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Dermatoglyphic Markers in Forensic Science: A Bio-Psychosocial Study of Juvenile Delinquency and Behavioral Traits

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ABSTRACT
Juvenile delinquency represents a significant socio-legal and psychological challenge, particularly in developing nations such as India. Dermatoglyphics, the scientific study of fingerprint ridge patterns, is grounded in the premise that fingerprint formation occurs concurrently with neurodevelopment during fetal life and remains unchanged thereafter. The present study investigates the relationship between dermatoglyphic patterns, psychological attributes (self-efficacy and resilience), and socio-environmental factors influencing juvenile delinquent behavior. Using a bio-psychosocial framework, the study integrates biological, psychological, and environmental dimensions.The study adopted a descriptive–correlational research design to examine the relationship between dermatoglyphic patterns, psychological characteristics, and juvenile delinquent behavior. A mixed-method design was adopted with a sample of 100 juveniles aged 10–18 years. Dermatoglyphic analysis was conducted using the Ten-Digit Classification System, while psychological attributes were measured through standardized scales. Socio-economic and environmental data were collected via structured interviews.Findings reveal that loop patterns were predominant (60%), followed by whorls (30%). Significant associations were found between fingerprint patterns and crime types ($\chi^2 = 31.1$, $p < .05$). Psychological assessment indicated varied levels of self-efficacy and resilience, with higher resilience linked to better adaptive outcomes. Socio-economic adversity, family disruption, and peer influence emerged as key environmental contributors.The study concludes that dermatoglyphics, when ethically integrated with psychological assessment, can function as a supportive early-identification and preventive tool, rather than a deterministic or punitive measure. The outcomes support a rehabilitative and preventive approach aligned with the objectives of the Juvenile Justice system, emphasizing early intervention, counseling, and individualized rehabilitation strategies for at-risk youth.
Keywords: Dermatoglyphics, Juvenile Delinquency, Self-Efficacy, Resilience, Bio-Psychosocial Model, Forensic Psychology

INTRODUCTION

Juvenile delinquency has become an increasingly pressing concern globally, particularly in rapidly developing societies where socio-economic inequalities and environmental stressors significantly influence youth behavior. In India, the rise in juvenile offenses—including theft, assault, and cybercrime—necessitates a multidisciplinary approach to understanding and prevention.Traditional criminological approaches often focus on post-offense investigation; however, modern research emphasizes predictive and preventive frameworks. Dermatoglyphics, introduced by Cummins, refers to the study of fingerprint, palmar, and plantar ridge patterns, which are genetically determined, unique to individuals, and remain unchanged throughout life. It is well established that the ridge patterns of the fingerprints are unique and help in personal identification. The unique and persistent nature of dermatoglyphic features serves as a valuable tool for the inclusion and exclusion of the suspect at a crime scene. Dermatoglyphics is the study of human fingerprints and relation to aspects of a person's behavior. This inheritance and uniqueness of the dermatoglyphics draw attention from the different disciplines such as anthropology, psychology, genetics and forensic science (1).

According to Dermatoglyphics, fingerprint patterns can be used to understand the nature of a person's inborn. These properties include nature, self-esteem, self-potential, personality, and preferences of the person (2). Juvenile crimes have become such common portents that they raise serious concern in any nation. A "juvenile" or child means a person who has not completed eighteenth year of his/her age. Under JJA 2000 section 2(k) a boy or a girl less than 18 years of age is a juvenile or child. While, if we will got to know, who is a juvenile in conflict with law section 2(l) of JJA 2000, "as a juvenile who is alleged to have committed an offence and has committed an offence and has not completed eighteenth year of age as on the date of commission of such offence". Thus those offences committed by adults and punishable, which when committed by children or youth under the age of eighteen are denoted as juvenile crimes and the juvenile courts deal with such cases. The problem of juvenile delinquency is not confined to a particular country or a particular generation; it is a global phenomenon.

Psychological constructs such as self-efficacy and resilience further influence behavioral outcomes. Individuals with higher self-efficacy demonstrate greater control over their actions, while resilience determines adaptability to adverse conditions. Additionally, socio-environmental factors such as family structure, peer influence, and socio-economic status play a crucial role in shaping behavior (3,4).

