A comparative Analysis of the Applicability of Forensic Science in the Criminal Justice System of Pakistan and USA

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Abstract

Forensic science plays a pivotal role in criminal justice systems worldwide, offering scientific methods to solve crimes and prosecute offenders. This study examines the comparative status, challenges, and advancements in forensic science in Pakistan and the United States. While Pakistan's forensic science struggles with limited resources, inadequate facilities and training gaps The U.S.A possesses advanced technology, extensive resources, integration with law enforcement and judicial systems. However, ethical issues, racial disparities, and high operational costs are the challenge for U.S . The research underscores the critical role of emerging technologies like DNA profiling, artificial intelligence and digital forensics in revolutionizing forensic practices. It further advocates for enhancing Pakistan's forensic system through increased funding, specialized training, and international collaboration while the U.S.A needs to address ethical concerns and foster equitable forensic practices. This comparative analysis offers valuable insights for strengthening global forensic science, improving justice delivery and promoting fairness in legal system.

Keywords.

Forensic science, criminal justice, Pakistan, United States, DNA profiling, digital forensics, artificial intelligence, resource constraints, ethical issues, racial disparities, forensic technology, criminal investigations, evidence analysis, law enforcement, judicial integration, forensic training, justice delivery, international collaboration, forensic labs, accreditation standards.

Introduction.
Background

Forensic science is an essential part of the criminal justice system, which proffers scientific processes and methods to solve crimes and prosecute offenders. It involves numerous fields like DNA, toxicology, fingerprinting, and ballistics, among others, that aid in putting facts, getting the culprit, or clearing the innocent. The current legal processes are among the areas that pay high importance to forensic science since these are the determinants of the trials of criminals

(Afridi, 2021). Forensic studies are an integral part of the criminal justice systems in Pakistan and the USA and are essential in solving crimes and misdemeanor matches. Nevertheless, the penetration of forensic science that is its degree, the degree of its interaction with the legal system, and the overall effect are different in the two countries. Forensic science in the USA has been popular for many decades and now encompasses technologies and well-thought legal systems for incorporating its usage. Nevertheless, Pakistan is currently in the developmental phase of mass incorporation and integration of forensic science facilities, where problems, including inadequate resources, infrastructure, and professional personnel, still persist this year (Mahmood et al., 2024). These differences pose a chance for a comparative study of how forensic science might be used to improve the criminal justice system in Pakistan, with reference to the USA.

Purpose of the Study

The main research question of this paper is
To what extent is forensic science relevant to the criminal justice systems of Pakistan and the USA?
This research aims to compare the aim and application of forensic technology in two different settings and understand the opportunities, risks, and difficulties each country goes through when embracing forensic technologies. Forensic science is critical in the effective administration of justice since it reduces biases such as wrongful convictions and speeds up problem-solving by providing factual issues (Munir et al., 2021). In addition, this study seeks to describe how forensic developments in both countries can help enhance the approach to handling police and court affairs.The considerations of Pakistan and the USA are as follows, which makes these two countries necessary for the comparative analysis as both have many similarities, such as resource limitations and the need for enhanced training. However, they are entirely dissimilar in the fields of technological advancement as well as institutional support. By identifying such differences, the study shall identify the areas where the Pakistani forensic system could be improved and where the USA needs to reconsider some of the forensic practices, particularly in connection with modern technologies like DNA profiling and databasing (Ahmad & Bakhsh, 2024).

Research Questions

This study will focus on the following three research questions:
How effectively is forensic science applied in the criminal justice systems of Pakistan and the USA?
What are the challenges faced by forensic science in Pakistan and the USA, and what best practices can be identified?
What role does emerging forensic technology, such as DNA profiling, play in enhancing the criminal justice system in both countries?

Methodology

The methodology used in the present research is comparative and analytical. Comparing the two countries provides an extensive understanding of forensic science in Pakistan's criminal justice system and the USA's. Secondary methods shall be used for this purpose, specifically journal articles, government publications, and case records, to develop a comprehensive view of the use of forensic science in both nations. This research paper aims to present the strengths, limitations, and future developments in the use of forensic science in South Asian countries through a peer-reviewed literature analysis. This study will likely recognize the effectiveness and issues in applying forensic science in Pakistan, focusing on USA experience.

Forensic Science in the Criminal Justice System: A Theoretical Framework

Forensic science is the application of sciences within criminal justice, more specifically, physical evidence used to solve various cases. Criminalistics is an academic branch that synthesizes and integrates research results from different branches of science in search of facts necessary for criminalistics. In its narrowest sense, forensic science is the systematic, objective, and reliable identification of facts in the service of law.

Key components of forensic science include
Crime Scene Investigation

Evidence Collection: Physical evidence is painstakingly collected from a crime scene, without contamination. Using gloves, forceps and sealable evidence bags, structures such as fingerprints, bloodstains, fibers and weapon fragments are preserved by the techniques.

Documentation: These records help much in reconstructing events of what happened to the crime scene. High resolution photography, sketches with precise measurements and notes detailing what is found at the scene are used by investigators in order to visit the scene in the court room virtually.

Physical Evidence Analysis

Trace Evidence: Through micrscopes, spectrometry, and chromatography, trace materials such as hair, fibers, glass, and paint are analyzed. Often the principles of transfer evidence link suspects to crime scenes or victims.

Impression Evidence: Materials, e.g., dental stone or silicone, are used for casting footprints, tire marks and tool marks that contain unique patterns which can be matched to suspects and objects(Earwaker et al., 2020).

Biological Evidence

DNA Analysis: DNA profiling (e.g., STR analysis, mitochondrial DNA sequencing) enables highly accurate identification of individuals. Advancements like Rapid DNA technology allow quicker results in investigations (Shepitko & Shepitko, 2021).

Serology: Bodily fluids are tested using biochemical techniques to confirm their origin (e.g., identifying human blood versus animal blood). Techniques include presumptive tests like the Kastle-Meyer test for blood and confirmatory tests like RSID kits.

