certified emergency physician. Emergency medicine is an Accreditation Council for Graduate Medical Education (ACGME)-approved medical specialty that focuses on the diagnosis and management of any life-threatening condition. Emergency medicine practice, because of its intimate involvement with acute medical conditions, requires that the practitioner integrate patient complaint; presentation of illness; medical, family and social history; knowledge of anatomy; and the impact of physiology on structure and function of the

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human body to arrive at an accurate diagnosis and deliver targeted interventions. Emergency physicians utilize a broad range of tests, including ultrasound, echocardiograms, radiology, and laboratory studies, to arrive at diagnoses and to guide therapy. I have over 25 years of clinical practice experience (including internship, residency, and subspecialty training) in which I have treated hundreds of patients with acutely life-threatening conditions ranging from vascular catastrophes (e.g., aortic structural abnormalities and failure), heart attacks, strokes, and sepsis, among other conditions. As a result of my diagnostic skills, I was recognized as Master Physician by Brigham and Women's Hospital of Harvard Medical School.

5. I am a board-certified medical toxicologist. Medical toxicology is an Accreditation Council for Graduate Medical Education (ACGME)-approved medical subspecialty that focuses on toxicity, poisoning, substance abuse, overdose, adverse effects, and drug interactions from all manner of potential intoxicants, including dietary supplements, herbal products, and medications. As a medical discipline, medical toxicology is particularly concerned with the adverse effects of psychoactive substances. A significant portion of medical toxicology practice and experience is related to the clinical effects of substances with mu-opioid receptor ("MOR") activity such as kratom and other psychoactive substances, as well as the signs, symptoms and outcomes of diversion, misuse, abuse and withdrawal of each of these agents.

6. I have over 25 years of clinical practice experience (including internship, residency, and subspecialty training) in which I have treated several thousand patients with a wide variety of adverse drug events, drug interactions, toxicities, and withdrawal symptoms. I have treated anticipated and unanticipated side effects of xenobiotics, including prescription medications, illicit substances, illegal drugs, dietary products, herbal remedies, and novel psychoactive substances, alone and in combination with each other. As a clinician focusing on the treatment of adverse effects of xenobiotics, I have treated several hundred patients with adverse effects, drug interactions, and toxicity from all manner of MOR agonists, including kratom. In particular, I have considerable clinical experience directly with kratom.

7. I have served on the medical staff of UMass Memorial Medical Center (2001-2016), Brigham and Women's Hospital (2016-2022), the Toxicology Service at Children's Hospital, Boston (1999-2021), and the Regional Center for Poison Control and Prevention Serving Massachusetts and Rhode Island (1999-2021). I now serve on the medical staff of The Ohio State University Wexner Medical Center (2021-present), Nationwide Children's Hospital (2024-present), and the Central Ohio Poison Control Center (2024-present).

8. I was a 2018 Fulbright Scholar funded to study the pharmacophysiologic outcomes in kratom users in Malaysia. In addition, I have received funding from the National Institute on Drug Abuse, part of the National Institutes of Health ("NIH"), to conduct original research investigations related to opioid analgesic medications (2001-present). I have also served as an NIH-funded research mentor for international trainees from Thailand, Malaysia, and Indonesia on kratom use. My research studies examine psychoactive substance use (including kratom), opioid abuse, innovative technologies, and HIV.

9. In addition, I have served as an expert consultant to the Community Epidemiology Working Group, the National Institute on Drug Abuse organization that monitors trends in

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substance use, including kratom (2004-2007). I have served on the scientific advisory board for the National Drug Early Warning System (2016-2020). I have conducted research for National Institutes on Drug Abuse subcontractors related to opioid analgesic overdose, toxicity, misuse, and abuse (2004).

10. I have also served as a research mentor directing mentees performing a wide variety of investigations in several scientific and medical specialties. My doctorate in synthetic organic chemistry prepared me for my postdoctoral investigations into protein design; in this area I studied the structure, cellular handling, folding, organization and activity of cellular proteins. My research supervision and mentoring has spanned investigations into cardiology, cardiac remodeling, cardiac arrest management, cardiac arrhythmia detection, and hepatology. My research mentoring work has also extended to behavioral science, addiction medicine, infectious disease, injury prevention, medical toxicology, and emergency medicine studies.

11. Because of my expertise, I have been invited to deliver expert addresses including lectures on kratom and the clinical effects of alkaloid components of kratom at national conferences, including the American Society of Addiction Medicine (2009), College on Problems of Drug Dependence (2018), Northeastern University's conference on Chemistry and Pharmacology of Drug Abuse (2019), to members of the United States Congress, and the University of Florida's International Kratom Symposium (2025). In 2024 I was invited to author the Kratom card for UpToDate, the leading medical information database. Finally, I was the 2008 NIH Distinguished Scientist in Natural Products Neuroscience for my formative work describing the clinical effects of kratom.

12. I have extensive experience in assessing the quality of medical literature as well as in determining whether published findings apply to specific patient care questions. I served on the Massachusetts Medical Society's Committee on Publications, which oversees the Editorial Board of New England Journal of Medicine (2016-2021). I have served as associate editor for the Journal of Medical Toxicology and been a member of the editorial board of ToxED, an online clinical database resource that assists clinicians in identifying adverse effects of numerous substances. In this capacity, I have reviewed the literature describing the toxicity, adverse events, and drug interactions of numerous substances, including kratom.

13. I have considerable expertise in the assessment of the scientific validity of research investigations. I have participated extensively in the NIH scientific review process—one of the most rigorous and objective scientific review processes in existence. I am a member of the College of CSR Reviewers, and in my service with NIH Scientific Review Groups I have examined grant applications submitted to NIH that are related to behavioral and social science, substance abuse, and HIV (2005-present). The FDA recognizes my experience in medical toxicology and invited me to review the scientific validity of applications for funding of clinical trials (2004, 2022). I have also assessed the scientific validity of grant applications submitted to the US Centers for Disease Control ("CDC") related to HIV testing in emergency departments (2006). Related to these activities are my service as an expert reviewer for journals such as New England Journal of Medicine; Neuropsychopharmacology; Drugs, Drug and Alcohol Dependence; American Journal on Addictions; Academic Emergency Medicine; Journal of Medical Toxicology; Chest – CRITICAL Care Medicine; Clinical Toxicology; Journal of Forensic Science; and Forensic

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Science International, among others.

14. I have expertise in the toxicology of MOR agonists including mitragynine, 7-hydroxymitragynine, mitragynine pseudoindoxyl, and other kratom alkaloids. This experience is drawn from education in medical school, internship, residency, post-graduate work, editorial assignments, continuous reading, teaching, and postgraduate instruction. I supervised the University of Massachusetts Medical Toxicology fellowship training program (2002-2015), where I was responsible for teaching fellows, residents, and clinical pharmacists from six different academic medical centers the adverse effects, drug interactions, and toxicity of all manner of potential intoxicants. I was a member of the Division of Toxicology of Harvard Medical School (2016-2021). In addition, I served as a core faculty member of the Brigham and Women's Hospital Department of Psychiatry Training Program in Addiction Medicine (2020-2021). I am now Professor with Tenure at The Ohio State University and a member of the staff of the Central Ohio Poison Control Center.

15. As part of these academic assignments, I teach basic and applied medical toxicology to medical students, residents, fellows, physicians-in-practice, behavioral science practitioners, Doctor of Pharmacy students, and pharmacy practice residents. I have taught courses on clinical presentations and outcomes of overdose at the Boston and Worcester campuses of the Massachusetts College of Pharmacy (1999-2003), and the Central Ohio Poison Center (2023-present). I have been invited to lecture to psychiatry physicians-in-training at Harvard Medical School teaching hospitals on pharmacology-related topics, including kratom toxicity (2005, 2019). As an instructor in CME courses offered by Harvard Medical School and Albert Einstein College of Medicine, I lectured on adverse effects of drugs with central nervous system ("CNS") activity, substance abuse, and addiction.

16. I have published in peer-reviewed journals. In particular, my work related to kratom has appeared in *Addiction*, *Drug and Alcohol Dependence*; *American Journal on Addictions*; *Journal of Medical Toxicology*; *Current Topics in Medicinal Chemistry*; *Journal of Psychoactive Drugs*, *Journal of Addictive Diseases*, *Frontiers of Psychiatry*, *Journal of Toxicology and Pharmacology*; *Malaysian Journal of Medicine and Health Sciences*; *International Journal of Drug Policy*; and *Journal of Ethnopharmacology*. My other original research, literature reviews, case reports, and perspectives have been published in the *New England Journal of Medicine*; *Journal of the American Medical Association ("JAMA")*; *Pediatrics*; *Drug and Alcohol Dependence*; and *Academic Emergency Medicine*, among others. Those articles have covered a range of issues pertaining to drug toxicity, substance abuse, drug side effects, and behaviors of patients with chronic pain.

17. My general understanding of toxicology is based upon the length and scope of my graduate and post-graduate education, including the study of scientific methodology at Vanderbilt and Columbia Universities, pre-clinical pharmacology and neurosciences as well as clinical courses at Columbia College of Physicians and Surgeons, and the scope of my post-graduate training in medical toxicology at Children's Hospital Boston/Harvard Medical School. My ongoing study of medical toxicology continues with literature assessment and epidemiological analysis, including those instances where medications are involved in overdose and toxicity.

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18. In my work as an academic physician, research scientist, and practicing toxicologist, I have compiled and analyzed data related to chronic pain and opioid analgesic overdose, toxicity, misuse and abuse, as well as the pharmacology and toxicology of numerous pharmacologic substances. This work has enabled me to render conclusions about the likely factors that explain, to a reasonable degree of medical certainty, the toxicology of substances such as kratom, alone and in combination with other substances.

19. Since 2021, I have previously testified as an expert witness in the following matters:

- a. *Denise Zane, as Special Administrator of the Estate of Lucille Stroh vs. Jeanne Wilson, MD, Rehabilitation Specialists Of Chicago, LLC, and The Ingalls Memorial Hospital*, Circuit Court of Cook County, Illinois County Department, Law Division. No.: 13 L 5182;
- b. *United States of America, Plaintiff vs Nine2Five LLC, Sebastian Guthrey*, Case No. 23-cr-1079-TWR (S.D. Cal.);
- c. *Susan Weber v. OPMS a/k/a Optimized Plant Mediated Solutions.*, Case No 23EV000485, ongoing in the State Court of Fulton County, Georgia;
- d. *Susan Eppard, et al. v. JML Wholesale, Inc., et al.*, Case No. 24-004438 – NP, Circuit Court of Muskegon County, Michigan;
- e. *John Zheng Yan Ching v. White Dragon Botanicals, LLC, et al.*, Case No. CVPO21-0198083, Travis County, Texas; and
- f. *National Collegiate Athletic Association v. Jennifer Finnerty*, Case No. 49D01-1808-CT-33896, Marion Superior Court, Indiana.

BACKGROUND

Kratom

18. Kratom (*Mitragynia speciosa* Korth) is a tree-like plant native to Thailand, Malaysia, Indonesia, and other parts of southeast Asia. Indigenous users create a “juice” by boiling fresh kratom leaves for several hours that is then diluted with hot water to make kratom tea. Kratom is used in traditional environments to treat diarrhea, hypertension, cough, fever, impotence, and other ailments. Kratom is used by manual laborers for its mild stimulant effects, a replacement remedy for individuals with problematic opioid use, and as a mild analgesic agent. In the west, many different kratom formulations are available, including tinctures, extracts, capsules, softgels, concentrated products, as well as dried leaf powders and cut leaf material.

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Kratom in western countries is most commonly used as a remedy for opioid addiction, chronic pain, depression, and anxiety.

19. The neurobehavioral effects of kratom are more subtle than the commonly described stimulant effects at low doses and opioid effects at higher doses. Low doses of kratom increase alertness, energy, and talkativeness. At doses greater than 5 grams, however, kratom users describe the persistence of heightened alertness coupled with analgesia. These effects account for the use of kratom as a mild stimulant for manual laborers, a replacement remedy for individuals with problematic opioid use, and as a mild analgesic agent.

20. Some of the biological effects of kratom arise from binding of alkaloidal components to a number of neurotransmitter receptors in the central nervous system, including the μ -opioid (MOR), κ -opioid, serotonergic (5-HT), and alpha (α 1) receptors, among others. MOR activity is particularly important. MOR activation mediates pain, respiratory rate, gastrointestinal transit time, nausea, and pruritis, among other effects. Each of these effects is mediated via distinct signaling pathways following binding of an agonist to the MOR receptor.

21. Classical opioid agonists (*e.g.*, morphine and fentanyl) are “unbiased” agonists in that they indiscriminately activate all biological effects mediated by MOR. Kratom is different. The most prevalent—and best studied—alkaloid in kratom is mitragynine. In contrast to classical unbiased MOR agonists, mitragynine is a “biased” agonist in that it produces some, but not all, effects that arise from receptor binding of a classical MOR agonist such as morphine or fentanyl.

22. For example, while mitragynine produces analgesia, it does not produce the stupor characteristic of classic, unbiased MOR agonists. Instead, kratom produces increased alertness. Furthermore, mitragynine does not produce the respiratory depression that is a leading cause of mortality from classical unbiased MOR agonist overdose (Macko 1972; Varadi 2016; Kruegel 2019; Boyer 2012).

23. In fact, the clinical features as well as the time course of the toxidrome from kratom has never been described. Testing for mitragynine is generally limited to commercial forensic companies and medical examiner offices. Mitragynine itself undergoes postmortem redistribution; the postmortem concentration of mitragynine measured by forensic laboratories is over three times higher than premortem blood.

24. In general, adverse events attributed to kratom have been derived from database studies, poorly controlled case reports, or small case series, each of which has serious deficiencies in patient background information, including medical, social, or family history; clinical evaluation; scene findings; or analytical technique. These poorly controlled studies at times associate kratom with agitation, seizures, liver injury, renal injury, ventricular dysrhythmia, and respiratory depression. Individually and collectively, these studies lack the scientific heft to establish causation between kratom use and any adverse event.

25. For example, case reports describing right ventricular failure in the setting of intermittent kratom ingestions are complicated by the distant use of kratom, the lack of clarity

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regarding intensity of kratom use, analytical testing to confirm kratom use, and the concomitant delivery of multiple interventions.

