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Original Article

Investigating Correlations in the Inheritance of Fingerprints and Blood Groups of Indian Families, Residing in Gurgaon

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Abstract - *A fingerprint is a unique pattern of valleys and ridges on an individual's finger. Given its ability to verify or refute identity, fingerprint evidence can be extremely valuable in criminal investigations. The study's principal objective was to examine fingerprint inheritance in Indian families living in Gurgaon and investigate whether there may be a correlation between fingerprint inheritance and blood groups. A number of 40 offspring and their respective parents (a total of 120 individuals) were randomly chosen from families residing in Gurgaon. A pre-designed form outlining the process for collecting thumb impressions and blood types was created and disseminated. It had the necessary area for sample collection. Following collection, the prints were categorized using Henry's approach, which divides fingerprints into three categories: loops, whorls, and arches. Blood Group O, the recessive blood type, was observed to have a higher prevalence of Arches, which may be a recessive feature. Loops and whorls were more prevalent in co-dominant blood types A, and B. Higher inheritance of fingerprints was observed between father to daughter and mother to daughter compared to father to son and Mother to son.*

Keywords - *Inheritance, Fingerprint Patterns, Blood Group, Offsprings.*

1. Introduction

Dermatoglyphics studies fingerprints, exploring patterns on fingers, hands, and feet. Fingerprints are defined as the patterns found on the fingertips formed with ridges and furrows. Fingerprints are one type of biometrics, a science that utilizes physical traits to identify individuals. These are unique; no two individuals can have the same pattern, even monozygotic twins. Interestingly, fingerprints have different types of patterns that are inheritable; they are genetically inherited. Individual details might differ, but their patterns match those of either one of the parents.[1] Marcello Malpighi, an Italian physician and biologist, first discovered Fingerprint Analysis in 1686.[2] According to his studies, fingerprints often feature one of four patterns: ridges, whorls, loops, or arches. In 1823, Professor Johannes Evangelista Purkinje continued this research and documented nine geometric fingerprint patterns: arch, tented arch, ulna loop, radial loop, peacock's eye/compound, spiral whorl, elliptical whorl, circular whorl, and double loop/composites.[3-4] Fingerprint formation is the development of unique patterns of ridges on the surface of a person's fingertips. The process of fingerprint development would include prenatal development, genetic factors, mechanical forces, and permanence. Prenatal development is the formation of fingerprint patterns during the fetus's development stage (10th to 24th weeks of gestation). During this process, genetic factors significantly determine the overall pattern of ridges and valleys.[5] As the fingers and hands grow in the womb, mechanical forces such as pressure and movement cause the skin to buckle and fold. These forces contribute to the formation of ridge patterns. Once the fingerprints have been formed during fetal development, they remain relatively stable throughout a person's life. An individual's fingerprint is primarily based on the patterns of skin ridges. As mechanical and genetic factors play a role in the development of fingerprints, this feature tends to be unique, irrespective of one's heredity.

There has been a debate regarding the heritability of certain traits, including fingerprints, in humans for a considerable period.[6] Studies conducted by Jutika Devi et al. (2023)[7] stated that arches are possibly a recessive trait, and the same is prevalent in Blood Group O, known as a recessive blood type. Loops and whorls, on the other hand, would be visible in the co-dominant blood groups A and B. Furthermore, Eric O. Aigbogun Jr. et al. (2019)[6] suggest that fingerprints are predominantly genetically determined, with slight environmental influences. On the contrary, the qualitative qualities of fingerprint pattern similarity in families using scientific evidence are limited because most studies have used quantitative approaches. Moreover, the available classifications could not provide a strong scientific foundation for their application in family-based studies[7]. The current study was based on deriving a correlation between the inheritance of fingerprints and the blood groups of Indian families residing in Gurgaon.

