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The prevalence and pattern of human color traits in nigerian adults

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ABSTRACT

Objective: We determined the prevalence and pattern of human color traits in young adults in Eastern Nigeria and assessed whether there were gender differences and inter-relationships in the prevalence of these color traits. **Methods:** Three hundred young adults aged 18-40 yrs, participated in the study. The iris color was categorized into four; light brown, dark brown, dark, and blue-grey colors. The skin color was categorized into three colors; fair, brown and black. Three hair colors-black, brown and blond were identified amongst the study population. **Results:** The present data indicated that dark brown iris color (69%), brown skin color (50.3%) and black hair color (56.7%) were the most prevalent color traits in the study population. Data indicated gender differences ($P < 0.01$ or $P < 0.001$) in the distribution of the three color traits. In both genders, data indicated significant interactions ($P < 0.05$; $P < 0.01$; $P < 0.001$) amongst the three color traits, suggesting that these color traits are highly inter-correlated. **Conclusion:** The most prevalent human color traits among young adults in the Eastern Nigeria were dark brown iris, brown skin and black hair colors. There were gender differences and inter-correlations amongst the three human color traits.

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1. Introduction

Differences in color of the hair, the eyes and the skin are perhaps the most obvious and impressive variations that distinguish individuals and population [1]. These physical color traits are primarily due to the activities of melanocytes present in the epidermis of skin, the eye and hair roots, which secrete pigment granules. Variation in skin pigmentation is notable between populations, hair colour variation is most notable within populations of European origin and the pattern of human iris pigmentation is highly variable within and between populations [2, 3, 4]. The genetic basis underlying normal variations of these pigmentation traits of the skin, hair and eye colors is still not completely understood and has been the subject of intense research [5, 6]. Iris color can provide a large amount of information about an individual, and a classification of various colors may be useful in documenting pathological changes or determining how a person may respond to various ocular pharmaceuticals [7]. Iris, skin and

hair colors are included as very important soft biometric markers and useful tools in forensic science investigation [8,9]. Furthermore, these physical color traits have considerable influence on esthetics. Estheticians have always been faced with the challenge of matching color traits with the surrounding environment of the body with the aim of enhancing physical appearance.

Very few studies have been done on the pattern or distribution of iris, skin and hair colors in the general population, and to the best of our knowledge, no previous reports on the pattern of these human color traits have been documented in Nigeria. Furthermore, it is not certain whether correlations exist among the human color traits within individuals of a given population. The present study was designed to demonstrate the prevalence of the three human color traits among young adult Nigerians and assess whether there were gender differences in these prevalences. We also investigated whether the three human color traits were inter-related with each other.

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2. Methods

Three hundred subjects aged 18-40 years (males, n = 150; females, n = 150) were recruited by random sampling, from young adult population in Anambra State University and its environs, located in the Eastern part of Nigeria. The subjects were properly informed and educated about the study and the procedures. All the subjects who were willing to participate in the study were recruited after informed consents were obtained from them. The subjects were interviewed to obtain information about their age, gender, occupation, past medical history (with emphasis on ocular, skin and hair diseases), and whether they wear contact lens, or dyed their hairs or use skin-lightening creams. Subjects who use contact lens, dyed or colored their hairs or use lightening creams on their skins were excluded from the study. One of the investigators collected data to ensure standardization. The Research and Ethical Committee of the Anambra State University, Uli, Anambra State approved the study.

To determine the iris color, the participant's iris and undilated pupil was illuminated with a penlight during the baseline examination. The examination of the subject's iris was repeated and photographed using a digital camera and compared with photographic standards. Iris color definition for 'light brown' and 'blue or grey' colors were based on Beaver Dam eye study [10], while 'dark brown' and 'dark' colors were added to the study based on the iris color prevalent in the Nigerian population. Participants were asked to blink or roll their eyeballs to ascertain whether they wore contact lens. Any of these actions would cause a measurable rotation or movement of the contact lens.

The skin color categorization was done using Fitzpatrick skin tone scale [11], in which skin color was divided into six colors, light, fair, medium, olive, brown, and black. For this study, three categories of skin colors, 'fair', 'brown' and 'black' were identified. Visual inspection by subjective evaluation was used to categorize hair color [12] and three colors were identified amongst the study population. They are, 'black', 'brown' and 'blond'. These colors were compared to standards in accordance with the Fischer-Saller scale.

Data Analysis

The prevalence of the human pigmentation traits in the population was determined using the cross-tab analysis. Pearson's Chi-square test of independence was used to determine associations between gender and different color traits. Non-parametric Chi-square (goodness-of-fit) test was used to compare the observed frequencies between genders for iris, skin and hair colors. SPSS for Windows (version 16.0) was used to perform all statistics. Statistical significance was set at $P < 0.05$.