26. Virtually all adverse events associated with kratom use have occurred in individuals who can be proven to have taken substances in addition to kratom, or who have an underlying medical condition predisposing them to medical events attributed to kratom. The most systematic examination of the relationship between specific medical outcomes and kratom has been done in a large cohort of Malaysian kratom users who have undergone a number of medical tests to identify effects arising from kratom use.

Case Synopsis

27. Harmony Moller had no known significant issues in her medical history, though she used cannabis and ethanol.

28. On or about February 5, 2023, she complained that she did not feel well and developed vomiting. The next day, Ms. Moller collapsed and was found by her mother (Kathleen Moller), who called 911. First responders found Ms. Moller in cardiac arrest. Paramedics intubated Ms. Moller and administered naloxone with no effect. Paramedics made a field declaration of death.

29. Ms. Moller's autopsy was performed on February 8, 2023. The examining pathologist identified areas of nutmeg liver "consistent with chronic passive congestion." In thorax, the bronchi contained blood, and the pathologist noted that the "[p]ulmonary cut surfaces demonstrate hemorrhage, congestion, and edema." From her heart, the pulmonic valve was harvested for transplant, but the remainder was not used (St. Tammany Parish Coroner Records).

30. Ms. Moller's heart was shipped to the Jesse E Edwards Registry of Cardiovascular Disease in St Paul, MN. Pathologists at that facility identified an enlarged heart (cardiomegaly) with hypertrophy of both ventricles (mild biventricular hypertrophy) with mild dilation of the right ventricle. In the left ventricle, the pathologist identified that the left coronary artery "arises 5 mm above the left sinotubular ridge with an acute angle of origin. There is an inferior aortic wall flap over the origin of the left coronary artery." (Jesse E Edwards Registry of Cardiovascular Disease records). In addition, the left ventricular wall was thickened at 15 mm and the intraventricular septum was 17 mm.

31. On microscopy, pathologists noted hypertrophy of atrial and ventricular myocytes, with increased right ventricular interstitial and perivascular fibrosis. The posterior wall of the right ventricle contained hypertrophic myocytes. While the AV node was normal, the ventricular septum and the lateral wall of the left ventricle are hypertrophic with scattered hypereosinophilic myocytes. Interstitial and perivascular fibrosis were present. The anterior wall of the left ventricle had hypertrophic myocytes with interstitial and perivascular fibrosis.

32. Postmortem analyses were performed by two different laboratories. National Medical Laboratories measured a mitragynine concentration of 150 ng/mL, along with caffeine, naloxone, cannabis/metabolites, diphenhydramine, and promethazine (NMS Laboratories

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documentation). The Gerona lab at UCSF, as part of the DEA TOX program, measured the mitragynine concentration as 158 ng/mL with a concentration of 7-hydroxymitragynine that was below the lower limit of quantification (Clinical Toxicology and Environmental Biomonitoring Laboratory Report dated 4/18/2023).

33. The St. Tammany Parish medical examiner assigned a final diagnosis of abnormally high left coronary ostia takeoff exacerbated by mitragynine use.

BASES FOR OPINION

34. To form the basis of my expert opinion, I relied on all of the information forwarded to me as described in the section under document review. From my personal review, including my careful examination of Ms. Moller's medical, social, and family history as well as the pharmacology and medical toxicology of kratom, I am able to support the factual basis for the following statements:

- 35. Harmony Moller had no known significant issues in her medical history;
- 36. Harmony Moller ingested dietary supplements, including ashwagandha and caffeine;
- 37. Harmony Moller used cannabis and alcohol; and
- 38. Harmony Moller vaped.

In addition:

39. Harmony Moller on the day before her death felt ill and began vomiting (St. Tammany Parish Sheriff's Office records);

40. Death scene investigators found in Harmony Moller's bedroom cannabis products, drug paraphernalia, multiple empty liquor bottles, and vaping devices; and

41. Death scene investigators also identified dietary supplements and ayurvedic remedies.

Furthermore,

42. Postmortem examination revealed a high takeoff of the left coronary artery with an acute angle of origin;

43. Postmortem examination also revealed an aortic wall flap covering the opening of the left coronary artery;

44. Postmortem examination identified cardiac hypertrophy;

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45. Harmony Moller also had chronic liver congestion;

46. Histological analysis of the heart identified that Harmony Moller had interstitial and perivascular fibrosis, hypertrophic myocytes, and hypereosinophilic myocytes;

47. Organ procurement specialists harvested only the pulmonic valve from Harmony Moller's heart;

48. Organ procurement specialists declined to utilize the harvested aortic valve;

49. Pathologists initially identified the cause of death as "chronic congestion of liver" (Southern Eye Bank Donor Information worksheet).

Additionally,

50. Kathleen Moller reported on social media that Harmony Moller's death was "caused by a cardiac anomaly that caused her heart to suddenly stop beating from lack of blood flow in a cardiac artery."

51. Another listed cause of death was "chronic congestion of liver";

52. Harmony Moller's blood mitragynine concentration was measured by two separate toxicology labs at 150ng/mL and 158 ng/mL; and

53. The medical examiner determined Ms. Moller's cause of death was due to her high takeoff of the coronary artery complicated by mitragynine use.

However,

54. Harmony Moller had several medical conditions and behaviors that could have produced sudden cardiovascular collapse;

55. According to the medical examiner, Harmony Moller had a high takeoff of the left coronary artery with an acute angle of origin;

56. A high takeoff of the coronary artery with an acute angle of origin is associated with sudden cardiac death;

57. A high takeoff of the coronary artery with an acute angle of origin is associated with sudden cardiac death, even in the absence of mitragynine;

58. Harmony Moller had an inferior aortic wall flap overlying the origin of her left coronary artery that had an acute angle of origin;

59. An aortic wall flap can further limit blood flow into the opening of the left coronary artery, even in the absence of mitragynine;

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60. Occlusion of the coronary artery decreases blood flow through the coronary artery, even in the absence of mitragynine;

61. Decreased blood flow through the coronary artery leads to myocardial hypoperfusion, even in the absence of mitragynine;

62. Decreased blood flow to the heart leads to lethal cardiac arrhythmias, even in the absence of mitragynine; and

63. Lethal cardiac arrhythmias cause sudden cardiac death.

In addition,

64. Harmony Moller used dietary supplements that contained caffeine and ephedrezine (a proprietary product that includes yohimbine and the methylxanthines caffeine and theobromine, among others);

65. Caffeine increases heart rate;

66. Caffeine increases aortic stiffness;

67. Caffeine increases aortic blood pressure; and

68. Harmony Moller died from her congenital heart disease complicated by caffeine use.

Finally,

69. The toxidrome of kratom has not been determined;

70. Mitragynine undergoes postmortem redistribution;

71. The peripheral blood concentration of mitragynine approximately triples in the period between death and measurement at autopsy;

72. A postmortem blood mitragynine concentration of 150 ng/mL or 158 ng/mL is not elevated; and

73. Harmony Moller did not die because of her kratom use.

CONCLUSIONS

74. Based upon the information provided to me, I am able to assert my conclusions to a reasonable degree of medical and toxicologic certainty.

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75. No evidence supports the contention that Harmony Moller’s use of kratom contributed to her death. The postmortem concentration of mitragynine identified in Ms. Moller’s blood was 158 ng/mL as measured by the Gerona lab (St. Tammany Parish Coroner records); commercial clinical laboratories measured the mitragynine concentration as 150 ng/mL (St. Tammany Parish Coroner records). Mitragynine undergoes postmortem redistribution, a process where the concentration of a substance changes following death. The available scientific literature demonstrates that the postmortem concentration of mitragynine is approximately triple that of pre-mortem measurements (Osawa 2025). To a reasonable degree of medical certainty, therefore, Ms. Moller’s premortem concentration of mitragynine was approximately 50 ng/mL, a value that occurred in human clinical trials involving kratom. Notably, none of the participants in these studies developed cardiac toxicity, much less a life-threatening event. Ms. Moller did not die from her kratom use.

76. In fact, medical examiners initially noted that the cause of death was “chronic liver congestion.” Chronic liver congestion is a medical condition often associated with right heart failure; backup of blood (i.e., “congestion”) into the liver produces fibrotic changes that become apparent even on visual inspection of the liver. Notably, kratom has not been associated with chronic liver congestion, even among patients where right heart failure was putatively associated with distant and undefined kratom ingestion (Alameh 2025).

77. Although I agree with the medical examiner’s finding that Ms. Moller died from complications of her unrecognized congenital heart disease—that has a recognized association with sudden cardiac death—I find that the medical examiner errs in failing to consider adequately the pharmacophysiology of the full range of substances identified on postmortem testing.

78. I find that the medical examiner errs in determining that Harmony Moller’s kratom use contributed to her death. In fact, the pharmacophysiology of kratom is more likely to be *protective* against cardiac sudden death in a patient such as Ms. Moller who had a high takeoff of the coronary artery with an acute angle of origin complicated by an inferior aortic flap. Following ingestion, mitragynine exerts parasympathetic effects on the cardiovascular system (Saengmolee 2022; Prevete 2024). These effects, measured generally as a slight *decrease* in systolic and diastolic blood pressure even in the setting of greater alertness, are insufficient to contribute to morbidity and mortality of an individual with high takeoff of the coronary artery with an acute angle of origin of the coronary artery complicated by an inferior aortic flap (Saengmolee 2022; Prevete 2024).¹

79. I also find that the medical examiner errs in ignoring other substances more likely than mitragynine to worsen the congenital heart disease described in the medical record. Normally, the aorta has “elasticity,” meaning it can dilate slightly during a pulse of blood from the heart. Harmony Moller ingested caffeine. Caffeine is an over-the-counter stimulant that increases pulse rate and intra-aortic blood pressure, but caffeine also limits the elasticity (i.e., how much the blood vessel can expand in response to increased blood pressure) of the aorta. (Mahmud 2001,

¹ Ms. Moller’s mother also initially believed that her congenital heart disease alone caused her death. (Mande’s Restaurant Facebook account: <https://www.facebook.com/mandesrestaurant/posts/647328647396846>).

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Vlachopoulos 2003)). Caffeine's pharmacologic actions make it dangerous in a person with high takeoff of the left coronary artery with an acute angle of origin. Caffeine increases aortic blood pressure and decreases aortic elasticity. These direct pharmacologic effects of caffeine compress the opening of the coronary artery precisely because the coronary artery has an acute angle of origin that narrows as the aorta expands (Virmani 1984). Moreover, the inferior aortic flap is an additional obstruction to blood flow into the coronary artery as the increased aortic blood pressure caused by caffeine presses it against the wall of the aorta. Ms. Moller's caffeine use occluded the coronary artery and hindered blood flow into heart muscle. This decrease in cardiac perfusion caused a malignant arrhythmia culminating in sudden cardiac death. Caffeine, not mitragynine, exacerbated Ms. Moller's congenital heart disease and contributed to her death.

80. Even if Ms. Moller was not taking her caffeine supplements, she also had "Mini Thins," a weight-loss remedy. This product contains caffeine and yohimbine, among other plant products. Yohimbine is a presynaptic alpha-2 antagonist. The pharmacologic effects of yohimbine are to increase pulse rate and blood pressure. These direct pharmacologic effects of yohimbine, either with or without caffeine, compress the opening of the coronary artery precisely because the coronary artery has an acute angle of origin that narrows as the aorta expands (Virmani 1984).

81. Even if Harmony Moller did not die of her congenital heart disease complicated by her caffeine use, she had other, more plausible causes of death than mitragynine toxicity. For example, Ms. Moller's vomiting was so severe that Kathleen Moller administered multiple antiemetics without improvement. Harmony Moller was taking two different caffeine-containing supplements. Caffeine is a methylxanthine. The methylxanthine toxidrome involves vomiting, seizure, and ventricular dysrhythmias (Shimane 2017). Death in methylxanthine-poisoned individuals arises from seizures or from malignant ventricular dysrhythmias (Shimane 2017; Poussel 2013). The medical examiner failed to quantify the postmortem concentration of caffeine even though Harmony Moller's clinical presentation (i.e., severe vomiting despite multiple antiemetics before being found down with no anatomic cause of death other than her congenital heart disease) was consistent with lethal methylxanthine poisoning. This clinical presentation is also inconsistent with mitragynine toxicity.

82. Harmony Moller did not die from any contribution of mitragynine to her congenital heart disease.

83. Harmony Moller did not die from mitragynine toxicity

84. Harmony Moller did not die from her kratom use.

85. I am able to defend rigorously these conclusions, made within a reasonable degree of medical and toxicologic certainty. I reserve the right to supplement, amend or addend these opinions based on additional or new information, including other expert reports.

Rebuttal Opinions

Rebuttal to Christopher Williams's report

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86. I have reviewed the report generated by Plaintiff's expert Christopher Williams, PhD, a laboratory researcher and NIH-funded scientist. Dr. Williams acknowledges he cannot "identify cause of death" or provide "clinical diagnostic information."

87. Dr. Williams attempts to link together all negative aspects of opioids, kratom and kratom alkaloids. He attempts unsuccessfully to establish a toxic profile of kratom alkaloids, each with an atypical corynanthe structure, by drawing parallels with formal opioids having phenanthrene, anilidopiperidine, and diphenylpropylamine chemical structures.

88. In formulating his opinions on the effects of kratom alkaloids on health, Dr. Williams picks and chooses among the scientific literature while making numerous scientific omissions and factual errors. His literature review is insufficient to allow an understanding of the complexity of kratom pharmacology, behaviors following use of the plant, or pharmacophysiologic outcomes of kratom use.

89. Dr. Williams cannot explain why kratom might contribute to Harmony Moller's death from her congenital heart disease (that is lethal by itself), and he does not describe any putative physiologic or clinical effect of mitragynine that might directly affect Ms. Moller's congenital heart disease.

90. Dr. Williams highlights molecules such as 7-hydroxymitragynine (a metabolite of mitragynine) and mitragynine pseudoindoxyl (a rearrangement product of 7-hydroxymitragynine). But the concentrations of neither were measured, and the medical examiner did not identify any connection between 7-hydroxymitragynine or mitragynine pseudoindoxyl and Harmony Moller's death. Despite opining on opioid effects, Dr. Williams fails to explain how opioid activity relates to a high takeoff of the coronary artery with an acute angle of origin.

