## B100 The Power of Statistics and Machine Learning Applied to Orthogonal Rapid Methods for the Identification of Inorganic Gunshot Residue (IGSR) and Organic Gunshot Residue(OGSR) Markers

*Korina Menking-Hoggatt, MS*, Morgantown, WV 26501; Colby E. Ott, MS, Shippensburg, PA 17257; Courtney H. Vander Pyl, MS, Department of Forensic and Investigative Science, Morgantown, WV 26506; Tatiana Trejos, PhD, West Virginia University, Morgantown, WV 26506; James M. Curran, PhD*, University of Auckland, Auckland 1142, NEW ZEALAND*

**Learning Overview:** After attending this presentation, attendees will be aware of a novel fast approach to detect IGSR and OGSR and machine learning tools to interpret the data.

**Impact on the Forensic Science Community:** This presentation will impact the forensic science community by presenting a method to rapidly detect GSR that could provide investigative leads and improve intelligence operations for firearm-related crimes, which could create a greater sense of well-being in society, considering the risk to public safety posed by firearms.

Machine learning is a powerful tool for providing rapid information in our data-driven world. Reliance on these algorithms extends to everyday life in order to search the internet, to provide directions when traveling, to protect devices using facial recognition, and to enhance the reliability of a medical diagnosis, to name a few applications. Machine learning can be applied to the identification and interpretation of forensic evidence, providing fast results when time is of the essence. Firearm-related investigations is a field in forensics that requires fast decision-making. In one example, acoustic systems have been adopted in more than 90 United States cities to detect the location of possible gunshots and allow for police response to the scene in a matter of minutes. In another example, the current method of detection of GSR from the hands of individuals of interest is time-consuming and cannot deliver results fast enough to provide efficient investigative leads. This research presents the development of a rapid method for the detection of both IGSR and OGSR using two orthogonal technologies: Laser-Induced Breakdown Spectroscopy (LIBS) and Electrochemistry (EC), with machine learning for data interpretation.

A study was conducted on 100 background samples and 80 known shooter samples collected using conventional GSR stubs (carbon adhesive on aluminum Scanning Electron Microscopy [SEM] pin mounts) and processed using two sequential rapid methods on the same sample. First, LIBS was conducted using micro-chemical mapping to provide IGSR detection within less than two minutes per sample. Following LIBS, EC was performed on the same stub. The ablation area was spiked with 50µL of acetate buffer pH 4.5 followed by 50µL of acetonitrile, which was evaporated and reconstituted with the aqueous fraction before being applied to a disposable Screen-Printed Carbon Electrode (SPCE). Square-wave voltammetry was applied for an analysis time within five to ten minutes. Lastly, data preprocessing was performed for the application of three different prediction algorithms: Naïve Bayes, logistic regression, and a neural network.

LIBS allowed the detection of IGSR markers (lead [Pb], barium [Ba], antimony [Sb], copper [Cu], aluminum [Al], zinc [Zn]) while electrochemistry complemented the detection of IGSR (e.g., Sb, Cu, Zn, and superior detection of Pb) and also identified the presence of OGSR compounds, such as 2,4-Dinitrotoluene (DNT), Diphenylamine (DPA), Nitroglycerin (NG), Methyl Centralite (MC), and Ethyl Centralite (EC). The performance of these methods was evaluated individually, then combined. Alone, the accuracy of the LIBS method was better than 86%, and the EC method was better than 75%, depending on the classification method. When the two techniques were combined, the accuracy improved to better than 92%.

In the future, this study will be expanded to include modern ammunition that could lack the typical GSR markers of Pb, Ba, and Sb to test the ability of machine learning to differentiate between different classes of ammunition. In addition, samples from individuals with professions or hobbies where false positives are common will be included and deemed a “high-risk” sample population. The high accuracy of the combined methods fills a critical need in the forensic science community for a rapid technique for the detection of GSR.

**Gunshot Residue, Machine Learning, Rapid Technology**



*Presenting Author