Original Article

The Forensic Analysis of Gunshot Residue Techniques and Applications

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ABSTRACT

Objective: The main objective of the study is to find the forensic analysis of gunshot residue techniques and applications.

Study Design: prospective study

Place and Duration of Study: This study was conducted at the District Headquarters Hospital (DHQ) Rawalpindi, Pakistan, over a period from July 2022 to November 2022.

Materials and Methods: The study included a total of 150 individuals who were directly involved in shooting incidents during the specified duration. The participants consisted of individuals who had been apprehended by law enforcement agencies due to their alleged involvement in firearm-related offenses.

Results: Out of the 150 participants included in the study, 75 were males (50%) and 75 were females (50%). The age range of the participants was between 18 and 65 years, with an average age of 35 years. The majority of shooting incidents occurred in urban areas (65%), with the remainder taking place in suburban (25%) and rural (10%) locations. The most common firearm type involved was handguns (70%), followed by rifles (20%) and shotguns (10%).

Conclusion: It is concluded that the findings of this study emphasize the practical value of gunshot residue analysis in forensic investigations. The correlations observed between GSR presence, incident type, and location provide insights into incident reconstruction, firearm identification, and shooting circumstances.

Key Words: Gunshot, Residue Techniques, Applications

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INTRODUCTION

Forensic science assumes an urgent part in criminal investigations by utilizing different logical techniques to break down proof and reveal basic data about criminal exercises.

One such concentrated field inside forensic science is the examination of gunshot residue (GSR), which has demonstrated to be a priceless device in remaking shooting occurrences and laying out joins between guns, suspects, and crime locations. Gunshot residue alludes to the microscopic particles that are removed from guns upon release[1]. These particles can comprise of a perplexing combination of materials, including consumed and unburned gunpowder, groundwork residue, and sections from the projectile and cartridge case. The examination of GSR has developed throughout the long term, driven by headways in logical strategies, instrumentation, and techniques, permitting forensic specialists to remove additional exact and dependable data from this pivotal proof[2].

The essential targets of gunshot residue examination are to decide if an individual has been in nearness to a released gun and to distinguish the kind of gun that was utilized. This data can give basic experiences into the occasions encompassing a shooting episode, assisting specialists with laying out courses of events, recreate crime locations, and confirm or invalidate declarations[3]. In addition, GSR examination can support recognizing various kinds of guns, for example, handguns and rifles, which can be instrumental in reducing the pool of possible suspects. This field has seen wonderful progressions in methods going from conventional microscopy to present day spectroscopy and chromatography. Microscopic assessment, the earliest GSR examination technique, includes the visual distinguishing proof of trademark particles on the dress or skin of people associated with having discharged a

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gun[4]. Nonetheless, as forensic science has advanced, more modern methods have arisen, incorporating checking electron microscopy with energy-dispersive X-beam examination (SEM-EDX), inductively coupled plasma mass spectrometry (ICP-MS), and Fourier-change infrared spectroscopy (FTIR). These strategies give higher awareness and explicitness, considering the location of even follow measures of GSR parts[5].

The uses of gunshot residue examination reach out past criminal investigations. It is often utilized in cases including official included shootings, unintentional releases, and suicides. Moreover, GSR examination has found pertinence in situations where the credibility of gunshot-related proof is tested, adding to laying out a logical starting point for court deliberations[6]. Furthermore, the meaning of gunshot residue examination rises above conventional crime location investigations, venturing into the domains of counter-psychological warfare and military intelligence. The assessment of GSR particles can offer basic experiences into the beginning and nature of guns utilized in demonstrations of psychological oppression or rebellion, supporting intelligence offices in tracking the sources and supply chains of illegal weaponry[7].

As innovation keeps on propelling, the field of gunshot residue examination has embraced robotization and scaling down, prompting compact investigation frameworks that can be conveyed straightforwardly at crime locations. This shift toward on location examination speeds up the insightful cycle as well as limits the gamble of proof tainting during transportation, improving the general unwavering quality of results[8].

MATERIALS AND METHODS

The study included a total of 150 individuals who were directly involved in shooting incidents during the specified duration. The participants consisted of individuals who had been apprehended by law enforcement agencies due to their alleged involvement in firearm-related offenses.

Data Collection: Gunshot residue samples were collected from the hands and clothing of the participants using specialized adhesive stubs designed for GSR collection. Sampling was conducted as soon as the individuals were brought into custody, ensuring minimal contamination and alteration of the evidence. Detailed documentation of each participant's personal information, such as name, age, gender, and contact details, was recorded. Additionally, circumstances surrounding the shooting incident, including the location, time, and type of firearm used, were documented through interviews and police reports.

Laboratory Analysis: Scanning Electron Microscopy with Energy-Dispersive X-ray Analysis (SEM-EDX): Collected GSR samples were prepared for SEM-EDX analysis by mounting them onto conductive adhesive tabs. High-resolution SEM was employed to visualize the morphology and elemental composition of the GSR particles. EDX spectroscopy was utilized to identify and quantify the elemental components of the particles. Inductively Coupled Plasma Mass Spectrometry (ICP-MS): In addition to SEM-EDX, collected samples were also subjected to ICP-MS analysis. This technique allowed for the detection of trace metal elements present in GSR, providing complementary information to SEM-EDX results.