91. Dr. Williams also attempts to demonstrate that mitragynine, a metabolite (i.e., 7-hydroxymitragynine), and a rearrangement product all "rival the potency of clinically available opioids" without scientific support. Dr. Williams makes a fundamental scientific mistake by conflating 'potency' with 'affinity'.

92. In his report, Dr. Williams implies that large amounts of 7-hydroxymitragynine are produced following ingestion of kratom, with a mean ratio of 0.20-0.29. This conflates parent/metabolite ratios from *single* dose administration and *multiple* dose administration. Single dose administration produces the ratio cited by Dr. Williams. Repeated ingestion of kratom by individuals, such as Ms. Moller, produces substantially lower ratios from poorer conversion of mitragynine to 7-hydroxymitragynine (Heustis 2024). The ratio of conversion in Ms. Moller, based upon the scientific literature, is closer 0.15-.21 (Heustis 2024). Even if a higher conversion ratio occurred in Ms. Moller from intermittent use of kratom, the amount of 7-hydroxymitragynine is toxicologically irrelevant. (Chiang 2025; Hill 2021)

93. Dr. Williams states, "[T]he ingestion of Kratom yields significant amounts of both MG and 7HMG, and subsequently yields pharmacological activity associated with both compounds throughout the duration of exposure." (Williams Report, page 3) The term "significant" carries precise scientific meanings associated with specific mathematical

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comparisons which Dr. Williams never makes in his report. In addition, the term “pharmacological activity” can mean anything related to the body’s handling of a xenobiotic; that these activities arise throughout the duration of exposure is unsurprising since pharmacologic activities can only occur from the moment a xenobiotic is introduced until it is totally eliminated. Finally, powdered kratom, the sort of which was used by Ms. Moller, contain small amounts of mitragynine and a toxicologically negligible mass of 7-hydroxymitragynine (Chakraborty 2021; Zhang 2021; Smith et al., 2024).

94. While the toxicological behavior of a molecule can be explained by its pharmacology, “pharmacological activity” does not by itself equal or even connote *toxicological* activity. Dr. Williams cannot point to a single proven effect of kratom or any of its alkaloids that can exacerbate a high takeoff of the coronary artery with an acute angle of origin.

95. Dr. Williams claims that “cardiotoxicity has been clearly linked to . . . kratom, which includes QT prolongation,”² citing a single case report. (Williams Report, page 4). But human studies have demonstrated daily kratom use is not associated with prolongation of the QT interval (Abdullah J. Tox 2021). Additionally, a separate human subjects study found mitragynine blood concentrations below 9,400 ng/mL were not associated with prolongation of the QT interval, and even individuals whose blood mitragynine concentration exceeded 22,000 ng/mL demonstrated slight increases in the QT interval but exhibited no cardiotoxicity. (Abdullah Frontiers in Pharmacology 2021) Unlike these studies, the single case report on which Dr. Williams relies suffers from methodologic deficiencies, including not verifying the use of kratom and relying upon standard urine drug screens to disprove use of additional substances. Moreover, the patient in Dr. Williams’s case report³ received an intervention that is different than those used to treat Torsades de Pointes, the cardiac rhythm caused by QT prolongation (Abdullah, 2019).

96. In an attempt to highlight putative effects of kratom on the QT interval, Dr. Williams cites Krantz 2023. As recognized by Dr. Williams, Krantz relies upon the FDA Adverse Event Reporting System (FAERS). But there are profound shortcomings of this dataset that color the outcome of the study. These limitations include but are not limited to ambiguity about the role of the ingested xenobiotic, lack of characterization of the product, use of concomitant medications, and effect of underlying disease on outcome. Each of these conditions applies to Ms. Moller. Additionally, reporting of the FAERS data set is biased “by patient’s or reporters’ perception of the drug/natural product.” (Li 2024). In fact, the FDA in its recent report entitled “7-Hydroxymitragynine (7-OH): An Assessment of the Scientific Data and Toxicological Concerns Around an Emerging Opioid Threat” declined to even analyze FAERS data because of the striking limitations of the database. (https://www.fda.gov/files/drugs/published/7-hydroxymitragynin_7-oh_an_assessment_of_the_scientific_data_and_toxicological_concerns_around_an_emerging_opioid_threat.pdf).

² The QT interval is a measure of cardiac repolarization on the electrocardiogram that has been associated with a specific type of ventricular dysrhythmia known as Torsades de Pointes (<https://my.clevelandclinic.org/health/diseases/21915-torsades-de-pointes>).

³ No cardiac rhythm was described in the case report, only that the patient was “pulseless” (Abdullah 2019).

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97. Dr. Williams also claims there are “significant drug-drug interactions involving MG and 7HMG,” but he cannot point to any scientifically sound example where kratom or its alkaloids led to any pharmacodynamic interactions between kratom, its alkaloids, and other drugs.

Rebuttal to Josef Thundiyl’s report

98. I have reviewed the report of Dr. Thundiyl. Dr. Thundiyl disagrees with both the medical examiner and cardiac pathologists, disregarding important autopsy findings that inform the cause of death. For example, he reports the high origin of the left coronary artery, but he disregards the acute angle of origin and its recognized association with sudden cardiac death. Similarly, Dr. Thundiyl ignores entirely the anatomic flap that obscures the origin of the artery. Any anatomic feature that obstructs blood flow into an artery is likely to produce end organ damage. Depending on the location of the obstruction (e.g., near the takeoff of a major artery) and the organ that artery perfuses (e.g., the heart), death is a likely outcome—exactly as recognized by several publication in the medical literature (Rizzo 2021; Taylor 1992; Muriago 1997; Loukas 2016; Virmani 1984; Nishida 2014).

99. Dr. Thundiyl incorrectly states that a mitragynine blood concentration of 150 ng/mL is sufficient to be lethal. First, a blood concentration of 150 ng/mL is within the range of concentrations achieved in clinical trials where no adverse events occurred (Heustis 2024). Second, Dr Thundiyl disregards the known postmortem redistribution of mitragynine. Based on the existing literature, Ms. Moller’s likely premortem concentration of mitragynine is approximately 50 ng/mL (Osawa 2025).

100. Dr. Thundiyl recognizes the presence of caffeine as identified by the medical examiner, but he misses that the methylxanthine toxidrome could be present. Dr. Thundiyl also overlooks Ms. Moller’s use of multiple dietary supplements that contained caffeine and other vasoactive compounds for which there is evidence of use. Furthermore, Harmony Moller exhibited a well-recognized toxidrome of protracted vomiting unresponsive to antiemetics, had no anatomic cause of death other than her congenital heart disease that is known to be lethal by itself, and had a qualitative caffeine measurement.

101. Dr. Thundiyl correctly disagrees with Dr. Williams that neither diphenhydramine nor promethazine contributed to Ms. Moller’s death. As no pharmacodynamic interactions have plausibly been attributed to kratom use, the likelihood that one arose now, particularly involving multiple medications with minimal cardiovascular effects at such low concentrations, is low.

102. I am able to defend rigorously these conclusions, made within a reasonable degree of medical and toxicologic certainty. I reserve the right to supplement, amend or addend these opinions based on additional or new information including other expert reports.

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Sincerely,

/s/ Edward Boyer
Edward Boyer, M.D. Ph.D.

APPENDIX A**Edward W Boyer MD PhD
Curriculum Vitae**

Date Prepared: October 19, 2025

Name: Edward Wright Boyer

Office Address: 410 West 10th Ave
Prior Hall
Columbus, OH 43210

Home Address: 387 South Parkview Avenue
Bexley, OH 43209

Work Phone: 617 413 0924

Work Email: Edward.boyer@osumc.edu

Place of Birth: Memphis, Tennessee

Education:

1979-1983	BS, <i>magna cum laude</i>	Chemistry	Vanderbilt University, Nashville, TN
1983-1984	MA	Organic Chemistry	Columbia University, New York, NY
1984-1986	MPhil	Organic Chemistry	Columbia University
1984-1987	PhD	Organic Chemistry (Dissertation Advisor: WC Still)	Columbia University
1991-1995	MD	Medicine	Columbia University College of Physicians and Surgeons, New York, NY
2021	AB	Honorary degree	Harvard College, Cambridge, MA

Postdoctoral Training:

1987 – 1989	NIH Postdoctoral Fellow (Emil T Kaiser)	Bioorganic Chemistry and Biochemistry	The Rockefeller University, New York, NY
1995 – 1996	Intern	Emergency Medicine	The Medical College of Pennsylvania, Philadelphia, PA

1996 – 1999	Resident	Emergency Medicine	Hospital of the University of Pennsylvania, Philadelphia, PA
1999 – 2001	Fellow	Medical Toxicology	Boston Children's Hospital, Boston, MA

Faculty Academic Appointments:

1999 – 2001	Clinical Fellow	Pediatrics	Harvard Medical School, Boston, MA
2001 – 2005	Assistant Professor	Emergency Medicine	University of Massachusetts Medical School, Worcester, MA
2001 – 2015	Lecturer	Pediatrics	Harvard Medical School, Boston, MA
2005 – 2011	Associate Professor	Emergency Medicine	University of Massachusetts Medical School
2011 – 2016	Professor	Emergency Medicine	University of Massachusetts Medical School
2015 – 2017	Lecturer, Part Time	Pediatrics	Harvard Medical School, Boston, MA
2016 – present	Professor, Adjunct (Non-Voting)	Emergency Medicine	University of Massachusetts Medical School
2017 – 2019	Lecturer on Emergency Medicine	Pediatrics	Harvard Medical School
2017 – 2021	Associate Professor, full time	Emergency Medicine	Harvard Medical School, Boston, MA
2021 – 2022	Professor, full time	Emergency Medicine	Harvard Medical School, Boston, MA
2022 – present	Visiting Professor	Emergency Medicine	Harvard Medical School, Boston, MA
2022 – present	Professor with Tenure	Emergency Medicine	Ohio State College of Medicine, Columbus, OH

Appointments at Hospitals/Affiliated Institutions:

1999 – 2001	Attending Physician	Emergency Medicine	Northeast Hospital Corporation, Beverly, MA
2001 – 2016	Attending Physician	Emergency Medicine	UMass-Memorial Medical Center, Worcester, MA

2001 – 2016	Attending Physician	Medical Toxicology Consulting Service	UMass-Memorial Medical Center, Worcester, MA
2001 – 2021	Attending Physician	Emergency Medicine (Toxicology)	Children's Hospital, Boston, Boston, MA
2010 – 2014	Research Staff	Addiction Medicine	Edith Nourse Rogers Memorial Veteran's Administration Medical Center
2012 – 2017	Consultant	Infectious Diseases	Massachusetts General Hospital
2016 – 2021	Attending Physician	Emergency Medicine	Brigham and Women's Hospital
2016 – 2021	Attending Physician	Emergency Medicine	Brigham and Women's Faulkner Hospital, Boston, MA
2018 – present	Adjunct Faculty	Behavioral Medicine	The Fenway Institute, Boston, MA
2021 – present	Attending Physician	Emergency Medicine	Ohio State University Wexner Medical Center

Other Professional Positions:

1989–1990	Patent Agent Trainee	Fish & Neave, New York, NY
2014-2017	Chair, Data Safety Monitoring Board	Brown University

Major Administrative Leadership Positions:

Local

2002 – 2016	Chief, Division of Medical Toxicology	UMass-Memorial Medical Center
2008 – 2009	Acting Chief, Division of Research	UMass-Memorial Medical Center
2008 – 2016	Core faculty member	Addiction Medicine Fellowship Training Program, UMass-Memorial Medical Center
2016 – 2018	Director of Academic Development	Department of Emergency Medicine, Brigham and Women's Hospital Boston, MA
2018 – 2021	Director of Research and Academic Development	Department of Emergency Medicine, Brigham and Women's Hospital Boston, MA
2019 – 2021	Director of Vaping Toxicology	Division of Pulmonary Medicine, Boston Children's Hospital Boston, MA
2019 – 2021	Core Faculty Member	Core faculty, Addiction Medicine Fellowship Program Brigham and Women's Hospital Boston, MA

2021 – present	Director, Grantsmanship series	Nationwide Childrens Hospital Columbus, OH
2024 – present	Director, Postgraduate Workforce Development	The Ohio State University Columbus, OH
2024 – present	Member, Strategic Planning, OSU CTSI	The Ohio State University Columbus, OH
National		
2013 – 2018	Scientific Advisory Board	NIDA P50 Center for Technology and Behavioral Health, Dartmouth College, Hanover, NH
2016 – 2020	Scientific Advisory Board	NIDA Drug Early Warning System (NDEWS)
2020 – 2021	Executive Advisory Board	Mary Horrigan Connors Center for Women's Health and Gender Biology

Committee Service:**Local**

2001 – 2003	Institutional Review Board	University of Massachusetts Medical School
2001 – 2012	Graduate Medical Education Committee	University of Massachusetts Medical School
2005 – 2016	Division Directors Committee	UMass-Memorial Medical Center
2007 – 2012	Recruitment Committee	UMass-Memorial Medical Center
2008 – 2016	Research Committee	UMass-Memorial Medical Center
2011 – 2016	Morbidity and Mortality Committee	UMass-Memorial Medical Center
2012 – 2016	Junior Faculty Development Committee	University of Massachusetts Medical School
	2012 – present	Steering Committee Member
2012 – 2016	K-Award Writing Committee	UMass-Memorial Medical Center
	2012-2016	Senior Member
2012 – 2013	Overdose Management Committee	UMass-Memorial Medical Center
2012 – 2015	Technology Assessment Committee	UMass-Memorial Medical Center
2016 - 2021	K Review Group	Division of Infectious Diseases, Massachusetts General Hospital
2017 - 2021	iHub advisor	Brigham and Women's Hospital
2017 - 2021	Academic Mentoring Committee	Department of Emergency Medicine
2017 - 2021	Departmental Leadership Committee	Department of Emergency Medicine
2019 - 2021	Clinical Investigation Committee	Brigham and Women's Hospital
2020 - 2021	Covid Research Review Committee	Brigham and Women's Hospital
2020 - 2021	Research Recovery Executive Advisory Committee	Brigham and Women's Hospital

Regional

2014 – 2017	Chair, Data Safety Monitoring Board	Brown University
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National

