UNIVERSITY OF
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**FORENSIC SCIENCE
PROGRAM**

FORENSIC
SCIENCE
DAY

24th Annual Forensic Science Day

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**FORENSIC SCIENCE
PROGRAM**

FORENSIC SCIENCE DAY
STUDENT INTERNSHIP PRESENTATIONS

FORENSIC SCIENCE AT THE UNIVERSITY OF TORONTO MISSISSAUGA

Each year, the Forensic Science Program attracts some of the brightest students from around the world to take part in our unique education experience. The program admits roughly 130 students per year out of the hundreds who apply. Over the last few years, students have joined us not only from every province east to west, but also internationally from many different countries.

Students obtain an Honours BSc Degree in Forensic Science by choosing to complete one of our four Specialist Programs: Forensic Anthropology, Forensic Biology, Forensic Chemistry or Forensic Psychology. Alternatively, students can choose to complete a Forensic Science Major in conjunction with a second major from one of the following disciplines: Anthropology, Biology, Chemistry, or Psychology. In addition to the above programs, we have also just recently introduced a new Minor Program in Forensic Science. The Minor Program can be taken in combination with any specialist or major program, including those from the Social Sciences and Humanities. This Minor program complements degrees in criminology, sociology, geography, political science, and any other field that intersects with the legal system.

Students in our program learn forensic theory as well as at least one applied skill set through lectures and labs. Today, we are celebrating the hard work and success of our Specialist degree students.

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**FORENSIC SCIENCE
PROGRAM**

INTERNSHIP IN FORENSIC SCIENCE AND THE IMPORTANCE OF MENTORS

FSC481 and FSC483 are the fourth year internship courses required for all graduates of the Forensic Science Specialist Program at the University of Toronto Mississauga. In addition to spending at least 200 hours at a forensic agency participating in on-the-job training or job shadowing, assisting with professional tasks and collaborating with a professional forensic specialist on an original research project, students also attend classes on professional practice and research skills. Experiential learning combined with a first class science degree is the keystone of the UTM Forensic Science Program. Successful internships benefit the student, the mentor, and the agency through an exchange of ideas, learning opportunities, and resources dedicated to addressing a research problem or question of interest to the forensic agency and its employees. Forensic Science Day is the culmination of these partnerships.

In addition to class assignments designed to develop professional skills (a mock job interview, writing a cover letter and resume, practice presentations, critical assessment of colleague's research, and a mock trial), students also learn research skills such as obtaining ethics permission for research and writing a detailed research proposal. The research results are submitted in the form of a manuscript suitable for publication, written to the specifications of the Journal of Forensic Sciences. After final grading and editing by the course instructor, we anticipate that, with the mentors' approval (and given co-authorship), at least half of the research projects presented today will be accepted for publication in a peer-reviewed journal. We also ask that all students provide a PDF of their corrected paper to the FSC program to keep on file for future reference so that their data and conclusions can be made available to others in the forensic sciences.

It is our pleasure to thank the mentors, and to praise the initiative and efforts of these very bright students.

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FSC481Y5

INTERNSHIP IN FORENSIC SCIENCE

ADRIENNE CHIANG

Potential of false positives in a roadside oral-fluid device, Dräger DrugTest 5000 (DDT 5000)

ABSTRACT

Background: Roadside oral-fluid testing device has been approved in Canada since 2018 to detect the presence of drug in suspected drug-impaired drivers. Careful considerations need to be taken when dealing with the possibility of false positives. In Canada, DDT 5000 has been approved for use for the detection of two commonly encountered drugs in impaired driving cases: tetrahydrocannabinol (THC) and cocaine. **Purpose**: The purpose of this research is to evaluate the potential of false positives in the roadside oral-fluid device, Dräger DrugTest 5000 (DDT 5000) using potential interferents based on the frequency of use (gum, mouthwash) and media reports of false positives (poppy-seed cake). This research is significant because it can establish the reliability of this device and provide law enforcement with valuable evidence during a drug-impaired driving investigation. **Methodology**: Thirty volunteers (n=19 females, n=11 males) participated in the study. An oral fluid sample from each individual was obtained prior to the start of testing using the DDT 5000 and its test cartridge. Sample groups were limited to volunteers who were drug-free. Once subject had provided a negative result, they were assigned to one of the three groups (n=10 for each interferent). A second oral fluid sample from all three test groups was obtained immediately after exposure to the interferent. **Results**: In all test subjects, no positive THC or cocaine results were detected using the Dräger DrugTest 5000. **Conclusion**: The results of the study show that the use of either gum, poppy-seed cake or mouthwash immediately prior to the test did not produce any false positive results in any test subjects for either THC or cocaine.

Keywords: forensic science, forensic chemistry, oral fluid, false positives, THC, cocaine, impaired driving

Supervisor: Dr. Karen Woodall, Assistant Professor, Teaching Stream, University of Toronto Mississauga

ALISHA BAGGA

Which of the *Lucilia sericata* artifacts yield the most human DNA?

ABSTRACT

Purpose: the purpose of this research is to determine which blowfly artifact yields the most human DNA by testing samples of blowfly artifacts obtained from flies fed on human blood using real-time polymerase reaction. The usage of this research is significant to laundered blood spatter scenes where the body itself or a reliable source of DNA is not present. **Background**: blowfly species, *Lucilia sericata* act as decomposers at crime scenes where bodily fluids such as blood are present, they ingest this source of food and create patterns resembling bloodstains called artifacts. These artifacts contain human deoxyribonucleic acid (DNA) which can optimize DNA evidence collection. **Methodology**: Fifty *Lucilia sericata* pupae were placed inside a wooden cage made of two mesh walls, three white Bristol board walls, and one wall with a mesh entrance. Once they emerged, they were then provided 20mL of fresh human blood. The blowflies were allowed to feed on the blood source and deposit artifacts for three days. Deposit surfaces were swabbed using the Copan and Puritan swabs for both types of artifacts. Artifacts were categorized based on physical characteristics such as shape, light, texture and size. To assess DNA yield, the Qubit and QuantStudio-5 apparatuses were used. **Results**: The Mann-Whitney-Wilcoxon Test indicated that the two artifacts do not differ significantly in yield of human DNA (p-value=1). Furthermore, if both non-human specific and specific DNA yields are considered, the difference is still insignificant (p-value=0.24). **Conclusion**: Due to there being an insignificant difference in the type of artifact collected and its DNA yield, both artifacts should be collected. Pooling the two artifacts may suggest a larger DNA yield hence assist in DNA profiling. A human specific DNA quantification method shall be used.

ANJALIKA BALASURIYA

Characterization of the Canadian South Asian population

ABSTRACT

Purpose: The purpose of this research was to generate allele frequencies at forensically relevant short tandem repeat (STR) loci for the Canadian South Asian population by utilizing massive parallel sequencing (MPS) technology. This research is significant as it investigated the unique genetic diversity present in the Canadian South Asian population. **Background**: The generation of a deoxyribonucleic acid (DNA) profile and its corresponding statistics rely upon accurate allele frequencies generated for specific populations. Such large-scale Canadian population studies relevant to the field of forensics are scarce. In this research, allele frequencies for the understudied Canadian South Asian population were generated using a newer method of DNA analysis known as MPS. This technology allows for the identification of unique sequence variation within alleles at STR loci as well as their allele lengths, which have traditionally been obtained by capillary electrophoresis. **Methodology**: This research analyzed 96 sample extracts from self-identified Canadian South Asian individuals. The concentration of DNA in these extracts was quantified and then sequenced using the MiSeq FGx™ Forensic Genomics System (Illumina). **Results**: Allele frequencies at 27 loci were calculated, as well as Hardy-Weinberg equilibrium (HWE) and linkage disequilibrium (LD). Chi-squared test results are pending. **Conclusion**: Final conclusions are yet to be determined. This research provides forensic biologists with reliable allele frequencies for more accurate DNA profile statistics. Moreover, this research has far-reaching implications for the overall scientific community as it provides novel information about the genetic make-up of Canada's population.