2. Methods

The study was conducted in Gurgaon, India, from August 2023 to March 2024. A total of 40 randomly selected families were selected to estimate the pattern similarity of the offspring compared to their parents. Random sampling was conducted as the genetic variation is likely higher, and all participants have an equal probability of being chosen (Unbiased selection/ representation). The primary criteria for family selection included those with at least a father, mother, and child and no medical history of congenital abnormalities.[9] Incomplete families such as single parents or no child and families with an adoption history were all excluded. A survey was conducted on both the children and their parents. All 120 participants participated in the survey by providing samples of their Right Thumbprints and data regarding their blood groups. Individuals between the age group 10 to 18 were taken into account to ensure no alterations had been made to one's fingerprint due to skin elasticity and as the age group was accessible easily. All the participants voluntarily participated in the survey. After obtaining their consent, the prints of the left-hand thumbs were collected from the students and their parents through the survey.

A pre-designed form containing columns for thumbprints and students' names and a row for blood groups was provided to each student and their parents. Thumb pads were used to smear the thumb with color, and then the thumb was placed on the paper to collect the impression. The procedure for fingerprint collection and blood group identification was explained to the students before distributing the pre-designed paper for sample collection. After the fingerprint and blood group samples/ data were procured, the prints were thoroughly analyzed using a magnifying glass. The fingerprints were divided based on the pattern of their ridges, which were either Whorls, Loops, or Arches.

The data was then documented in an Excel Sheet to conclude the same. In the study, the prints were classified according to Henry's system. In Henry's system, the patterns are classified based on the presence and position of 'Core' and 'Delta.' The core is the central position of the patterns, while the delta is a triangular shape formed by the ridges of the print. Whorls were identified by the core in the middle, formed by ridges in a whirlpool manner and two deltas on either side. The loop was identified with a core in the middle formed by ridges that flow either toward the direction of the thumb (Radial Loop) or toward the direction of the little finger (Ulnar loop), with only one delta found at the base of the bend.[6] Arches were identified, with the ridges being in a wave-like pattern with the delta being at the core or absent.

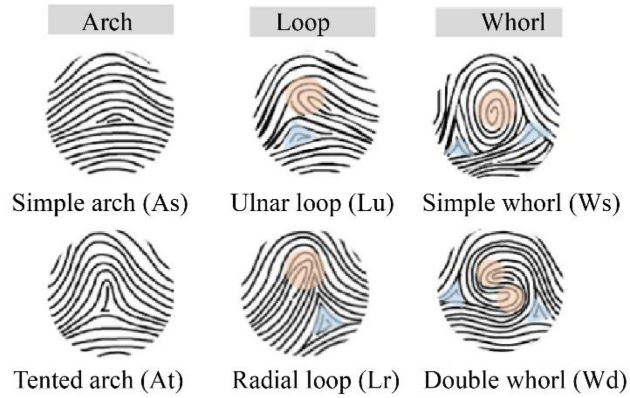

Fig. 1 I dentification of Fingerprints[8]