2003	Drugs and Crime Practitioners' Workshop	National Institute of Justice
2003	"Black Hat" Expert Advisory Panel on Chemical Terrorism Agents of Opportunity	US Centers for Disease Control & Agency for Toxic Substances and Diseases Registry
2005	Expert Advisor	NIDA CEWG
2005	Expert Advisory Panel on Dextromethorphan Abuse	Rand Corporation
2005	Expert Advisory Panel on Prescription Drug Abuse	Rand Corporation
2005	Expert Advisory Panel on Club Drug Abuse	Rand Corporation
2007	Consultation and Debriefing Meeting on the Response to Fentanyl-Related Overdose and Death	Substance Abuse and Mental Health Services Administration
2007	2007	Co-Chair
2008	Drug Interaction Work Group	Substance Abuse and Mental Health Services Administration
2009	Buprenorphine in the Treatment of Opioid Addiction: Balancing Medication Access with Quality Care	Department of Health and Human Services
2009	2009	Invited Expert
2009	Public Health Emergency Preparedness	Agency for Healthcare Research and Quality
2009	2009	Invited Expert
2009	Uniform Case Definitions Work Group	Substance Abuse and Mental Health Services Administration
2010 – 2015	Drug Safety and Risk Management Advisory Committee	US Food and Drug Administration
2010	2010	Temporary Voting Member
2010	Translating Screening and Intervention Research for Implementation in Emergency Departments	National Institutes on Drug Abuse
2017	Abuse Deterrent Formulation Meeting	US Food and Drug Administration/National Institutes on Drug Abuse
2017	Smart and Connected Health Visioning Meeting	Invited Participant
2017	2017	National Science Foundation
		Invited Participant

International:

2017	Oversight Committee, Poison Control Development Project	Ramaiyah Medical School, Bangalore, India
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Professional Societies:

2001 – present	American College of Medical Toxicology 2001-present 2007	Member Fellow
2001 – 2010	American College of Emergency Physicians 2001-2010 2007-2010	Member Research Committee Member
2001 –present	Society for Academic Emergency Medicine 2001-present	Member
2012 – 2021	Massachusetts Medical Society 2012-2022	Member, Committee on Publications
2014 – 2016	Massachusetts Hospital Association 2014-2016	Member, Opioid Overdose Prevention Committee
2018 –present	College on Problems of Drug Dependence 2018-present	Member

Grant Review Activities:

2004 – 2005	Orphan Drug Project Review Panel 2004-2005	Food and Drug Administration Ad hoc Member
2006	HIV III Review Committee 2006	Centers for Disease Control Ad hoc Member
2006	Review panel ZRG1 AARR 15 2006	National Institutes of Health Ad hoc Member
2009	Challenge Grant Review Panel 4 2009	National Institutes of Health Ad hoc Member
2009	Challenge Grant Review Panel 27 2009	National Institutes of Health Ad hoc Member
2009	Challenge Grant Review Panel 37 2009	National Institutes of Health Ad hoc Member
2009 – 2010	Behavioral & Social Consequences of HIV/AIDS (BSCH) 2009 - 2010	National Institutes of Health Ad hoc Member
2009	Special Emphasis Review Panel ZRG1 AARR G15 2009	National Institutes of Health Ad hoc Member
2010	NIDA Center (P30) and Center of Excellence (P50) Awards 2010	National Institutes of Health Ad hoc Member
2011	Special Emphasis Review Panel ZRG1 AARR-F-(02) 2011	National Institutes of Health Ad hoc Member
2011	Special Emphasis Review Panel ZRG1 HDM-K-(55)	National Institutes of Health

2011	2011 Special Emphasis Review Panel ZRG1 GXM-A-(06)	Ad hoc Member National Institutes of Health
2011	2011 Special Emphasis Panel SBIR Topic 137	Ad hoc Member National Institutes of Health
2011	2011 Special Emphasis Panel SBIR Topic 143	Ad hoc Member National Institutes of Health
2011	2011 Special Emphasis Panel SBIR Topic 39	Ad hoc Member National Institutes of Health
2012	2011 Cutting Edge Basic Science Research Award (CEBRA) 2012/05 ZDA1 SXC-E	Ad hoc Member National Institutes of Health
2012	2012 NIDA Conference Grant Review Committee 2012/05 ZDA1 MXL-F (09)	Ad hoc Member National Institutes of Health
2013 – 2019	2012 Behavioral and Social Science Approaches to Preventing HIV/AIDS (BSPH) 2013 – 2018; name changed in 2019 to Population and Public Health Approaches to HIV/AIDS (PPAH)	Ad hoc Member Standing member National Institutes of Health
2015	Avenir Mechanism Grant Review 2015	National Institutes of Health Ad hoc Member
2015	Smart and Connected Health Review Panel	National Institutes of Health and National Science Foundation
2018	2015 PPAH	Ad hoc Member National Institutes of Health
2019	2018-2019 Smart and Connected Health NSF 18-541	Standing Member National Science Foundation
2019	2019 Work and Education NSF 19-541	Ad hoc Member National Science Foundation
2020	2019 Fulbright Scholars Review Committee	Ad hoc Member The Fulbright Commission
2024	NIDA Project Grant Review Committee 2024/05 ZRG1 IIDB-R (40)	National Institutes of Health
	2024	Ad hoc Member

Editorial Activities:

Ad hoc Reviewer

New England Journal of Medicine
 Lancet
 Pediatrics
 Drug and Alcohol Dependence
 Pediatric Emergency Care
 Journal of Toxicology
 Critical Care Medicine
 Critical Care
 Journal of Clinical Psychopharmacology
 Chest
 Dermatology
 Neuropsychopharmacology
 Academic Emergency Medicine
 Journal of Medical Toxicology
 Forensic Science International

Other Editorial Roles

2005	Associate Editor	Aghababian's Textbook of Emergency Medicine
2007	Associate Editor	Gold Standard Online Toxicology Text
2010 – 2013	Associate Editor	Journal of Medical Toxicology
2018 - 2020	Associate Editor	Smart Health

Honors and Prizes

1999	Resident Teaching Award	Hospital of the University of Pennsylvania, Department of Emergency Medicine	
2008	NIH Distinguished Lecturer in Natural Products Neurosciences	University of Mississippi, Oxford, MS	
2010	College of CSR Reviewers	National Institutes of Health, Bethesda, MD	Awarded for Exceptional Service to Center for Scientific Review
2011	National Research Award	American College of Medical Toxicology, Phoenix, AZ	
2012	Champions of Excellence	UMass-Memorial Medical Center	Awarded for quality of care service
2013	Best User Experience Award	Health and Wellness Innovations MIT Media Lab, Cambridge, MA	Overall Winner
2015	Nominee, Best paper in mHealth	IEEE 48 th Annual Hawaii International Conference on	Nominee

2015	Citation Award	Systems Science, Maui, HI Society of Behavioral Medicine, Milwaukee, WI	Awarded to the top three research submissions to the annual SBM national conference
2016	Innovations in Healthcare	Medstro, Boston, MA	Overall Winner
2018 – 2019	Fulbright Scholarship	William J Fulbright International Scholarship Board	Recipient
2021	Nominee, Best paper in mHealth	IEEE 54th Annual Hawaii International Conference on Systems Science, Maui, HI	Nominee
2021	Pillars of Excellence Awardee	Brigham and Women's Hospital	Awardee

Report of Funded and Unfunded Projects

Funding Information:

Past

1988 – 1989	Design and synthesis of a peptide model of the Trp repressor NIH F32GM12200 Role: Principal Investigator Real time detection of cocaine use in natural environments
2002 – 2005	Examining the relationship between the internet and illicit drug use NIH R21DA14929 Role: Principal Investigator Sought to determine the role of the internet in initiation of illicit drug use
2005 – 2010	Club drugs, adulterants, coingestants, and associated HIV risk NIH R01DA18572 Role: Principal Investigator Examined the impact of club drugs, adulterants and coingestants on HIV risk
2007 – 2008	Risk factors for severe opioid-related overdose NIH R01DA020030 Role: co-investigator (Wines, PI) Examined the impact of depression on the risk of opioid overdose requiring naloxone for reversal
2007 – 2010	Opioids, internet pharmacies, self-treated chronic pain, and HIV/AIDS NIH R21DA022677 Role: Principal Investigator

	Examines the extent to which internet pharmacies contributed to opioid misuse
2008 – 2011	The Sentinel Events Model: A dynamic model of substance use cessation NIH R01DA023170 Role: Co-investigator A new behavioral model to guide substance abuse treatment development
2008 – 2011	Computer-assisted interventions for drug abuse in the ED NIH R42DA021455 Role: Co-Investigator (Boudreaux, PI) Assists drug abusers, while patients in the ED, find drug treatment
2010 – 2011	Bioinformatic Generated and Learned Acute Assessment Models (BIOGLAAM) DoD SBIR A09A-027-0201 Role: Consultant (Gorman, PI) learning approaches to the detection of shock
2010 – 2012	A mobile Enabling Technology to enhance adherence to behavioral therapy NIH RC1028428 (ARRA Challenge Grant) Role: Principal Investigator Machine learning approaches to detection of drug craving based on wearable biosensor data
2011 – 2014	iMStrong, an innovative remote monitoring system for detecting cocaine use NIH R01DA033769 Role: Principal Investigator Real time detection of cocaine use in natural environments using wearable biosensors
2011 – 2016	A mobile, personalized intervention with real-time adaptation to HAART adherence NIH R01DA031081 Role: Principal Investigator mHealth interventions to support antiretroviral adherence
2015 – 2016	NIDA National Early Warning Network (iN3): An innovative approach NIH R56DA38266 Role: Principal Investigator (multi-PI proposal) Social media-based detection of emerging drugs of abuse using machine Learning
2014 – 2017	Trending: Social media analyses to monitor cannabis & synthetic cannabinoid use NIH R01DA39454 Role: Co-investigator (Danuilaityte PI); \$67,434 Used social media and web semantic approaches to identify changes in cannabinoid use
2014 – 2026	Mentoring in advanced mHealth interventions for drug abuse & ART adherence NIH K24DA027109

	Role: Principal investigator; \$879,845 Provides for mentoring of junior faculty in mHealth interventions
2017-2018	2017 National Institute on Drug Abuse (NIDA) International Visiting Scientists and Technical Exchange Program INVEST Program Role: Principal investigator. Darika Saingam PhD, mentee; \$60,084 Pharmacokinetics of kratom
2018-2019	Wearable biosensors to detect kratom use in Malaysian heroin users Fulbright Scholars Program Role: Principal Investigator; \$15,630 Used wearable biosensors in heroin users seeking drug treatment to ascertain the pharmacophysiology of kratom
2018-2019	Sentanyl: Emergency department-based surveillance for clandestine opioids NIH R21DA46734 Role: Co-investigator (Babu, PI); \$265,269 Used advanced testing protocols to identify unrecognized opioids such as fentanyl congeners in heroin overdose victims
2018-2019	Feasibility and Acceptability of wireless biometric monitoring using a novel wearable sensor Philips Healthcare PCMS-CSV-G10BWH-2018-10290 Role: Co-investigator (Chai, PI); \$194,956 This grant investigates the operational barriers and usability of a novel wireless biosensor that collects real-time biometric data in emergency department patients.
2018-2019	Feasibility and Acceptability of Digital Pills to Monitor PrEP adherence in MSM with Substance Abuse (DigiPrEP) Gilead ISR-17-10189 Role: Co-investigator (Chai, PI); \$150,000 This grant investigates the use of digital pills to measure real-time PrEP adherence in MSM with substance use disorders.
2018-2020	Feasibility and Acceptability of wireless biometric monitoring using a novel wearable sensor in respiratory illness Philips Healthcare Role: Co-investigator (Raby, PI); \$194,956 Investigates the operational barriers and usability of a novel wireless biosensor that collects real-time biometric data in emergency department patients with respiratory illness.
2019-2020	Sound cancelling earbuds to improve transition to night shifts Bose Health Role: Principal Investigator. This project examines the utility of Bose Sleepbuds in assisting residents transition to and recover from night shifts.
2017 – 2021	MyTPill: A Novel Strategy to Monitor Antiretroviral Adherence among HIV+ Prescription Opioid Users/Diversity Supplement

R01DA047236-S1
 Role: Principal investigator; \$187,334
 Compares two electronic adherence measures for antiretroviral adherence.
 2018 – 2021 CUPID: Context-aware Unobtrusive Prediction of Indicators for Diagnosis of Health Risks
 DARPA FA8750-18-C-0025
 Role: Principal investigator; \$1,505,752
 Uses digital phenotyping to identify traumatic brain injury and acute febrile illness

Current

2018 – 2025 Violence and depressive symptoms among at-risk adolescents
 NIH HD093655
 Role: Co-investigator (PI: Megan Ranney)
 Seeks to develop mobile health-based behavioral interventions directed toward adolescents with depression and exposure to violence

2018 – 2024 Systematic assessment of geriatric elements in atrial fibrillation (SAGE-AF)
 NIH R01 HL126911
 Role: Co-Investigator (David McManus, PI)
 Seeks to optimize the design of a machine learning-based approach to detection of paroxysmal atrial fibrillation in the elderly

2019 – 2024 MyTPill: A Novel Strategy to Monitor Antiretroviral Adherence among HIV+ Prescription Opioid Users
 R01DA047236
 Role: Principal investigator; \$3,185,724
 Compares two electronic adherence measures for antiretroviral adherence.

