

## Overview of Fingerprint-Based Blood-Grouping using Various Tools and Techniques

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### Abstract

Blood grouping plays a crucial role in medical diagnostics, transfusion practices, and forensic investigations. Traditional methods for determining blood groups involve serological testing of blood samples, which, while accurate, require invasive procedures, trained personnel, and time. Researchers have recently explored non-invasive alternatives, among which biometric approaches such as fingerprint analysis have gained attention. The emerging field of fingerprint-based blood grouping presents a revolutionary, non-invasive alternative by leveraging the unique biochemical composition of fingerprint residues and the distinct patterns of epidermal ridges. This approach offers significant value by enabling rapid, cost-effective, and hygienic blood type determination, with profound benefits for enhancing emergency response efficiency, streamlining donor registration in blood banks, and advancing forensic investigations. The purpose of this comprehensive review is to synthesize current research and provide a detailed overview of the methodologies underpinning this technology. We examine the scientific basis for the correlation between fingerprint patterns and ABO/Rh blood groups, evaluate traditional chemical and spectroscopic techniques, and analyze the cutting-edge integration of artificial intelligence (AI) and deep learning models for automated classification. Furthermore, the review discusses the practical applications, advantages, and current limitations of the technology, concluding with an outlook on future directions for research and implementation. This paper underscores the transformative potential of fingerprint-based blood grouping as a viable and promising solution for modern medical and forensic challenges. However, further research with larger and more genetically diverse populations is required to validate and refine the predictive models. In conclusion, while fingerprint-based blood grouping cannot yet replace conventional methods, it offers a compelling supplementary tool for rapid, non-invasive blood group estimation.

**Keywords:** Biometric Blood Typing, Deep Learning and Machine Learning, AI-based Pattern Recognition, Predictive Healthcare Technology, Genetic-Biometric Correlation

### Introduction

Blood group identification is a critical aspect of medical diagnostics, transfusion practices, and emergency care. Traditionally, this process relies on serological techniques that require direct sampling of blood, specialized reagents, and trained personnel.

While effective, these methods are invasive, time-consuming, and often inaccessible in remote or under-resourced environments. With the increasing demand for non-invasive, rapid, and cost-effective diagnostic tools, researchers have begun exploring innovative biometric alternatives—one of the most promising being fingerprint-based blood grouping.

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Fingerprints, or dermatoglyphics, are unique, permanent, and genetically influenced. Given that blood group antigens are also genetically determined, a potential correlation between fingerprint patterns – such as loops, whorls, and arches – and blood groups has sparked growing scientific interest. Recent advancements in data analytics, artificial intelligence (AI), and machine learning have made it possible to analyse large biometric datasets with high precision, uncovering subtle patterns and associations that were previously undetectable. Innovations in image processing and mobile health (mHealth) technologies have further accelerated the feasibility of this approach. Fingerprint scanners integrated with smartphone apps or portable devices can now capture high-resolution images quickly and reliably, making the technology scalable and user-friendly. AI-powered predictive models trained on biometric and blood group data have demonstrated encouraging accuracy levels, suggesting real-world applicability in settings where conventional blood testing is not viable, such as disaster zones, remote clinics, and forensic investigations. This paper investigates the potential of using fingerprint patterns as a non-invasive predictor for blood grouping. By combining biometric analysis with AI-driven models, we aim to assess the strength of correlation, improve prediction accuracy, and explore practical use cases. This novel approach not only holds promise for faster and more accessible healthcare but also aligns with the broader movement toward personalized, tech-enabled medicine. <sup>[1][2]</sup>

Some real-life examples are:

### **1. The Colin Pitchfork Case (UK, 1983–1987) – First DNA Exoneration Using Blood Grouping**

- Case: Two young girls were raped and murdered in Leicestershire, UK. A suspect, Richard Buckland, confessed to the second murder but denied the first.
- Blood Group Evidence: Semen samples from both crime scenes revealed the killer had blood type A and was a secretor (blood group antigens present in bodily fluids). Buckland was typing B, so he was excluded.

- Outcome: This led to the first mass DNA screening, ultimately identifying Colin Pitchfork as the real killer. Blood grouping helped eliminate an innocent suspect before DNA profiling was fully established.