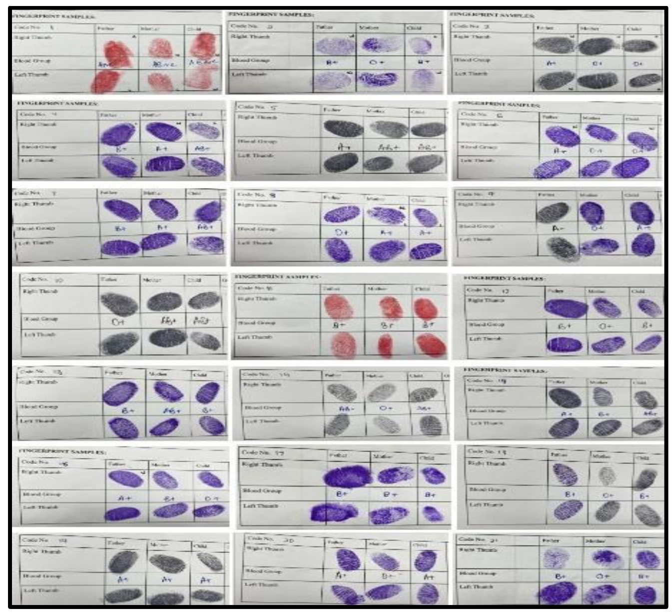

Fig. 2 Fingerprint Samples of Family 1-21

3. Results and Discussion

The data gathered during the survey was organized into a master spreadsheet. Figures 2 and 3 depict photos of the fingerprints submitted by all participants. Table 1 represents the inheritance of fingerprints between parents and their offspring. The highest frequency of inheritance was observed between the father and daughter (28.6%), followed by the mother and daughter (22.4%), and the lowest percentage or frequency was observed between the father and son (14.3%). The results showed that 16.3% of the offspring showed no correlation between fingerprints and their respective parents. The inheritance of fingerprints between mother and son was 18.4%. The study also depicted a higher inheritance of fingerprints between father to daughter and mother to daughter compared to father to son and mother to son. The preceding results are consistent with those from a study by Jutika Devi et al. (2023) regarding the inheritance of fingerprint patterns and their association with ABO blood groups.[7]

Table 1. Distribution of fingerprints

Sr. No	Inherited From	Frequency
1	Mother to Son	9
2	Father to Son	7
3	Mother to Daughter	11
4	Father to Daughter	14
5	Unrelated	8

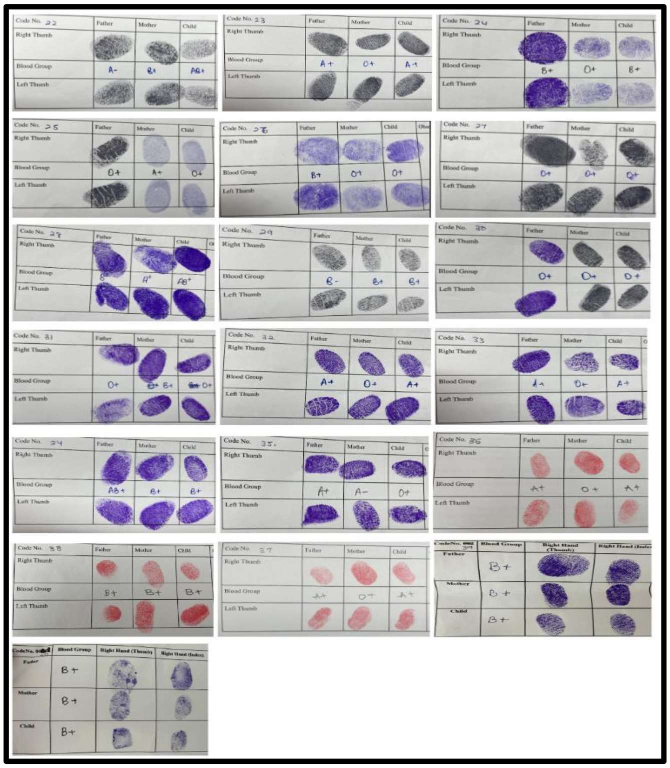

Fig. 3 Fingerprint Samples of Family 22- 40

Table 2 shows that the most common blood group in the sample population was B+, encompassing 39 individuals (32.5%). The second most frequent blood group was O+, with 33 individuals out of 120 participants. On the contrary, the least frequent blood group that was evident was AB- and O- (0 participants). The second least common blood group was B-, with only 1 participant representing the blood group. The study results clearly state that Rh-positive blood groups are more common than Rh-negative blood groups.

Rh-positive blood groups (A+, B+, AB+, and O+) comprise 96.7% of the sample population, while Rh-negative (A-, B-, AB-, and O-) encompass 3.3% of the sample population under study. In addition to that, it is evident that in terms of the ABO groups, Blood Group B is most common (40 individuals), followed by Blood Group O, with 33 participants. Proceeding from that, blood group A is the most common (32 individuals), and the least frequent blood group is AB, with only 15 participants representing the same. The total number of offspring participating in the study was 40 individuals. The distribution of blood groups with respect to gender for the offspring portrays that the maximum number of males have the blood groups A (+ve and -ve) and AB (5 individuals, respectively). On the contrary, the minimum number of male offspring represented by Blood Group B (+ and - ve) was 1 participant. For female offspring, the maximum number of participants who had blood group B was 12, while only 4 female offspring showcased the AB blood group. The total number of parents participating in the study was 80. From the data, it is evident that the father has a higher likelihood of having blood group A or B (16 individuals) ($^{+}$ve and $^{-}$ve). However, the blood group AB (2 participants) was least common among males. Similarly, for females (mothers), the most frequent blood group seen was O (18 participants), while the least common blood group was AB for females as well, having only 4 individuals.