2021 – 2026 Digital phenotyping, machine learning and biosensing: NextGen mentoring in HIV/drug abuse research
 NIH K24DA37109
 Role: Principal investigator; \$879,845
 Provides for mentoring of junior faculty in advanced technologies

Projects Submitted for Funding

2022 – 2025 Advanced learning systems for triage
 DARPA
 Role: Principal investigator; \$879,845
 Uses machine learning to refine mass casualty triage

Training Grants and Mentored Training Grants

2003 – 2007 fMRI assessment of organophosphate neurotoxicity
 K08 ES012897
 Role: Mentor. Steven B Bird, PI; \$505,056
 Uses fMRI to characterize the neuronal basis of organophosphate neurotoxicity

2013 – 2018 Text message-based depression prevention for high risk youth in the ED
 K23MH095866

	Role: Mentor. Megan Ranney, PI; \$730,889 Develops mHealth depression prevention methods in adolescents suffering peer violence
2014 – 2017	Understanding atrial remodeling and fibrillation using miRNA KL2 TR001455 Role: Mentor. David McManus, PI; \$458,100 Uses wearable biosensors and machine learning to distinguish cardiac rhythm (eg, atrial fibrillation) from smartphone camera-based pulse characteristic detection
2016 – 2019	iSense: Wearable biosensors to evaluate the evolution of opioid tolerance KL2 TR001455 Role: Primary mentor. Stephanie Carreiro, PI; \$458,100 Uses mobile biosensors to detect the development of opioid tolerance
2018 – 2023	Development of ingestible biosensors to enhance PrEP adherence in substance users. K23 DA044874 Role: Primary mentor. Peter Chai, PI; \$979,800 Uses fMRI to characterize the neuronal basis of organophosphate neurotoxicity

Unfunded Projects

2015-present	Co-Investigator. Drones in mass casualty events This project evaluated operational characteristics of drones in mass casualty simulations (UMass-Memorial Medical Center)
2016-present	Co-Investigator. Fentanyl and heroin This project examined the presence of fentanyl and congeners in heroin (UMass-Memorial Medical Center)
2017-present	Mentor. Detection of extrapyramidal TB using ultrasound This project examined the utility of ultrasound in detecting extrapulmonary TB in resource limited settings (Brigham and Women's Hospital)
2017-present	Principal Investigator. Music in ART adherence and drug abuse This project examined the utility of machine learning-derived music in improving affect to improve drug use and ART adherence (Brigham and Women's Hospital)

Report of Local Teaching and Training

Teaching of Students in Courses:

Columbia University

1983 – 1985	Organic chemistry laboratory	Columbia University, New York, NY
	30 undergraduate students	3-hr session per week x 18 weeks
1985 – 1986	Honors organic chemistry recitation	Columbia University
	25 undergraduate students	1-hr session per week x 18 weeks

Massachusetts College of Pharmacy

1999	Street drugs	Massachusetts College of Pharmacy, Boston, MA
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2000	200 Pharmacy Students Medical Information 200 Pharmacy Students	8 hours/year Massachusetts College of Pharmacy One hour lecture
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Harvard College

2018	Frontiers in Therapeutics: Poisoning 50 Undergraduate Students	Harvard College One hour guest lecture
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Harvard Medical School

2002	Independent study, illegal drugs 3 MPH Students	Harvard School of Public Health Three hour discussion group
2002 – 2004	Occupational Toxicology: Heavy Metals 25 MPH Students	Harvard School of Public Health One hour lecture
2017	Health Sciences Technology Introduction to Clinical Medicine Second year HMS medical students	Brigham and Women's Hospital 6, 1.5 hour precepting sessions
2017	Epidemiology 208 Workshop	Harvard School of Public Health One 2 hour precepting session
	Summer Program in Clinical Effectiveness	
2018	Health Sciences Technology Introduction to Clinical Medicine Second year HMS medical students	Brigham and Women's Hospital 6, 1.5 hour precepting sessions

University of Massachusetts Medical School

2006	Emergency Medicine mini-elective	University of Massachusetts Medical School 30 hours
2008 – 2012	20 Medical Students Pharmacology course: Herbal products 150 Medical Students	University of Massachusetts Medical School Two hour lecture

Formal Teaching of Residents, Clinical Fellows and Research Fellows (post-docs):**Harvard Medical School**

2001 – 2016	Toxicology Case Conference Emergency Medicine residents from BIDMC, BWH/MGH, BMC, Brown University and Kent Hospital	UMass-Memorial Medical Center 2-hr sessions per wk x 44 weeks
2001 – 2021	"Tox Tuesday" Toxicology Lecture Series 10 EM residents, fellows, & faculty	Boston Children's Hospital 2-hr sessions per wk x 4 weeks
2016 – 2021	Toxicology Conference 20 EM residents, fellows, & faculty	Brigham and Women's Hospital 2-hr sessions per month x 6 months

University of Massachusetts Medical School

2001 – 2016	Toxicology Case Conferences 20 EM residents, fellows, & faculty	UMass-Memorial Medical Center 2-hr sessions per wk x 44 weeks
2001	Introduction to toxicology 75 Internal Medicine residents	UMass-Memorial Medical Center Six one-hour lectures
2003	Serotonin Syndrome 20 Neurology residents	UMass-Memorial Medical Center One hour lecture
2007	Drugs of abuse 10 Psychiatry residents	UMass-Memorial Medical Center One hour lecture
2007	Aspirin toxicity 30 EM residents	UMass-Memorial Medical Center One hour lecture
2010	Medicolegal case review 50 EM residents and faculty	UMass-Memorial Medical Center One hour lecture

Clinical Supervisory and Training Responsibilities

1999 – 2001	Attending Physician, Emergency Medicine	Northeast Hospital Corporation 600 hours per year
2001 – 2016	Attending Physician, Emergency Medicine	UMass-Memorial Medical Center 800-1000 hours per year
2001 – 2021	Consulting Physician, Medical Toxicology	Boston Children's Hospital 250 hours per year
2016 – 2021	Master Physician, Emergency Medicine	Brigham and Women's Hospital 479 hours per year
2021 – present	Attending Physician	Ohio State Wexner Medical Center 400 hours per year
2024 – present	Attending Physician	Nationwide Childrens Hospital 400 hours per year

Laboratory and Other Research Supervisory and Training Responsibilities

2001 – 2021	Supervision of post-doctoral research fellows / UMass-Memorial Medical Center	One group meeting per week and 1:1 supervision three hours per week
2018 – 2021	Supervision of research team studying Bose Sleepbuds	One group meeting per week and 1:1 supervision three hours per week
2019 – 2021	Supervision of research team studying pain and anxiety in oncology patients in the ED	One group meeting per week and 1:1 supervision three hours per week
2023 – present	Supervision of grantsmanship efforts of junior faculty	One group meeting per month and 1:1 supervision three hours per week

Formally Mentored Harvard Medical, Dental and Graduate Students

2010 – present	Kathleen L Boyle MD (MPH candidate, HSPH 2019)
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- 2017 – present Currently conducting research into geocoding naloxone administration in heroin/fentanyl overdoses. Successfully received NIH LRP funding in 2016
Jamaji Nwanaji-Enwerem (MD-PhD student, HMS)
Currently completing the clinical portion of his training. Successfully received T32 and F31 funding. Served on dissertation defense committee for toxicity of nanoparticles, HSPH
- 2017 – 2018 Octavio Viramontes (MD student, HMS)
Currently beginning the clinical portion of his training; conducting research into the use of drones to perform the physical examination

Other Trainees and Mentored Faculty

- 2002 – 2016 **Steven B Bird, MD / Professor and Vice Chair for Education; Chief Experience Officer, University of Massachusetts Medical Center**
Career Stage: fellow, faculty. Mentoring Role: Academic and research mentor. Accomplishments: Mentoring in grantsmanship has led to NIH-funded K08, R21, U01 grants; six publications
- 2002 – 2016 D. Eric Brush, MD / Associate Professor, University of Massachusetts Medical Center.
Career Stage: Resident, faculty. Mentoring Role: Academic and career mentor
Accomplishments: Four publications
Career Stage: fellow, faculty. Mentoring Role: academic mentor.
- 2004 – present **Kavita Babu, MD / Professor, University of Massachusetts Medical Center; Chief Opioid Officer, UMass; Chief, Division of Medical Toxicology.**
Career Stage: fellow, faculty. Mentoring Role: academic and research mentor. Accomplishments: Eleven publications, risk management research grants, NIH R21
- 2004 – 2007 James Courtney, MD / Attending Physician, Milford Regional Hospital
Career Stage: fellow. Mentoring Role: academic mentor.
Accomplishments: one publication
- 2004 – 2007 Michael Ganetsky, MD / Assistant Professor, Harvard Medical School
Career Stage: fellow, faculty. Mentoring Role: academic mentor.
Accomplishments: Two publications
- 2006 – 2016 Richard Church, MD / Associate Professor, University of Massachusetts Medical Center.
Career State: Fellow, faculty. Mentoring role: Academic
Accomplishments: one publication
- 2006 – 2010 Michael Levine MD / Assistant Professor, University of Southern California School of Medicine.
Career Stage: resident, fellow, faculty. Mentoring role: Research mentor.
Accomplishments: four publications
Career Stage: resident, fellow, faculty. Mentoring Role: academic mentor.
- 2007 – 2009 Najla Khoja, RPh / Director, Poison Service, King Faisal Medical Center, KSA
Career Stage: fellow. Mentoring Role: academic supervisor.
Accomplishments: Mentoring in approaches to the academic medical center led to the creation of the first poison control center in the Kingdom of Saudi Arabia
- 2007 – 2009 Kevin Kent, MD / Attending, Milford Regional Hospital
Career Stage: fellow. Mentoring Role: Fellowship director. Instrumental in guiding his career path based on prolonged discussions.
- 2007 – 2015 **Chad Darling, MD / Assistant Professor, University of Massachusetts Medical School**

Career Stage: faculty. Mentoring Role: academic advisor.

Accomplishments: Mentoring led to Dr. Darling receiving NIH K23, R21 awards

- 2007 – 2012 Richard Ribon Fletcher, PhD / Research Scientist, MIT
Career Stage: research scientist. Mentoring Role: research supervisor.
Accomplishments: Mentoring in health applications of biosensor technologies led to a Gates Foundation award and three publications
- 2008 –present **Andrew Monte, MD PhD / Professor, University of Colorado Medical Center; Medical Director, Rocky Mountain Drug Information Center**
Career Stage: fellow, faculty. Mentoring Role: academic and research mentor. Accomplishments: Mentoring in grantsmanship, the structure of manuscripts, and presentation of results led to one publication, NIH K23, and NIH R01
- 2008 - 2013 Kathryn Weibrecht, MD / Associate Chief of Emergency Medicine, Morton Hospital.
Career Stage: fellow. Mentoring Role: career supervisor.
Accomplishments: One publication
- 2008 – 2012 Christopher Rosenbaum, MD / Attending Physician, Newton-Wellesley Hospital
Career Stage: fellow. Mentoring Role: academic supervisor.
Accomplishments: Six publications
- 2008 – 2012 Jeanine Ward, MD, PhD / Attending Physician, York Hospital
Career Stage: fellow. Mentoring Role: academic supervisor.
Accomplishments: one industrial grant, two publications
- 2009 – 2010 Jennifer Englund, MD / Attending Physician, Regions Hospital
Career Stage: fellow. Mentoring Role: fellowship director. Instrumental in guiding her career path based on prolonged discussions.
- 2009 – 2011 Jarrett Burns, DO / Associate Chief of Emergency Medicine, Heywood Hospital
Career Stage: fellow. Mentoring Role: academic supervisor.
Accomplishments: Four publications
- 2010 – 2012 Brian Wolk, MD / Assistant Professor, Loma Linda Medical School
Career Stage: fellow. Mentoring Role: academic supervisor.
Accomplishments: One publication
- 2011 – 2017 **Keith Horvath, PhD / Professor, San Diego State University**
Career Stage: faculty. Mentoring Role: academic mentor
Accomplishments: Two publications; NIH R34 award; one R01 submitted
- 2011 – 2016 **David McManus, MD / Professor, University of Massachusetts Medical School; Chair, Department of Medicine**
Career Stage: faculty. Mentoring Role: research mentor.
Accomplishments: Mentoring in grantsmanship for submissions involving innovative technologies related to cardiac care culminated two publications; NIH KL2, R01, and UO1 awards
- 2011 – present **Megan Ranney, MD MPH / Winslow Professor of Public Health, Yale; Dean, Yale School of Public Health**
Career Stage: faculty. Mentoring Role: research and academic mentor.
Accomplishments: Fourteen publications, a NIH K23 award, a PCORI R01 award; three NIH R01s
- 2011 – 2016 Mark Neavyn, MD / Assistant Professor, University of Massachusetts Medical School
Career Stage: fellow, faculty. Mentoring Role: academic mentor.
Accomplishments: One publication, fellowship director

- 2011 – 2016 Jennifer Carey, MD / Associate Professor, University of Massachusetts Medical School
Career Stage: fellow. *Mentoring Role:* academic mentor.
Accomplishments: UMass Faculty Development award, SAEM and Holyoke Foundation awards
- 2011 – 2015 Matthew Zuckerman, MD / Assistant Professor, University of Colorado Medical School
Career Stage: fellow. *Mentoring Role:* academic mentor.
Accomplishments: one publication; development of ToxNow podcast series
- 2011 – 2015 Lynn Farrugia, MD / Assistant Professor, University of Florida Medical School
Career Stage: fellow. *Mentoring Role:* academic supervisor. Instrumental in guiding her career path based on prolonged discussions
Accomplishments: Chief of Medical Toxicology Service, Hartford Hospital
- 2013 – present** **Stephanie Carreiro, MD / Associate Professor, University of Massachusetts Medical School; Director of ToxInnovation Lab**
Career Stage: fellow, faculty. *Mentoring Role:* research supervisor.
Accomplishments: 4 publications; LRP; NIH KL2 and K23 awards
- 2013 – 2016 Alex Manini, MD / Associate Professor, Mount Sinai School of Medicine
Career Stage: faculty. *Mentoring Role:* research advisor.
Accomplishments: 2 publications; NIH R01, R56 awards
- 2013 – 2016 Raminta Daniuliatyte, PhD / Assistant Professor, Wright State University
Career Stage: faculty. *Mentoring Role:* academic advisor.
Accomplishments: 4 publications; NIH R01, R21, R56 awards
- 2013 – 2015 Lisa Hightow-Weidman, MD / Professor, University of North Carolina School of Medicine.
Career Stage: faculty. *Mentoring Role:* academic advisor.
Accomplishments: Mentoring in grantsmanship for submissions related to innovative technologies in HIV care culminated in Dr Hightow's successful \$18M NIH award
- 2013 – 2016 John Haran, MD / Associate Professor, University of Massachusetts Medical School
Career Stage: faculty. *Mentoring Role:* research mentor.
Accomplishments: My mentoring led to 4 publications; NIH LRP award, a SAEM career development and K23 awards
- 2014 – 2019 Kelley Wittbold, MD / Harvard Affiliated Emergency Medicine Residency
Career stage: resident. *Mentoring Role:* research supervisor.
Accomplishments: 2 publications; Winner, 2015 Society for Behavioral Medicine Citation Award for application of wearable biosensors for the identification of cocaine use in natural environments
- 2014 – present **Peter Chai, MD, MMS / Associate Professor, Brigham & Women's Hospital**
Career stage: faculty. *Mentoring Role:* research supervisor.
Accomplishments: 35 publications, five invited international lectures related to google glass, drones, digital pills, biosensors, and music-based interventions, as well as a K23, R21, and DP5 awards
- 2015 – 2018 Jose Castillo-Mancilla, MD / Associate Professor, University of Colorado Medical School
Career Stage: faculty. *Mentoring Role:* academic advisor.
Accomplishments: 2 publications and a NIH R01 award
- 2016 – 2019 Kelli O'Laughlin, MD / Assistant Professor, University of Washington Medical School
Career Stage: faculty. *Mentoring Role:* academic advisor.

