# Beyond the Colors: Exploring the Association between Eye Color and Hair Color for Forensic Identification

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**Abstract:**
**Objectives:** This study aimed to investigate the association between eye color and hair color within the local population of Pakistan for forensic identification purposes.
**Methodology:** Data on eye color and hair color were collected from 293 MBBS students at Sahara Medical College Narowal over three academic years (2021-2023). Data were collected using a questionnaire, with data on specific colors of hair and eyes, and analyzed. Statistical tests including the chi-square test, were conducted to assess the association between eye color and hair color.
**Results:** The findings revealed a statistically significant relationship between eye color and hair color (p value <0.01). Brown and black hair colors were predominant among the study population, while brown and black eyes were the most common eye colors. The association between these phenotypic traits has practical implications for forensic identification, highlighting their importance as distinctive markers of individual identity.
**Conclusion:** The association between eye color and hair color underscores their potential utility for forensic identification purposes. Integrating information on these phenotypic traits into forensic investigations can enhance the accuracy and reliability of identification techniques, contributing to the administration of justice. *Al-Shifa Journal of Ophthalmology 2024; 20(1): 15-20. © Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan.*

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## Introduction:

Forensic identification plays a pivotal role in criminal investigations providing crucial evidence for identifying individuals involved in various legal proceedings[1]. In the history of forensic science, anthropometry proposed by Alphonse Bertillon in the late 19th century stands as a landmark method for individual identification. Central to Bertillon's system were physical measurements of various body parts but equally essential were distinctive features such as eye color and hair color[2]. For ages, these were considered the sole choices until the traditional methods of identification such as fingerprinting and DNA analysis have long been employed by forensic scientists and investigators[1,3]. However, now advancements in genetic analysis techniques have opened new avenues for forensic identification, including the

exploration of phenotypic traits such as eye color and hair color[4].

Eye color, a phenotypic trait determined by the amount of melanin in the iris is influenced by complex genetic factors. Variations in genes such as HECT domain and RCC1-like domain-containing protein 2 (HERC2) and ocular albinism (OCA2) have been associated with different but most prominent eye colors for identification purposes including green, brown, and black[5]. Similarly, hair color is determined by the presence and abundance of melanin in the hair follicles with variations in genes related to melanin production contributing to differences in hair color including blond, brown, and black making it valuable for forensic identification[6,7].

The association between eye color and hair color has attracted interest in forensic medicine due to its potential implications for establishing individuality based on physical characteristics[8]. By examining the relationship between these two phenotypic traits forensic scientists aim to explore associations to develop more accurate methods for identifying individuals from forensic evidence[9].

However, despite the potential significance of the association between eye color and hair color for forensic identification, relatively few studies have systematically investigated this relationship, particularly within specific populations relevant to current ethnic origin. Therefore, the present study aims to fill this gap by examining the association between eye color and hair color among of Pakistani population.

Unknown individuals are brought for medicolegal and postmortem examination very frequently to the Department of Forensic Medicine. Establishing identification always remains to be the first task by the medical personnel[10]. By elucidating the relationship between eye color and hair color in this population, the research seeks to contribute valuable insights to the field of forensic medicine, potentially enhancing forensic identification techniques and advancing our understanding of the genetic basis of phenotypic traits[11]. Ultimately, the findings of this study may have implications for forensic investigations assisting medical personnel and law enforcement agencies in the accurate identification of individuals involved in criminal activities[12].

## Materials and methods:

The study received approval from the Institutional Review Board (IRB) to ensure compliance with ethical standards. A cross-sectional descriptive study design was adopted to explore the association between eye color and hair color for forensic identification. After getting informed consent, the students were invited to participate.

A non-probability convenient sampling technique was employed for participant selection. The study population comprised 293 third year MBBS students enrolled at Sahara Medical College Narowal over three academic years (2021-2023), consisting of 106 males and 187 females. Data on eye color and hair color were collected from each participant through a standardized pre-tested questionnaire. Participants self-reported their eye color categorized as green, brown, or black, and hair color categorized as blond, brown, or black.

Statistical analysis was conducted to assess the association between eye color and hair color. Chi-square tests were used to determine the strength and significance of the association with a p-value $<0.05$.

## Results:

The study was conducted on 293 research participants, with 106 males and 187 females included in the study. The mean age of the individuals in the study was $20.94 \pm 0.76$.

Table 1 displays the frequency and percentage distribution of different eye colors among study participants. The eye colors included in the table are green, brown, and black the most predominant eye colors observed in Pakistan. The study in

the table 01 revealed that the brown eyes were the most prevalent accounting for 161 students which constitutes 54.9% of the total sample. While the black eyes were found to be the second most common with 128 students making up 43.7% of the total sample. The green eyes were accounted to be the least common, with only 4 students representing 1.4% of the total sample. To simplify the participants under study in the sample had predominantly brown or black eyes while green eyes are significantly less common.

Table 2 presents the frequency and percentage distribution of different hair colors among research participants in this study. The hair colors studied in this research were categorized as blond, brown, and black. Black hair was the most prevalent with 216 cases constituting 73.7% of the total sample amounting to almost 3/4th of the population under study. The brown hair was found to be the second most common with 75 cases under study making up 25.6% of the total sample. The blond hair was analyzed to be the least common with only 2 cases, representing 0.7% of the total sample.