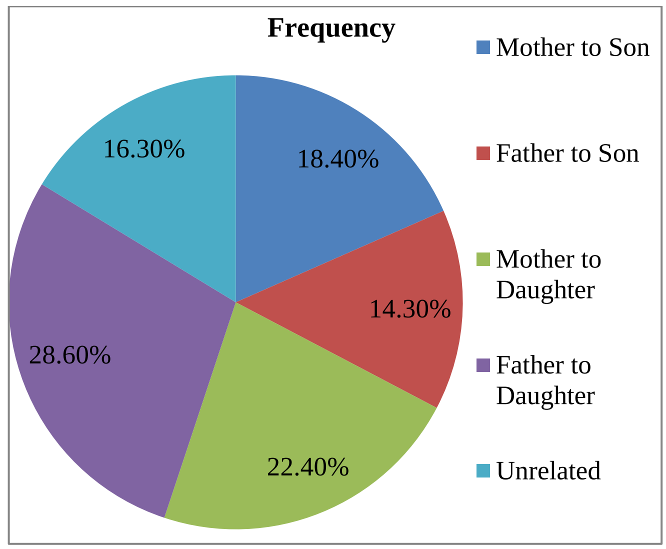

Fig 4. Frequency of fingerprints inheritance

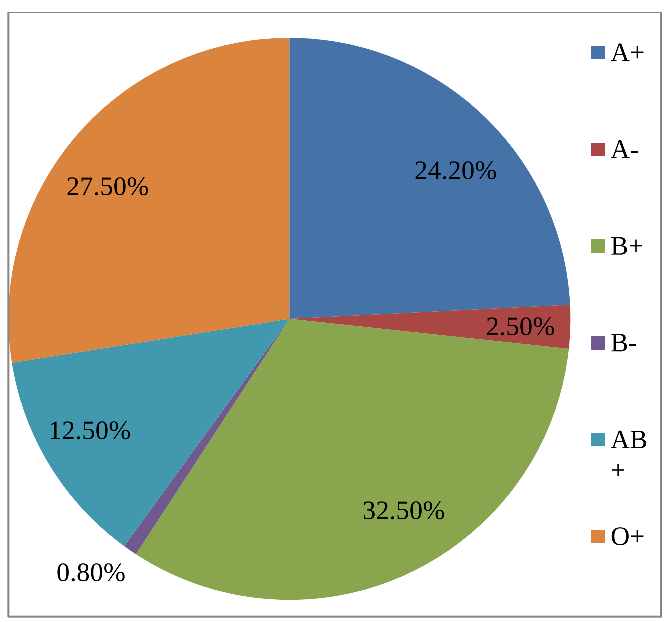

Fig. 5 Percentage of blood group distribution

Table 2. Percent distribution of blood groups

Blood Group	A^+	A^-	B^+	B^-	AB^+	AB^-	O^+	O^-	Total
Frequency	29	3	39	1	15	0	33	0	120
% Distribution	24.2	2.5	32.5	0.8	12.5	0	27.5	0	100