Accomplishment: K23 award.

2016 – 2019 Lubabah Ben-Ghaly, MD / Resident, Harvard Affiliated Emergency Medicine Residency
Career stage: Resident. *Mentoring role:* Research supervisor. *Accomplishments:* One paper in progress

2016 – 2021 **Scott Weiner, MD / Associate Professor, Harvard Medical School**
***Career Stage:* faculty. *Mentoring Role:* research and academic mentor**
***Accomplishments:* two publications; R01 award; R01 renewal in progress**

2016 – 2018 John Broach, MD / Assistant Professor, University of Massachusetts Medical School
Career stage: faculty. *Mentoring role:* Research supervisor.
Accomplishments: 1 paper in progress

2016 – present **Kei Ouchi MD MPH / Assistant Professor, Harvard Medical School**
***Career stage:* faculty. *Mentoring role:* Research advisor**
***Accomplishments:* One paper published; R03 award, NIA Beeson K76 award**

2017 – 2021 Haipeng Zhang DO / Instructor, Harvard Medical School
Career stage: Faculty. *Mentoring role:* research advisor. *Accomplishments:* Two publications

2017 – 2018 **Naomi Green / Lecturer, Harvard Medical School**
***Career stage:* Assistant Professor. *Mentoring role:* research supervisor.**
***Accomplishments:* NIH LRP award**

2017 – present **Patricia Henwood MD / Assistant Professor, Thomas Jefferson Medical School**
***Career stage:* Assistant Professor. *Mentoring Role:* Academic mentor**
***Accomplishments:* Two publications, DARPA award.**

2018 – present **Roland Merchant MD DSc / Professor, Mount Sinai School of Medicine**
***Career stage:* Associate Professor. *Mentoring Role:* Academic mentor**
***Accomplishments:* NIH K24**

2019 – present **Eric Nilles MD / Assistant Professor, Harvard Medical School**
***Career stage:* Assistant professor. *Mentoring Role:* Academic mentor**
***Accomplishments:* LRP, seven CDC grants on emerging viral infections**

2019 – present **Desire Azizoddin PhD / Assistant Professor, University of Oklahoma**
***Career stage:* Instructor. *Mentoring Role:* Academic mentor**
***Accomplishments:* Cancer foundation career development award; one R34**

2020 – 2022 **Eric Kaczor MD / Fellow, UMass-Memorial Medical Center**
Career stage: Instructor. *Mentoring Role:* Academic mentor

2018 – present **Michael Chary MD / Assistant Professor, Mount Sinai School of Medicine**
***Career stage:* Assistant Professor. *Mentoring Role:* Academic mentor**
***Accomplishments:* Two publications, two grants submitted; LRP.**

2018 – present **Emily Cleveland MD / Assistant Professor, Boston Medical Center**
Career stage: Resident. *Mentoring Role:* Academic mentor
Accomplishments: Industrial research grant

2019 – present **Nicole Duggan MD / Instructor, Harvard Medical School**
Career stage: Faculty. *Mentoring Role:* Academic mentor
Accomplishments: MassLifeSciences Research Grant

2020 – present **Anita Chary MD / Assistant Professor, Baylor School of Medicine**
***Career stage:* Faculty. *Mentoring Role:* Academic mentor. One publication; one R03; One K76 in progress**

2020 – 2022 **Charlotte Goldfine MD / Instructor, Harvard Medical School**
Career stage: Faculty. *Mentoring Role:* Academic mentor

2020 – present	Andrew Marshall MD / Instructor, Harvard Medical School Career stage: Instructor. Mentoring Role: Academic mentor
2020 – 2021	Onyekachi Otugo MD / Instructor, Harvard Medical School Career stage: Instructor. Mentoring Role: Academic mentor
2020 – present	Farah Dadabhoy MD / Resident, Harvard Affiliated Emergency Medicine Residency Career stage: Fellow. Mentoring Role: Academic mentor
2020 – present	Dana Im MD / Instructor, Harvard Medical School Career stage: Faculty. Mentoring Role: Academic mentor
2021 – present	Katherine Buck MD / Assistant Professor, Ohio State College of Medicine Career stage: Assistant Professor. Mentoring Role: Academic mentor. One K08
2021 – present	Jason Bischof MD / Assistant Professor, Ohio State College of Medicine Career stage: Assistant Professor. Mentoring Role: Academic mentor
2021 – present	Nana Zhang MD / Assistant Professor, Ohio State College of Medicine Career stage: Assistant Professor. Mentoring Role: Academic mentor. One R03

Formal Teaching of Peers (e.g., CME and other continuing education courses):

No presentations below were sponsored by outside entities

2001	What's new on the street Harvard Medical School Department of Continuing Medical Education Addiction Medicine Course	One hour lecture Boston, MA
2002	The Internet and Drug Use Harvard Medical School Department of Continuing Medical Education Addiction Medicine Course	One hour lecture Boston, MA
2002	What's new on the street Harvard Medical School Department of Continuing Medical Education Addiction Medicine Course	One hour lecture Boston, MA
2003	Evidence-based toxicology Harvard Medical School Department of Continuing Medical Education Addiction Medicine Course	One hour lecture Boston, MA
2005	Emerging drugs of abuse Harvard Medical School Department of Continuing Medical Education Addiction Medicine Course	One hour lecture Boston, MA
2019	Street drugs Harvard Medical School Department of Continuing Medical Education Toxicology Course	One hour lecture Boston, MA
2023	Environmental disasters OSU APP CME course	One hour lecture Columbus, OH

Local Invited Presentations

No presentations below were sponsored by outside entities

1998	9 month old girl with somnolence / Grand Rounds Dept of Emergency Medicine, Hospital of the University of Pennsylvania
1998	8 Year old boy with somnolence / Grand Rounds Dept of Emergency Medicine, Hospital of the University of Pennsylvania
2004	Space toxicology / Grand Rounds Occupational and Environmental Health Residency, Harvard School of Public Health
2005	Club drugs / Residency didactic lecture Dept of Psychiatry, Brigham & Women's Hospital.
2005	Chemical mass casualty events / Society for Critical Care Medicine lecture series UMass-Memorial Medical Center.
2005	Drug testing / Addiction Practitioners Conference Cambridge Health Alliance.
2005	Legal highs for adolescents / Grand Rounds Department of Pediatrics, Cambridge Health Alliance.
2007	Calcium Channel Blockers / Grand Rounds Boston MedFlight Grand Rounds.
2009	A case of acute trifluoroacetic acid exposure / Grand Rounds Occupational and Environmental Health Residency, Harvard School of Public Health
2010	From case report to R01 / Residency Lecture Series Dept of Emergency Medicine, Beth Israel Deaconess Medical Center.
2015	Opioid overdose / Interdisciplinary Grand Rounds UMass-Memorial Medical Center.
2016	Senior Scholars Keynote Address University of Massachusetts Medical School
2016	Innovative research/Educational Lecture Media Fellows, University of Massachusetts Medical School

Report of Regional, National and International Invited Teaching and Presentations

No presentations below were sponsored by outside entities

Regional

1999	Pediatric Case Studies: Toxicology / Didactic Residency Lecture Dept of Emergency Medicine, Boston Medical Center.
1999	Toxicology / Grand Rounds Dept of Emergency Medicine, Alpert Medical School-Brown University.
1999	Toxicology / Grand Rounds Dept of Emergency Medicine, Alpert Medical School-Brown University.
2000	Toxicology / Grand Rounds. Dept of Emergency Medicine, Alpert Medical School-Brown University.
2000	Toxicology Case Studies / Didactic Residency Lecture Dept of Emergency Medicine, Boston Medical Center.

- 2001 Drug use in adolescents
Annual Meeting of the Eastern Massachusetts Nursing Association; Pharmacy Course, Newton, MA
- 2003 Developing a sustainable research program / Grand Rounds
Dept of Emergency Medicine, Boston Medical Center.
- 2003 The internet, adolescent, and drugs / Grand Rounds
Dept of Psychiatry, Tufts-New England Medical Center.
- 2003 The internet, adolescent, and drugs / Grand Rounds
Dept of Psychiatry, Tufts-New England Medical Center.
- 2003 Incorporating the internet into theories of drug use / Grand Rounds
Dept of Psychiatry, Tufts-New England Medical Center.
- 2008 The Serotonin Syndrome / Grand Rounds
Dept of Emergency Medicine, Hartford Hospital.
- 2014 Opioid overdose / Presentation to House Ways and Means Chief of Staff
Massachusetts Hospital Association Overdose Task Force.
- 2015 Neurontin, medical toxicology, and plaintiff's attorneys: How to create your own
product liability lawsuit / Knight Science Journalism Seminar Series
Massachusetts Institute of Technology.
- 2015 Emergency Medicine Research / Plenary Speaker
Research Day, Dept of Emergency Medicine, Warren Alpert Medical School/Brown
University. Providence, RI.
- 2019 Fentanyl: Facts and Myths
Massachusetts Emergency Preparedness Annual Conference, May 8, Quincy, MA
- 2019 Two Truths and a Lie
Harvard Longwood Psychiatry Grand Rounds, October 31, Boston, MA.

National

No presentations below were sponsored by outside entities

- 2002 Psychoactive drugs and the internet. Bethesda, MD
National Institutes on Drug Abuse Conference
- 2002 Rhabdomyolysis and HMG CoA reductase inhibitors / Pre-meeting Symposium
speaker
North American Congress of Clinical Toxicology. Palm Springs, CA
- 2002 New antipsychotic agents / Pre-meeting Symposium speaker
North American Congress of Clinical Toxicology. Palm Springs, CA
- 2003 Establishing a successful track record on obtaining federal grants / Session speaker
American College of Medical Toxicology Fellow's Conference. Atlanta, GA
- 2005 Use of the Internet for ethnographic identification of drug use trends /
North American Congress of Clinical Toxicology. Orlando, FL
- 2006 Serotonin Syndrome / Grand Rounds
Salem Hospital, Salem, OR.
- 2006 Serotonin Syndrome (CME)/Lecture
Pediatric Neuropsychopharmacology Series, Albert Einstein College of Medicine
- 2007 Opioids, chronic pain, and Internet pharmacies / Plenary speaker
RADARS Scientific Meeting, Bethesda, MD Toxicology.
- 2008 Establishing a research career in emergency medicine / Grand Rounds

- Dept of Emergency Medicine, Washington University, St Louis, MO.
- 2008 The role of the medical toxicologists in addiction medicine: Harm reduction and Research opportunities / Session speaker
6th Annual American College of Medical Toxicology Spring Course. San Diego, CA.
- 2008 NIDA Panel on emerging drugs of abuse / Panel
American Psychiatric Association. Washington, DC.
- 2008 NIH Distinguished Scientist in Natural Products Neuroscience / Plenary Lecture
Dept of Pharmacy, University of Mississippi, Oxford, MS.
- 2009 Linkage between basic and clinical sciences: New Directions / Plenary lecturer
Dept of Pharmacy, University of Mississippi, Oxford, MS.
- 2009 Internet pharmacies and substance abuse / Session speaker
North American Congress of Clinical Toxicology. San Diego, CA
- 2009 Snus and kratom: The self-treatment of addiction / Plenary lecturer
State-of-the-Art Conference in Addiction Medicine, American Society of Addiction Medicine. Washington, DC.
- 2009 Buprenorphine diversion / Plenary lecturer
State-of-the-Art Conference in Addiction Medicine, American Society of Addiction Medicine. Washington, DC.
- 2010 Toward mobile detection of changes in affective states / Invited lecture
Annual Meeting of the Association of Behavioral and Cognitive Therapists. San Francisco, CA
- 2012 Generation X to Z and emergency medicine research: Using computer-based technology for recruitment, consent intervention, and follow up / Session speaker
Annual Meeting of the Society of Academic Emergency Medicine. Chicago, IL.
- 2012 Prescription drug misuse / Session speaker
Annual Meeting of the Society of Academic Emergency Medicine. Chicago, IL.
- 2012 Opioid drugs: 21st Century killers / Keynote Speaker
Annual Meeting of the Society of Forensic Toxicology. Boston, MA.
- 2012 Opioids / Grand Rounds
Dept of Emergency Medicine, Methodist Hospital / University of Indiana School of Medicine. Indianapolis, IN
- 2012 Biosensing / Works-in-Progress Lecture Series
Reigenstrief Institute, University of Indiana School of Medicine. Indianapolis, IN.
- 2013 Biomonitoring and behavioral interventions / Seminar
Behavioral Science Seminar Series, NIDA P30 Center of Excellence in Technology and Behavioral Health, Dartmouth College School of Medicine. Hanover, NH.
- 2013 Advanced behavioral interventions / Seminar
Behavioral Science Seminar Series, Behavioral Pharmacology Research Unit, Johns Hopkins School of Medicine, Baltimore, MD.
- 2015 Opioids / Plenary speaker
Frank Dunham Federal Criminal Defense Conference, Eastern and Western Districts of Virginia. Charlottesville, VA (Sponsored by Public Defender's Office, 4th Federal Circuit)
- 2015 Hidden Populations / Session speaker
Society of Academic Emergency Medicine Didactic Series Annual Meeting of the Society of Academic Emergency Medicine, San Diego, CA.
- 2016 NIH funding workshop / Workshop
Society of Academic Emergency Medicine Faculty Development Series. Annual Meeting of the Society of Academic Emergency Medicine, New Orleans, LA.
- 2018 Clinical effects of kratom