Research emphasizes that criminal behavior, especially among juveniles, results from a complex interaction of genetic predispositions, psychological traits, and environmental influences including family background, peer pressure, socioeconomic status, and exposure to crime. Juvenile delinquency is therefore understood as a multifactorial phenomenon, with adolescents being particularly vulnerable due to ongoing cognitive and emotional development (3).Previous studies exploring the relationship between dermatoglyphic patterns and criminal behavior suggest that certain fingerprint types (loops, whorls, arches, and ridge counts) may occur more frequently among offenders or individuals displaying aggressive or impulsive traits. When combined with psychological assessments, dermatoglyphics may enhance early behavioral assessment and offender profiling. However, previous researchers consistently caution that dermatoglyphic patterns alone cannot predict criminal behavior and must be interpreted within a broader psychosocial framework (4,5) Harold Cummins, regarded as the pioneer of dermatoglyphics, established the scientific foundation for the study of fingerprint, palmar, and plantar ridge patterns, emphasizing their genetic origin, individuality, and permanence (1). Mavalwala, 1973 further expanded this work by linking dermatoglyphic patterns to genetic and neurodevelopmental processes, proposing that fingerprints may serve as biological markers reflecting brain development (4). The behavioral and psychological relevance of dermatoglyphics has been explored by Castilla, 1979, who suggested associations between specific fingerprint patterns (loops, whorls, arches) and personality traits such as aggression and impulsivity. These findings laid the groundwork for using dermatoglyphics as a supplementary tool in behavioral and forensic profiling (5). Research conducted by Pricilla et al., 2018 explored the dermatoglyphic variations among convicted offenders, reporting statistically significant differences between offenders and non-offenders. Their work highlighted the potential of dermatoglyphics for early behavioral assessment while cautioning against deterministic interpretations (6). Smail, 2020 critically evaluated the ethical, methodological, and predictive limitations of dermatoglyphic profiling, emphasizing the risks of stigmatization, particularly in juvenile populations, and advocating for ethical safeguards (7). The integration of dermatoglyphics with psychological profiling and advanced technologies has been discussed by Matos and Batista-Foguet, 2010, who emphasized the need for cross-cultural validation and multivariate models incorporating biological, psychological, and socioeconomic variables (8). They highlighted gaps in longitudinal data and called for culturally sensitive, ethically grounded profiling frameworks. Recent literature also points to the growing role of biometric technologies, artificial intelligence, and machine learning in enhancing pattern recognition and predictive accuracy, as discussed by Smail, 2020 and Pricilla et al., 2018. (6,7).

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This study aims to integrate these dimensions into a comprehensive bio-psychosocial model to better understand juvenile delinquency. Dermatoglyphics has been widely studied as a genetic and developmental marker. Research suggests correlations between fingerprint patterns and personality traits, although such relationships are probabilistic rather than deterministic. Psychological research highlights impulsivity, aggression, and low emotional regulation as key predictors of delinquency. Self-efficacy and resilience are particularly important protective factors. Socio-economic adversity, family instability, and peer influence have consistently been identified as major contributors to juvenile delinquency. Contemporary research supports an integrated model where biological predispositions interact with environmental conditions.

MATERIAL AND METHODOLOGY

Sample Collection: In this study, descriptive and correlation design was chosen under quantitative approach as the study was non-experimental descriptive research measuring two variables i.e., Dermatoglyphics & Psychological profiling. While undertaking naturalist observation in typical environment and assessing co-relation of the test results drawn through statistical analysis. The study requires participants who are between 12 yrs to 18 yrs of age, of both genders of rural and urban areas of Delhi region who were by the decision of court due to committing a delinquent act, referred to juvenile correctional institutions were collected. Confidentiality, informed consent, and non-stigmatization were strictly maintained. The Psychological scales which were taken into consideration for analysis of the samples are i) Resilience scale (Dr. Vijaya Lakshmi & Dr Shruti Narain) and ii) Self-efficacy scale (Dr. Arun Kumar Singh & Dr Shruti Narain).

Data Collection

- Dermatoglyphic analysis (Ten-Digit Classification System)
- Psychological scales (self-efficacy and resilience)
- Structured interviews (socio-economic variables)

Statistical Method

- Correlation
- ANOVA (two-way)
- T-Test
- Mean
- Standard Deviation

RESULTS AND DISCUSSION

Table 1: Demographic Characteristics of Juvenile Offenders by Age, Gender, and Residential Background (N = 100)

Variable	Category	Frequency	Percentage
Age	10–12	10	9.9
	13–15	56	55.4
	16–18	34	33.7
Gender	Male	91	91.0
	Female	9	9.0
Area	Rural	65	65.0
	Urban	35	35.0

Table 2: Distribution of Reported Offense Types among Juvenile Offenders

Crime Type	Frequency	Percentage
Assault	24	24.0
Cybercrime	11	11.0
Drug Abuse	14	14.0
Kidnapping	16	16.0
Murder	8	8.0
Sexual Offense	15	15.0
Theft	12	12.0

The distribution (as seen in Table 2) shows that assault is the most prevalent offense, followed by kidnapping and sexual offenses, indicating a notable presence of violent and interpersonal crimes among juveniles. The presence of cybercrime and drug abuse reflects emerging and diversified patterns of delinquency.