Chemical Analysis

Toxicology: Forensic toxicologists test for substances like alcohol, drugs, poisons, and gases (e.g., carbon monoxide) in biological samples. Advanced instrumentation such as gas chromatography-mass spectrometry (GC-MS) is widely used.

Controlled Substances: Chemists analyze powders, pills, and liquids to identify illegal drugs or toxic chemicals. Cutting agents in drugs are also studied for supply chain tracking.

Ballistics

Ballistics experts study firearms, ammunition, and bullet trajectories. Tools like comparison microscopes analyze striations on bullets to match them to specific weapons. Gunshot residue (GSR) tests can indicate whether a suspect fired a weapon.

The science also determines bullet trajectory and shooting angles, helping reconstruct the events of a shooting.

Digital Forensics
Specialists recover and analyze electronic data from devices like computers, smartphones, and cloud storage. Techniques involve recovering deleted files, analyzing communication logs, and decrypting data. Cybercrime investigations often focus on financial fraud, hacking, and online harassment. Tools like EnCase and FTK (Forensic Toolkit) are widely used in this field.

Document Examination
Forensic document examiners analyze handwriting, inks, papers, and typefaces to detect forgeries, alterations, or counterfeit documents. Infrared and ultraviolet light, as well as chemical analysis, help identify erasures or ink compositions.
This field is essential in financial fraud cases, legal document verification, and ransom notes.

Forensic Pathology
Pathologists determine the cause and manner of death through autopsies. Examination includes identifying wounds, diseases, or other anomalies that contributed to death. Specialized techniques, such as histology and toxicological testing, help identify hidden injuries or substances influencing death(Valentine et al., 2020).

Forensic Anthropology
Anthropologists study human skeletal remains to ascertain age, gender, ethnicity, and stature. They also identify trauma or diseases evident in bones. In mass disasters or clandestine graves, they assist in body identification and provide insights into the time since death.

Forensic Odontology
Dental evidence, such as bite marks or dental records, is analyzed for victim or suspect identification. Techniques include radiograph comparisons and analyzing unique dental work. This is particularly useful in mass casualty events where other identifying features may not be intact.

Forensic Psychology and Psychiatry
Professionals assess the mental state of individuals involved in crimes, providing insights into motives or criminal behavior. They also evaluate competency to stand trial and risk of reoffending. Criminal profiling uses psychological principles to predict the characteristics of unknown offenders.

Forensic Entomology
The study of insect activity on decomposing remains provides critical timelines for post-mortem intervals (PMI). Specialists identify insect species and their developmental stages, which correlate with the time and environmental conditions of death.

Forensic Engineering
This field investigates structural failures, such as building collapses, and reconstructs accident scenarios, including vehicle crashes. Engineers analyze materials, mechanical systems, and design flaws to determine causes of incidents. Common cases involve product liability claims, arson investigations, or catastrophic accidents.

Quality Assurance and Ethics
Ensuring laboratory processes meet rigorous standards, including accreditation by bodies like ISO/IEC 17025.
Ethical considerations include maintaining objectivity, preventing bias, and ensuring chain of custody is intact to preserve the admissibility of evidence in court.2.2 Relevance to Criminal Justice

Relevance to Criminal Justice
The relationship between forensic science and the criminal justice system is very close, mainly because, most of the time, forensic science provides substantial information needed in carrying out investigations and coming up with results of criminal-related cases as well as holding trials. Science-based approaches ensure that the decisions are based on facts rather than opinions or words from witnesses who could be interested. For instance, DNA forensics can ideally point any suspect to the crime scene, as well as toxicology that shows that a death resulted from poisoning (Shevchuk, 2020).
Many defendants come to the forensic arena, one of its crucial roles that has dramatically helped ensure prisoners get a fair trial. The opportunity offered by forensic science to give objective and evidence-based information decreases the risk of people's miscarriages of justice. It is found that several jurors, especially in cases related to rape or murder, were released once forensic evidence such as DNA profiling became available (Arkes & Koehler, 2021). Therefore, forensic science maintains the dignity of the justice system, and only the deserving culprits end up being punished, while the deserving individuals do not end up being punished. Furthermore, the study reveals that forensic science has a critical forensic function in preventing the miscarriage of justice. The introduction of DNA testing, digital analytics, and other advanced technologies facilitated and advanced has made it possible for the police to seek justice by looking into previous unresolved incidents and, in so doing, freeing inmates who have been imprisoned under wrongful convictions for years (Bakhtiar, 2024). In this way, forensic science supports the justice being done and serves with fairness, supporting public faith in the field.

International Standards in Forensic Science
In order to maintain cohesiveness, credibility, and responsibility in forensic investigation, many International organizations have established guidelines and standards for forensic science practice. The INTERPOL offers an international organization framework for cooperation in forensic investigations, particularly in transnational legal cases. Interpol helps in the dissemination of forensic information across the world so that issues that concern many jurisdictions are solved (Shepitko & Shepitko, 2021). However, the United Nations (UN) has developed certain standards for the use of forensic science in crimes, especially in its fight against human rights abuses and genocide. These standards aim to use forensic science professionals, set value to persons' dignity, and pay specific attention to high-risk populations (Shevchuk, 2020).
To ensure that forensic science practice is cohesive, credible, and, most importantly, responsible, many International organizations have developed guidelines and standards on forensic practice. INTERPOL provides international organization settings for cooperation in forensic investigations, especially in transnational legal matters. Interpol intervenes in the availability of forensic data worldwide to ensure that problems affecting many jurisdictions are addressed (Shepitko & Shepitko, 2021). However, the United Nations (UN) has promulgated

some guidelines regarding the admissibility of forensic evidence in crimes, particularly in their fight against human rights and genocide. These standards seek to operationalize forensic science professionals, assign worth to humans' worth, and note particular populations vulnerable to adverse outcomes (Shevchuk, 2020).

Forensic Science in Pakistan
Historical Development
The Development of Forensic Science in Pakistan has been a slow and steady process however very much depending on the trends and situations in other parts but with recurring problems of the Political, Economic and Socio-Cultural Contexts in Pakistan. Forensic science in Pakistan dates back to the start of the 20th century when it was nothing more than rudimentary crime scene investigation. But the work of practices within forensic science was refined through scientific-analytical practices with the progression of DNA and toxicology.