- 2018 College on Problems of Drug Dependence. Annual Meeting, San Diego, CA
- 2018 Oncogenesis
- 2018 American College of Medical Toxicology Board Review Course, Chicago, IL
- 2018 Psychomimetic drugs
- 2018 American College of Medical Toxicology Board Review Course, Chicago, IL
- 2018 Anticonvulsants
- 2019 American College of Medical Toxicology Board Review Course, Chicago, IL
- 2019 Kratom—Clinical effects and toxicity in humans
- 2024 Chemistry and Pharmacology of Drug Abuse, Boston, MA
- 2024 Kratom Pharmacology and Toxicology
- 2025 Utah Department of Agriculture and Forestry
- 2025 Kratom: Examining acute toxicity in humans
- 4th International Kratom Science Symposium, Orlando, FL

International

No presentations below were sponsored by outside entities

- 2015 You need to get them where they feel it: Conflicting perspectives on how to Maximize the structure of text-message psychological interventions for adolescents / Presentation selected from submitted paper
- 48th Hawaii International Symposium on System Science.
- 2015 Formative research for mHealth HIV adherence: The iHAART App / Presentation selected from submitted paper
- 48th Hawaii International Symposium on System Science.
- 2016 Synthesizing effective research groups comprising behavioral scientists, software engineers, and computer scientists / Symposium leader
- 49th Hawaii International Symposium on System Science.
- 2016 Ingestible biosensors for real-time medication adherence: MyTMed presentation / Selected from submitted paper
- 49th Hawaii International Symposium on System Science.
- 2017 Social media in clinical toxicology practice - Current topics in drug abuse research / Session speaker
- European Association of Poison Centres and Clinical Toxicologists, Basel, Switzerland.
- 2017 The potential use of ketum in opioid addiction / Plenary lecture
- International Symposium on Ketum, Penang, Malaysia. (Sponsored by NIDA)
- 2017 Emerging topics in drug use / Plenary lecture
- Society for Emergency Medicine India, Jaipur, India.
- 2018 Drugs of Abuse Critical Care Update
- Asia-Pacific Critical Care Conference, New Delhi, India
- 2018 Drugs of Abuse Toxicology Update: Emphasis on Club Drugs
- Asia-Pacific Critical Care Conference—Toxicology Pre-Meeting, New Delhi, India
- 2018 Toxicology of antidepressants, antipsychotics, and sedative hypnotics
- Asia-Pacific Critical Care Conference—Toxicology Pre-Meeting, New Delhi, India
- 2018 Update on drug testing
- Asia-Pacific Critical Care Conference—Toxicology Pre-Meeting, New Delhi, India

2018	Novel challenges in the opioid epidemic in the USA International Symposium for Research Development in Clinical Toxicology, Taipei, Taiwan
2019	Using emergency department data and wastewater analysis to detect club drugs, Institute of Strategic and International Studies Malaysia, Kuala Lumpur, Malaysia
2019	Cannabis, recreational or medicinal use, Asia-Pacific Association of Medical Toxicology, Putrajaya, Malaysia
2023	Grantsmanship for toxicologists, North American Congress of Clinical Toxicology, Montreal, Canada
2023	Ethics in toxicology research, North American Congress of Clinical Toxicology, Montreal, Canada
2024	Forensic Toxicology of Club Drugs Christian Medical College, Vellore, India
2024	Kratom Pharmacology Christian Medical College, Vellore, India
2025	Kratom toxicology World Health Organization, Vienna, Austria
2025	Kratom and 7OH epidemiology Christian Medical College, Vellore, India

Report of Clinical Activities and Innovations

Current Licensure and Certification:

1999 – 2021	Massachusetts State Medical License (#159310)
1999 – 2021	Massachusetts State Controlled Substance License
1999 – present	United States Drug Enforcement Administration Controlled Substance License
2000 – present	Board certification in emergency medicine
2002 – present	Board certification in medical toxicology
2021 – present	Ohio State Medical License (#35.143041)

Practice Activities:

1999 – present	Staff Toxicologist, Medical Toxicology	Massachusetts Poison Center	Level of activity: 25 days per year
1999 – 2001	Attending Physician, Emergency Medicine	Beverly Hospital	
2001 – 2016	Attending Physician, Emergency Medicine	UMass-Memorial Medical Center	
2001 – 2016	Consultant in Toxicology, Medical Toxicology	UMass-Memorial Medical Center	
2001 – 2021	Consultant in Toxicology, Medical Toxicology	Boston Children's Hospital	20 days per year
2016 – 2021	Master Physician, Emergency Medicine	Brigham and Women's Hospital	479 hours/year

9/2021 – present Professor, Emergency Medicine Ohio State University 800 hours/year

Clinical Innovations

Hyperinsulinemia-euglycemia therapy (2001)	In 2001, I published, in NEJM and the pediatrics literature, the use of hyperinsulinemia-euglycemia therapy for calcium channel blocker poisoning. This intervention, which is directed toward an overdose that is unresponsive to conventional treatment, has been internationally adopted by medical toxicologists as the preferred management of calcium channel blocker overdose.
Dietary supplement safety (2001)	I observed the severe poisoning from a dietary supplement that was administered to a hospitalized child. In response to this preventable poisoning, I developed protocols that define the handling of the dietary supplements drawn from home supply that are administered to inpatients. These recommendations were published and adopted locally.
Fomepizole without hemodialysis (2001)	I was the first to recognize that ethylene glycol poisoning, historically managed with the antidote Fomepizole and hemodialysis, could be safely and more economically treated without extracorporeal removal of the toxin. Moreover, I recognized that this approach could be safely used in children. This intervention strategy has been internationally adopted by medical toxicologists.
Suboxone poisoning in children (2006)	I recognized that preclinical pharmacokinetic studies of buprenorphine had limited relevance to children—and that the clinical predictors of opioid overdose had never been defined in the pediatric population. My recommendation that all toddlers exposed to buprenorphine be observed for 24 hours irrespective of clinical status has become the national standard of care, and contributed to the voluntary withdrawal of a buprenorphine formulation by the manufacturer
Suboxone diversion (2008)	In 2008, I published the first study examining diversion of Suboxone among individuals with problematic opioid use. The breadth of abuse highlighted in this study contributed to calls for greater medication-assisted treatment of opioid addiction.
Kratom use (2008)	I was one of the first to report the use of kratom to self-treat opioid withdrawal in patients with chronic pain. This knowledge contributed to the 2016 federal regulatory decision to delay scheduling kratom as an illicit substance.
Kratom adverse effects (2008)	I was the first to define the adverse effect profile of kratom with a report of seizures in a user of the drug. My initial report, published in 2008 and replicated internationally, contributed to federal regulatory decision-making surrounding the scheduling of kratom in 2016.
Opioid analgesic overdose	In my NEJM review on management of opioid analgesic overdose, I presented the rationale for minimum dosing of the antidote, naloxone, as a

(2012)	means to avoid precipitating severe opioid withdrawal and promote engagement with care. My recommendations have been widely adopted by the emergency medicine and medical toxicology community.
Digital pills to prevent substance abuse (2015)	In 2015 I was Principal Investigator of a study examining ingestible biosensors (eg, digital pills that measure their own adherence) to measure directly medication-taking events. Data from the digital pills demonstrates that patients in the Emergency Department with extremity fractures often require only three days of PRN oxycodone before the need for opioid-level analgesia ceases.
Google Glass (2015)	Beginning in 2015, I directed the efforts to use Google Glass as a simple, inexpensive telemedicine platform capable of transmitting clinical information with sufficient validity to change treatment approaches to the poisoned patient. This approach has been adopted nationally by medical toxicology groups working in hospitals with geographically huge catchment areas.
Vaping Service (2019)	Beginning in 2019, I helped develop responses to the vaping-associated pulmonary injury epidemic; as a result of my efforts, I was asked to join the new Vaping Clinic at Boston Children's Hospital as the Director of Vaping Toxicology. As part of our initial work, we have developed diagnostic and treatment guidelines that have been adopted nationally by pediatricians and medical toxicologists.

Report of Teaching and Education Innovations

Serotonin syndrome (2005)	I synthesized, in a 2005 NEJM publication, a large volume of disparate medical information to generate a coherent clinical description of serotonin syndrome as well as its treatment. My teachings embodied in this review have been included in educational content offered in emergency medicine and medical toxicology training programs, and has been cited in over 1300 subsequent publications in journal such as NEJM, JAMA, and Addiction.
Writing retreat (2013)	I developed the concept of a "writing retreat" as a method to improve academic productivity. This approach, which improved grantsmanship and accelerated scholarly output, has been adopted regionally by academic departments of emergency medicine at Brigham and Women's Hospital and UMass-Memorial Medical Center. This work has also been highlighted by Insights, a publication of Harvard Medical School.
Improving productivity of clinician scientists (2018)	I improved on the writing retreat concept by establishing writing groups of clinician-scientists, many of whom were unfunded. This group would meet on an iterative basis to accelerate academic output by establishing short deadlines for crafting manuscripts. This finding has been replicated at multiple academic medical centers across New England.

Report of Technological and Other Scientific Innovations

Role of the Internet in substance abuse (2001)	In 2001, I became one of the first NIH-funded researchers to explore the role of the Internet on emerging drug use behaviors. I developed new qualitative methods to identify 1) the range of media that individuals used to learn about drugs of abuse; 2) the use of mobile technologies to disseminate drug use information; and 3) new psychoactive substances, abuse of which was poorly described. The data from my research affected the assessment of and treatment for problematic substance use in adolescents in drug treatment facilities locally and nationally
Kratom for Opioid withdrawal (2008)	US patent application number US 12/623,064 This patent application described a method for treating withdrawal from addictive compounds using kratom, a southeast Asian plant.
Wearable Biosensors in health (2009)	In 2009, I became a NIH-funded Principal Investigator of a study that integrated wearable biosensors and wireless connectivity to 1) collect continuous real-time biological, affective, and behavioral data, 2) recognize health risk behaviors, and 3) respond with individualized, evidence-based interventions designed to enhance compliance with behavior modification strategies. My use of machine learning methods to interpret wearable sensor data are now used internationally by investigators in the United States, Europe, and Asia.
Detection of cocaine use (2013)	In a follow up study, I was Principal Investigator of a study used wearable biosensors to identify relapse to cocaine in real time and in natural environments. By obtaining continuous, real-time measures of the timing and duration of substance use, my methods overcame shortcomings of urine drug screens or self-report. Ultimately, detecting episodes of drug use as they occur will help establish the efficacy of drug abuse interventions by allowing researchers to reliably discern drug use patterns over time that may reflect the positive effects of treatment. My approach won the Citation Award at the 2015 Annual Meeting of the Society of Behavioral Medicine. My methods have been adopted in a NIH-funded clinical trial (NCT02915341) to detect relapse to drug use.
Combinatorial Linguistics (2012)	In 2012, I was a Principal Investigator on a NIH-funded study to prevented fatigue from repeated administration of behavior interventions through the use of combinatorial linguistics to automate the creation of tens of millions of personalized intervention messages that are couched in evidence-based theory, to support medication adherence. Directed toward improving treatment outcomes in HIV-positive stimulant abusers, this investigation also uses advanced graphical interventions to overcome the effects of poor numeracy in treatment populations. My approach received the award for Best User Experience at the MIT Media Lab's Health and Wellness Innovations 2013 conference.

Identification of new drugs of abuse (2014)	In 2014, I was Principal Investigator on one of the first NIH-funded studies to use Web Semantic approaches, a brand of natural language process, to identify the emergence of new drugs of abuse. Our methods also are capable of identifying the location in which new drugs are being used. The findings from this work were incorporated into NIDA's Drug Early Warning System (NDEWS).
Drones (2016)	In 2016, I was Principal Investigator of a study examining the use of drones in mass casualty environments. My co-investigators and I demonstrated that paramedics with no flight training were capable of flying the devices and identifying victims of mass casualty environments.
Music, Machine-Learning, & Interventions (2017)	I became one of the first NIH-funded Principal Investigators to explore the use of the musical features of songs (identified by machine learning, a branch of artificial intelligence) as a method to improve affect, decrease pain, control anxiety, and elevate mood.
DNA methylation age and tobacco use (2018)	In 2018, I supervised a study examining the impact of smoking and smokeless tobacco use on DNA methylation age. My co-investigators and I demonstrated that buccal cells may be a more sensitive measure of smoking index, itself a predictor of health outcomes from tobacco use. This work was recognized with the 2019 Best Student Paper Award from the International Association of Exposure Science
Smartphone detection of traumatic brain injury (2018)	In 2018, I initiated a study examining the ability to use all lines of smartphone data collection to diagnose mild traumatic brain injury as well as malaria. My co-investigators and I will use machine learning to identify variations in usage—speech patterns, texting rates, mistake frequency, locomotion, and other measures of activity—to diagnose these conditions in absence of a clinician.
Drones in the physical exam (2018)	In 2018, I directed a study examining the use of drones to perform the physical examination. My co-investigators and I demonstrated that drones could transmit information regarding physical examination findings as well as change in patient condition to remotely located treating physicians.
Improving sleep in shift workers (2019)	In 2019, I directed a study examining the use of sleepbuds to assist in the transition to and the recovery from night shifts. My co-investigators and I demonstrated that smart sleepbuds could improve the duration and quality of sleep in resident physicians working overnight shifts.
Robots for remote vital sign measurement (2020)	In 2020, I helped develop a study using "Dr. Spot", a walking robot, to remotely measure vital signs on patients at risk for Covid.