Table 3. Distribution of offspring blood group v/s gender

Sex	A	B	AB	O
Male	5	1	5	2
Female	4	12	4	7
Total	9	13	9	9

Table 4. Distribution of parent's blood group v/s gender

Sex	A	B	AB	O
Male	16	16	2	6
Female	7	11	4	18
Total	23	27	6	24

Table 5. Distribution of the total participant's blood group v/s gender

Sex	A	B	AB	O
Male	21	17	7	8
Female	11	23	8	25
Total	32	40	15	33

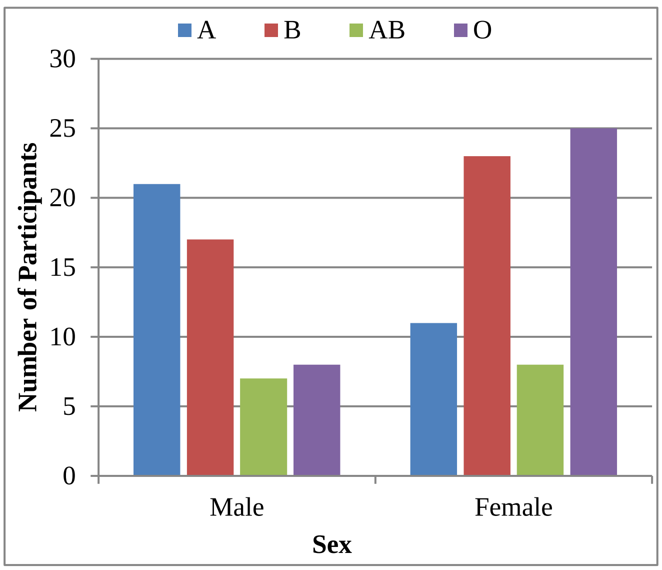

Fig. 6 Distribution of blood group v/s gender of the participants

Table 6. Distribution of fingerprint types

Fingerprint Types	Loops	Whorls	Arches
Frequency	52	44	24

In general, the distribution of blood groups with respect to gender varies to some extent. The most frequent blood group for males (parent +Offsprings) is A (21 individuals), while the least frequent blood group for them would be AB, with only 7 participants representing the same. For females (parent +Offsprings), the most represented blood group is O, with 25 females, whereas the blood group that constitutes the minimum ABO blood group is AB, with 8 participants. As can be seen, AB has the minimum number of participants, both females and males. There were 120 survey participants; 40 of them were students (13 males and 27 girls), while the remainder were parents. The most common fingerprint among the 120 participants was Loops, which accounted for 43.3% of the overall population studied. Proceeding with the loop prints, the second most common fingerprint that was evident was whorls, representing 36.7% of the population (44 individuals). The lowest occurrence was that of arches, with only 24 individuals (20%) from the population surveyed. Similar results were documented by Jutika Devi *et al.* (2023)[7] and Urvik Kukadiya *et al.* (2020).[10] These results clearly highlight that the loop pattern of fingerprints is more dominant, whereas arches are the recessive pattern. Table 7 shows that the fingerprint loops and Blood Group B have the most frequent distribution.

The same is likely due to the fact that both loops and blood group B are dominant in nature. Following that, Blood Group A and fingerprint Whorls, as well as Blood Group O and fingerprint Loops, are closely related, accounting for 16 people and 13.3% of the population, respectively. When analyzing the dominant and recessive nature of fingerprint patterns and blood groups, it was observed that arches (possibly a recessive trait) were more prevalent in Blood Group O, also being a recessive blood type.[10] Loops and whorls were often seen in blood types A and B co-dominant. It was observed that arches (present in one of the parents) were not inherited by 7.5% (3 in 40) of children who participated in the survey. It was either a loop or a whorl that was observed to be expressed in the child. Therefore, the arch pattern may be a recessive trait. On the other hand, the dominant or recessive nature of whorls and loops could not be determined because, if any case of a family were to be considered, it was observed that if one parent had a whorl and the other a loop, their child inherited either of the two patterns without indicating the dominance of the pattern.