Keywords: forensic science, forensic genetics, allele frequency, Canadian South Asian population, massive parallel sequencing, short tandem repeat

Supervisor: Dr. Nicole Novroski, Assistant Professor, Research Stream, Department of Anthropology, University of Toronto Mississauga

ALESSIA CAMPOLI

Determining the efficacy of the WRPS POP: effects of age and residency

ABSTRACT

Purpose: The purpose of this research is to determine how effective the Waterloo Regional Police Service's (WRPS) Prolific Offender Program (POP) is compared to the British Columbia Priority Prolific Offender Program (PPOP), in reducing recidivism. It also aims to examine the effects of age and residency on the efficacy of the WRPS POP. This research is significant as PO's pose a great threat to public safety. Thus, it is pertinent to determine if the WRPS POP is achieving its goal. **Background**: Prolific Offenders (PO)'s are known to commit offences at high frequency, hindering many goals set out by the Criminal Justice System, thus PO management strategies have become increasingly popular. In 2017, the WRPS launched their POP modelled around programs implemented in Alberta and BC a decade prior; a major difference is that the WRPS POP does not offer rehabilitative services. Rather, this program aims to reduce recidivism by increasing surveillance/sentencing of PO's, despite well-established literature suggesting tough on crime strategies are unsuccessful. Research also suggests that young offenders and those who lack suitable housing are more likely to reoffend. **Methodology**: This pre-post study entailed a secondary analysis of archival data previously collected by the WRPS. 19 male PO's aged 21-54 comprised the sample. Data was obtained from both the WRPS PO tracking sheet and criminal records; number of offences, number of negative police interactions, and maximum sentences were tallied and recorded for each offender, for both time periods. Offenders were then grouped based on age (21-37)/(38-54) and if they had provided police with an address (Yes/No). **Results**: A Wilcoxin signed-rank test indicated that the POP was only successful in reducing number of offences (p= 0.05) and number of negative interactions (p=0.01) in PO's aged 21-37, who provided an address. **Conclusion**: Overall the BC PPOP was found to be more effective in reducing recidivism than the WRPS POP; proving the importance of rehabilitative services. Additionally, age and residency do seem to effect the efficacy of this program, such that offenders 21-37 who provided an address showed the most significant improvement.

Supervisor: Dr. Nicole Novroski, Assistant Professor, Research Stream, Department of Anthropology, University of Toronto Mississauga

CATERINA CAVALLO

The impact of adverse childhood experiences on treatment responsiveness for adult male incarcerated offenders

ABSTRACT

Purpose: The purpose of this research is twofold: to evaluate the effectiveness of the Freedom from Substance Abuse (FFSA) treatment program at the Ontario Correctional Institute (OCI); and, to determine if childhood adversity predicts treatment responsiveness among adult male offenders. This research contributes to a larger discussion on how to treat offenders who have experienced childhood trauma. **Background**: Childhood adversity is a significant predictor of criminal versatility and recidivism; however, little is known about the relationship between childhood adversity and treatment responsiveness. Preliminary research with clinical patients suggests that high exposure to adversity may reduce treatment responsiveness. **Methodology**: Analyses were conducted using secondary data collected from 259 adult male offenders between 2014 and 2018. These offenders completed the FFSA program while serving provincial sentences at OCI. To evaluate the FFSA program, pre- and post-treatment scores from six assessment measures were compared. Scores from the Adverse Childhood Experience (ACE) Questionnaire were used as an index of childhood adversity. The relationship between ACE scores and pre-post change on all six assessment measures was examined. **Results**: Paired-sample t-test results indicated that post-treatment scores differed significantly from pre-treatment scores across all six measures. The post-treatment changes were in the expected direction of change. Regression analyses indicated that change scores were independent of ACE scores across all assessment measures. **Conclusion**: The results indicate that the FFSA treatment program is effective. Regression analyses suggest that childhood adversity is a distal risk factor that seems to have a weak association with treatment responsiveness in adulthood.

Keywords: forensic science, forensic psychology, childhood adversity, ACE questionnaire, treatment responsiveness, offenders

Supervisor: Dr. Christopher Koegl, Research Director, Ontario Correctional Institute

GRACE CHAN

Evaluating Ca:P ratios in bone and correlations to age at death

ABSTRACT

Purpose: The purpose of this research is to increase understanding of age-related calcium to phosphorus (Ca:P) ratio changes in bone, including how to best analyze this relationship. This research is significant because it will aid in the development of new forensic techniques for age estimation. **Background**: Past research suggests that there is a significant negative correlation between the age of an individual and the Ca:P ratio in bone. The current study seeks to validate this correlation and will additionally evaluate the most appropriate area of bone from which to obtain Ca:P ratios. **Methodology**: The sample consists of 12 femoral bone sections, sourced from males between ages 60-100 at time at death. An SEM/EDX was utilized to obtain Ca:P ratios for each sample in three microscopic views: full field of view, osteons only, and interstitial lamellae only (within the same field of view). **Results**: A Pearson's correlation test indicated that the Ca:P ratios obtained from the samples have a moderate negative correlation with age in the full field of view ($r=-0.5$) and interstitial areas ($r=-0.36$), and a weak negative correlation in the osteonal area ($r=-0.03$), but none of these correlations were statistically significant. Paired t-tests indicated that a statistically significant difference was found between the full field of view and interstitial lamellae only (p-value $=0.006$). **Conclusion**: Additional data collection will be performed to enlarge the sample size for a more comprehensive validation study, but this data supports that a full field of view should be used for analysis going forward.

Keywords: forensic science, forensic anthropology, age estimation, biological profiling techniques, calcium phosphate ratio

Supervisors: Dr. Tracy Rogers, Forensic Anthropologist and Associate Professor, University of Toronto Mississauga; Celine Moyen, M.Sc. candidate, University of Toronto Mississauga.

VICTORIA CHEUNG

Accuracy and reproducibility of bloodstain pattern analysis using Leica Map360

ABSTRACT

Purpose: The purpose of this research is to determine the accuracy and reproducibility of blood spatter area of origin (AO) calculation using the Leica Model RTC 360 scanner in conjunction with the bloodstain pattern analysis (BPA) module in the three-dimensional (3D) software program, Map360, to test the validity of the software in accurately calculating true AO. Validating Map360 will allow the software to be utilized in future criminal investigations involving BPA. **Background**: The AO is the calculated 3D location of where stains converge. Map360 visualizes, analyzes, and interprets the AO. Calculating the AO can lead to information about what occurred at the scene, the manner of death, and corroborate or refute eyewitness testimonies. The recommended error range for AO has been found to be 20cm and has been used in past research studies. **Methodology**: The sample consists of 15 impact patterns, with the impact device at a height of 100cm and distances of 50, 75, and 100cm. 2mL of sheep's blood was used per impact, at a temperature of 36ºC. The angle of the device arm was set at 55º for 50cm and 65º for 75 and 100cm. 5 impacts were made at each distance. Scans were taken of the impacts at a high resolution of 3mm at 10m using the laser scanner. The scans were aligned using Register360 and then imported into Map360. ~30 stains were analyzed per impact. 4 analysts will process the data utilizing the BPA module in Map360 to test the repeatability. **Results**: This research is ongoing. To date, the researcher has analyzed the Y and Z coordinates, where Y is the height and Z is the distance, for all 15 trials. The trials analyzed at a distance of 50cm and 75cm have an average deviation of less than 20cm from the known Y and Z coordinates. The trials analyzed at a distance of 100cm have an average deviation of more than 20cm from the known Y coordinate, however, the average deviation for the Z coordinate was less than 20cm from the known. **Conclusion**: The results of the research will discuss the error rates associated with the calculated AO as well as the inter-observer error. If the Y and Z coordinates deviate less than 20cm from the known AO, it can be concluded that Map360 has an acceptable BPA module. Future work can be done by Leica to improve their BPA module if the coordinates deviate more than 20cm from the known. Overall, the findings may serve as a validation for the BPA module in the software when conducting bloodstain pattern analysis.

Keywords: forensic science, bloodstain pattern analysis, accuracy, Map360, validation, impact pattern

Supervisor: Brad Joice, Detective Sgt., York Regional Police Forensic Identification Unit

NATALIE CUEI

Effectiveness of fluorescent fingerprint powders in developing quality prints on bank countertops

ABSTRACT

Purpose: The purpose of this research is to assess the effectiveness of various fluorescent fingerprint powders at developing identifiable prints on multi-coloured bank countertops. This research is significant because it quantitatively compares the effectiveness of different fluorescent powders against each other and help inform and improve scenes of crime officers' procedures. **Background**: High color contrast between the powder used and the background is required for a successful fingerprint development. In cases with bank countertops that are often multi-colored, non-fluorescent powders do not offer enough contrast. Therefore, fluorescent powders that can be visualized using alternative light sources have been proved useful. **Methodology**: A total of 560 latent prints of sebaceous (280) and natural (280) origins are deposited onto bank countertops and developed using seven types of fluorescent powders. Each of the developed prints are graded using the Bandey Scale, obtaining a score between 0-4. A non-identifiable print is scored between 0-2, and a print is identifiable if scored between 3-4. **Results**: Descriptive analysis indicated that most fluorescent powders developed identifiable prints for at least 80% of their respective sebaceous samples, except for Sciluminate. For natural prints, most fluorescent powders could only produce identifiable prints for 22%-66% of their samples. **Conclusion**: The most successful powder in both sebaceous and natural print samples is fluorescent magnetic, a powder already in use by the officers at the Toronto Police Service. The agency will use this study as a guide on the use of powders at scenes with bank countertops in questioned, such as robbery cases.