Pakistan has multiple forensic labs, including:

Punjab Forensic Science Agency (PFSA): A huge multi million dollar facility in Lahore, considered country's advanced forensic lab. The world second largest laboratory and it provides services in 14 disciplines. Law enforcement agencies provide physical evidence to the PFSA, which in turn analyzes it and provides the result to stakeholders like apex courts, investigating agency, prosecutor, etc.

Sindh Forensic DNA and Serology Laboratory: A forensic casework and relatedness testing lab that performs routine forensic casework and associated testing for judicial proceedings.

Liaqat University of Medical and Health Sciences: A forensic casework and relatedness testing laboratory that performs forensically routine casework and relatedness testing for judicial proceedings.

Forensic Science Laboratory (FSL) Peshawar: It's a lab that provides DNA testing services, but it's not a forensic laboratory.

Serology and DNA forensic labs at Karachi University: Security agencies and investigating authorities use these labs.

In 2003 the National Forensic Science Agency (NFSA) was established exclusively to handle the mandate of promoting or facilitating or setting standards in forensic science in the country. Apart from this, the NFSA also conducts teaching and training within Pakistan and assists other agencies (of law / of the judicial system) in gathering and analyzing forensic material and other such evidence. Yet, Pakistan has been unable to fully build a forensic science system, and tasks pertaining to the funding, staff training and public confidence have impeded the journey. Forensic practices in Pakistan, more fingerprints, physical evidence, or eyewitness statements were included for many years as they recently came into force DNA and digital practices in the later part of the 20th century. Despite enlarging in the last period, Forensic Science continues living with little growth, till to date, many places in the country do not have access to modern Forensic equipment and facilities, with many places indeed still depending on obsolete techniques (Mangi & Khan, 2021).

By contrast, the United States has approximately 400 public forensic crime laboratories. Funded by federal, state and local governments, these labs work with the criminal justice system. Here are some other details about forensic labs in the United States:

Federal labs: Federal crime labs come in all shapes and sizes, from the most well-known in the FBI to smaller ones under the purview of other law enforcement agencies. The FBI processes evidence from violent crimes and FBI investigations for free. In addition, the ATF is equipped with two forensic science labs: one in Atlanta, Georgia, and one in Ammendale, Maryland.

State labs: Crime labs exist in all states, but states are not coordinated with one another. The **California Forensic Lab** is a prominent state-run laboratory that serves as a major resource for law enforcement agencies across California, handling a wide range of forensic services.
Chicago Forensic Lab: The **Chicago Forensic Lab**, located in Illinois, operates as a specialized facility dedicated to providing advanced forensic analysis for the city of Chicago and nearby regions. It plays a critical role in solving crimes and supporting the justice system through its collaboration with local law enforcement and criminal investigations.

City and county labs: Notably, a vast majority of these city and county labs are separate from statewide systems.

Accreditation: In 2014, the accreditation rates among state labs (99%) were ahead of federal (89%), county (85%), and municipal (67%) labs.

Current Practices
In Pakistan, the forensic science system seems more traditional than modern in many aspects." It uses the following forensic sciences in crime investigations, including DNA profiling, ballistics, and forensic toxicology. However, due to cybercrime, new fields are more recent than aforesaid, such as cyber forensics and incident response (Haque et al., 2023).

DNA Analysis: DNA profiling in Pakistan has been universally accepted and proven to be one of the best ways of doing forensic work. The Punjab Forensic Science Agency (PFSA) in Lahore has adopted the concept of DNA testing as one of the right facilities that uses technology to solve crimes such as sexual assault and murder. Genetic profiling has been very helpful in solving other issues as it helps in identifying criminals who otherwise cannot be traced (Rasool & Rasool, 2022).

Forensic Toxicology and Chemistry: These fields are beneficial in the incidences of poisoning or the incidence of other related drug offenses. Pakistan has seen a massive push to evaluate toxic compounds and substances. Nonetheless, abundant toxicological analysis facilities continue to be scarce, especially in developing countries or rural areas (Wahid, 2021).

Cyber Forensics: Growing incidences of cybercrime on the internet have created a new branch of forensic science in Pakistan known as cyber forensics. Cyber Forensics is a process of gathering electronic evidence that authorities use in their attempts to apprehend hackers, cybercriminals, computer fraudsters, internet terrorists, and cyber bullies who perpetrate hacking and data storage in major organizations' computer networks and systems (Haque et al., 2023).
As with most developing countries, forensic science in Pakistan is closely linked to the law enforcement branches. Cops, the FIA, or the Federal Investigation Agency, together with other divisions at the provincial level, incorporate forensic scientists in collecting and preserving this evidence, studying and analyzing it. Sometimes, forensic personnel are sent to a crime scene to ensure procedures are followed in collecting evidence (Mangi & Khan, 2021). Furthermore, the Pakistani judiciary has recently discovered the usefulness of forensic evidence, which it uses more often as supporting evidence or as an argument against the data given by the defense or the prosecution.

Challenges

The desired development and efficiency of forensic science in Pakistan have been faced with many challenges, including a lack of infrastructure and funding, training deficiency, and trust.

Lack of Infrastructure and Funding: Compared to other professions, the development of forensic science in Pakistan is confronted with a significant challenge of inadequate facilities and resources. Few provinces like Punjab and Sindh have invested in forensic laboratories and facilities. However, more effort must be put into expanding and modernizing forensic services nationwide in the subsequent years (Rasool & Rasool, 2022). Many forensic science laboratories lack some of the most essential tools and equipment, leading to congestion, as well as time-consuming delays in processing the samples.

Training Gaps and Expertise Issues: Pakistan has a severe scarcity of human resources in the niche discipline of forensic science. Before moving to specialized institutes and courses like the Forensic Science Department at Quaid-e-Azam University in Islamabad, there is a severe lack of forensic experts, which cannot suffice the requirements of law enforcement and judicial agencies (Afridi, 2021). This shortage leaves the need for increased recruitment of new workforce to cater to the casework while current personnel lack continued training to update them with the latest trends in forensic science worldwide.