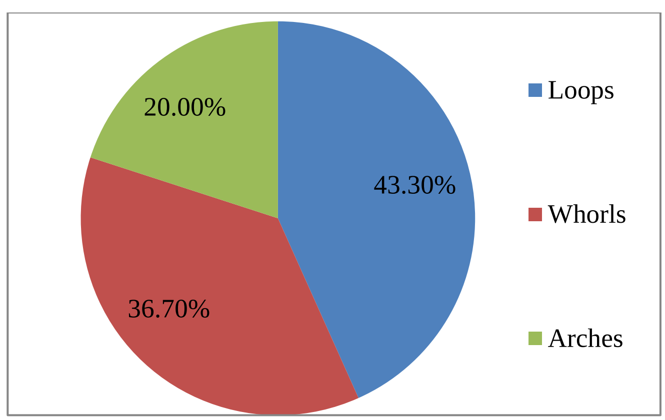

Fig. 7 Frequency of fingerprint pattern

Table 7. Distribution of a particular fingerprint in one blood group

Fingerprints Pattern	Blood Group A	%	Blood Group B	%	Blood Group AB	%	Blood Group O	%
Loops	9	7.5	19	15.8	8	6.7	16	13.3
Whorls	16	13.3	15	12.5	4	3.3	9	7.5
Arches	7	5.8	6	5	3	2.5	8	6.7

4. Conclusion

The presented study portrays a viable correlation in the inheritance of fingerprints and blood groups among Indian families residing in Gurgaon. The Blood Group B (40 out of 120) was most commonly evident in the samples, along with the fingerprint pattern loops (52 out of 120). In addition, it was observed that 32 out of 40 offspring inherit both fingerprints and blood groups from either parent. The same portrays a strong correlation between the inheritance of blood groups and fingerprints from parents to offspring. Apart from that, a maximum number of participants had blood group B and fingerprint loops, while the least number of people had blood group AB and fingerprint arches. The results and conclusions from this study can play a key role in various scientific advancements. Firstly, by establishing a database of fingerprints, one can understand the potential genetic correlations that might enhance the methods for identifying individuals in criminal cases or disaster victim identification. In addition to that, associating fingerprints with blood groups can enhance advancements in healthcare and disease management. Exploring and understanding the genetic phenotype and its correlation can streamline and strengthen various aspects of medical diagnosis, treatment, and preventive healthcare. The study has certain limitations that may influence the robustness of its findings. Primarily, the sample size was limited, which could impact the generalizability of the results to a broader population. The random sampling method also led to an uneven male-to-female ratio, which might introduce gender-based bias in the inheritance pattern observations. These constraints highlight areas for improvement to achieve more representative results. In terms of future scope, expanding this research to a larger, more diverse sample size would enhance the reliability of the findings and help validate the observed inheritance patterns. Further, studies that could specifically involve monozygotic twins, who share identical DNA, could provide deeper insights into the genetic correlations between blood groups and fingerprint patterns. This focus could significantly strengthen our understanding of inheritance mechanisms, as analyzing such genetically identical individuals would help distinguish environmental effects from genetic factors in phenotypic traits like fingerprints and blood groups.

The current study could have involved the selection of a larger sample pool size. In addition, the random sampling method used could have led to a discrepancy in the female-to-male ratio. The prospects of this research paper would entail conducting this study with solely monozygotic twins. As monozygotic twins tend to share their DNA (which is identical), studying the similar fingerprints and blood groups between twins would enhance knowledge and understanding of inheritance.

Ethical Considerations

Participant privacy was prioritized. All collected data, including fingerprints and blood groups, was anonymized using unique codes to remove personally identifiable information, with access restricted to my mentor and me. The data was securely stored, not shared with others, and will be responsibly discarded after publication. Participation was voluntary, with a week's prior notice, and individuals could withdraw at any time without consequences.