Keywords: forensic science, forensic identification, fingerprint development, fluorescent powders, bank countertops

Supervisor: Thomas Greer, Detective Constable, Toronto Police Service; Jaclyn Slaney, Lab Technician, Toronto Police Service; Cameron Power, Lab Technician, Toronto Police Service

JASSIMRAN GILL

Using ante- and post-mortem facial morphometry comparison for confirming identification

ABSTRACT

Purpose: The purpose of this research is to determine whether facial landmarks change ante- and post-mortem. This will be done by comparing linear distances, proportions and angles between different landmarks in ante- and post-mortem images of the deceased, so that a method for confirming identification of the deceased can be developed. This is significant because it will strengthen visual identification by decreasing subjectivity and increasing reliability. **Background**: Current methods used for identification include medical/dental records, fingerprints, DNA and visual identifications made by the coroner. These require ante- and post-mortem samples which can hard to obtain. Visual identification may lead to misidentifications due to its subjectivity. **Methodology**: There were 16 samples (8 experimental, 8 control) analyzed from which antemortem images were any piece of government issued ID and postmortem images were images taken at the provincial forensic pathology service. Facial landmarks were labelled, the linear distances and angles between the landmarks were measured from which proportions were calculated. **Results**: Paired T-tests indicated that the right and left endo-exocanthion proportions to the glabella and to the subnasale did not change significantly ($T=-1.15, df=6, p=0.29$; $T=-1.11, df=6, p=0.31$, and $T=-1.74, df=6, p=0.13$; $T=-0.50, df=6, p=0.64$, respectively) after death in the experimental group. Control group results for proportions also indicated that there were no significant changes ($T=-1.02, df=7, p=0.34$; $T=-1.74, df=7, p=0.13$, and $T=-2.11, df=7, p=0.07$; $T=-0.73, df=7, p=0.49$, respectively) between the right and left endo-exocanthions to the glabella and to the subnasale. **Conclusion**: The results of this pilot study indicate that there is no difference between ante and post-mortem which allow for confirming an identification for both treatment groups.

Keywords: Forensic Science, Forensic Anthropology, Forensic Pathology, Anthropometry, Facial Landmarks, Facial Recognition, Geometry-Based Extraction, Visual Identification.

Supervisor: Dr. Christopher Ball, Forensic Pathologist, Ontario Forensic Pathology Service

BEN-CHANOWAK JAMIR

Testing the effect of weight on Standardized Field Sobriety Test performance

ABSTRACT

Purpose: The purpose of this research is to determine if weight affects a sober individual's performance on the Standardized Field Sobriety Test (SFST). This research is significant because it will help provide scientific validation for the usage of the SFST. **Background**: The SFST is comprised of 3 components: The Horizontal Gaze Nystagmus, the Walk and Turn and The One Leg Stand. Past research has shown that the SFST is capable of indicating whether an individual has been driving over the legal intoxication limit. Not much research has been specifically done to show whether or not sober individuals can perform well on the SFST. The effect of weight on balance has been researched but not in the context of the SFST. **Methodology**: 18 sober males between the heights of 5'8 and 5'10 were made to participate in the SFST. Their weights, which were recorded with a scale, ranged from 129 to 205 lbs. Their scores for each component were assessed and recorded. **Results**: A chi-square test correlation test was conducted to see if any of the components were directly affected by weight. None of the tests showed a correlation between weight and the performance scores for any of the components. **Conclusion**: Weight does not have a correlation with how sober individuals perform on the Standardized Field Sobriety Test. This research provides validation to the usage of the SFST and it should continue to be used to test for impairment in the future.

Keywords: forensic science, Standardized Field Sobriety Test, SFST, sober, weight, height

Supervisor: Dr Vivienne Luk, Forensic Science Assistant Professor, University of Toronto Mississauga

CASSANDRA KAPSA

The use of liquid latex to recover latent fingerprints covered in debris on the exterior glass surfaces of vehicles

ABSTRACT

Purpose: The purpose of this research is to determine if latent fingerprints deposited on the exterior glass surfaces of vehicles, then covered in debris, can be recovered. This research is significant because it will aid investigators when processing vehicles involved in a crime. **Background**: Past research used liquid latex to lift soot to recover trace evidence. Recently, liquid latex has been used to recover latent fingerprints along the bottom of vehicles. **Methodology**: A total of 216 latent fingerprints were deposited on the exterior windows of three forensic vehicles. Three control and three experimental latent fingerprints were placed on each side window. The vehicles collected debris for either two, three or four weeks. After debris collection, liquid latex was applied to the experimental fingerprints. The underlying fingerprints were developed with white granular powder. Control fingerprints were developed directly with white granular powder. **Results**: A Chi-square test revealed a significant difference in fingerprint recovery between the control and liquid latex method (X^2=9.026, d.f.=1, p=0.003). An odds ratio determined that the control method increases the probability of latent fingerprint recovery by 2.68. Fisher's Exact test indicated that there is no statistically significant difference between the detail of the recovered control and experimental fingerprints (p=0.065). **Conclusion**: This study demonstrates the disadvantage of the liquid latex technique for vehicle processing on the glass exterior. If latent fingerprints are thought to be present on the exterior glass surfaces of vehicles, the control method should be used to improve vehicle processing by investigators.

Keywords: forensic science, forensic identification, Bandey scale, debris, latent fingerprints, liquid latex, vehicles

Supervisor: SC. Meadow Libby, SC. Michael Ho, Sgt. Annette Huys, Hamilton Police Forensic Services

MASHAL KHAN

Influence of extreme low ambient temperatures (below 0°C) on the shape of drip stains deposited at different heights

ABSTRACT

Purpose: The current literature on Bloodstain pattern analysis (BPA) lacks research analyzing the effect of temperature on the formation of bloodstains despite the extreme low temperature found across Canada. Therefore, the aim of this study was to determine whether extreme low ambient temperatures significantly affect the dimensions of bloodstains by comparing the diameter of circular drip stains deposited at different temperatures and heights. This study is a first step towards assessing the reliability of BPA techniques when applied in cold environments. **Background**: The dimensions of bloodstains are required for area of origin estimation and are dependent on physical properties of blood which can be influenced by ambient temperature. **Methodology**: 50µL of bloodstains, heated to 37°C were deposited at four temperatures; room temperature, 8 to10°C, -5 to -8°C and -27 to -29°C, from three different heights; 1m, 1.5m and 2m. Bloodstains were deposited on a non-absorbent surface at a 90° angle. There were 12 experimental sets with 20 trials/set (n=240). **Results**: The Kruskal-Wallis test indicated a significant decrease in the diameter of drip stains with a decrease in ambient temperature at all heights ($p<0.05$). Additionally, the analysis showed that effect of decrease in temperature became more significant as the height of deposition increased with larger effect size at higher heights; $\varepsilon 2 = 0.266$ at 1m, $\varepsilon 2 = 0.375$ at 1.5m and $\varepsilon 2 = 0.643$ at 2m. **Conclusion**: These results indicate that the current BPA techniques which rely on bloodstain dimensions might not be reliable when applied in cold environments thus, calling for further evaluation of these techniques.

Keywords: Forensic science, bloodstain pattern analysis, diameter, drip bloodstains, ambient temperature, height of deposition, reliability.

Supervisor: Irv Albrecht, Detective Constable, Forensic Identification Services, Toronto Police.

NINA LUI

An expert's perspective on communication with lawyers

ABSTRACT

Purpose: The purpose of this research is to investigate the communication between experts and lawyers by anonymously surveying experts on their experiences with lawyers. This research is significant because it will provide solutions to improve how forensic evidence is presented and used in court, assisting in preventing miscarriages of justice. **Background**: Forensic evidence is increasingly being used in court and has been linked to miscarriages of justice, notably in the Goudge Inquiry and the Motherisk Commission, where forensics was misunderstood, but several systemic issues are involved in miscarriages of justice. These inquiries also emphasized the role of counsel to understand the evidence and the expert to ensure its proper usage, and pre-trial meetings can aid with this. **Methodology**: A 50-question survey on Google Forms was emailed to experts at the Centre of Forensic Sciences to anonymously complete. The survey focused on pre-trial collaboration, the trial itself, and the expert's expectations and satisfaction level. **Results**: Chi-square tests showed no relationship ($p=0.079$) between the quality of questions during direct and cross examinations and a significant relationship ($p<0.001$) between Crown and Defence meeting beforehand, where Crown is 230.4 times more likely to meet with experts than Defence. Further, while all experts agreed that pre-trial meetings are useful and helps them feel ready to testify, their preferences for pre-trial meetings were often not the same as reality. **Conclusion**: Lawyers should take the time to properly meet with experts and adequately prepare for trial, ensuring that they are asking the right questions and avoid introducing any misunderstandings.