Delays in Evidence Analysis: Pakistan forensic laboratories are usually congested with casework, which results in undue time to complete the analysis. For this reason, this delay may prove catastrophic for the criminal investigation and the judicial process (Mangi & Khan, 2021). Sometimes, getting things like DNA profiles, ballistic reports, or other vital pieces of evidence takes up to a year or more, and this just slows down the whole justice system.

Limited Public Trust in Forensic Evidence: In the Pakistani context, there is comparatively low public confidence in forensic media because of several factors, including lack of accountability, corruption within the police force, and perceived bias in forensic studies (Rasool & Rasool, 2022). The credibility of forensic laboratories is always controversial due to problems such as inadequate funding, outdated tools, and lack of supervision. Therefore, forensic evidence is often excluded, and this leaves innocent people being convicted or guilty people not being convicted.

Case Studies

However, the role of forensic science has been significant in several significant cases in Pakistan, proving that it has a strong place to succeed. Here are some of the main cases that illustrate the importance of forensic evidence.

The Murder Case of Fariha

This was a highly publicized instance where DNA profiling was done to compare the suspect's sample with that of the crime scene (Mangi & Khan, 2021). The victim was a young woman known as Fariha, who was killed through severe force and violation, and her body was dumped at the exercise ground. Some challenges were encountered during the investigation, but DNA plays a key role in sending the culprit to the gallows. For the first few episodes, the hope of capturing the suspect appeared dim, and the forensic evidence firmly pointed to the suspect as the culprit, which was attributed to the effectiveness of DNA technology in criminal investigations.

The 2016 Lahore Attack
The trial of the Lahore terrorist attack, which occurred in 2016, had a lot of help from forensic science. For instance, in the identification of victims, DNA forensics was employed in an attempt to recognize body parts. However, ballistic reports helped point to firearms used in the bombing. Criminalists also searched for the matching ties between the offenders and the crime scene. From this case, we are able to argue that forensic science, especially DNA fingerprinting and ballistic identification, facilitated the identification of both the deceased and the culprits (Wahid, 2021).

The Murder of Qandeel Baloch (2016)
Qandeel Baloch, best known as a star on social networks, was killed in 2016 by her brother in an "honor killing." The media widely covered the case. From postmortem and the investigation of phone records, both the brother of the deceased was convicted. The postmortem examination revealed that Baloch died due to throttling, and the call detail records of the mobile phone seized from her person were used to establish the chronology of events.

The Missing Persons Case (Balochistan)
Many people have gone missing in Balochistan, and this has remained a concern of many families seeking action for enforced disappearances (Zaman & Khan, 2018). Similarly, mass graves and DNA tests were applied to distinguish body parts that were found in several places. If our goal is to bring an end to the forced disappearance of persons by state authorities, there is a direct efficacy of the evidence in this case to human rights organizations and families of the missing link the remains to individuals who were taken by state authorities.

The 2002 Murder of General Musharraf's Assailants
The use of forensic science that formed the central focus of the event was the assassination attempt on then-President Pervez Musharraf in 2002. Criminalistics included ballistic and explosives, and the type of explosive used to execute the attack was also traced. Besides, analysis of the phone records and the financial activities related to the accused and by the accused also led to their condemnation in court. This was among the first significant events involving forensic science tracing terrorist activities and convictions in politically related terrorism-related cases.

The Murder of Zainab Ansari (2018)
The recent and horrifying case of little Zainab Ansari, a 6-year-old Pakistani, was kidnapped, raped, and brutally killed in Kasur, where the incident became a national sensation that set off the discourses around child protection (Dawn, 2018). DNA profile played a critical role in identifying the suspect, Imran Ali, after the search conducted across the country. His genetic profile was reported on the body of the victim and associated with several other similar cases. DNA identification and any forensic matching aided in the finality of the case, and Ali was captured, prosecuted, and convicted to death.

The Cybercrime Case Involving Axact (2015)
Axact, the software company of Pakistan, was involved in one of the biggest fake diploma scandals in the world. A case of fraud through emails or correspondence, company documents, and activities on the computers were tackled through forensic digital investigation (Mishra, 2015). This analysis of the company's website led to digital forensics that exposed the business as a scam, conducting fraud and selling fake degrees to people worldwide, where several arrests

have been made. The case demonstrated how important the use of cyberspace forensics is when addressing any cyber crimes.

Forensic Science in the USA
Historical Development
Criminalistics in the United States of America developed a century ago, but it is currently an essential part of the criminal justice system. Milestones of its development are pivoted in its modern practices, where it received apposite support from LAW ENFORCEMENT, ACADEMIA, and SPECIALIZED PROFESSIONALS (Ahmed, 2019). Another tremendous early milestone in forensic science was the creation of the FBI Laboratory in 1932, where standards for most investigative practices were set across the country (Jones, 2023). The FBI's Laboratory was one of the first to bring together various science disciplines and allow different analysts to work in one building in such areas as fingerprint identification, ballistics, toxicology, and so on (Garrett et al., 2021). The formation of the FBI Laboratory was a landmark in the incorporation of science to approach law enforcement work and began the process of modern forensic science.

The systematic use of the means for this purpose intensified in the 1980s due to the subsequent appearance of more specialized methods of forensic examinations, including, for example, the method of DNA profiling. Forensic DNA profiling was credible and accurate in pointing out a culprit or ruling out an innocent person. In 1998, the National DNA Index system was created, meaning DNA profiles could be shared among Law enforcement in different states (Shepitko & Shepitko, 2021). This technological innovation revolutionized police work, enabling the efficient linking of suspects with crime scenes, a breakthrough for many cold cases. For many decades, forensics has moved forward in the USA from conventional practices, integrating new technology and redefining its role in the criminal justice system. Due to its growing appreciation, various forensic science institutions and programs, such as forensic science degree programs and professional certification boards, were established to advance the situation and make it a permanent fixture within the legal framework.