### **2. The Narborough Village Murders (UK, 1986) – Blood Grouping in Serial Rape-Murders**

- Case: Two teenage girls were raped and murdered in a similar fashion year apart.
- Blood Group Evidence: Semen samples from both crimes showed the killer was a type A secretor.
- Outcome: Blood grouping narrowed down suspects before DNA testing confirmed the killer (Colin Pitchfork, same as above).

### **3. The Lindbergh Kidnapping Case (USA, 1932) – Early Use of Blood Typing**

- Case: Charles Lindbergh's baby was kidnapped, and a ransom was paid, but the child was later found dead.
- Blood Group Evidence: A ladder used in the kidnapping had bloodstains matching type A, while the suspect, Bruno Hauptmann had type O.
- Outcome: The mismatch was used to suggest Hauptmann's involvement, though other evidence (ransom money, wood grain analysis) was more decisive.

### **Benefits of Blood group prediction in the Medicolegal aspect**

1. Paternity and Kinship Disputes
2. Crime Scene Investigations
3. Identification of Unknown Bodies or Mass Disasters
4. Blood Transfusion and Medical Malpractice Cases
5. Disputed Maternity Cases (Rare but Possible)
6. Rape and Sexual Assault Cases

### Limitations in Medicolegal Use:

- Blood grouping is less discriminatory than **DNA profiling** (which provides near-certain identification).
- It cannot uniquely identify an individual but can exclude suspects or establish possible relationships.
- Advances in DNA technology have reduced reliance on blood grouping, but it remains useful in resource-limited settings.

### Chronological Development of Blood Grouping

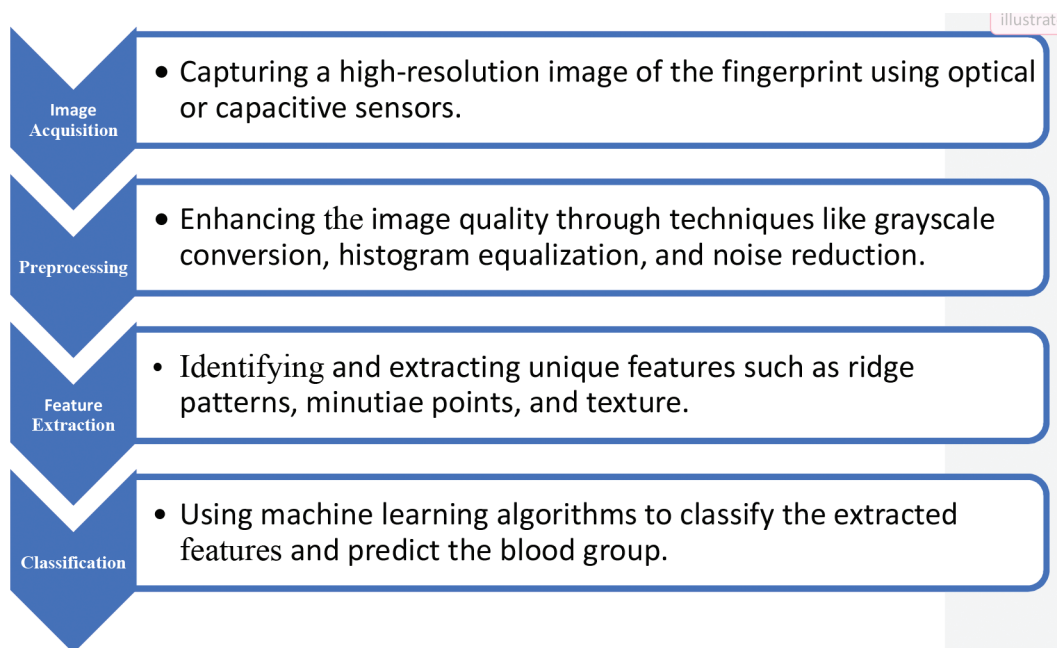
1. *Early Studies:* Early research into the relationship between dermatoglyphics (fingerprint patterns) and blood groups dates back to the mid-20th century. Initial studies suggested statistical correlations between certain fingerprint patterns and specific blood groups. However, these studies were limited by small sample sizes, subjective analysis, and a lack of automation.
2. *Advancements in Technology:* With the advent of digital imaging and machine learning, more sophisticated methods have emerged. Researchers have employed various algorithms to analyse fingerprint images and predict

blood groups. For instance, studies have utilized Support Vector Machines (SVMs), Convolutional Neural Networks (CNNs), and hybrid models that combine traditional and deep learning techniques to enhance prediction accuracy.