Keywords: forensic science, forensic psychology, communication, criminal justice system, expert opinion testimony, lawyers

Supervisor: Caitlin Pakosh, Assistant Crown Attorney and Instructor, University of Toronto Mississauga

ALEXANDER MIERZYNSKI

The effects of freezing temperature on bloodstain impact angles

ABSTRACT

Purpose: The purpose of this research is to determine whether freezing temperatures affect the calculation of bloodstain impact angles for gravity-produced droplets falling onto smooth surfaces. This research is significant as it will test the effectiveness of bloodstain pattern analysis (BPA) in relation to regions that experience below 0°C climates. **Background**: The Balthazard formula is the angle of impact is determined by calculating the width-to-length ratio of a blood droplet ellipse, then applying the inverse sine function to derive the apparent impact angle. The length/width dimensions of an impact angle can be facilitated through the 2-D ellipse program in Cloud Compare (ELlipser app): the analyst outlines an ellipse to fit inside the borders of a bloodstain shape. Bloodstain morphology depends on physical properties of blood: both viscosity and surface tension can increase if exposed to a decrease in ambient temperature, potentially influencing the shape of a bloodstain. **Methodology**: The sample consisted of 200x0.05 ml drops of human blood exposed to room temperature (22.2°C) and three freezing outdoor temperatures (0°C, -6.1°C, and -15.4°C). The blood was dropped from a constructed apparatus, at impact angles of 15°, 30°, 45°, 60°, and 75° onto sheets of printer paper. For each angle and temperature grouping, ten trials were conducted. Before all drop impacts, the blood was kept at 37°C. The paper sheets were scaled and photographed and the length/width of the stains were collected in the 2-D ellipse program, allowing the Balthazard's impact angle formula to be manually calculated. **Results**: A one-way ANOVA revealed significant differences in the 60° (p-value = 0.000) and 75° (p-value = 0.002) impact angle groups; both were strong enough to withstand the Bonferroni correction and remain significant. One-sample t-tests showed that freezing temperature groups yield results more closely associated with the real impact angle. **Conclusion**: This research suggests freezing environments are an unaccounted variable in BPA, contributing to different error rates, but the number of trials, limitations of impact angle function, and positioning of the ellipse tool contributed to bias. It is recommended that future studies repeat the methodology in temperatures below -15°C and employ rigid bias-prevention models.

Keywords: forensic science, bloodstain pattern analysis, angle of impact, Balthazard's formula, blood drop, freezing temperature, 2-D ellipse software

Supervisor: Michelle Pflug (MSc., CBPA), Forensic Identification Section, Ontario Police College

JENNY NGUYEN

The validity of the standardized field sobriety tests based on age and sex

ABSTRACT

Purpose: The purpose of this research is to determine whether the performance on the Standardized Field Sobriety Test (SFST) varies by age or sex for sober individuals using the SFST Battery Procedure. The significance is that a proper control study has not been made to determine the success/failure rate of sober individuals which makes the significance of a failed test less scientifically meaningful. **Background**: There is a decline in hand-eye coordination and perception skills as age increases. A 1998 study that focused on age differences in balance stability, where participants stood in a tandem stance, they concluded that the latter group involving the elderly had a 62% success rate. In a 1997 stabilometer platform study, the researchers looked at the difference in equilibrium performance between the sexes. The authors found that males had a greater instability due to having a higher center of gravity. **Methodology**: Sample size consists of 63 participants (28 females and 35 males) within the ages of 18-49. All participants are deemed healthy by the Erindale College Special Response Team (ECSpeRT) and undergo a Breathalyzer Test to confirm their sobriety. The participant is then evaluated on their performance on the SFST by the primary researchers. **Results**: Chi-square results indicate that sex is not a factor that influences the performance on the SFST. Statistical analyses were not performed on age-related data. **Conclusion**: Biological sex does not affect performance on the SFST and no conclusions were made regarding age-related data due to the study's limitations.

Keywords: forensic science, forensic toxicology, age, sex, sober individuals, Standardized Field Sobriety Test (SFST)

Supervisor: Dr Vivienne Luk, Forensic Science Assistant Professor, University of Toronto Mississauga

JOCELYN NGUYEN

Accuracy of backtracked trajectories for .45 and 9mm caliber handguns as a function of distance

ABSTRACT

Purpose: The purpose of the research is to quantify the angular errors resulting from the assumption that .45 and 9mm caliber handgun bullets maintain straight flight paths, as the shooting distance increases. This research is significant because it provides information on the accuracy of current trajectory reconstruction methods. **Background**: Current reconstruction methods assume that bullets fly in a straight line. In reality, a bullet's trajectory is parabolic due to aerodynamic forces. Therefore, the assumption that bullets maintain straight flight paths is a source of error. **Methodology**: An unloaded handgun (.45 cal and 9mm) was secured in a gun rest, with the barrel orthogonal gravity, and aimed at a drywall panel placed at a distance of 5m, 10m, or 20m. The FARO Focus S350 laser scanner recorded the scene. The gun was then loaded and fired. The laser scanner documented the area again. The process was repeated for a total of five shots per distance per handgun. The scans were exported into a trajectory analysis program to extrapolate the shooting angles. **Results**: The difference between the shooting angles before and after firing the gun lie between 0.18°-0.62° and 0.32°-0.74° above the line of bore for the .45 cal and 9mm respectively. Pearson's correlation coefficient found that shooting distance and angular errors were strongly negatively correlated: .45 cal, r(14)=-0.80; 9mm, r(14)=-0.87. **Conclusion**: Significant errors occur from the assumption of straight bullet flight paths, with an increasingly downward pointing bullet as shooting distance increases. New shooting reconstruction procedures should be developed to increase the accuracy of the reconstructions.

Keywords: forensic science, shooting reconstruction, bullet trajectory, external ballistics, laser scanner

Supervisor: Eugene Liscio, P.Eng., 3D Forensic Technologist, ai2-3D Forensics

ANGELA OLVER

The effects of camera resolution and distance on suspect height analysis using PhotoModeler

ABSTRACT

Purpose: The purpose of this research was to examine how camera resolution and the suspect-camera distance affect the accuracy and precision of photogrammetric suspect height measurements. This research is significant because suspect height can serve as exclusionary evidence and allow differentiation between multiple suspects at a scene. **Background**: Photogrammetry has been the standard method for suspect height analysis since the early 2000s due to its high accuracy and precision. Novel techniques for photogrammetry include software like PhotoModeler, and 3D laser scanners, which measure scenes to model them in 3D. While the method is validated for estimating height, factors like camera resolution and distance have been proposed as potential error sources. **Methodology**: Sixteen volunteers and a control stadia rod were filmed stopping at fifteen distance points on seven cameras [resolution settings 240p-4K, distances 2.6-66.5 m]. Still images from the footage were referenced to points in 3D laser scan data of the scene to calibrate them in PhotoModeler. Heights were measured on the images for comparison to known heights. **Results**: Kruskal-Wallis tests on error data provided p-values of 0.000 indicating significant differences, but data interaction plots showed no linear relationship for resolution, and the highest distance errors were at 2.6 m and 36.5 m. Precision ranged from +/- 0.45-1.2 cm, being greatest with higher resolution and closer distances. **Conclusions**: Accuracy and precision decrease at distances over 36.5 m and cameras under 720p resolution. The maximum error was found to be 3.5 cm, falling under the acceptable 5% threshold for height estimations.

Keywords: forensic science, suspect height, accuracy, camera resolution, distance, height estimations, photogrammetry, PhotoModeler, precision, 3D laser scanning

Supervisor: Helen Guryn, HBSc, 3D Forensic Technologist, ai2-3D Forensics

JESSICA REYNOLDS

Determining accuracy of area of origin for impact bloodstain patterns on the ground

ABSTRACT

Purpose: The purpose of this research is to determine the accuracy of area of origin for impact bloodstain patterns found exclusively on the ground. This study was completed by using the bloodstain tool in the FARO Zone 3D software in order to understand the errors associated with an area of origin analysis. **Background**: The bloodstain tool is a click and drag tool used to measure the size and impact angle of bloodstains. Virtual strings are created for all measured stains, in which the intersection of the strings is deemed the area of origin. **Methodology**: Impact bloodstain patterns were created on white butcher paper at 10cm, 20cm and 40 cm above the ground using a wooden piston traveling at 2.36 m/s. 5 trials were completed at each height, and 50 elliptical stains were analyzed per trial (n=750). Photographs and scans of each trial were analyzed in FARO Zone 3D. The latitude (x), longitude (y) and elevation (z) position and standard deviation of each area of origin was recorded. **Results**: A paired t-test indicated there was no significant difference (p value = 0.744) between the x and y coordinates (area of convergence), while an ANOVA test indicated there was a significant difference (p value = 7.63×10^{-12}) between the x, y and z coordinates (area of origin). **Conclusion**: The elevation (z position) is the main factoring influencing the accuracy of an area of origin analysis for impact stains on the ground. Accounting for elevation errors will ultimately increase accuracy.