Machine learning interpretation of POCUS images (2021)

In 2021, I helped the Brigham and Women's Point of Care Ultrasound group navigate several institutional barriers so they could receive MassLife Science funding for machine learning-driven interpretation of POCUS images. This has translated into additional NIH funding under a R21 mechanism

Report of Education of Patients and Service to the Community

No presentations below were sponsored by outside entities

Activities

2001 – 2021 Staff Toxicologist, Center for Poison Prevention and Control Serving Massachusetts and Rhode Island.
Provided on-call support for poison control center operations

2023 – present Affiliated Toxicologist, Central Ohio Poison Center
Provided educational support for rotating residents and staff

Recognition

2003	Debate on recreational drug web sites	Interviewee	CBS Evening News, Jan 27, 2003
2004	Teens using cold medicine to get high	Interviewee	ABC 20/20, http://abcnews.go.com/2020/story?id=124334&page=1
2005	University of Massachusetts Hospital's Boyer discusses "Skittling", abusing Coricidin tablets which resemble the candy and contain dextromethorphan	Interviewee	The Today Show, Media ID: NY-TDY-20050322-0001
2010	Officials: Fishermen caught mustard gas off NY	Interviewee	Boston.com, June 8, 2010
2010	NJ fisherman caught mustard gas in Atlantic	Interviewee	Deseret News, June 8, 2010
2010	Local man hurt as Atlantic City Clam boat dredges up mustard gas munitions in Massachusetts	Interviewee	Press of Atlantic City, June 9, 2010
2010	Mustard gas on fishing boat confirmed	Interviewee	Cape Cod Times, June 9, 2010
2010	A soft spot for circuitry	Interviewee	New York Times, July 4, 2010
2011	Bath salts	Interviewee	ToxNow podcast, October 1, 2011, available at the ToxNow website
2011	Agitated delirium and NACCT	Interviewee	ToxNow podcast, October 14, 2011
2011	Halloween and dabigatran	Interviewee	ToxNow podcast, November 22, 2011

2011	Medical marijuana and more	Interviewee	ToxNow podcast, December 30, 2011
2012	Best articles of 2011	Interviewee	ToxNow podcast, February 7, 2012
2012	UMass Medical uses smart phones to treat drug abuse	Interviewee	BizJournal, February 23, 2012
2013	Should kratom be legal?	Interviewee	Scientific American, September 30, 2013
2015	Vitamix blenders spin off shards of Teflon—but it's probably OK	Interviewee	Buzzfeed, February 18, 2015
2015	How google glass could save lives in the ER	Interviewee	Huffington Post, June 6, 2015
2015	Mobile Biosensors	Interviewee	ToxNow podcast, October 23, 2015
2015	Massachusetts doctor on the power and limitations of naran	Interviewee	WBUR, November 13, 2015
2016	Kratom, an addict's alternative, is found to be addictive itself	Interviewee	New York Times, January 2, 2016
2016	Universities researching drone technology to deliver aid	Interviewee	Drone Life, August 9, 2016
2016	Kratom: Natural painkiller of addictive drug?	Interviewee	CNN, August 31, 2016
2016	Banning a promising cure of opioid addiction is a bad idea	Interviewee	Wired, September 13, 2016
2016	What is kratom? Why has the DEA wanted to ban it?	Interviewee	WebMD, September 19, 2016
2016	If DEA blocks kratom, promising research on opioid alternative may suffer	Interviewee	Public Broadcasting Service, September 29, 2016
2016	DEA backs down on plan to ban Kratom	Interviewee	The Seattle Times, October 13, 2016
2016	Room for Debate: Is kratom the plant that heals, or kills?	Interviewee	The New York Times online opinion section, October 19, 2016
2016	Opioid Plant	Interviewee	Canadian Broadcasting Corporation (http://www.cbc.ca/radio/asithappens/as-it-happens-Thursday-edition.1.4824041) October 20, 2016
2016	Is Kratom a deadly drug or a life-saving medicine?	Interviewee	Bloomberg Businessweek, December 12, 2016
2017	Experts say some slime ingredients may be harmful	Interviewee	NECN March 16, 2017
2017	In between life and death, opioid use can cause dozens of injuries	Interviewee	WBUR March 17, 2017
2017	The queen of poisons strikes in San Francisco	Interviewee	Forbes March 17, 2017

2017	Digital pills successfully monitor opioid use after injury	Interviewee	Science Daily November 20, 2017
2017	Digital pills track how patient use opioids	Interviewee	MIT Technology Review December 11, 2017
2017	Why it's so hard to cure your hangover, according to experts	Interviewee	Time December 29, 2017
2018	How opioids kill	Interviewee	Scientific American January 9, 2018
2018	Kratom saved me	Interviewee	Stand up/speak up podcast Feb 12, 2018
2018	Kratom is hailed as a natural pain remedy, assailed as an addictive killer. The US want to treat it like heroin	Interviewee	Washington Post Feb 10, 2018
2018	Liquids nicotine is a poison, so why is it packaged like junk food?	Interviewee	The Verge May 1, 2018
2018	PA prisons spend \$15M after guards were sickened by K2. But what if it was all in their heads?	Interviewee	Philadelphia Inquirer September 6, 2018
2018	Ohio pushed kratom ban with disputed claims about deaths, use trends	Interviewee	Huffington Post September 6, 2018
2019	Is kratom safe during pregnancy? Researchers start to investigate	Interviewee	The Scientist July 26, 2019
2019	Why the vaping lung illness crisis is exploding now, according to Boston doctors	Interviewee	Boston Globe September 17, 2019
2023	Here's why people are so concerned about the Ohio train derailment	Interviewee	Buzzfeed February 18, 2023
2023	How over-the-counter Narcan can help reverse opioid overdoses	Interviewee	Scientific American April 11, 2023
2023	Wife of Ukraine's top military intelligence official hospitalized with apparent heavy metals poisoning	Interviewee	CNN November 28, 2023

Report of Scholarship

Peer-Reviewed Scholarship in print or other media:

Research Investigations

1. Weber JE, Chudnofsky CR, Boczar M, **Boyer EW**, Wilkerson MD, Hollander JE. Cocaine-associated Chest Pain: How Common Is Myocardial Infarction? Acad Emerg Med 2000;7: 873-87.

2. **Boyer EW**, Mejia M, Woolf A, Shannon M. Severe Ethylene Glycol Ingestion Treated without Hemodialysis. *Pediatrics* 2001;107: 172-174. (See comment, *Pediatrics* 2001;10:7 170-171).
3. **Boyer EW**, Shannon M. Treatment of Calcium Channel Blocker Intoxication with Insulin Infusion. *NEJM*. 2001; 344:1721-1723.
4. **Boyer EW**, Shannon M, Hibberd PL. Misinformation on Illicit Drugs Available on the Internet. *NEJM*. 2001;3 45: 469-471.
5. Dickson E, *Bird S, Gaspari R, **Boyer EW**, Ferris C. Diazepam attenuates central respiratory depression due to organophosphate poisoning. *Acad Emerg Med* 2004; 10:1303-6.
6. **Boyer EW**, Shannon M, Hibberd, PL. The Internet and psychoactive substance use among innovative drug users. *Pediatrics*, 2005; 115:302-5.
7. Cohen MH, Hrbek A, Davis RB, Schacter SC, Kemper K, **Boyer EW**, Eisenberg DM. Emerging credentialing practices, malpractice liability policies, and guidelines governing complementary and alternative medical practices and dietary supplement recommendations. A descriptive study of 19 integrative health care centers in the United States. *Arch. Int. Med*, 2005;165;289-296.
8. Quang LS, Levy HL, Law T, Desai MC, Maher TJ, **Boyer EW**, Shannon MW, Woolf AD. Laboratory diagnosis of 1,4-BD and GHB overdose by routine urine organic acid analysis. *Clin Toxicol* 2005; 43:321-3.
9. Geib AJ, *Babu KM, Burns-Ewald M, **Boyer EW**. Adverse effects in children after unintentional buprenorphine exposure. *Pediatrics* 2006; 118 (4): 1746-1751.
10. **Boyer EW**, Lapen PT, Macalino G, Hibberd PL. Dissemination of Internet information on psychoactive substances. *Cyberpsych Behav*. 2007; 10(1): 1-6.
11. Levine MD, **Boyer EW**, Geib AJ, Mick N, Pozner A, Thomas SD. Assessment of hyperglycemia following calcium channel blocker overdoses involving diltiazem or verapamil. *Crit Care Med* 2007; 35(9): 2071-75 (see editorial: *Crit Care Med* 2007; 35(9) 2216-17).
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16. *Monte AA, Mandel T, Wilford BB, Tennyson J, **Boyer EW**. Diversion of buprenorphine/naloxone coformulated tablets in a region with high prescribing prevalence. *J Addict Dis* 2009; 28:226-31.
17. **Boyer EW**, McCance-Katz EF, Marcus S. Methadone and buprenorphine toxicity in children. *Am J Addiction* 2009; 19:89-95.
18. **Boyer EW**, Fay, RJ, Cook A, Buckosh M, Hibberd, PL, Case P. Conducting drug abuse investigations in natural environments: Potential directions for medical toxicology research. *J Med Tox*, 2010; 6:56-62.
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Narrative Report

Clinical innovation and research investigations have formed the twin pillars of my academic career. My clinical contributions, the most important of which have been published in high-impact general medical journals, have been adopted internationally by clinicians working in emergency medicine, medical toxicology, pediatrics, infectious diseases, psychiatry, addiction medicine, and behavioral science. My body of work has substantively improved the treatment of highly lethal poisonings, identified the economic benefit of antidotes, increased the safety of dietary

supplements, prevented pediatric overdose, informed management of opioid overdose, and boosted adherence to medications for common, intractable, and expensive medical conditions.

My research career, supported continuously by NIH since 2001 and informed by observations I make as a bedside clinician, has emphasized two main areas of investigation. In a series of studies from 2007, I have pioneered the use of signal processing and machine learning to identify, in real time and in natural environments, relapse to cocaine use, behavioral transitions to increased health risk, emerging population-wide drug use behaviors, and the opioid sparing effect of machine learning-tagged music. My second field of study involves advanced technologies in health. My studies related to mobile biosensors have provided vivid, indisputable evidence of medication ingestion, detected opioid use as well as the development of opioid tolerance, and apps that modulate pain and anxiety.

Recognizing the innovativeness of my science and its impact on multiple scientific disciplines, NIH awarded me a K24 mid-career award—the first emergency physician to be so funded—so that I could mentor junior faculty into skilled clinician-scientists. This funding led to a flowering of my academic career as the scope of my research expanded even further. My research grown to include web semantic learning to identify new patterns of psychoactive substance use, Bluetooth-labeled naloxone syringes to determine the fate of opioid antidote distributed into the community, and ingestible biosensors that measure, rather than infer, the actual time at which patients take their medications, and the study of machine learning-tagged music as an intervention for pain and anxiety.

One outgrowth of my mentoring efforts has been improvements in academic practice and the study of methods to accelerate academic productivity. My initial effort in this area emphasized writing retreats that focused on providing a linkage of junior authors to senior faculty; follow up work focused on establishing iterative writing periods where participating junior faculty provided critiques and writing suggestions for others' work. By replacing a didactic approach to authorship with faster support and editorial review, this fundamental advance accelerated the academic careers of junior faculty, particularly those of female faculty. I have also extended my mentoring work to the study of resident wellness where I led a study evaluating commercial sound-cancelling sleepbuds to help clinicians transition to and recover from overnight shifts.

The innovation of my work has been recognized by four different academic disciplines. First, I was named the 2008 NIH Distinguished Lecturer in Natural Products Neurosciences, an award from the medicinal chemistry community for my studies related to adverse effects of kratom. Then, in 2011, I received the American College of Medical Toxicology's annual Research Award for career accomplishments in research investigations. In 2013, my work related to graphical presentations of complex clinical data was recognized by the engineering and mHealth communities with the Best User Experience Award at MIT Media Lab's Health and Wellness Innovations 2013. My studies to extend the capacity of wearable biosensors into drug abuse treatment was applauded by the Society of Behavioral Medicine with the 2015 Citation Award. In 2016, I was the overall winner of the Medstro Innovations in Healthcare Challenge for my work related to digital pills for medication ingestion monitoring. Finally, in 2018 I was named a Fulbright Scholar to Malaysia to study the pharmacophysiology of kratom in Malaysian heroin injectors. Few emergency physicians have been recognized by such disparate academic disciplines, and I look forward to creating a pipeline of clinician scientists capable of making my own accomplishments look small.

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APPENDIX B

Documents Reviewed:

- Third Amended Complaint
- Plaintiff's Initial Disclosures
- St. Tammany Parish Sheriff's Office Incident Report, STPSO000001-000018
- St. Tammany Parish Coroner's Office Records,
- Plaintiff's Answers to Defendant JOpen, LLC's First Set of Interrogatories, dated 1/2/2025
- Plaintiff's Supplemental Responses to Requests for Production of Documents, dated 9/9/2025
- Plaintiff's Supplemental Answers to Interrogatories, dated 9/9/2025
- Excerpts from the following Body Cam Videos from St. Tammany Parish Sheriff's Office:
 - STPSO000019_(Extraction_1.1)_127_HWY_22_E.mp4
 - STPSO000020_(Extraction_1.1)_127_HWY_22_E-2.mp4
 - STPSO000021_(Extraction_1.1)_127_HWY_22_E-3.mp4
 - STPSO000022_(Extraction_1.1)_127_HWY_22_E-4.mp4
 - STPSO000023_(Extraction_1.1)_127_HWY_22_E-5.mp4
- Obituary, Harmony Anne Moller, <https://www.dignitymemorial.com/obituaries/covington-la/harmony-moller-11148925>
- *Mother Blames Companies Behind Kratom for Daughter's Death*, LEGAL NEWSLINE, Chris Dickerson, https://www.legalnewsline.com/louisiana-record/mother-blames-companies-behind-kratom-for-daughters-death/article_7c3ae0f1-0293-548c-9556-fd7911ae275e.html (February 28, 2024)
- NMS Labs Records, dated January 13, 2025
- Crime Scene Photos produced by St. Tammany Parish Sheriff's Office
- TRUEPILL000001-3
- Plaintiff's Expert Reports
- MOLLER_000023-24
- MOLLER_000025-26
- 911 call made by Kathleen Moller
- The following Facebook Posts

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- Mande's Restaurant, dated February 15, 2023, linking Harmony Moller Obituary, <https://www.dignitymemorial.com/obituaries/covington-la/harmony-moller-11148925>,
- Kathi Moller's post, dated August 6, 2023, and comments
- Kathi Moller's post, dated February 8, 2023, and comments
- Kathi Moller's post, dated April 13, 2024, and comments
- Kathi Moller's post, dated April 12, 2024
- Kathi Moller's post, dated December 5, 2023
- Kathi Moller's post, dated November 12, 2023
- Kathi Moller's post, dated April 7, 2023
- Kathi Moller's comment on Mande's Restaurant's post, dated February 15, 2023
- Kathi Moller's post, dated May 29, 2023, and comments
- St. Tammany Fire District #4, Patient Care Record
- ASPEN0000001-12
- LIFENET000001-8
- The following records from the Louisiana Organ Procurement Agency:
 - LNH Chart
 - Audio Recording of call between Kathleen Moller and LOPA Representative
 - Cardiectomy Report
 - Louisiana Organ and Tissue Donor Registry Verification
- Paradigm Health System (certification of lack of records)
- HIPAA Compliant Authorization for Release of Protected Health Information/Records