3. Results

The distribution of the iris, skin, and hair colors are as presented in Table 1. In the general population, the iris color regimen, 'dark brown' was the most prevalent color (69%), while 'blue or grey' color (2.3%) was the least prevalent. The pattern of

skin color in the study population indicated that those with 'brown' skin color had the highest prevalence (50.3%). The least prevalent skin color was 'dark' color (24%). The black hair color (56.7%) was the most prevalent color in the study population while 'blond' (1.6%) was the least prevalent hair color. The prevalence of other iris, skin and hair colors are as shown in Table 1. The present data also indicated significant associations between gender and iris ($X^2 = 11.01$; $df = 3$; $P < 0.05$), skin ($X^2 = 12.70$; $df = 2$; $P < 0.01$), and hair ($X^2 = 44.63$; $df = 2$; $P < 0.001$) color traits respectively. Comparative analysis using chi-square test further revealed gender differences in the prevalence of light brown iris ($X^2 = 7.36$; $P < 0.01$), dark iris ($X^2 = 4.56$; $P < 0.05$), dark skin ($X^2 = 9.39$; $P < 0.01$), black hair ($X^2 = 18.44$; $P < 0.001$) and brown hair ($X^2 = 25.99$; $P < 0.001$) color traits respectively. The light brown iris color was appreciably more in females (n = 34) compared to the males (n = 15), while dark iris was significantly more prevalent in males (n = 25) compared to the females (n = 12). The dark skin was statistically more prevalent in males (n = 49) compared to the females (n = 23). The black hair color was more prevalent in males (n = 113) compared to the females (n = 57), while brown hair was significantly more in females (n = 91) compared to the males (n = 34). The prevalence of other iris colors (dark brown and blue-grey), skin colors (fair and brown) and blond hair color did not indicate gender differences respectively.

Table 1. The prevalence of human color traits and comparison between males and females in the study population

COLOR TRAITS	MALES N (%)	FEMALES N (%)	TOTAL N (%)	P
IRIS COLOR				
Light Brow	15 (10.0)	34 (22.7)	49 (16.3)	0.007*
Dark Brown	107 (71.3)	100 (66.7)	207 (69.0)	0.63
Dark	25 (16.7)	12 (8.0)	37 (12.3)	0.03*
Blue or Grey	3 (2.0)	4 (2.7)	7 (2.3)	0.70
Total	150 (100)	150 (100)	300 (100)	
SKIN COLOR				
Fair	32 (21.3)	45 (30.0)	77 (25.7)	0.14
Dark	49 (32.7)	23 (15.3)	72 (24.0)	0.002*
Brown	69 (46.0)	82 (54.7)	151 (50.3)	0.29
Total	150 (100)	150 (100)	300 (100)	
	113 (75.3)	57 (38.0)	170 (56.7)	
HAIR COLOR				
Black				
Brown	34 (22.7)	91 (60.7)	125 (41.6)	0.000*
Blond	3 (2.0)	2 (1.3)	5 (1.7)	0.000*
Total	150 (100)	150 (100)	300 (100)	0.66

*Significant gender difference.

2. Methods

Table 2. Distribution of iris color traits and their interaction effects on the skin color traits in males and females.

IRIS COLOR TRAITS	SKIN COLOR TRAITS			TOTAL	CHI ² TEST
	Fair N (%)	Dark N (%)	Brown N (%)		
(a) Males					
Light Brown	14 (93.3)	1 (6.7)	0 (0)	15 (100)	X ² =83.15;
Dark Brown	15 (14.0)	30 (28.0)	62 (57.9)	107 (100)	df=6;P=0.000
Dark	0 (0)	18 (72.0)	7 (28.0)	25 (100)	
Blue or Grey	3 (100)	0 (0)	0 (0)	3 (100)	
Total	32 (21.3)	49 (32.7)	69 (46.0)	150 (100)	
(b) Females					
Light Brown	23 (67.6)	0 (0)	11 (32.4)	34 (100)	X ² =83.15;
Dark Brown	16 (16.0)	19 (19.0)	65 (65.0)	100 (100)	df=6;P=0.000
Dark	4 (33.3)	3 (25.0)	5 (41.7)	12 (100)	
Blue or Grey	2 (50.0)	1 (25.0)	1 (25.0)	4 (100)	
Total	45 (30.0)	23 (15.3)	82 (54.7)	150 (100)	

Tables 2 shows the distribution of iris color traits according to skin color in males and females. Data indicated that amongst the study population who had light brown iris, majority had fair skin in males (93.3%) and in females (67.6%). Brown skin was most prevalent amongst those with dark brown iris in males (57.9%) and females (65.0%). Those with dark iris were mostly dark skinned (72%) compared to other skin colors in males but almost evenly distributed among females' skin colors. Blue/grey iris was predominantly prevalent in males with fair skin color (100%) but evenly distributed in females. A chi square analysis indicated significant associations (P <0.001) between iris color and skin complexion in both genders.