Keywords: forensic science, bloodstain pattern analysis, FARO Focus Scanner, FARO Zone 3D, Forensic technology

Supervisor: Eugene Liscio, P.Eng., 3D Forensic Analyst, ai2-3D Forensics

RACHEL SHADOFF

Evaluating the accuracy of sequence-based phenotype predictions in an admixed population

ABSTRACT

Purpose: The purpose of this research is to evaluate the accuracy of phenotype markers for predicting hair and eye colour in an admixed population. This research is significant because phenotype predictions should only be used in criminal investigations if they are accurate in all populations. **Background**: DNA identification in criminal investigations is only possible when a suspect profile is available. In instances without a DNA profile for comparison, phenotype predictions can provide additional information about the perpetrator. Admixed individuals are those who have ancestry from 2 or more major population groups, and this diverse ancestry presents a unique challenge to phenotype predictions. **Methodology**: This research considers the sequencing data and phenotype predictions for 88 admixed individuals. Sequencing of DNA samples was performed using the ForenSeq DNA Prep Kit. Illumina's Universal Analysis Software was used to generate phenotype predictions. These predictions were compared to the self-identified hair and eye colour of each sample. **Results**: A majority of the samples failed to reach the prediction threshold of 70%. Using a two proportion Z test, eye colour prediction accuracy was shown to be significantly higher than hair colour prediction accuracy across all ancestral groups (p=0.0001). Higher than expected heterozygosity was observed at significant prediction locations, and the absence of intermediate eye colour markers resulted in a distinct lack of intermediate eye colours being predicted. **Conclusion**: Admixture has a profound impact on prediction accuracy. This data shows that phenotype predictions made using the ForenSeq Prep Kit should be interpreted with caution.

Keywords: forensic science, forensic biology, phenotype prediction, genetic admixture, ancestry and phenotype

Supervisor: Dr. Nicole Novroski, forensic geneticist, University of Toronto

NIKITA SHANKAR

Detecting the presence of blowfly activity in blood using the Phadebas® press test

ABSTRACT

Purpose: The purpose of this research is to determine if the Phadebas® Press Test is a suitable presumptive test for the presence of blowfly activity in human blood. This research is significant because there are currently no presumptive tests for the detection of fly activity. **Background**: Blowflies commonly found at crime scenes can create additional bloodstains. The Phadebas® test detects a digestive enzyme called alpha-amylase. This enzyme is present in blowflies. This test has not been used for the detection of alpha-amylase in fly artifacts with blood. **Methodology**: Newly emerged blowflies were placed in a mesh enclosure lined with cardstock paper and allowed to feed on human blood. 101 artifacts were collected via sterile swabs. Each sample was categorized as either regurgitated, defecated, or unknown stains. Samples were then placed on individual pieces of Phadebas® test paper with a weight on top. The paper was observed for up to 40 minutes. A blue colour change on the paper indicated a positive reaction and no colour change indicated a negative reaction. **Results**: Positive reactions were observed in 17 samples (16.8%). This data indicates that fly artifacts in blood do not produce a significant reaction to the paper. **Conclusion**: The trend towards a negative reaction indicates that the Phadebas® test may not be the best presumptive test to use for the detection of fly activity in blood. Some alpha-amylase was detected, but not at significant levels. This data can be used to identify a more appropriate presumptive test in the future.

Keywords: forensic science, forensic entomology, alpha-amylase, bloodstain pattern analysis, blowfly, Phadebas® Test, presumptive test

Supervisor: Detective Constable Clayton Asano, Peel Regional Police

KATIE SIEBER

Accuracy of Post-Mortem Interval (PMI) estimation for long-term submerged remains in Lake Simcoe using Accumulated Degree Days (ADD) and Total Body Score (TBS).

ABSTRACT

Purpose: This research evaluated the effectiveness of postmortem-interval estimation formulae (ADD $= 10^{(TBS^{1.6}+212)/125}$ and ADD$=10^{(TBS+3.706)/7.778}$) using accumulated degree days (ADD) for water temperature and total body score (TBS) for degree of decomposition. **Background**: TBS is a quantitative approach to assess decomposition wherein the decompositional stages of the body are arranged on a scale and utilized to convert decomposition into a measurement. ADD refers to the accumulated temperatures that a set of remains has been subjected to. This concept reflects the fact that the biological processes involved with decomposition are greatly dependent on temperature. **Methodology**: Two pigs (*Sus scrofa*) were submerged at various depths in Lake Simcoe. Video footage was obtained with a Deep Trekker DTG3 Expert ROV. Using the video footage, the decomposition of both pigs was assessed and scored following the Heaton and colleagues system. After ADD was calculated, the estimated submersion date was determined by subtracting the daily average water temperatures from the result until 0 was reached. **Results**: The Moffatt and colleagues formula was not accurate in predicting ADD. The estimated ADD for the shallow pig only was within the upper and lower 95% Confidence Intervals using the Heaton and colleagues formula. Cohen's kappa revealed poor to good inter-observer agreement for the scoring system. **Conclusion**: The Moffatt and colleagues formula was not useful. The Heaton and colleagues formula can only be reliably used to estimate PMI of remains for those submerged above 20 feet or with extensive decomposition.

Keywords: forensic science, forensic anthropology, accumulated degree days, long-term tissue decomposition, post-mortem submersion interval, total body score

Supervisor: Greg Williams, Ret. Staff/Sergeant, York Regional Police

KIM TRAN

The limitations found in exemplar fingerprints versus simulated crime scene fingerprints

ABSTRACT

Purpose: The purpose of this research is to determine if exemplar fingerprints can mimic the limitations of simulated crime scene prints using the Bandey scale to compare the level of detail. This determined whether exemplar prints can still be used to train AI or if it would limit the data found using databases such as AFIS. **Background**: AFIS uses an algorithm to search for fingerprints in its database however the results may take hours for latent fingerprints. One suggestion is to determine whether the quality of these would be different so that a new training method can be developed with simulated crime scene fingerprints over good quality ones. **Method**: 568 fingerprints were taken from 19 participants. The live scan Realscan-G10 (exemplar) was used for 190, 188 were deposited on glass, and 190 were deposited on a crowbar. The simulated fingerprints were developed with silver and black granular fingerprint powder respectively and photographed within 30 minutes of deposition. Each image was ranked from 0-4 on the Bandey scale. **Results**: A Wilcoxon rank sum test indicated that there is a significant difference between the quality of exemplar fingerprints compared to ones deposited on glass ($p = 1.8 \times 10^{-17}$) and the crowbar ($p = 7.8 \times 10^{-30}$). **Conclusion**: The quality of a fingerprint differed from the exemplar prints to latent prints. This data can be used to support another possible way to train the algorithms of databases such as AFIS improving the efficiency and lowering the time it takes to identify latent fingerprints.

Keywords: forensic science, forensic identification, fingerprint analysis, latent fingerprints, Artificial intelligence

Supervisor: Etienne Pillin, Founder and CEO, Clotho AI

MARIE CATHERINE VIAU

Ketoacidosis-related deaths: tolerance and lethality

ABSTRACT

Purpose: This research investigated why certain individuals can survive higher ketoacidosis levels than others by reviewing autopsy reports of ketoacidosis deaths to identify medical conditions decreasing survivability. Understanding underlying mechanisms and interactions of ketoacidosis allows its efficient prevention and identification in autopsies. **Background**: Ketoacidosis is the potentially lethal acidification of blood due to an increased level of ketone bodies, a substitute cell energy source. The two most common types are alcoholic (AKA), and diabetic (DKA) ketoacidosis. They are measured through femoral blood's levels of beta-hydroxybutyrate (BHB), a ketone body. **Methodology**: The 250 most recent ketoacidosis deaths autopsy reports at the Ontario Forensic Pathology Service were reviewed. Their BHB level, type of ketoacidosis, age, sex, body mass index (BMI), and heart, lungs, liver, or kidney diseases were recorded. **Results**: A Mann-Whitney U analysis ($\alpha=0.05$) confirmed that the BHB levels of AKA patients were significantly lower than those of   DKA patients (U=2027, p=4.3E-10). AKA and DKA patients only were tested, separately, lowering the sample size to 200. A Mann-Whitney analysis yielded no significant differences (p<0.05) between sexes, nor between the individuals with and without heart, lungs, liver, or kidney diseases. In DKA patients, the age has a significant moderate negative correlation with the BHB level (r = -0.33, p=8.5E-5), and the BMI a significant weak negative correlation with the BHB level (r = -0.28, p=0.007). **Conclusion**: The ketoacidosis type has a significant impact on survivability to ketoacidosis, age and BMI impact it slightly, and decreased heart, lungs, liver, or kidneys functions do not impact it at all.