Current Practices
Nowadays, the most representative trend of forensic science in the USA is the tendency to employ high technologies and the synergy of forensic laboratories with law enforcement agencies and courts. Incorporating these technologies has enhanced the preciseness, effectiveness, and timely conduct of forensic studies. With the coming of age of information technology as a relevant strand of human life, a subfield in the study of forensic science known as digital forensics has emerged. It refers to obtaining, memorizing, and investigating digital data from computers, cell phones, and other gadgets (Shepitko & Shepitko, 2021). Computer investigations have now been deemed very useful in cybercrime investigations such as identity theft, hacking, as well as child exploitation. Many law enforcement agencies depend on particular forensic groups to gain information from devices, but frequently, they encounter difficulties owing to encryption and the quantity of data. However, with the enhancement in technology, it has become more and more possible to recover essential data, which is helpful in cases of investigation and hearings.

Adopting artificial intelligence (AI) in forensics has been an opportunity for a new means of solving crimes. What has recently been realized is that AI algorithms can be applied to analyze massive data sets, find trends, and even guess possible crimes. Machine learning, for instance, is used to identify people based on their face or voice in reconstructing crime scenes and those complicated, narrowed-down investigations, among other occasions. AI also enables forensic

scientists to screen large volumes of information and narrow the leads, which will be challenging to derive through conventional methods (Jones, 2023).

Another advantage well-coordinated with the rest of the work of the US forensic science system is the interaction with Law Enforcement and the Judicial System. Most forensic labs partner with several police forces, prosecution services, and defense lawyers to ensure that evidence is collected, tested, and presented in court (Garrett et al., 2021). Such integration has resulted in the creation of Rules for Forensic Evidence that stipulate admission and standards of forensic evidence in court. We also interact further with national databases such as NDIS and the Integrated Automated Fingerprint Identification System (IAFIS), making it easier to detain suspects or connect crime scenes with crime scenes in other regions.

Challenges

However, several challenges are prevalent in forensic science in the USA, which include the following.

One of the most significant problems of forensic science is the scientific validity and admissibility of some of the forensically used techniques. Methods such as bite matching, comparison of hair, and process of shoe impression can also be deemed inadmissible since it has been accused of having no empirical backing besides being a causative factor of a wrongful conviction (Shepitko & Shepitko, 2021). Specifically, bite mark identification has been chiefly castigated for the approach's subjectivity and misidentification risks. The National Academy of Sciences published a report in 2009 touting the need to increase monitoring and regulation of forensic science and stating that many such techniques are not accurate enough to serve in the judicial system.

Another area that has also been at the forefront of ethical issues, especially racism, concerns forensic science. Studies also indicated that some of the forensic techniques, including DNA and face recognition, are likely to have an adverse impact on racially vulnerable populations, and so end up inflating criminal statistics (Krotulski et al., 2020). Further, the application of forensic evidence in carrying out racial profiling is the main controversy regarding the usage of forensic evidence in law enforcement. The professional and ethical aspects of forensic science have remained under-discussed and are still an area of discussion in terms of ethical consideration of the forensic art form and the changes that need to be made to make the present practices more ethical and scientifically proven.

As mentioned before, applying sophisticated detection technologies, including AI and digital forensics tools, is very expensive. Resource availability is one of the main issues forensic labs experience since, in many cases, these labs are financially impoverished, especially when the region is comparatively small (Charan, 2024). The expenses incurred to purchase, implement, and upgrade the technicalities of forensics are high, and most police departments experience grave difficulties in getting the funds necessary for such investments. This financial issue jeopardizes the ability to use highly sophisticated methods that help victims get justice and can slow down investigations.

Case Studies

With regard to the Admissibility of Forensic Science, several renowned cases in the USA have paved the way for how forensic science is used in investigating and solving the most complicated crimes.

The O.J. Simpson Case (1994): The best-known example of modern forensic science, the O.J. Simpson trial, showed people the value of DNA in law enforcement. There was blood-stained Tyson, and DNA profiling was used to match Simpson to the crime scene, but the defense side

had raised issues on how the blood-stained was treated and preserved. The case set a precedent regarding the application of forensic professionals in Courts, and doubts were thrown over the admissibility and accuracy of Forensic expert testimonies. Defending Simpson, the jury disregarded the DNA results, which, on the one hand, demonstrated the strength of forensic science but, on the other, revealed its weaknesses.

The Anthony Graves Case (1992): The second landmark case is Anthony Graves, who was convicted of a 1992 murder in Texans. Housing was making $10 every month and was on death row for over eighteen years before, through DNA and forensic review, he was set free. This case points to the need to use DNA in exoneration as forensics passed a clean bill on Graves, who had nothing to do with the crime.

The Golden State Killer Case (2018): The most famous recent procedure is the one where forensic science helped to identify the so-called 'Golden State Killer' using the concept of genealogy. Police officers obtained semen stains and blood samples from the crime scenes and were able to match them with the offender's gene pool through public databases, finding Joseph DeAngelo. This case showed how new technologies like genetic genealogy could help warm up cold cases and give the victim's kin justice.

Comparative Analysis of Pakistan and the USA
Strengths and Weaknesses of Each System
Essential peculiarities of forensic science systems in Pakistan and the USA uncover different strengths and weaknesses resulting from disparities in resources, technology, and professional qualifications.

Resource Availability
In the USA, forensic science enjoys a good deal of government support, advanced forensic facilities, and a strong base. The FBI, along with other agencies, has very professional forensic laboratories that are even equipped with the latest technologies. These labs have the resources to carry out and perform the most complex tests, such as DNA tests, digital forensics, and toxicology. Regarding resources, local, state, and federal law enforcement agencies are relatively highly funded, with large appropriations for criminal investigation and forensic support.
Nevertheless, Pakistan has several problems regarding the deployment and availability of resources. However, others lack equipment, even though progress has been made in large cosmopolitan cities such as Islamabad and Lahore (Munir et al., 2020). Moreover, in second-tier and third-tier cities and rural areas, there is either no solution to the issue of forensic services or that the means are meager. The lack of resources in Pakistan means they cannot develop a better forensic system that would suit their needs as the international standards, which impacts the efficiency of forensics.