3. *Recent Developments:* Recent studies have focused on enhancing the accuracy and reliability of fingerprint-based blood grouping systems. Techniques such as data augmentation, transfer learning, and multi-modal biometric systems have been explored to tackle challenges like dataset imbalance, overfitting, and environmental variability.<sup>[3][4]</sup>

### Methodologies

- ✓ *Traditional Methods:* Traditional blood grouping methods involve mixing blood samples with specific antibodies and observing agglutination reactions. While accurate, these methods are invasive and require laboratory settings.
- *Fingerprint-Based Blood Grouping:* Fingerprint-based blood grouping involves capturing a high-quality image of an individual's fingerprint and analysing specific features to predict their blood group. The process typically includes:<sup>[5][6]</sup>



## Traditional Blood Grouping Methods

Traditional methods of blood grouping include:

- i. *Slide Agglutination Test*: This method involves placing blood on a slide and adding specific antibodies. The presence of agglutination indicates the presence of corresponding antigens.
- ii. *Tube Test*: Similar to the slide test but conducted in test tubes, allowing for more precise results. <sup>[7]</sup>
- iii. *Gel Column Agglutination*: A modern method that uses gel columns to separate agglutinated cells, providing accurate and reliable results. While these methods are accurate, they are invasive and require laboratory equipment and trained personnel.

## Modern Techniques in Fingerprint-Based Blood Grouping

Modern techniques have brought machine learning (ML), deep learning (DL), and artificial intelligence (AI) into the spotlight for analysing biometric data like fingerprints. These technologies provide automated, scalable, and more accurate methods of identifying patterns that could relate to an individual's ABO and Rh blood group. <sup>[8]</sup>

- A. *Machine Learning Approaches*: Machine Learning models are trained on datasets containing fingerprint images with known blood groups to learn patterns and make predictions.

Key Techniques:

- **Support Vector Machines (SVM)**:
  - ❖ Separates data into different classes (A, B, AB, O) by finding the optimal boundary (hyperplane).
  - ❖ Suitable for small- to medium-sized datasets.
  - ❖ Often used after handcrafted feature extraction (like ridge count, ridge frequency, etc.).

- **Random Forest**:

- ❖ An ensemble learning technique that builds multiple decision trees and averages their output.
- ❖ Robust against overfitting and effective when working with non-linear data.

- **k-Nearest Neighbours (k-NN)**:

- ❖ Classifies new data points based on the majority label of the k most similar points. <sup>[9]</sup>
- ❖ Works well with structured data, but is computationally expensive with large datasets.

### Steps in ML-based Prediction:

1. **Fingerprint Acquisition**: Capturing images using digital scanners.
2. **Preprocessing**: Enhancing quality, removing noise, and segmenting the region of interest.
3. **Feature Extraction**:
  - Ridge density
  - Ridge orientation
  - Minutiae points (bifurcations, ridge endings)
  - Pattern classification (loop, whorl, arch)
4. **Model Training and Evaluation**:
  - Data split into training and test sets.
  - Accuracy, sensitivity, and specificity measured. <sup>[10]</sup>

### Performance:

- Accuracy typically ranges from 65% to 80%, depending on the dataset quality and preprocessing techniques.
  - Improvement is possible through feature selection and parameter tuning.
- B. *Deep Learning Techniques*: Deep Learning is a subset of ML that automatically learns features from raw data using neural networks.

In fingerprint blood group prediction, DL has enabled higher accuracy and better generalization.<sup>[11]</sup>

#### Key Architectures:

- **Convolutional Neural Networks (CNN):**
  - ❖ Designed for image data.
  - ❖ Automatically learns spatial hierarchies and texture features from fingerprint images.
  - ❖ CNNs can distinguish between subtle variations in ridge orientation and minutiae patterns.
- **Recurrent Neural Networks (RNN) & LSTM (Long Short-Term Memory):**
  - ❖ While typically used for sequence data, they may be incorporated to analyse sequential features in fingerprint ridges.
- **Hybrid CNN-SVM (Support Vector Mechanism) Models:**
  - ❖ CNN extracts features.
  - ❖ SVM handles classification, improving accuracy, especially when the dataset is small.<sup>[12][13]</sup>

#### Techniques Used in DL-Based Models:

- **Data Augmentation:** Enhancing the dataset by rotating, flipping, and adding noise to fingerprint images.
- **Transfer Learning:** Using pretrained models (like VGGNet, ResNet)<sup>[14]</sup> fine-tuned on fingerprint data.
- **Dropout and Batch Normalization:** Techniques to reduce overfitting and accelerate training.