Table 3: Frequency Distribution of Dermatoglyphic Fingerprint Patterns in the Study Population

Pattern	Frequency	Percentage
Loop	60	60.0
Whorl	30	30.0
Arch	5	5.0
Composite	5	5.0

As seen in Table 3, the dominance of loop patterns suggests a general prevalence of adaptable behavioral tendencies among the sample, while the substantial presence of whorls indicates a segment potentially associated with assertive or aggressive traits. Arches and composite patterns remain relatively rare.

Table 4: Association between Dermatoglyphic Patterns and Categories of Juvenile Offenses (Cross-Tabulation Analysis)

Pattern	Assault	Cyber	Drug	Kidnap	Murder	Sexual Offence	Theft
Arch	1	3	0	1	0	0	0
Composite	0	0	3	0	1	0	1
Loop	14	6	6	13	4	9	8
Whorl	9	2	5	2	3	6	3

The cross-tabulation demonstrates that loop patterns are widely distributed across all crime types, whereas whorls show relatively higher representation in violent offenses. This supports a possible association between dermatoglyphic variations and behavioral tendencies, though not deterministically.

Table 5: Distribution of Self-Efficacy Levels among Juvenile Offenders

Level	Frequency	Percentage
Low	33	33.0
Average	30	30.0
High	37	37.0

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The distribution of self-efficacy levels shows a relatively balanced spread, with a slight predominance of high self-efficacy. This suggests that while some juveniles possess confidence in their abilities, it may not necessarily translate into socially acceptable behavior.

Table 6: **Distribution of Resilience Levels among Juvenile Offenders**

Level	Frequency	Percentage
Low	35	35.0
Average	33	33.0
High	32	32.0

Resilience levels are fairly evenly distributed, with a marginally higher proportion in the low category. This indicates that a significant number of juveniles may lack effective coping mechanisms, increasing vulnerability to maladaptive behaviors.

Table 7: **Prevalence of Dominant Psychological Traits among Juvenile Offenders**

Trait	Frequency	Percentage
Aggressive	35	35.0
Manipulative	34	34.0
Impulsive	17	17.0
Anxious	14	14.0

Aggressive and manipulative traits dominate the sample, highlighting key behavioral tendencies associated with delinquency. The presence of impulsive and anxious traits further indicates emotional and behavioral instability among offenders.

Table 8: **Prevalence of Diagnosed Mental Health Conditions in the Juvenile Offenders**

Condition	Frequency	Percentage
Conduct Disorder	22	22.0
Depression	16	16.0
Anxiety	15	15.0
Psychopathy	15	15.0
ADHD	14	14.0
None	18	18.0

The findings (as seen in Table 8) reveal a notable prevalence of conduct disorder, followed by depression and anxiety, emphasizing the role of mental health issues in juvenile delinquency. However, the presence of individuals without diagnosed conditions suggests that delinquency is not solely attributable to clinical disorders.

Table 9: **Family Structure Distribution among Juvenile Offenders**

Type	Frequency	Percentage
Single Parent	40	40.0
Both Parents	31	31.0
Guardian	29	29.0

A higher proportion of juveniles from single-parent and guardian-based households indicates the potential impact of family instability and reduced supervision on delinquent behavior.

Table 10: **Levels of Peer Influence Reported by Juvenile Offenders**

Level	Frequency	Percentage
Low	38	38.0
Moderate	30	30.0
High	32	32.0

The distribution shows that peer influence is a significant factor, with moderate to high levels reported by a majority of juveniles. This underscores the role of social learning and group dynamics in shaping delinquent behavior.

Table 11: Descriptive Statistics of Key Study Variables (Self-Efficacy, Socioeconomic Status, Peer Influence, and Psychological Traits)

Variable	Mean	SD	N
Self-Efficacy	68.3	12.2	100
Socioeconomic Status	1.91	0.6	100
Peer Influence	1.9	0.7	100
Psychological Trait	2.2	1.0	100

The descriptive statistics (as seen in Table 11) indicate moderate variability in self-efficacy and socio-environmental factors, suggesting heterogeneity within the sample and reinforcing the need for individualized assessment.

Table 12: **Chi-Square Test of Association between Fingerprint Patterns and Types of Offenses**

Test	Value	df	p-value
Pearson Chi-Square	31.1	18	0.028
Likelihood Ratio	27.9	18	0.063
N	100		

The chi-square results indicate a statistically significant association between fingerprint patterns and crime types ($p < .05$), supporting the study's hypothesis of a relationship between biological markers and behavioral outcomes, while acknowledging limitations.

