Toxicologists: The Investigators of Poison
Response Paper 1

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ENVR 300/PLSC 379: Toxic Politics: Environmental Justice in Richmond and Beyond
September 24, 2019

Today, in the United States, the Environmental Protection Agency regulates commercial use of harmful chemicals and toxins. In ancient civilization, poisons were deliberately administered to political opponents to overthrow a kingdom. Later on, in Greece, philosophers, physicians and scientists sought answers by studying the relationships between poison, disease, and remedies. Since then, toxicologists investigate poisonous substances to classify, prevent, cure, and set standards of harmful toxins in the environment. The study of toxicology has evolved into many specialties, heavily focused on research advocating for the detection and treatment of human poisoning, particularly with the rise of lead contamination in the twenty-first century. In response to theories and practices in *Brush with Death,* I will uncover the medical breakthroughs of toxicologists and the correlations of dosage and toxicity. I will highlight pioneer toxicologists in the field that balanced health advocacy with the implementation of occupational limits of lead control. I will also validate the impact of the scientific research that exposed the dangerous lead levels in the Flint water. Toxicologists are of growing importance to society as infrastructure ages and scientific technology brings comprehension to harmful substances, invisible to human vision.

The history of modern toxicology began in the 16th century with Paracelsus, who was born in 1493 and acquired a heightened interest in chemistry and biology, derived from the influence of his physician father. Paracelsus was a radical thinker and although formally educated, he thought his education could be broadened by traveling to experience “health and the causes of disease …” (Borzelleca 2000, 2). He was one of the first physicians to study occupational hazards and related medicinal practices. He was at the forefront of detecting the positive relationship between lung disease in miners relative to their inhalation of minerals and ores (Gantenbein 2017, 6).Though his methods of combining inorganic substances for therapy

were deemed too toxic, he became known as the founder of modern toxicology and the predominant alchemist of the time. His studies encouraged testing on animals to better understand dosages and the human effect (Borzelleca 2000, 3). “The dose makes the poison”; he claimed that every chemical agent has two sides - a helpful and harmful element, one that cures and the other that toxifies (Gantenbein 2017, 9). This dose-response relationship explains not just the toxic properties, but the amount at which the compound is given. John Timbrell’s *Introduction to Toxicology* (2003) states measurements can be “all or none” lethal dosages or “graded” with specific enzymes (11). Any substance, even salt can be poisonous, if not prescribed at a certain threshold. Paracelsus’s belief that toxicity can be drawn to specific body parts, where “diseases and poisons were localized to particular organs”, would later be validated (3-4). Mathieu Orfila, 19th century Spanish physician, took a more scientific approach of detecting and treating poisons leading to forensic toxicology (5). He determined certain bodily tissues absorb chemicals, which he then proved through administration and recovery with animal experimentation. From this point forward, a toxicology exam was not considered thorough if it examined just “the gastrointestinal contents and or the suspected food or medicine” and not the entire body (Myers 1961, 181). These toxicologists embraced the relationship between dosage and the response that is likely to be encountered by humans and animals. They had the foresight to combine theory with practice and consider the human exposure to daily natural and occupational toxicity levels and provide remedies.

Brush with Death describes the remarkable careers of Alice Hamilton and Robert Kehoe, toxicologists, born in the late 1800s, who revolutionized the story of lead in industrial medicine. Companies responsible for workers relied on “assumption of risk, contributory negligence, and fellow-servant rule”, which most workers did not contest or negotiate because the lead

companies were too massive (Warren 2001, 73). Hamilton's work through The Illinois Commission on Occupational Diseases made employers "provide safety measures and monthly medical examinations" to employees within the state (Nickels 2014). She had the "opportunity to lead the first survey of "industrial sickness" in the United States: to investigate workplaces that used lead, arsenic, brass, carbon monoxide, cyanides, and turpentine" (Nickels 2014). The manufacturing industry that worked with insidious chemicals, such as lead, were the focus for Hamilton's surveys, hunting for wherever she could find plumbism cases. Six states passed bills assuring the reporting requirement would be implemented, but Illinois was the only state to take Alice Hamilton and the Commission's recommendations to heart. The three-part protocol included "safety measures for reduction, examinations for prevention, and approved respirators…" (Warren 2001, 75-77). As important, was Hamilton's "groundbreaking research in recognizing the need for widespread dissemination of her findings" (Nickels 2014). Her research for causes and conditions of occupational hazards, as well as her advocacy for preventive measures, is so significant that her scientific advances are still recognized in the industry today.