Table 3. Distribution of iris color traits and their interaction effects on the hair color traits in males and females.

IRIS COLOR TRAITS	HAIR COLOR TRAITS			TOTAL	CHI ² TEST
	Fair N (%)	Dark N (%)	Brown N (%)		
(a) Males					
Light Brown	6 (40.0)	9 (60.0)	0 (0)	15 (100)	X ² =169.4;
Dark Brown	82 (76.6)	25 (23.4)	0 (0)	107 (100)	df=6;P=0.000
Dark	25 (100)	0 (0)	0 (0)	25 (100)	
Blue or Grey	0 (0)	0 (0)	3 (100)	3 (100)	
Total	113 (75.3)	34 (22.7)	3 (2.0)	150 (100)	
(b) Females					
Light Brown	6 (17.6)	28 (82.4)	0 (0)	34 (100)	X ² =86.27;
Dark Brown	41 (41.0)	59 (59.0)	0 (0)	100 (100)	df=6;P=0.000
Dark	8 (66.7)	4 (33.3)	0 (0)	12 (100)	
Blue or Grey	2 (50.0)	0 (0)	2 (50.0)	4 (100)	
Total	57 (38.0)	91 (60.7)	2 (1.3)	150 (100)	

Table 3 shows the distribution of iris colors according to hair colors in males and females. Data indicated that majority of the males (60%) and females (82.4%) who had light brown iris presented with brown hair color. Amongst those with dark brown iris, black hair (76.6%) was the dominant hair color observed in males, while brown hair (59%) was more prevalent compared to other colors in females. Those with dark iris were mostly dark haired (100%) in males and in females (66.7%) compared to other hair colors. Blond was the most prevalent hair color amongst males with blue/grey iris, while in females it was evenly distributed between those with black and blond hair colors. A chi square analysis indicated significant associations (P <0.001) between iris color traits and hair color traits in both genders.

Table 4. Distribution of skin color traits and their interaction effects on the hair color traits in males and females.

SKIN COLOR TRAITS	HAIR COLOR TRAITS			TOTAL	CHI ² TEST
	Black N (%)	Brown N (%)	Blond N (%)		
(a) Males					
Fair	16 (50.0)	13 (40.6)	3 (9.4)	32 (100)	X ² =21.79;
Dark	43 (87.8)	6 (12.2)	0 (0)	49 (100)	df=4;P=0.000
Brown	54 (78.3)	15 (21.7)	0 (0)	69 (100)	
Total	113 (75.3)	34 (22.7)	3 (2.0)	150 (100)	
(b) Females					
Fair	10 (22.2)	33 (73.3)	2 (4.4)	45 (100)	X ² =28.63;
Dark	19 (82.6)	4 (17.4)	0 (0)	23 (100)	df=4;P=0.000
Brown	28 (34.1)	54 (65.9)	0 (0)	82 (100)	
Total	57 (38.0)	91 (60.7)	2 (1.3)	150 (100)	

4. Discussion

The present findings indicated that dark brown iris color, brown skin color and black hair color were the most prevalent color traits among young adults in the Eastern part of Nigeria, and the distribution of these color traits showed gender differences. In addition, we observed significant inter-correlations amongst the three human color traits.

The colours of hair, skin and eyes provide some of the most visible variations between and within human populations [13]. The origin of these variations, the way in which the polymorphism is maintained and functions it may serve are obvious problems for biologists, geneticists, anthropologists and the public at large. In healthy humans, the visible pigment differences are the result of the activities of specialized cells, the melanocytes, present in the epidermis and hair roots, which secrete the melanin pigment granules [1, 14].

Very few studies exist on the distribution of iris color in the population. The available studies however used different definitions and measurement techniques for iris colors, thus making comparisons with other reports difficult. In the present

study, we grouped iris colors into four categories of light 'brown', 'dark brown', 'dark' and 'blue/grey', which is similar to previous studies [10, 15]. Our data indicated that 69% of the study population had dark brown as most prevalent iris color, while grey-blue iris was observed in only 2.3% as the least prevalent. These findings indicate variation in the distribution of iris color when compared to previous studies mostly done in Europe [6]. Variations in iris color prevalence and distribution is attributed to genetics and race of the studied population [4, 16]. Dark brown eyes have been shown to be dominant in humans and in many parts of the world, it is nearly the only iris color present [17]. Dark pigment of brown eyes is most common in East Asia, Southeast Asia, South Asia, West Asia, Oceania, Africa, Americas, etc. as well as parts of Europe such as Spain and Southern Italy [18]. Grey-blue eye color has also been shown to be the least prevalent in the Tehran eye study [14] and consistent with the present study.