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References

[1] Michael Kücken, and Alan C. Newell, "Fingerprint Formation," *Journal of Theoretical Biology*, vol. 235, no. 1, pp. 71-83, 2005. [CrossRef] [Google Scholar] [Publisher Link]

[2] Rafael Romero Reverón, "Marcello Malpighi (1628-1694), Founder of Microanatomy," *International Journal of Morphology*, vol. 29, no. 2, pp. 399-402, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[3] History of Fingerprinting, CPI OpenFox, 2023. [Online]. Available: https://www.openfox.com/history-of-fingerprinting/

[4] History of Fingerprint Analysis - DMIT Analysis, Brainwonders. [Online]. Available: https://www.brainwonders.in/fingerprint-history.php

[5] H.M Slatis, M.B Katznelson, and B. Bonné-Tamir, "The Inheritance of Fingerprint Patterns," *American Journal of Human Genetics*, vol. 28, no. 3, pp. 280-289, 1976. [Google Scholar] [Publisher Link]

[6] Eric Aigbogun, Chinagorom Ibeachu, and Ann Lemuel, "Fingerprint Pattern Similarity: A Family-Based Study Using Novel Classification," *Anatomy*, vol. 13, no. 2, pp. 116-121, 2019. [Google Scholar] [Publisher Link]

[7] Jutika Devi, Bhabana Das, and Jyotismita Das, "Study on Inheritance of Fingerprint Pattern and its Association with ABO Blood Groups at Nagaon, Assam," *Indian Journal of Science and Technology*, vol. 16, no. 23, pp. 1694-1701, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[8] Fingerprint Patterns are Linked to Limb Development Genes, EurekAlert. [Online]. Available: https://www.eurekalert.org/news-releases/938824

[9] Thank God C. Omuruk et al., "An Investigation of Inheritance Pattern of Fingerprints of Nigerian Families Resident in Rivers State, Nigeria," *Saudi Journal of Medicine*, vol. 4, no. 2, pp. 122-129, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[10] Urvik Kukadiya et al., "Study of Fingerprint Patterns in Relationship with Blood Group and Gender in Saurashtra Region," *International Journal of Anatomy and Research*, vol. 8, no. 2.3, pp. 7564-7567, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[11] Michael Kücken, and Alan C. Newell, "Fingerprint Formation," *Journal of Theoretical Biology*, vol. 235, no. 1, pp. 71-83, 2005. [CrossRef] [Google Scholar] [Publisher Link]

[12] Rafael Romero Reverón, "Marcello Malpighi (1628-1694), Founder of Microanatomy," *International Journal of Morphology*, vol. 29, no. 2, pp. 399-402, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[13] History of Fingerprinting, CPI OpenFox, 2023. [Online]. Available: https://www.openfox.com/history-of-fingerprinting/

[14] History of Fingerprint Analysis - DMIT Analysis, Brainwonders. [Online]. Available: https://www.brainwonders.in/fingerprint-history.php

[15] H.M Slatis, M.B Katznelson, and B. Bonné-Tamir, "The Inheritance of Fingerprint Patterns," *American Journal of Human Genetics*, vol. 28, no. 3, pp. 280-289, 1976. [Google Scholar] [Publisher Link]

[16] Eric Aigbogun, Chinagorom Ibeachu, and Ann Lemuel, "Fingerprint Pattern Similarity: A Family-Based Study Using Novel Classification," *Anatomy*, vol. 13, no. 2, pp. 116-121, 2019. [Google Scholar] [Publisher Link]

[17] Jutika Devi, Bhabana Das, and Jyotismita Das, "Study on Inheritance of Fingerprint Pattern and its Association with ABO Blood Groups at Nagaon, Assam," *Indian Journal of Science and Technology*, vol. 16, no. 23, pp. 1694-1701, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[18] Fingerprint Patterns are Linked to Limb Development Genes, EurekAlert. [Online]. Available: https://www.eurekalert.org/news-releases/938824

[19] Thank God C. Omuruk et al., "An Investigation of Inheritance Pattern of Fingerprints of Nigerian Families Resident in Rivers State, Nigeria," *Saudi Journal of Medicine*, vol. 4, no. 2, pp. 122-129, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[20] Urvik Kukadiya et al., "Study of Fingerprint Patterns in Relationship with Blood Group and Gender in Saurashtra Region," *International Journal of Anatomy and Research*, vol. 8, no. 2.3, pp. 7564-7567, 2020. [CrossRef] [Google Scholar] [Publisher Link]