#### Performance:

- Achieved accuracy of 85% to 92% in recent studies.
- Deep learning models outperform traditional ML in larger datasets due to their ability to capture complex patterns.

c. *Artificial Intelligence Systems:* AI systems combine ML/DL models with other smart systems to create intelligent diagnostic platforms. These systems not only predict blood group but also automate decision-making, handle uncertainty, and integrate with healthcare infrastructures.<sup>[15]</sup>

#### Components:

- **Predictive Engine:** Based on ML/DL models.
- **User Interface (UI):** Allows technicians or healthcare workers to input fingerprint scans and receive results.
- **Database Integration:** Links with electronic health records (EHRs) or biometric identity systems.
- **Cloud-Based Storage:** Enables remote access and long-term data storage.<sup>[16]</sup>

D. *Blockchain Mechanism in Blood Grouping Using Fingerprints:* Blockchain is a decentralized, distributed ledger technology that ensures data integrity, transparency, and security. It operates through a network of nodes (computers) where each transaction or data entry (block) is time-stamped and linked to the previous block, creating an immutable chain. This technology is widely used in cryptocurrencies, but its potential extends far beyond digital currencies, including applications in healthcare, biometrics, and identity verification.

**Blockchain for Fingerprint-Based Blood Group Prediction:** Integrating fingerprint-based blood grouping with blockchain technology can revolutionize how biometric data, including health-related information like blood types, is stored and shared. The key benefit here is blockchain's security, transparency, and decentralization, ensuring that users' sensitive data (fingerprints, blood groups) is securely stored and accessed only by authorized parties.<sup>[17]</sup>

## Result

**Summary Table: Comparison of Techniques**

Technique	Accuracy	Data Requirement	Automation Level	Practical Use
Manual Dermatoglyphic Analysis	50 – 60%	Low	Low	Education, Historical
Machine Learning (SVM, k- NN)	65- 80%	Medium	Medium	Prototype Tools
Deep Learning (CNNs)	85-92%	High	High	Research, Advanced Tools
AI Systems (Hybrid + Ingrate)	90%	High	Very High	To ensure the Safety and security of blood delivered to the patient

**Figure 1: Table to show the comparison of techniques**

Reference: <https://images.app.goo.gl/nzyF3ErmEUDh7oQe7>

### Statistical Insights on Fingerprint Patterns and Blood Groups

Studied Regions	Sample Size	Blood Group Distribution	Fingerprint Patterns	Findings	Source
Uttarakhand Region, India	140 MBBS students aged 18–25	Not specified	<b>Loops:</b> 58.29% <b>Whorls:</b> 37.00% <b>Arches:</b> 4.71%	Loops were predominant in all ABO blood groups, except for blood group A positive, where whorls were slightly more common. A significant association was found between fingerprint patterns and blood groups.	<sup>[18]</sup> ( <i>View of a Study of Fingerprint in Relation to Gender and Blood Group Among Medical Students in Uttarakhand Region, n.d.</i> )
Zawia, Libya	305 medical students	<b>O:</b> 48.9% <b>A:</b> 33.1% <b>B:</b> 12.8% <b>AB:</b> 5.2%	<b>Loops:</b> 50.5% <b>Whorls:</b> 35.1% <b>Arches:</b> 14.4%	In Rh-positive cases of blood group, A and O, loops were most common, while whorls were predominant in blood group B. High frequencies of loops were observed in the thumb, index, and little fingers	<sup>[5]</sup> (Fayrouz et al., 2011b)

Continue....