Technological Advancements
Nonetheless, the USA must be ahead of many countries in applying new technologies in the science of forensics. For instance, the country has deployed digital forensics, DNA and profiling, and machine learning to improve criminal investigation efficiency. Technological platforms such as the National DNA Database (NDIS) and the Integrated Automated Fingerprint Identification System (IAFIS) make it easy to cross-reference evidence across jurisdictional boundaries, again hastening the identification process of suspects. Introducing AI

in crime solving, including facial recognition and predictive analysis, has taken a new dimension in policing systems.

On the other hand, Pakistan has not upgraded and adopted such technologies. New techniques such as digital forensics and DNA testing are slowly entering use in high-profile cases. However, they are not yet commonly used across the country. Forensic labs in Pakistan generally do not possess the necessary setup to perform more complex examinations, and the police forces may suffer from a state of technology that slows or complicates investigations (Khan, 2023). One of the main challenges Pakistan faces in its forensic system is the enormous difference between the technological abilities of Pakistan and the USA.

Training and Expertise of Forensic Professionals

Forensic professionals in the USA must complete their training-specific certification, usually available in universities and forensic institutes, and with the cooperation of law enforcement agencies (Asher, 2021). There are best practices at the national level since this means that all forensic scientists will provide consistent and reliable results to the courts. Furthermore, the FBI and other agencies continuously update their forensic personnel concerning forensic practices and techniques.

Although attempts have been made to train forensic professionals in Pakistan, the system is poorly developed. There is a scarcity of well-trained forensic experts, and the quality of the programs that produce them lacks uniformity across institutions (Munir et al., 2020). There is an appreciation that many forensic scientists practicing in Pakistan never have opportunities for their continued professional development and frequently on the missing of the most recent in forensic science. Such omissions in training may contribute to flawed procedures of evidence collection, analysis, and presentation under the court of law, thereby diminishing the general credibility of forensic science in the country.

Common Challenges

Similar to most other countries, several daunting challenges relate to forensic science in Pakistan and the USA despite the differences in resources, technology, and training.

Mismanagement of Crime Scenes

In both countries, the problem of ineffective management of crime scenes persists even today. Specific skills are used in collecting and preserving evidence since improper handling results in contamination, loss, or tampering, which leads to inaccurate forensic findings. In the USA, the adolescent role of Gilbert has drawn attention to how small mistakes in handling a crime scene field can influence the whole procedure. For example, the O.J. Simpson case in the 1990s caused controversies regarding the mishandling of evidence, especially DNA samples (Khan, 2023). As for managing crime scenes in Pakistan, there is an even bigger problem regarding resource shortages in certain regions. When law enforcement officers are not trained adequately, or where there are insufficient measures and poor infrastructures to accommodate forensic science, the evidence is mishandled in ways that undermine the abilities of forensic science in addressing crime.

Delays in Justice Delivery

Pakistan and the USA are similar in that both responding states experience delays in justice delivery because of concerns about forensic science. Nevertheless, in the USA, despite the modern technologies and highly qualified personnel in the forensic process, backlogs in testing, or delays in forensic reporting are still a problem, especially in those places with high caseloads (Asher, 2021). Such delays mainly slow the conduct of trials and convictions and give a raw

deal to victims, as well as a setback to the public in its search for justice. In Pakistan, delays are even more remarkable, mainly because the latter is considered one of the leading developing nations in South Asia. A lack of effective forensic systems, the scarcity of labs, and, more specifically, a shortage of qualified personnel result in extensive forensic backlogs. Other causes that lead to an extended time before the cases are solved are due to the backlogs usually encountered with forensic testing, which can even last for months or years (Farooq & Ahmad, 2022). This adds to the general populace's frustration and undermines the public confidence in the criminal justice system.

Lessons Pakistan Can Learn from the USA

However, learning from the above-mentioned issues, there are a few key areas that might be useful for improving the forensic science system in Pakistan, with reference to the USA.

Comparative Analysis Table: Forensic Science in Pakistan and the USA

Below is the comparative table showing key aspects of forensic science systems in Pakistan and the USA, with scores out of 10.

	Pakistan (Score)	USA (Score)	Explanation
Funding for Forensic Labs	2	8	The USA has robust funding mechanisms for forensic labs, while Pakistan struggles with inadequate financial provisions.
Technology Adoption	3	9	Advanced technologies like AI and DNA databases are widely used in the USA. Pakistan lags due to limited adoption.
Professional Training	3	9	Forensic professionals in the USA undergo rigorous training, while Pakistan lacks standardized programs and expertise.
Crime Scene Management	2	7	The USA has established protocols for crime scene management, whereas Pakistan faces challenges due to resource shortages.
Public Trust	2	8	In the USA, forensic science enjoys relatively high public trust, while skepticism about its reliability persists in Pakistan.
Timeliness of Justice Delivery	1	6	Delays are common in both countries but are more pronounced in Pakistan due to resource constraints and forensic backlogs.