Keywords: forensic science, forensic pathology, beta-hydroxybutyrate, cardiac, hepatic, pulmonary, renal

Supervisor: Dr. Maggie Bellis, Forensic Pathologist, Ontario Forensic Pathology Service

CHERLYNE WONG

Effectiveness of hypersexuality treatment in non-offending adult males

ABSTRACT

Purpose: The purpose of my research is to evaluate the effectiveness of hypersexuality treatment at the Centre for Addiction and Mental Health (CAMH). This research is significant because hypersexuality is highly prevalent in men convicted of sexual offenses and is correlated with increased recidivism. **Background**: Hypersexuality is a pattern of uncontrollable and excessive sexual fantasies, urges, and behaviours. It is characterized by sexual preoccupation and repetitive engagement, as well as unsuccessful attempts to reduce behaviours, and a disregard for potential harm or consequences. **Methodology**: 112 men that met the criteria for hypersexuality participated in 12-week treatment groups conducted from 2014 - 2019. Questionnaires assessing hypersexual behaviour, procrastination, relationship anxiety and avoidance, and self-efficacy were administered prior to and after treatment. 56% completed pre-treatment and post-treatment questionnaires. Paired t-tests were conducted for the pre and post-treatment scores and an independent t-test was conducted to compare the pre-treatment questionnaires of participants that completed post-treatment questionnaires and those that did not. **Results**: Participants demonstrated significant decreases on questionnaires assessing hypersexual behaviours after treatment. They also reported increased self-confidence, and decreased avoidance in their relationships. Treatment did not result in significant changes on procrastination or relationship anxiety. **Conclusion**: This research demonstrates that a 12-week, group-based, cognitive-behavioural therapy treatment is highly effective in reducing hypersexual behaviours, increasing self-confidence and reducing relationship avoidance. These findings can provide insight to sexual offending programs to reduce sexual recidivism.

Keywords: forensic psychology, hypersexuality treatment, sexual offending, recidivism

Supervisor: Dr. Ainslie Heasman, Clinical Psychologist, Centre for Addiction and Mental Health

GINN LI XUAN WONG

Enhancing bloodstain patterns on low contrast surfaces for digital Area of Origin analysis

ABSTRACT

Purpose: This investigative study aimed to assess the accuracy of Area of Origin (AO) analysis on low contrast surfaces using FARO Zone 3D (FZ3D) with either a chemical enhancement (CE) or Infrared (IR) photography to visualize the bloodstains. This helps to investigate whether these techniques are feasible to assist in criminal investigation. **Background**: The bloodstain's trajectories are established by marking the bloodstains in the photo that is aligned in FZ3D to determine AO. The contrast of surfaces and blood in the photo is then essential to facilitate marking, thus, IR photography and CE using Leucocrystal Violet (LCV) is employed to enhance the visibility of the bloodstains. **Methodology**: The total error (Etotal) used to compare these methods is calculated based on the difference between the known AO and the calculated AO obtained from 10 impacts, which were created 40cm away onto two red orthogonal walls. Three clusters of bloodstains with elliptical-shaped bloodstains were chosen, and photographed with three reference markers using four different technique: standard-DSLR camera (control variable), IR camera with 720nm lens filter (LF), IR camera with 850nm LF, standard-DSLR camera with LCV. Etotal of each technique is determined in FZ3D. **Results**: The mean and 50% error range of the enhancement techniques is lower than the control, but based on the Friedman test conducted, there is no significant difference among the Etotal of the techniques ($p > 0.05$). **Conclusion**: With 100% of the Etotal are within the accepted error range of 20cm, the improvement on the visibility of the bloodstains remains uncertain.

Keywords: forensic science, bloodstain pattern analysis, blood visualization, chemical enhancement, FARO Zone 3D, forensic photography, Infrared photography, leucocrystal violet, LCV, 3D forensic

Supervisor: Quan Le, HBSc., 3D Forensic Technologist, ai2-3D Forensics; Eugene Liscio, P.Eng., 3D Forensic Technologist, ai2-3D Forensics

CRYSTAL TONG WU

The effects of training on the ability of HRD canine to locate human remains

ABSTRACT

Purpose: The purpose of this research is to determine the effectiveness of field testing with distractors to improve the specificity of HRD canines in recovering human skeletal remains, reducing the number of false positives at crime scenes. In forensic investigations where decompositional fluids may no longer be associated with remains, improvement of skeletal remain detection by HRD canine is necessary. **Background**: Canines have a significant amount of olfactory sensory cells, capable of specialized scent detection. Through their enhanced detection skills, they are capable of distinguishing between different volatile organic compounds emitted during the decomposition process. Canines can be trained to recognize and indicate particular scents for the purposes of detection, primarily trained on fresh decomposition material. **Methodology**: Canine- and-handler teams repeated 3 trials of simulated field testing with the objective of locating 4 of the 6 planted human bones and avoiding 3 pig bones. Detection of each of the 9 bones present were scored nominally with 1 as 'indicated', 2 as 'shown interest in', and 3 as 'overlooked'. Results were compiled following each trial of field testing and compared. **Results**: Chi-squared tests were performed to determine whether increasing the number of field tests improved or worsened the ability of the canine to detect human or animal bones. The correlation value between the number of field tests and the successful detection of human bones was 0.019. The correlation value between the number of field tests conducted and the detection of animal bones was 0.185. A trend demonstrated that detection of animal bones decreased over the course of testing, but the null hypothesis could not be rejected as neither test achieved the critical value of 90% probability with two degrees of freedom (4.61). **Conclusion**: There was an insignificant correlation between the number of field tests conducted and improvement in the canine ability to detect human remains. This may be attributed to the small sample size and limited number of tests conducted.

Keywords: forensic science, forensic anthropology, detection canine, human remains detection, odour detection, skeletal remains, volatile organic compounds.

Supervisor: Dr. Tracy Rogers, University of Toronto Mississauga; Sgt. Michael McGuigan and Sgt. William Gillespie, York Regional Police Canine Unit

FILBERT YUNG

An investigation of demographic and drug-use patterns in fentanyl and carfentanil deaths in ontario

ABSTRACT

Purpose: The purpose of the research is to investigate demographic and drug-related patterns associated with opioid deaths in Ontario from June 2017 to December 2018 using data collected from the Coroner's Opioid Investigative Aid (OIA). This work aims to provide insight on how the opioid epidemic affects certain demographics to aid investigators conduct targeted analyses and help public health officials identify vulnerable communities. **Background**: The opioid epidemic in Ontario has seen opioid-related deaths double in the past years, from 676 deaths in 2014 to 1,474 in 2018, with an overwhelming prevalence of fentanyl and fentanyl-analogues. The presence of drug paraphernalia and a history of drug-use is often a strong indicator of a drug-related death, indicating a need for toxicological analysis. **Methodology**: OIA cases from June 2017 to December 2018 (n=2,403) were analyzed. Chi-square and logistic regressions were conducted to evaluate if age and sex were predictors for the presence of drug paraphernalia, and if drug paraphernalia, sex, age, or history of drug use were associated with causes of deaths (COD). **Results**: Chi-Square analysis revealed that sex (p<0.001), the presence of drug-use history (p<0.001), and the presence of drug paraphernalia at the scene of death (p<0.001) were significantly associated with CODs. Logistic regression analysis indicated that age (p<0.001, OR=0.963) influenced the probability of opioid-related deaths. Probability models relating age to various opioid-related CODs were also generated. **Conclusion**: These results demonstrated that fentanyl-related deaths are more associated with younger males, individuals with a history or drug-use, and deaths scenes with drug paraphernalia present.

Keywords: forensic science, forensic pathology, carfentanil, drug paraphernalia, fentanyl, Ontario, opioid,

Supervisor: Dr. Jayantha Herath, Deputy Chief Forensic Pathologist, Ontario Forensic Pathology Service

NINA ZIBAR

Investigating misconceptions about forensic science among lawyers

ABSTRACT

Purpose: The purpose of this research is to examine lawyers' misconceptions about forensic science in an effort to obtain their perspectives and potentially understand the origins of misconceptions they have regarding forensic science; as a first step in correcting them. The research is significant because misconceptions regarding forensic science may result in lawyers mispresenting their evidence in court which may impact the sentences accused receive. **Background**: Forensic science is based on the scientific method in order to provide conclusions about physical evidence while law relies on the constitution and players of the court such as the judge to operate. Their intersection in court and their differences in origin can potentially give rise to misconceptions in several different manners; three of which will be explored in this research. **Methodology**: The final sample size of this study was 24 individuals, with the inclusionary parameter being a licensed lawyer. Data collection was performed through a survey distributed through the listservs of the Criminal Lawyers Association. Fisher's exact tests were performed in order to determine if results were statistically significant. **Results**: This study found that there was no association between perception of Fingerprint and DNA evidence based on a lawyer having a background in science, experience working with a forensic scientist and watching crime drama. **Conclusion**: The results of this research show that there might be other factors resulting in misconceptions regarding forensic science among lawyers. Further research should focus on the use of a larger sample size, different types of lawyers and the consideration of other factors.

Keywords: forensic science, forensic psychology, forensic scientists, lawyers, misconceptions of forensic science.