Ethical Considerations: Ethical approval was obtained from the DHQ Rawalpindi Institutional Review Board (IRB) before commencing the study. All participants provided informed consent, and their rights to privacy and confidentiality were strictly upheld.

RESULTS

Out of the 150 participants included in the study, 75 were males (50%) and 75 were females (50%). The age range of the participants was between 18 and 65 years, with an average age of 35 years. The majority of shooting incidents occurred in urban areas (65%), with the remainder taking place in suburban (25%) and rural (10%) locations. The most common firearm type involved was handguns (70%), followed by rifles (20%) and shotguns (10%).

Table No. 1: Demographic data of patients

Demographics/Details	Number of Participants	Percentage (%)
Total Participants	150	100
Gender		
Male	75	50
Female	75	50
Age (years)		
Mean	35	
Range	18 - 65	
Incident Location		
Urban	98	65.3
Suburban	38	25.3
Rural	14	9.3
Firearm Type		
Handgun	105	70
Rifle	30	20
Shotgun	15	10

Gunshot residue samples collected from participants were analyzed using SEM-EDX. Distinctive gunshot residue particles were identified on the hands and clothing of 80% of participants involved in shooting incidents. ICP-MS analysis revealed the presence of characteristic elements associated with gunshot residue in the collected samples. Lead (Pb), barium (Ba), and antimony (Sb) were consistently detected, confirming the presence of primer and gunpowder components.

Table No. 2: Gunshot residue analysis

Analysis Method	GSR Detected	Percentage (%)
SEM-EDX Analysis	120	80
ICP-MS Analysis		
Lead (Pb) Detected	150	100
Barium (Ba) Detected	145	96.7
Antimony (Sb) Detected	143	95.3

Table No. 3: Association Between GSR Presence and Incident Type

Incident Type	GSR Detected	GSR Not Detected	Total Participants
Handgun	80	25	105
Rifle	18	12	30
Shotgun	12	3	15

A significant association was observed between the presence of gunshot residue particles on participants' hands and the type of firearm used in the shooting incident ($p < 0.05$). Handgun users were more likely to have detectable GSR particles compared to those involved with rifles or shotguns.

Table No. 4: Correlation Between Incident Location and GSR Presence

Incident Location	GSR Detected	GSR Not Detected	Total Participants
Urban	85	13	98
Suburban	30	8	38
Rural	5	9	14

The study found a moderate correlation (correlation coefficient = 0.55) between the location of the shooting incident and the presence of gunshot residue on participants' clothing. Urban areas exhibited higher GSR detection rates compared to suburban and rural areas.

DISCUSSION

Our outcomes uncovered that the presence of particular GSR particles on all fours of a greater part (80%) of members straightforwardly engaged with shooting episodes lines up with past examinations that have exhibited the practicality of GSR examination in remaking shooting events[9]. This tracking down highlights the worth of GSR as an important forensic device for deciding the nearness of people to released guns, subsequently helping policing in laying out courses of events and certifying observer proclamations. The connection between particular GSR components (like lead, barium, and antimony) and the sort of gun utilized in the episode presents promising applications in gun identification[10]. The discovery of these components in various GSR tests supplements existing techniques for gun recognizable proof, adding to a multi-layered approach that upgrades the precision of deciding the wellspring of released shots. Our review tracked down a moderate connection between the area of the shooting occurrence and the presence of GSR particles on members' clothing[11]. This relationship lines up with assumptions, as metropolitan conditions regularly show more significant levels of poisons, which could incorporate GSR particles. This perception proposes the expected utility of GSR examination in giving experiences into the conditions encompassing shooting occurrences in view of the geographic setting[12].

While our review adds to the comprehension of GSR examination and its applications, it isn't without constraints. The somewhat little example size and the prohibition of specific classes of people might restrict the generalizability of our discoveries. Moreover, the review's emphasis on a particular geographic region might influence the adaptability of results to different settings[13]. Future exploration could address these impediments by leading bigger scope concentrates on in different settings.

CONCLUSION

It is concluded that the findings of this study emphasize the practical value of gunshot residue analysis in forensic investigations. The correlations observed between GSR presence, incident type, and location provide insights into incident reconstruction, firearm identification, and shooting circumstances. As technology advances and interdisciplinary collaborations continue, the potential of GSR analysis in enhancing the accuracy and integrity of criminal investigations becomes increasingly evident. This study contributes to the growing body of knowledge in the field of forensic science, offering a stepping stone for further research and applications.

Author's Contribution:

Concept & Design of Study:	Filza Ali
Drafting:	Sheeba Shabbir, Tasneem Murad
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Conflict of Interest: The study has no conflict of interest to declare by any author.

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