Eastern India	800 participants	<b>B+:</b> 35.8% <b>O+:</b> 28.1% <b>A+:</b> 22.5% <b>AB+:</b> 9.5%	<b>Loops:</b> 55.9% <b>Whorls:</b> 34.9% <b>Arches:</b> 6.1% <b>Composite:</b> 3.1%	Loops were most common in blood group AB (61.0%), while whorls were most common in blood group B (37.6%). A statistically significant association was found between fingerprint patterns and ABO blood groups (p=0.0003).	<sup>[15]</sup> Rastogi et al. (2023b)
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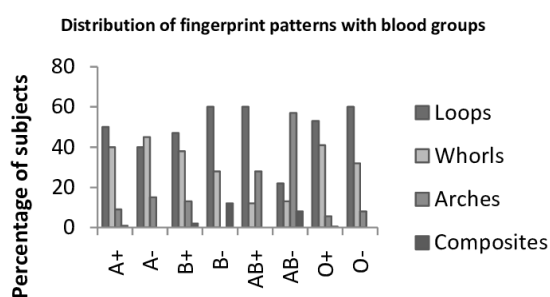


Figure 2: Distribution of fingerprint patterns with blood groups

Reference: <https://images.app.goo.gl/Xq2JstbL4dB37kvVA>

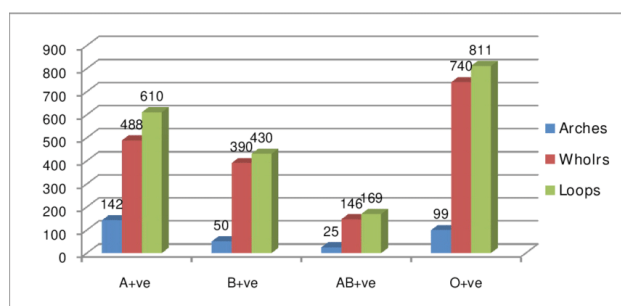


Figure 3: Distribution of fingerprint patterns with blood groups for a large sample size

Reference: <https://images.app.goo.gl/urAauRL4MeoUsRqE9>

### Discussion

#### Applications:

- **Healthcare**
  - Emergencies where blood group is unknown.

- Paediatric and geriatric care for non-invasive diagnostics.
- Mass screening in rural or remote locations.
- **Forensic Significance of Fingerprint-Based Blood Grouping**

#### (a) Personal Identification in Criminal Investigations

Fingerprints are unique to each individual and remain unchanged throughout life. This permanence makes them invaluable in forensic science for identifying individuals involved in criminal activities. By analysing fingerprint patterns, forensic experts can ascertain the blood group of a suspect or victim, aiding in establishing identity when traditional identification methods are unavailable.

#### (b) Correlation with Blood Grouping

➤ Studies have shown that certain fingerprint patterns are more prevalent in individuals with specific blood groups. For instance, loops are commonly found in individuals with blood group B, while whorls are more frequent in those with blood group O. This correlation can assist forensic experts in narrowing down potential suspects or victims based on fingerprint analysis. **Mobile Health (mHealth)**

- Apps for personal health monitoring that store biometric blood group data.
- Can be used by travellers, mountaineers, or remote workers.

➤ **Medical and Genetic Applications**

(a) Early Diagnosis of Genetic Disorders

The correlation between fingerprint patterns and blood groups can provide insights into genetic predispositions to certain diseases. For example, individuals with specific fingerprint patterns and blood groups may be at higher risk for conditions like diabetes mellitus. Identifying these patterns early can lead to proactive health monitoring and management.

(b) Personalized Medicine

Understanding the relationship between fingerprint patterns and blood groups can contribute to personalized medicine approaches. By analysing these biometric markers, healthcare providers can tailor treatments and interventions to individuals' genetic profiles, potentially improving treatment outcomes. <sup>[19][20]</sup>

➤ **Research and Development**

(a) Enhancing Forensic Techniques

Integrating fingerprint analysis with blood group determination can enhance existing forensic methodologies. This multidisciplinary approach can lead to the development of more robust identification systems, combining biometric data with genetic information for comprehensive analysis.

(b) Advancements in Biometric Research

Ongoing research into the relationship between fingerprint patterns and blood groups continues to uncover new insights. These findings can inform the development of advanced biometric systems, improving accuracy and reliability in personal identification processes.

➤ **Legal and Ethical Considerations**

(a) Privacy Concerns

The collection and analysis of biometric data, including fingerprints and blood group information, raises significant privacy issues. Ensuring that such data is handled responsibly and with consent is crucial to maintaining public trust and upholding individual rights.