Supervisor: Bhavan K. Sodhi, Claire Marie-Horsnell, The Innocence Project at Osgoode Hall

FSC483H5

COLLABORATIVE RESEARCH INTERNSHIP

AHMED AZEEMUDDIN

The use of adsorption isotherms to astimate the concentration of heavy metals in blood

ABSTRACT

Background: Some herbal medicines have been found to have toxic levels of heavy metals like arsenic. While fatalities are rare, that number is believed to be underreported. Traditional methods are costly, complex, and time-intensive. A semi-quantitative method can provide ease of you and relevant information. The Reinsch test is a qualitative test that previously has shown promise for semi-quantitative work but its dynamics are poorly understood. **Purpose**: The purpose of the research is to explore how the predictable the interaction between arsenic with the copper substrate of the Reinsch test is. The significance of the research is that it can be used as the basis for a time-efficient, affordable, semi-quantitative screening method for certain heavy metals in forensic work. **Methodology**: The Reinsch test was used to produce a calibration curve for arsenic from 1 ppm – 50 ppm. The Reinsch test was conducted by combining concentrated hydrochloric acid, tin (ii) chloride with an aqueous solution of arsenic in a test tube, adding a copper wire and heating the sample for approximately 30 minutes. The results were analyzed on the ICP-OES (Inductively Coupled Plasma – Optical Emission Spectroscopy) and then developed into an adsorption isotherm. **Results**: Average results show strong linearity from 3 ppm to 25 ppm. Individual trials showed high variance based on one-way ANOVA ($p=0.954$). **Conclusion**: The research provides a model of adsorption process of arsenic onto a copper wire in the Reinsch test. Arsenic extraction by the Reinsch test has considerable variance but may be predictable enough for semi-quantitative work.

Keywords: forensic science, forensic toxicology, adsorption isotherms, herbal medicines, heavy metal toxicity, Reinsch test

Supervisors: Dr. Vivienne Luk, Assistant Professor, University of Toronto Mississauga; Agata Gapinska-Serwin, Lab Technician, University of Toronto Mississauga

JULIETTE BÉLANGER-BIENVENUE

A novel analytical method for the screening of heavy metals: SEM-EDX conformation of Reinsch test

ABSTRACT

Purpose: The purpose of this research is to examine how different parameters affect the adsorption of heavy metals to the copper wire during the Reinsch test when analysed by the SEM-EDX. This research is significant because it will make the Reinsch test objective and standardise its method. **Background**: The Reinsch test is a well-established screening tool for heavy metals based on a colour change that has been used in forensic laboratories but has differing methods from lab to lab and is purely subjective. Colours commonly observed are variations of black and silver. **Methodology**: The Reinsch test was performed at 6 mg/L of Arsenic while changing one of the following variables: time in the water bath, length of the copper wire, or drops of Sn_2Cl. The plated copper wire was then analysed by the SEM-EDX to look at atom per cent. These tests were repeated three times ($n = 3$). **Results**: The amount of Sn_2Cl has no correlation to the atom per cent determined by the SEM-EDX ($r = 0.01$). The time trial had good correlation ($r = 0.97$) and the length trial had great correlation ($r = 0.99$) until both trials hit a plateau. **Conclusion**: The SEM-EDX does add an objective component and can be used to determine which heavy metals have plated following the Reinsch test. The Reinsch test's optimal parameters were 1 drop of Sn_2Cl, 1 cm of copper wire, and 45 mins in the water bath.

Keywords: forensic science, forensic toxicology, heavy metals, SEM-EDX, Reinsch test, analytical toxicology

Supervisor: Vivienne Luk, Assistant Professor, University of Toronto Mississauga

TSZ SHAN PHOEBE CHAN

Development and validation of a method for the quantification of heavy metals in whole blood using ICP-OES

ABSTRACT

Purpose: The purpose of the research is to develop a method for the quantification of selected heavy metals (lead, arsenic, bismuth and antimony) in whole blood to fill the gap of lack of established methods in the forensic community. **Background**: Heavy metal related death cases have been suspected, yet there is no established quantification method used in the forensic setting to confirm intoxication. **Methodology**: Sixty aliquots forensic sheep's blood were spiked with the four heavy metals at 50µg/L (around minimum toxic level, both single element and multiple element) were then homogenized with nitric acid and hydrogen peroxide at 4 different volumes and 4 concentrations, at 65-84oC using an electric hot plate until all liquid was boiled off. The remaining solid was re-dissolved in 1.5mL 2% nitric acid and the particulates were removed by either syringe filtration or centrifugation. The supernatant/filtrate was diluted to 5mL with 2% nitric acid for inductively coupled plasma optical emission spectroscopy (ICP-OES) analysis. **Results**: More of the target ions can be retained with centrifugation compared to the commonly used syringe filtering ($p < 0.005$, $\chi 2$-test). With centrifugation, arsenic shows promising results from the extraction, and low yield returned from lead. The instrument shows high limit of detection (LOD) for antimony and bismuth. **Conclusion**: The developed method is promising, but further optimization and validation are required to be adopted into the forensic science community. In order to lower the LOD to below the minimum toxic level, ICP- mass spectrometry which has lower instrumental LOD is recommended instead of the ICP-OES used.

Keywords: forensic science, forensic toxicology, analytical toxicology methods, heavy metal testing, inductively coupled plasma optical emission spectroscopy (ICP-OES)

Supervisor: Dr. Vivienne Luk, Assistant Professor, University of Toronto Mississauga; Agata Gapinska-Serwin, Lab Technician, University of Toronto Mississauga

TRACY THUY-TRAM VO

A literature review of the toxicity of heavy metals in herbal medicines

ABSTRACT

Background: Heavy metals in herbal medicines have been suspected to cause death, but current methods for heavy metal quantification are not used routinely. Thus, these deaths may be going undetected. **Purpose**: The goal of this research was to generate a range of toxic bodily levels for lead, arsenic, antimony, and bismuth, some of the heavy metals commonly found in herbal medicines, through a literature review. This is important to establish the limits of quantification in post-mortem fluids, and to assist forensic toxicologists in fatalities where heavy metals may be a contributing factor. **Methodology**: A comprehensive review of 34 articles, within the disciplines of toxicology, forensics, environment, medicine, and pharmacology, was conducted in three steps to generate a range of toxic concentrations: for each heavy metal, how the metal acts on the body was determined and the target location for toxicity was identified, at which the toxic levels were then generated. **Results**: According to the literature, lead toxicity occurs in blood at 50 - 2280μg/L (1,2). Arsenic and antimony cause toxicity in various areas, importantly in the muscles and liver, respectively (3,4). Bismuth causes toxicity primarily in the kidney (5). The toxicity levels for the latter three metals in their target locations could not be determined. **Conclusion**: There is only sufficient information to establish a limit of quantification for lead. Data regrading heavy metal toxicity in bodily fluids other than blood is limited, providing a focus of further research in order to contribute to the body of literature.

Keywords: forensic science, forensic toxicology, heavy metals, herbal medicines, mechanism of toxicity, toxicity level

Supervisors: Dr. Vivienne Luk, Assistant Professor, University of Toronto Mississauga; Agata Gapinksa, Laboratory Technician, University of Toronto Mississauga

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WILSON WAI-YIP CHUNG

Factor analysis of experimental parameters affecting the quantification of heavy metals in whole blood using ICP-OES

ABSTRACT

Purpose: The purpose of this research is to identify the most significant factors affecting the quality of data in the quantification of bismuth, arsenic, antimony, and lead, in whole blood by inductively coupled plasma torch – optical emission spectroscopy (ICP-OES), a classical method used for elemental analysis. This research is significant because it will aid in the further optimization of heavy metal quantification by identifying which parameters need optimization. **Background**: There has been a lack of a validated method for the quantification of heavy metals in a forensic setting. In many chemical analyses, there are many parameters that must be considered when optimizing a procedure for quantification. Factor analysis could be used to identify which parameters have the greatest effect on the signal generated from ICP-OES analysis of heavy metals. **Methodology**: Three parameters were analyzed; (1) concentration of acid used for digestion, (2) ratio of oxidizer to acid used, and (3) volume of acid used for reconstitution. A baseline experiment was conducted. Three additional experiments were conducted, each altering one parameter. Each experiment was conducted in replicates of 5. The deviation from the original experiment were analyzed using factor analysis on XLSTAT. **Results**: Correlation tables generated from factor analysis revealed that there were no significant changes in signal due to the parameters measured (correlation values > 0.98 to the original data set). **Conclusion**: It was found that the parameters measured had no significant impact on the signal generated from heavy metals in whole blood using ICP-OES. However, due to limited sample size, these parameters should still be taken into consideration when optimizing the procedure.

Keywords: forensic science, forensic toxicology, cause of death, elemental analysis, heavy metals.