Comparative Analysis Chart

■ Pakistan (Score) ■ USA (Score)
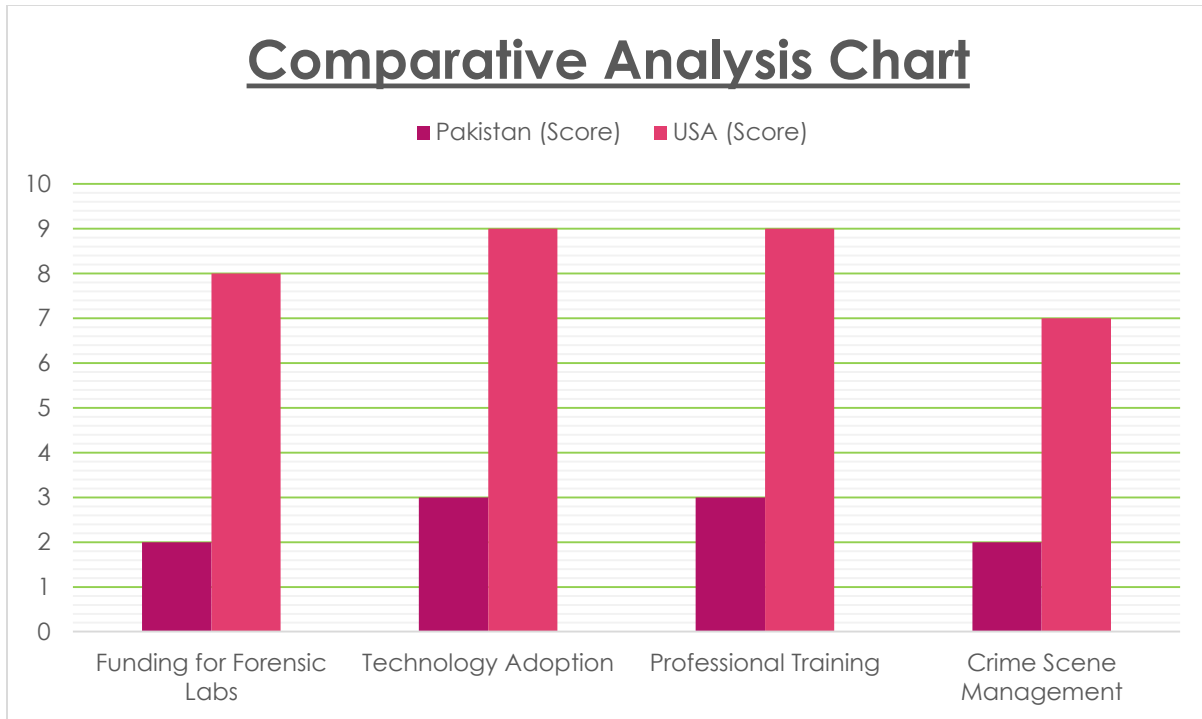
Explanation of the Table

Funding for Forensic Labs:
Pakistan: With limited funding outdated equipment, insufficient facilities, and slower case processing is what results. Expanding forensic services in broad areas is greatly affected by the lack of financial support.
USA: However, they have well funded forensic labs equipped with modernized equipment and fast turnaround times on investigation.

Technology Adoption
Pakistan: It's struggling to absorb all the advanced tools such as AI, machine learning and an all together comprehensive database on DNA.
USA: Utilizes cutting edge technologies in criminal investigations such as facial recognition or predictive analytics.

Professional Training
Pakistan: Huge shortage of trained forensic experts, never mind sporadic training programs among institutions.
USA: Provides specialized education and certifications for forensic professionals, with the aim of ensuring consistency and quality.

Crime Scene Management:
Pakistan: It faces problems of preserving evidence because standard procedures and personnel trained for the task are not available.
USA: The teams are well trained and the protocols that reduce evidence contamination are established.

Public Trust
Pakistan: Low public trust exists because forensic science is perceived as being corrupt, inefficient, and out of date.
USA: Forensic evidence, while the source of higher trust, generates controversy concerning race bias in forensic applications.

Timeliness of Justice Delivery:
Pakistan: Forensics labs are often backed up, and often, don't even have enough infrastructure to keep up. This often results in very long delays for cases to move forward.
USA: There are delays in large volume regions, but the system is faster and more efficient than in Pakistan.

Policy Improvements
Our experience from the USA, coupled with our existing situation matrix, defines some of the areas that Pakistan has to follow in order to enhance its forensic dexterity, the most crucial of which is the formulation of stringent forensic policies at the national level. The USA has a structured and well-developed procedure for forensic science with the National Forensic Science Commission, the national standards, the formation of databases like NDIS, and proper policies for collecting, storing, and analyzing forensic evidence (Munir et al., 2020). Pakistan may also need similar national policies that are definite about the guidelines of forensics that can help bring parity to jurisdictions. Furthermore, upgrading forensic research and training at entry, middle, and postgraduate levels of learning is mandatory. Consequently, Pakistan must develop professional forensics studies programs focusing on providing qualified specialists that will respond to the current needs of forensic science. The international experiences in dealing with different cases, along with training and coordination with other agencies like the FBI, may be helpful in building up more competent and efficient forensic expertise in Pakistan.

Investments in Forensic Science Infrastructure
The other important lesson Pakistan can learn from these British experiences is that more investment is required to improve the forensic science facilities. Most developed countries today, especially the USA, have invested many funds in modernized forensic laboratories and technology. Pakistan should pay adequate attention to enhancing its forensic setup, from procuring modern equipment for the respective labs to establishing digital forensics and DNA testing facilities (Farooq & Ahmad, 2022). Moreover, establishing the databases of each district and having a link between those databases would be very favorable in effectively resolving crimes in Pakistan.

Recommendations and Policy Implications
Recommendations for Pakistan
The forensic science system of Pakistan has several key issues, including inadequate resources, outdated technology, and a dearth of professional expertise. The following recommendations are thought necessary to address these challenges and enhance the quality of forensic practices.

Increased Funding for Forensic Labs
Another major weakness of forensic science in Pakistan is the qualifier of inadequate financial provisions for forensic laboratories. If forensic science and investigation are to be enhanced, then it is imperative that funding for forensic labs be enhanced. With this investment, it is possible to source new equipment, technocrats, and other necessities vital for performing other high-level forensic analyses ranging from DNA, Digital analysis, and Toxicology. Enough

funding would also ensure that labs increased their operational capacity, decreased backlog, and optimized the analysis of evidential, which would reduce delays in the justice system (Munir et al., 2020).

Specialized Training Programs for Law Enforcement and Judiciary

The absence of any legal mandate and requiring specialized training for police personnel or judicial authorities can compound Pakistan's forensic issues. There is a need to develop effective training systems to include the current trends in forensic practices, evidence collection, analysis, and presentation issues. Cops on the scene must be familiar with handling a crime scene, followed by collecting and preserving evidence. In the same regard, other judiciary officers such as Judges, lawyers, and any other judicial officer must be made aware of the use of forensics when handling criminal cases. This would help to bring out the realities of trials and increase the chances of credibility of the forensic experts in courts (Rasool & Rasool, 2022).