Of equal prominence, in the 1920s physiologist Robert Kehoe was brought in to study the toxicity among automotive plant workers to stave off occupational hazards due to the inhalation of leaded gasoline (Warren 2001, 105). In 1921 to gain a competitive edge, General Motors added "tetraethyl lead, in the laboratory engine" of their cars (Needleman 1999, 5). "The tremendous payoff that would result from putting an effective anti-knock additive" on gasoline was too intriguing for GM to overlook (Warren 2001, 120). Soon after production of tetraethyl lead began, workers in all three plants began to go crazy and die, often in straightjackets. "Somewhere between 13 and 15 known deaths occurred, and over 300 men became psychotic" (Needleman 1999, 5). Kehoe, as Medical Director of the Ethyl Corporation and a corporate

officer at GM implemented strict cleaning standards and preventative recommendations. Similarly, to Alice Hamilton, the committee Kehoe served on acted to "isolate hazardous processes, reduce the amount of dust; install adequate ventilation; provide safety equipment … and insisted on their use" (Warren 2001, 122). Later, he found the Kettering Laboratory of Applied Physiology, where he recognized the harmlessness and harmfulness of lead … and the necessary thresholds level to prevent poisoning (130). During this time, the effects of toxins, specifically lead poisoning had become an environmental, pediatric, and occupational hazard. Tetraethyl lead from car exhausts, flakes of lead paint, water, food, air contamination, and manufacturing conditions were just a few lead poisoning examples that contributed to death, mental retardation, physical impairments, and insanity (Timbrell 2003, 128-130). *Brush with Death* states three risks of tetraethyl lead: purity was deadly, its public exposure received no attention, and the oxides effect on public health (Warren 2001, 123). EPA guidelines issued in 1992, set forth principles and procedures to guide scientists in the conduct of risk assessments and to inform decision makers and the public about procedures in regard to lead exposure (9). Hopefully, governmental agencies will take an active part in detecting and remedying harmful effects of lead poisoning. Regardless, toxicologists Hamilton and Kehoe were regarded with high acclaim as advocates of workers exposed to lead inhalation and their work was respected well into the 1960s.

In the twenty-first century, the risks of lead poisoning are just as bad and continue to bring a health and mortality crisis to communities, most notably in the Flint water crisis. Marc Edwards and Dr. Mona Hanna-Attisha are credited for discovering the water contamination that affected residents of Flint, Michigan. While I will delay discussions of Dr. Mona Hanna-Attisha's contributions to the revelation of the Flint water crisis until we read *What the Eyes*

Don't See, Marc Edwards, an engineer, professor, and activist had previously uncovered the Washington, DC water crisis in the early 2000s, which tested for high levels of lead contamination, due to aging lead pipes. The government was slow to provide him with the reports and access he needed to properly document the contamination; but after that water crisis, he knew that another urban community besides DC would rely on his expertise one day. Then came Flint. He crossed "the line between science and activism" utilizing $150,000 of his own funds to assist 12,000 children exposed to high levels of lead affected by the Flint, Michigan tap water contamination crisis (Gewin 2016). In essence, Edwards risked his credibility by claiming reports were falsified, volunteering his time, and issuing Freedom of Information Act requests. He had many government antagonists in Flint. Originally, public officials claimed corrosion material control was unnecessary, continuing to attack Edwards and his team (ACLU Michigan 2016). Between April of 2014 and August of 2015, the water lead levels of data collected were deemed insufficient, as samples did not meet national criteria. They failed due to pre-flushing tactics, ignorance of testing lead service lines, and sampling in new property areas. Edwards and his team proved government officials wrong by sampling data with repetitive protocols from the same sources, truly understanding the levels throughout 2016 (Roy et al. 2019, 475). He detected levels of lead beyond normal thresholds rising from 104-707 μg/L over 10 months (Pieper et al. 2017, 2007). Testing revealed these levels were a result of "the destabilization of lead-bearing corrosion rust layers that accumulated over decades" explaining the discoloration which was likely a result of flushing (2007). The implications of ground zero have proven that one glass of water could increase a child's blood lead level by 0.5 μg/L as result of no corrosion control (2012). Results called for a national pandemic centered around Flint.