Table 3 presents the association between eye color and hair color among a total of 293 participants by applying chi square test of association. It displays the frequency

distribution of different combinations of eye and hair colors. Among cases with green eyes there were 2 individuals with brown hair and 2 individuals with black hair with a final total of just 4 cases. For individuals with brown eyes, there was just 1 case with blond hair, 57 cases with brown hair, and 103 cases with black hair totaling for accumulation of 161 students. Among those with black eyes, there was just 1 case of blond hair, 16 cases with brown hair, and 111 cases with black hair making a total of 128 students in this category. The totals for each hair color category indicate that there are 2 individuals with blond hair, 75 individuals with brown hair and 216 individuals with black hair among the entire sample. These numbers highlight the distribution of hair colors within each eye color category, providing prevalence aspect ratio into the association between these two characteristics among the individuals under the study.

The p-value $<0.01$ in the association between eye color and hair color highlights the level of statistical significance of the observed relationship. In this context, a p-value $<0.01$ indicates that the association between eye color and hair color is statistically significant at the chosen level of significance.

*Table 1: Frequency Distribution of Eye Color*

| Eye Color | Frequency | Percent | Valid Percent |
|-----------|-----------|---------|---------------|
| Green | 4 | 1.4 | 1.4 |
| Brown | 161 | 54.9 | 54.9 |
| Black | 128 | 43.7 | 43.7 |
| Total | 293 | 100.0 | 100.0 |

*Table 2: Frequency Distribution of Hair Color*

| Hair Color | Frequency | Percent | Valid Percent |
|------------|-----------|---------|---------------|
| Blond | 2 | 0.7 | 0.7 |
| Brown | 75 | 25.6 | 25.6 |
| Black | 216 | 73.7 | 73.7 |
| Total | 293 | 100.0 | 100.0 |

*Table 3: Association of Eye Color with Hair Color*

| Eye Colour | Hair Colour | | | Total | P value |
|---|---|---|---|---|---|
| | Blond | Brown | Black | | |
| Green | 0 | 2 | 2 | 4 | 0.000 |
| Brown | 1 | 57 | 103 | 161 | |
| Black | 1 | 16 | 111 | 128 | |
| Total | 2 | 75 | 216 | 293 | |

**Discussion:**

The findings of this study provide valuable information into the association between eye color and hair color among third year MBBS students, contributing to the body of knowledge in forensic medicine and toxicology. The results reveal a statistically significant relationship between these two phenotypic traits with a p-value of 0.000 indicating that the observed distribution of eye color and hair color combinations is highly unlikely to have occurred by chance alone.

The predominance of brown and black hair colors among the study population aligns with broader population trends reflecting the prevalence of these hair colors in various ethnic groups. Similarly, the distribution of eye colors with brown and black eyes being more common than green eyes, mirrors patterns observed in diverse populations worldwide[13]. These findings lay immense importance of considering population-specific characteristics when developing forensic identification techniques based on phenotypic traits[14].

The observed association between eye color and hair color has practical implications for forensic investigations particularly in cases where readily possible traditional methods of identification may be the only choice available[15]. By incorporating information on eye color and hair color into forensic databases and investigative procedures law enforcement agencies can enhance their ability to identify individuals from forensic evidence such as eyewitness descriptions confirmed from DNA samples collected from crime scenes[16].

Furthermore, the association between eye color and hair color highlights the complex interplay between genetics and phenotypic expression. While specific genes, such as HERC2 and OCA2, have been implicated in determining eye color variations, the genetic basis of hair color is equally multifaceted involving genes related to melanin production and distribution[17]. Future research exploring the genetic underpinnings of these traits may provide further insights into their inheritance patterns and variability across populations[16].

The study contributes to our understanding of the association between eye color and hair color for forensic identification purposes, highlighting the importance of these phenotypic traits in individual identification[18]. By elucidating the relationship between eye color and hair color among research participants, this research advances our knowledge of forensic medicine domain, paving the way for improved identification techniques and enhancing the capabilities of forensic science in solving crimes and serving justice[19].

The predominance of brown and black hair colors among the study population along with the distribution of eye colors, underscores the variability and complexity of human phenotypic traits. By analyzing the association between eye color and hair color, this research contributes valuable insights to the field of forensic science, providing a foundation for the development of more accurate and reliable identification techniques[20].

Practical implications of these findings extend to forensic investigations where eye

color and hair color can serve as valuable descriptors for identifying individuals from forensic evidence. Integrating information on these phenotypic traits into forensic databases and investigative procedures can enhance the efficiency and effectiveness of law enforcement efforts, ultimately contributing to the administration of justice[21].

Logically, the study investigated the association between eye color and hair color among the local population of Pakistan, shedding light on their potential utility for forensic identification purposes. The findings revealed a statistically significant relationship between these two phenotypic traits emphasizing their importance in individual identification within the context of forensic investigations.

## Conclusion:

In conclusion, this study advances our understanding of the association between eye color and hair color for forensic identification purposes underscoring their importance as distinctive markers of individual identity. By bridging the gap between genetics, phenotypic expression, and forensic science this research contributes to the ongoing quest for accurate and reliable methods of individual identification, ultimately serving to uphold the principles of justice and accountability in society.

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