(b) Ethical Use in Forensic Investigations

While fingerprint analysis is a powerful tool in forensic science, its use must adhere to ethical guidelines. The integration of blood group determination should be conducted with transparency and accountability to prevent misuse and ensure justice. <sup>[23]</sup>

Advantages:

Advantage	Description
<b>Non-Invasive</b>	No blood sample required
<b>Quick &amp; Portable</b>	Can be integrated into mobile devices for field use
<b>Cost-Effective</b>	No reagents or lab setup
<b>Scalable</b>	Suitable for large-scale screening
<b>Emergency Use</b>	Useful in disasters, accidents, and remote locations
<b>Integration-Ready</b>	Compatible with existing biometric systems

Disadvantages:

Disadvantage	Description
<b>Accuracy Not Yet Clinical-Grade</b>	Predictive accuracy is still below medical diagnostic standards
<b>Ethical Issues</b>	Biometric data privacy and consent concerns
<b>Population Variability</b>	Fingerprint-blood group link may differ by ethnicity
<b>Lack of Standardization</b>	No global clinical guidelines yet
<b>False Positives/Negatives</b>	Can lead to misclassification in sensitive scenarios

**Future Advancements and Directions**

1. *Multimodal Biometric Systems:* Future systems will likely integrate fingerprint data with other biometric inputs like iris patterns, facial features, retinal scans, and even DNA sequencing, creating a multimodal biometric

ID system. These systems could revolutionize personal identification, especially in high-security sectors, refugee tracking, and border control.

2. *Integration with Wearables and Mobile Health:* The next decade may see fingerprint scanning integrated into mobile devices and wearable sensors, capable of predicting blood group or flagging inconsistencies for health screening. Remote health apps may use these predictions for emergency alerts, donor matching, or first-aid guidance, particularly in areas with limited medical infrastructure.
3. *AI-Driven Population Studies:* AI will be pivotal in large-scale ethnographic and genomic studies, analysing fingerprint-blood group correlations across diverse populations and genetic backgrounds. This will help build standardized fingerprint-blood group databases, improving model generalizability and reducing demographic bias. <sup>[24]</sup>
4. *Blood Group Prediction in Paediatrics and Neonatology:* Since infants' veins are fragile, non-invasive fingerprint-based prediction could become an important tool in neonatal care, aiding early transfusion planning or identifying genetic risks linked with blood group types.
5. *Enhanced Forensic and Criminal Profiling Tools:* Law enforcement agencies may develop real-time crime scene analysis tools that use partial fingerprint data to predict blood group, gender, or even potential familial ties, expediting suspect identification and narrowing investigative leads. <sup>[21]</sup>

### **Future Advancements in Blockchain and Fingerprint-Based Blood Grouping**

- A. *Integration with Electronic Health Records (EHR):* In the future, fingerprint-based blood group data could be seamlessly integrated into existing Electronic Health Record (EHR) systems. By using blockchain technology, individuals could store and access their health records in a secure, decentralized manner. This would provide doctors with a real-time, accurate view of a patient's blood group and medical history, improving the efficiency of healthcare services, especially in emergencies or disaster-stricken areas.
- *Patient Control:* With blockchain, patients can have control over who views their health data. They could grant temporary access to their blood group and fingerprint data during emergencies (e.g., blood transfusions or organ donation) through smart contracts.
- B. *Decentralized Healthcare Ecosystems:* In the future, we could see the rise of decentralized healthcare ecosystems where medical practitioners, laboratories, and even insurance providers can access patient data in a secure and verifiable way. These ecosystems would be powered by blockchain and could include fingerprint-based blood grouping systems to quickly identify and verify individuals' blood types for urgent medical procedures.
  - *Global Access:* Blockchain's decentralized nature means that users' blood group information can be accessed globally by hospitals, clinics, and emergency teams, ensuring that universal blood compatibility is always taken into account.
- C. *Secure Blood Donation and Transfusion Systems:* One of the most promising future applications of blockchain in blood grouping is in the management of blood donation and transfusion networks. Blockchain could help ensure the traceability of blood products, including their origin (donor) and compatibility. Fingerprint-based blood group verification would be integrated into the system to match donors and recipients more efficiently and securely.
  - *Donor-Recipient Matching:* Blood donations could be linked with blockchain-based fingerprint records to ensure that the right blood type is given to the right patient. In emergencies, this could expedite the matching process, ensuring quick access to critical blood supplies. <sup>[23]</sup>

D. **Use in Forensic and Criminal Investigations:** Blockchain and fingerprint-based blood grouping could become essential in forensic science. Fingerprints found at a crime scene could be linked with blockchain records to help identify individuals and predict their blood types, which could be crucial for investigating crimes involving blood stains or victim identification.