According to scientific studies, natural human skin color diversity within populations is highest in Sub-Saharan African populations compared with European and East Asian populations [19, 20]. It is not certain which skin color is most common in Nigeria and to the best of our knowledge, no previous reports exist regarding skin color pattern in Nigeria. In this study, we observed variation in skin color. The 'brown' skin color had the highest prevalence of 50.3%, followed by the 'fair' color (25.7%) and the least prevalent skin color was 'dark' color (24%). Variation in natural skin color is mainly due to genetics, although the evolutionary causes are not completely certain. Approximately 10% of the variance in skin color occurs within groups, and approximately 90% occurs between groups [21].

Hair colour variations have been observed mostly within populations of European origin [2, 3]. In Europeans, genetic factors explain 92% of the variation in hair colour, while most of the rest of the variation is due to environmental influence [3]. In Nigeria, no previous data has been documented about human hair pattern or distribution. In the present study, we identified three categories of hair colors, black, brown and blond in the study population thus indicating variation in hair color distribution in the population. It has been reported that black hair is the most common in the world, followed by brown hair as the second most common; natural blonde hair is rare in adulthood, with some reports that only about 2% of the world's population is naturally blonde [Wikipedia]. These reports concur with the present findings, in which black hair was the most prevalent hair color, followed by brown hair, and blond hair as the least prevalent color.

The present findings indicated gender differences in the prevalence of light brown iris, dark iris, dark skin, black hair and brown hair colors respectively. Gender differences observed in iris color is in contrast with a previous finding [14] in which no statistically significant gender difference was found in iris color. Gender difference in skin color may be due to differing melanin and hemoglobin levels in the skin's outer layers. A previous study [22] has shown that women generally produce 3.4% less melanin in their skin than do men in all populations of the world. They suggest

that this is probably due to the fact that women have far higher calcium requirements during their reproductive years. Mate selection preference and other cultural practices may also be partly responsible for gender difference in skin coloration. Sex difference in skin color also arises because girls lighten in color much more than boys from puberty on. This sexual differentiation has been noted in a wide variety of populations including India and Spanish samples [23, 24]. Previous reports have shown that generally, black hair is more common in men than in women, while blond hair is more common in women than in men [25].

The present data indicated significant associations between iris color and the skin color traits in both genders. The same trend was also observed between iris color and hair color traits in both genders. Majority of subjects who had light brown iris color were more likely to have fair skin tone as well as brown hair color in males and females relative to other colors. Dark brown iris was more dominant in those with brown skin and individuals with black hairs than in those with other colors. Individuals with dark iris were more likely to have dark skin tone than other colors. Similarly, significant associations were observed between skin color and the hair color traits in both genders. Interestingly, black hair color was the most dominant hair color in all the skin color traits in males, while in females, the most prevalent hair colors were brown amongst those with fair and brown skin colors respectively and black amongst those with dark skin. Limited information exist on interactions amongst human pigmentations in the population. However, a previous study [5] has reported that populations with darker average iris color also tend to exhibit darker average skin tones and hair colors, and consistent with the our findings. The present findings therefore suggest that the three color traits are highly inter-correlated in the study population.

The mechanism behind the inter-correlations observed between color traits in the present study is not well understood and beyond the scope of our study. However, recent studies have revealed that interactive effects between genes may be responsible for potential interactions amongst eye, hair and skin colours. For example, previous studies have confirmed the association of *HERC2* with eye colour and showed that this SNP is also significantly associated with skin and hair colouration [17, 18, 26, 27].

It is believed that the understanding of these interactions between body color traits will be of great benefit to opticians and estheticians. The determination of the skin, eye and natural hair colors may be an important step in determining the contact lens color that will match and flatter an individual's coloring. Similarly, matching any of the color traits with the surrounding environment of the body by estheticians will enhance physical appearance of individuals.

Limitations of study: We categorized skin and hair colors using visual inspection by subjective evaluation and compared with standard color scales. Previous reports have shown that the difficulties in recording and measuring of skin and hair colors can be overcome by the use of reflectometers. In addition, this study was

carried out in a cross-section of the Nigerian population. It is believed that a broader study of different ethnic groups in Nigeria may show a wider variation in human color traits than observed in the present study. Despite these limitations, the present work could perhaps be one of the first conducted in Nigeria and may form the basis for future research.

Within the limitations of this study, we can conclude that dark brown iris color, brown skin color and black hair color were the most prevalent human color traits among young adults in the Eastern part of Nigeria and these prevalence indicated gender differences. In addition, we observed significant inter-correlations amongst the color traits. Further studies involving wider ethnic groups are recommended.

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