Table 13: **Correlation Matrix Showing Relationships among Psychological and Socio-Environmental Variables**

Variable	Self-Efficacy	SES	Peer	Trait
Self-Efficacy	1.00	0.07	0.05	-0.06
SES	0.07	1.00	0.06	-0.05
Peer	0.05	0.06	1.00	0.04
Trait	-0.06	-0.05	0.04	1.00

The correlation matrix (as depicted in Table 13) reveals weak associations among variables, indicating that no single factor strongly predicts delinquency. This supports the bio-psychosocial model, where multiple factors interact to influence behavior.

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DISCUSSION

The present study aimed to look at adolescent delinquency from a bio-psycho-socio-environmental dimension view. The findings presented below reveal important trends that will help us to understand and to profile juvenile offenders better. Our dermatoglyphics results show that the loop fingerprint pattern was the most predominant pattern comprising approximately 60% of our sample, and this pattern is representative of the wide variety of offenses indicated, from assault to kidnapping to sexual crimes to theft. The whorl patterns totaled 30% of the sample, and these patterns coincided particularly with more violent offenses such as murder and sexual assault. The arch and composite patterns were the least frequent and did not represent enough of the sample to support any trends.

As for offenses, assault was the most common type of offense, closely followed by kidnapping, and sexual crimes. Adolescent delinquency did appear to represent more than just impulsive or trivial acts of offense, but as also potentially serious and premeditated actions, or the latter as representing harm on society in general. The psychological profiles of the adolescents showed varying levels of resilience and self-efficacy. While some offenders showed good coping strategies and resilience, a significant number showed devices that were more moderately to less resilient and self-efficacious, and they also showed behaviors of anger, impulsivity, and manipulativeness. These findings contribute to the case for emotional regulation and behavioral control as important mechanisms to prevent a trajectory toward delinquency.

The mental health assessment reported conduct disorder as the most common diagnosis—almost one-quarter of the sample was affected. Other diagnoses reported were depression, ADHD, anxiety, and psychopathy, which signal unrecognized or unmanaged mental health problems as pivotal in delinquency. Only a few respondents did not exhibit a diagnosable psychological disorder, suggesting that environmental factors also play an important role in behavior. The socio-environmental data reiterated the trends present in the mental health assessment. The majority of participants came from single-parent households or was cared for by guardians, suggesting family instability. Many respondents reported that peer relationships were significant, particularly in relation to group offending and conformity under social pressure.

Approximately 63% of offenders came from impoverished, low income-earning families, evidenced by limited opportunities for education, employment, and legal behaviors reflective of poverty. Statistical analyses including regression and correlation confirmed that while no individual variable predicted delinquency behaviors, combinations of fingerprint types and psychological vulnerabilities with socio-environmental risk characteristics were uniquely associated to offending behaviors. While lower resilience and conduct disorders, plus higher risk fingerprint types, formed unique associations with violent and serious crime behaviors. These results support existing theories that adolescent delinquency is multi-factorial and thus requires multi-modal and/or integrated approaches to prevention and treatment.

CONCLUSION

The research aimed to examine the complicated interrelationships between dermatoglyphic patterns, psychological variables, and socio-environmental variables in relation to juvenile delinquency. By employing measures of biometrics, behaviors, and context, a more pervasive grasp of the variables expressed by young people involved in crime was achieved. The results showed that delinquent behavior could not be accounted for by one sole area - biological, psychological, or social. Instead, juvenile delinquency was shown to a product of biological conditions, cognitive and emotional conditions, and contextual pressures such as family instability, socio-economic disadvantages, and social peers. Dermatoglyphics exhibited different profiles among offenders suggesting possible biological correlates of behaviours and psychological profiles exhibited heightened aggression, and impulsivity, and low resilience, often co-morbidities enhanced by the adversities of social surroundings.

Most notably, the study commented on the importance of a multidisciplinary, biosocial approach in forensic research and practice. While it could be argued that dermatoglyphics will not tell if someone is criminal or not, when used with psychological analysis and socio-demographics, one can expand opportunities for risk assessment, offender categorization, and rehabilitation purpose as a whole. This falls in line with modern forensic psychology's emphasis on developing evidence-based, individualized intervention that meets the needs and vulnerabilities of young offenders. This research reiterates the value and efficacy of early intervention programs, family support programs, and the use of forensic psychology in juvenile detention centers. In addition, this research calls for enhanced legal safeguards and structures to ensure that any collection and use of biometric data is done so with privacy, dignity, and sensitivity in mind for children.

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