According to the ACLU documentary *Here's to Flint* (2016), Flint should have had an Optimized Corrosion Control Program utilizing phosphate, but that was not in place; Jerry Ambrose, a manager for the town and Michigan Department of Environmental Quality (MDEQ) insisted that lead was in the range of normal levels. Marc Edwards' goal to disapprove the case was lofty involving testing of homes, such as Lee Anne Walters, for over two years, before Michigan Governor Rick Snyder appointed a commission. At first, the MDEQ dealt with the situation by focusing on the conversation of lead infrastructure, such as piping. They denied the claims of Edwards study and his collaboration with Dr. Mona Hanna-Attisha, a pediatrician from Hurley Medical Center, who revealed high levels of lead during routine blood tests of children. The commission's results were terrifying to say the least, they found that MDEQ was more worried more about discrediting others than solving the problem at hand (ACLU Michigan 2016). Two years later, thousands affected, and only five resignations, Flint serves as a primary example of lead poisoning and scientists becoming community activists; four years later, new reports indicate that Flint is ground zero for Legionnaires disease. Life expectancy has decreased by over 15 years (Gross 2018). The majority of the EPA's budget "flows directly to the states" who don't have enough money to fund environmental causes (Stateside Staff 2017). Edwards and Hanna-Attisha have been awarded numerous accolades for the detection, resolution, and advocacy for citing the harmful effects of lead contamination in water -- and luckily for society, their work continues.

In 2019, under the Trump Administration, toxicologists claim that water contamination will persist, as cuts to the EPA are made. Toxicology will continue to affect the world we live in as mankind populates and pollutes. The importance of placing trust and respect with toxicologists and scientific evidence to understand the connection between the environment and

health risks is paramount. Protocols and safeguards to avert occupational hazards must be established and given equal importance to profits, in corporate America. From the beginning of time, toxins have affected humans in adverse ways, often leading to death. The pioneers of toxicology prioritized the health of communities and placed their careers in jeopardy. Activism and civil disobedience must prevail in the face of toxin deniers; and unfortunately, the story from DC to Flint, is just the beginning.

References

ACLU Michigan. "Here's to Flint." YouTube video, 44:54. March 8, 2016. https://youtu.be/x7ULFSaMooA

Borzelleca, Joseph F. 2000. "Profiles in Toxicology. Paracelsus: Herald of Modern Toxicology." *Toxicological Sciences* 53 (1): 2–4.

Environmental Protection Agency. 1992. "Guidelines for Exposure Assessment." *Federal Register* 57(104): 22888-22938. https://www.epa.gov/sites/production/files/2014-11/documents/guidelines_exp_assessment.pdf.

Gantenbein, Urs Leo. 2017. "Chapter 1 - Poison and Its Dose: Paracelsus on Toxicology." In *History of Toxicology and Environmental Health*, edited by Philip B T - Toxicology in the Middle Ages and Renaissance Wexler, 1–10. Academic Press.

Gewin, Virginia. 2016. "Turning point: Activist Engineer." Nature. Last modified September 14, 2016. https://www.nature.com/naturejobs/science/articles/10.1038/nj7620-439a.

Gross, Terry. 2018. "Pediatrician Who Exposed Flint Water Crisis Shares Her 'Story Of Resistance.'" NPR. Last modified June 25, 2018. https://www.npr.org/sections/health-shots/2018/06/25/623126968/pediatrician-who-exposed-flint-water-crisis-shares-her-story-of-resistance.

Myers, Richard O. 1961. "2—Mathieu Joseph Bonaventure Orfila (1787–1853)." *Medicine, Science and the Law* 1 (2): 179–85.

Needleman, Herbert L. 1999. "History of Lead Poisoning in the World." Biological Diversity. Accessed September 21, 2019. https://www.biologicaldiversity.org/campaigns/get_the_lead_out/pdfs/health/Needleman_1999.pdf.

Nickels, Leslie. 2014. "A Voice in the Wilderness: Alice Hamilton and the Illinois Survey." Center for Disease Control and Prevention. Last modified April 28, 2014. https://blogs.cdc.gov/niosh-science-blog/2014/04/28/alice-hamilton/.

Pieper, Kelsey J, Min Tang, and Marc A Edwards. 2017. "Flint Water Crisis Caused by Interrupted Corrosion Control: Investigating 'Ground Zero' Home." *Environmental Science & Technology* 51 (4): 2007–14. https://pubs-acs-org.newman.richmond.edu/doi/10.1021/acs.est.6b04034.

Roy, Siddhartha, Min Tang, and Marc A Edwards. 2019. "Lead Release to Potable Water during the Flint, Michigan Water Crisis as Revealed by Routine Biosolids Monitoring Data." *Water Research* 160: 475–83. https://www.sciencedirect.com/science/article/pii/S0043135419304865.

Stateside Staff. 2017. "Toxicologist says cuts to EPA mean Flint won't be the only community with unsafe water." Michigan Radio. Last modified July 31, 2017. https://www.michiganradio.org/post/toxicologist-says-cuts-epa-mean-flint-won-t-be-only-community-unsafe-water.

Timbrell, John A. 2003. *Introduction to Toxicology, Third Edition*. Vol. 3rd ed. London: CRC Press.

Warren, Christian. 2001. *Brush with Death: A Social History of Lead Poisoning.* Baltimore: John Hopkins University Press.