Supervisor: Dr. Vivienne Luk, Assistant Professor, University of Toronto Mississauga and Agata Gapinksa, Laboratory Technician – Chemistry & Forensic Science, University of Toronto Mississauga

FSC489H5

ADVANCED INDEPENDENT PROJECT

LEANNE BYRNE

Application of fingerprint enhancement reagents crystal violet and amido black using a household "slime" compound

ABSTRACT

Purpose: This research served to preliminarily investigate a household "slime" compound as an application method for chemically enhancing latent and patent fingerprint impression detail. **Background**: Present application techniques can employ a substantial volume of chemical reagent through the development process and the need for a post-rinse. The proposed technique decreases impractical chemical waste and improves efficiency through staining without background interference and the ability for repeated application. **Methodology**: A depletion series was deposited at varying times on four adhesive and two nonporous substrates. 2.07g of borax powder and 0.15g of crystal violet were dissolved in approximately 75ml of water, then continuously added to 67.5g of Elmer's School Glue until the desired consistency resulted. Trials were repeated using a separate crystal violet compound that was stored for one week and rehydrated with 3-5ml of distilled water. In applicable trials, 0.51g of amido black 10B was added and the compound applied after a fixative. **Results**: The crystal violet compounds demonstrated effective enhancement on the primary depositions of all adhesive substrates, exhibiting greater enhancement when applied to black electrical and beige packaging tape. The amido black compound enhanced impressions with moderate effectiveness, specifically exhibiting the best enhancement capabilities on faint impressions. This was achieved without the need for a separate post-rinse solution, however, its application on larger-volume impression areas caused detail to be altered via uptake. **Conclusion**: These results support the use of each compound in certain investigative circumstances, but further research is necessary to determine reliability of this technique in forensic investigation.

Keywords: forensic science, forensic identification, crystal violet, gentian violet, amido black, depletion series, fingerprint impressions

Supervisor: Detective Constable Wade Knaap (retired), Forensic Science Program, University of Toronto Mississauga

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Filbert Yung

Nina Zibar

SPECIAL THANKS TO THIS YEAR'S PARTICIPATING MENTORS

IRV ALBRECHT
Detective Constable, Forensic Identification Services, Toronto Police.

CLAYTON ASANO
Detective Constable, Peel Regional Police

CHRISTOPHER BALL
Forensic Pathologist, Ontario Forensic Pathology Service

MAGGIE BELLIS
Forensic Pathologist, Ontario Forensic Pathology Service

ERNEST FRIESEN
Constable, Waterloo Region Police Service

WILLIAM GILLESPIE
Seargent, York Regional Police Canine Unit

LAURA GORCZYNSKI
Chief Instructor of Senior Courses, Ontario Police College

THOMAS GREER
Detective Constable, Toronto Police Forensic Identification Service

HELEN GURYN
3D Forensic Technologist, ai2-3D Forensics

AINSLIE HEASMAN
Clinical Psychologist, Centre for Addiction and Mental Health

JAYANTHA HERATH
Forensic Pathologist and Coroner, Ontario Forensic Pathology Service

MICHAEL HO
Special Constable, Hamilton Police Forensic Services

ROBERT HOFSTETTER
Detective, Peel Reginal Police

CLAIRE HORSNELL
The Innocence Project, Osgoode Hall

ANNETTE HUYS
Seargent, Hamilton Police Forensic Services

BRAD JOICE
Detective Sergeant, York Regional Police Forensic Identification Unit

WADE KNAAP
Detective Constable (Retired), Forensic Identification Instructor, University of Toronto Mississauga

CHRISTOPHER KOEGL
Research Director at Ontario Correctional Institute

QUAN LE
3D Forensic Technologist, ai2-3D Forensics

MEADOW LIBBY
Special Constable, Hamilton Police Forensic Services

EUGENE LISCIO
3D Forensic Technologist, ai2-3D Forensics

VIVIENNE LUK
Assistant Professor, Teaching Stream, University of Toronto Mississauga

MICHAEL MCGUIGAN
Seargent, York Regional Police Canine Unit

CELINE MOYEN
Master of Science Candidate, University of Toronto Mississauga

NICOLE NOVROSKI
Assistant Professor, Research Stream, University of Toronto Mississauga

CAITLIN PAKOSH
Assistant Crown Attorney and Instructor, University of Toronto Mississauga

MICHELLE PFLUG
Forensic Identification Section, Ontario Police College

ETIENNE PILLIN
Founder & CEO, Clotho Ai

CAMERON POWER
Laboratory Technician, Toronto Police Forensic Identification Service

JACLYN SLANEY
Laboratory Technician, Toronto Police Forensic Identification Service

BHAVAN K. SODHI
The Innocence Project, Osgoode Hall

GREG WILLIAMS
Ret. Staff/Sergeant, York Regional Police

KAREN WOODALL
Assistant Professor, Teaching Stream, University of Toronto Mississauga

FORENSIC SCIENCE PROGRAM

STAFF

TERESA CABRAL
Forensic Science Program Administrator
Academic Advisor & Internship Coordinator

MURRAY CLAYTON
Forensic Science Program Officer & Outreach Coordinator

AGATA GAPINSKA
Forensic Science Lab Manager & Technician

CAROLYN LOOS
Forensic Science Program Manager

JOANNA SZURMAK
Forensic Science Librarian

FACULTY

MARC DRYER
Associate Professor, Teaching Stream
Biomedical Communications, Department of Biology

WADE KNAAP
Lecturer, Forensic Ident Specialist, Forensic Science Program
Detective Constable (Retired) Toronto Police Service

ULRICH KRULL
Vice-President & Principal, UTM
Professor, Department of Chemistry and Physical Science

UTM and AstraZeneca Chair in Biotechnology

VIVIENNE LUK
Assistant Professor, Teaching Stream, Forensic Chemistry

NICOLE NOVROSKI
Assistant Professor, Forensic Biology

TRACY ROGERS
Director, Forensic Science Program
Associate Professor, Department of Anthropology

FORENSIC SCIENCE PROGRAM

DAX URBSZAT
Senior Lecturer, Department of Psychology

ALISON WEIR
Senior Lecturer, Department of Mathematics & Computational Science

KAREN WOODALL, BSc, PhD
Assistant Professor, Teaching Stream, Forensix Toxicology; Ethics & Professionalism

VISITING PROFESSOR

RASMUS ROSENBERG LARSEN
Visiting Assistant Professor, Forensic Psychology & Philosophy

SESSIONAL LECTURERS

HELEN GURYN
FSC406H5 - Introduction To 3D Crime Scene Mapping And Reconstruction

CRAIG FRASER, ANDREW MCLEAN
FSC350H5 - Mental Health and the Justice System

CAITLIN PAKOSH, LLB
FSC360H5 - Evidence, Law and Forensic Science in Canada

JESSICA PIEKNY, MARY OLIVERIO
FSC303H5 - Techniques of Crime Scene Investigation

LELIA WATAMANIUK
FSC316H5 - Forensic Anatomy, FSC401H5 - Forensic Pathology

ADJUNCT PROFESSORS

EUGENE LISCIO, P.ENG
FSC406H5 - Introduction To 3D Crime Scene Mapping And Reconstruction

PROFESSOR EMERITI

W. RAYMOND CUMMINS

2020-2021 TEACHING ASSISTANTS

ELYSSA BADER, MSc., PhD Student, FSC271

MELISSA BERNARD, MSc. Student, FSC407

PATRICK BOZEK, MSc., PhD Student, FSC239, FSC406

KATHRYN CAMPEAU, PhD Student, FSC100, FSC239

ADVIKAA DOSAJH, HBSc. Student, FSC210

GRACE GREGORY-ALCOCK, MSc. Student, FSC271, FSC302, FSC303

JACKIE HAN, MSc. Student, FSC402

STEPHEN HO, MSc., PhD Student, FSC311

JONG IN KIM, MSc. Student, FSC300, FSC303

JENNA MACRAE, MSc., FSC101, FSC239

CELINE MOYEN, MSc. Student, FSC300, FSC360, FSC303, FSC371

ERNEST PRACK, MSc., PhD Student, FSC210

ALEXANDRA SALY, MSc., PhD Student, FSC330

JENNA SCHALL, MSc. Student, FSC100, FSC220, FSC239, FSC350

SHELBY SCOTT, MSc., PhD Student, FSC100, FSC101, FSC481, FSC316, FSC401

FRANCES SIMBULAN, MSc., FSC370

ASHLEY SMITH, MSc., PhD Student, FSC239

VICTORIA SNOWDEN, MSc., PhD Student, FSC315, FSC415

SHERYL SPIGELSKI, MSc., PhD Student,FSC101

JUSTIN VAN HOUTEN, MSc., PhD Student, FSC311

FORENSIC SCIENCE PROGRAM CONTACTS

DR. TRACY ROGERS

Director, Forensic Science Program
Department of Anthropology
Terrence Donnelly Health Sciences Complex, Room 400
University of Toronto Mississauga

905-828-5449 | tracy.rogers@utoronto.ca

CAROLYN LOOS

Forensic Science Program Manager
Terrence Donnelly Health Sciences Complex, Room 302
University of Toronto Mississauga

905-828-3741 | carolyn.loos@utoronto.ca

TERESA CABRAL

Forensic Science Program Administrator
Academic Advisor & Internship Coordinator
Terrence Donnelly Health Sciences Complex, Room 402
University of Toronto Mississauga

905-569-4423 | teresa.cabral@utoronto.ca

MURRAY CLAYTON

Forensic Science Program Officer & Outreach Coordinator
North Establishment, Room 5204
University of Toronto Mississauga

416-705-5876 | murray.clayton@utoronto.ca

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