Awareness Campaigns for Public and Legal Professionals

If the public and the legal profession have more confidence in forensic science, then awareness should be conducted. Such campaigns should be geared towards sensitizing citizens on the role of forensic evidence in criminal investigations and the possibility of forensic science in the delivery of justice. Lawyers and judges as legal experts should undergo education on the relevance of forensic evidence and avoid downplaying the value of forensic findings. The practice will help create an informed public and legal bar by improving the exclusion of forensic science in the criminal justice system (Wahid, 2021).

Recommendations for the USA

The USA's forensic science system is highly developed, but it has several ethical and racial problems that need to be solved to have justice in the USA. The following recommendations are indispensable:

Addressing Ethical and Racial Disparities in Forensic Applications

New questions related to the racial profiling of forensic uses, including DNA, fingerprints, and profiling, are emerging. People of color, especially blacks and Hispanics, are usually on the receiving end whenever there is misuse or misinterpretation of forensic procedures. The USA must employ affirmative steps to eradicate such ethical problems by laying down rules and regulations for forensic procedures for identifying, analyzing, and reporting, which exclude racially influenced results. Furthermore, forensic practitioners should also be trained to detect if there is any form of implicit bias in their work. This will also guarantee that forensic science will be offered to all equally, regardless of their color or origin (Charan, 2024).

Continuous Research and Innovation in Forensic Methods

The forensic science profession is dynamic, and it is not frozen because AI, machine learning, and even digital forensics are advancements that are just coming into sight. USA must focus on research and innovations in forensic techniques to remain ahead in crime solving. Grants for forensic research programs should be provided to make efficient, accurate, and more reliable forensic methods. In addition, the concepts of AI and machine learning have entered the field of forensic science, offering opportunities to advance crime-solving by increasing the overall efficiency of the analysis of the evidence and speeding up the process (Shepitko & Shepitko, 2021).

Global Implications

The difficulties and innovations described above are international in significance since forensic investigation is a critical component of criminal justice systems worldwide. Consequently, international cooperation and information sharing are acutely required to eliminate barriers to forensic science, especially in the developing world.

In particular, a country like Pakistan may greatly benefit from international cooperation in forensic science. Cooperation with more developed countries, such as the USA, can resolve deficiencies in developing forensic activities, materials, and equipment (Garrett et al., 2021). INTERPOL and UNODC are potential knowledge-sharing organizations through which countries can implement forensic science's best practices. In addition, developing global forensic networks may lead to sharing expertise and necessary equipment and tools for enhanced forensic systems in various countries. It could also create the conditions for establishing general forensic practices, increasing the reliability of forensic data globally.

With people moving and organizing themselves in a globalized world, international cooperation in forensic issues remains valuable and essential in dealing with cross-border crimes such as human trafficking, terrorism, and Organised crimes. Cooperation in forensic science facilitates the proper working out of a case with elements that cross international borders. Implementing a list of best practices for forensic workers or a number of shared databases could help the police forces of different countries track criminal activities and share valuable information, which would increase the level of lightning protection in the world.

Conclusion

Forensic science occupies a central position in the criminal justice systems of most developed and developing countries, being an indispensable means of identifying criminals, preventing false convictions, and preserving citizens' confidence in the law. This comparison of activities of forensic science in Pakistan and the USA depicts that minor differences hold the potential for both challenges and improvements in the advancements of the forensic system in Pakistan and the world as a whole through leveraging on the opportunities, enhancing the required infrastructural setups, training facilities, and high standard ethical code of conduct among others.

Summary of Key Findings

Pakistan is yet in its developmental stage of forensic science, being hampered by a lousy infrastructure in this respect, inadequate funding, and poor training for personnel involved in law enforcement and judiciary. The National Forensic Science Agency (NFSA) is a body that has achieved a set goal of enhancing forensic frequencies, but there are huge disparities across the resources and personnel. Moreover, there is low awareness among the population regarding the involvement of forensic science in the criminal justice system, which poses a problem with the credibility and admissibility of forensic evidence.

While the USA has also been implementing advanced technologies like digital forensics, artificial intelligence, and the enforcement of forensic laboratories' connection with law enforcement agencies and the judiciary, it has advanced significantly. However, issues like racism in the usage of forensic applications, ethical issues, and the high costs of the most modern technologies remain some of the major challenges. The USA has a more developed system of forensics, and it also needs constant improvement due to constant scientific development as well as ethical problems.

Importance of Forensic Science in Upholding Justice

According to the research, forensic science is a central cog in the wheel of justice. This application makes it possible for criminal investigations to be done without bias but rather scientifically without assumptions or biased opinions. In any investigative process, forensic science helps support the claims by presenting evidence that can be deemed accurate by even the judicial system. In nations like Pakistan, a sound structure of forensic sciences must be established for a proper and fair justice system. In the USA, for instance, the system has ethical problems that may compromise the fairness of the applications espe, especially for minorities, even though it enjoys the advanced means of forensics. For these reasons, solving these problems becomes crucial in rebuilding the public's trust in forensic practices. Forensic science can help bring about fair legal outcomes by increasing the efficiency of the techniques used and eliminating ethical and racial bias.

Future Directions for Research and Development in Forensic Science

There is every reason to agree with the authors that the future of forensic science will be characterized by change on a large scale due to the advances in technology and the expansion of international cooperation. The three papers establish that forensic advancement, especially in Pakistan and the USA, is on a continued rise, mainly in digital forensics and AI, which will only promote better and more efficient investigations. Forensic biology is an essential segment of this scientific specialization because it offers several directions for development in the sphere of DNA analysis, toxicology, and cyber forensics that have become particularly valuable when overcoming the new challenges of the present day's crimes. Moreover, future studies should identify the absence of ethical considerations in forensic science, including racial bias, privacy violation, and the possibility of abusing the offered technologies. Research on enhancing forensic education and training must become integral in training officers for instrumental tasks, given the complexities of cases expected in the future.

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