- **Chain of Custody:** Blockchain's immutable ledger can ensure the chain of custody for evidence collected from crime scenes, where fingerprints and blood group data can be used to confirm the identity of suspects or victims, offering a transparent and tamper-proof record.

E. **Multi-Layered Privacy and Security with Blockchain:** As privacy concerns around biometrics intensify, blockchain offers a robust solution to address these concerns. By combining blockchain's decentralized, immutable nature with advanced cryptographic techniques, users can maintain full ownership over their biometric data (such as fingerprints and blood groups) while also ensuring that only authorized parties can access this sensitive information.

- **Zero-Knowledge Proofs (ZKPs):** Future advancements might use Zero-Knowledge Proofs (ZKPs), a cryptographic technique that allows a party to prove they know a piece of information (like a blood type or fingerprint) without revealing the actual information. This would significantly enhance privacy while allowing for secure verification in biometric applications.

### Challenges to Overcome

- **Ethical concerns** around data privacy, biometric misuse, and informed consent.
- **Data diversity** and model bias due to uneven population sampling in current datasets.
- **Environmental and genetic variability**, which can affect fingerprint formation and complicate modelling.

- **Regulatory frameworks** for clinical application and forensic admissibility.
- **High initial cost** as the implementation of blockchain technology requires significant upfront investments in infrastructure, integration, and skilled personnel.
- **Complexities** are very high as it requires specialised knowledge about the field, so its implementation rate is very low.
- **Interoperability** of different blockchain networks may not easily be achieved, hindering integration with the existing healthcare system.<sup>[24]</sup>

While blockchain offers significant advantages, several challenges must be addressed:

- **Scalability:** As the number of users and the data stored on blockchain networks increase, scalability may become an issue. Future research will need to focus on developing more efficient blockchain architectures that can handle large-scale biometric data.
- **Regulation:** The use of blockchain for sensitive biometric data, especially related to healthcare, would require regulatory frameworks to ensure that privacy laws, such as GDPR (General Data Protection Regulation) or HIPAA (Health Insurance Portability and Accountability Act), are followed.<sup>[25]</sup>
- **Adoption:** Widespread adoption of blockchain for biometric identification in healthcare and law enforcement may require significant investment in technology and infrastructure, alongside the development of standardized practices for data collection and management.<sup>[26]</sup>

### Conclusion

The exploration of fingerprint-based blood grouping has revealed itself as a promising frontier at the intersection of forensic science, medical diagnostics, and biometric identification. Through decades of research, scholars have observed

statistically significant correlations between fingerprint patterns—loops, whorls, arches—and specific ABO and Rh blood groups. While this relationship may not yet support absolute blood group determination solely through dermatoglyphics, the observed associations offer valuable predictive insights, particularly when enhanced with artificial intelligence (AI) and machine learning (ML) models. Traditional blood typing, while clinically reliable, involves invasive techniques, the need for reagents, and trained personnel. In contrast, fingerprint analysis is non-invasive, inexpensive, rapid, and universally accessible—traits that make it particularly useful in forensic scenarios, rural healthcare settings, and disaster management. When combined with automated classification algorithms, such as Support Vector Machines (SVM), Convolutional Neural Networks (CNN), and decision trees, the predictive capability of fingerprint data can significantly support human identification and triage systems. Recent studies have shown prediction accuracies exceeding 85–90%, depending on data quality and algorithmic approach, particularly when enhanced by image preprocessing and data augmentation techniques. These achievements hint at the potential for semi-automated systems in hospitals, forensic labs, or even mobile apps, where users could obtain approximate blood group predictions with just a fingerprint scan.

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**Source of Funding:** None

**Ethical Clearance:** Not required

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