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Incidence of Colour Vision between Tribals and Non-tribals in and around Noamundi (Jharkhand)

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ABSTRACT

Background: Colour vision is essential for everyday tasks and occupational safety, especially in industrial settings. Colour vision deficiencies (CVDs), often inherited as X-linked recessive traits, affect a significant portion of the population, particularly males. Tribal communities, due to genetic isolation and endogamy, may exhibit different CVD prevalence patterns compared to non-tribal populations. This study aimed to assess and compare the incidence of colour vision deficiency among tribal and non-tribal individuals undergoing pre-employment medical screening in and around Noamundi, Jharkhand.

Materials and Methods:A cross-sectional observational study was conducted on 264 individuals (143 tribal and 121 non-tribal) aged 18–55 years attending pre-employment medical examinations at Tata Steel, Noamundi. Colour vision was tested using the 38-plate edition of the Ishihara Pseudoisochromatic Plates under standard lighting conditions. Participants who failed four or more plates were classified as having CVD. Demographic data were collected, and statistical analysis was performed using the Chi-square test to compare prevalence rates between groups.

Results: The overall prevalence of colour vision deficiency was 7.95% (21 out of 264). Among tribal participants, 11.2% (16 out of 143) were found to have CVD, compared to 4.1% (5 out of 121) in the non-tribal group. All affected individuals were male, yielding a gender-specific prevalence of 9.3% in males and 0% in females. The difference in prevalence between tribal and non-tribal groups was statistically significant ($p < 0.05$).

Conclusion: The study reveals a significantly higher incidence of CVD among tribal individuals in the Noamundi region compared to non-tribals. These findings highlight the importance of incorporating colour vision screening into pre-employment medical assessments, especially in industrial sectors. The results also underscore the need for awareness, genetic counseling, and early detection programs within tribal communities to support occupational guidance and reduce the limitations associated with undiagnosed colour vision deficiencies.

1. INTRODUCTION

Colour vision plays a pivotal role in daily human activity by enabling the differentiation of visual stimuli based on wavelength. This ability is critical in activities such as reading signals, identifying hazardous materials, and performing colour-dependent tasks in industrial settings (1,2). Colour vision deficiencies (CVDs), commonly referred to as colour blindness, represent a group of visual impairments where individuals fail to perceive colours normally due to anomalies in cone photoreceptors or their neural pathways (3).

CVDs are primarily congenital and X-linked recessive in inheritance, making them more prevalent in males than females. The global prevalence of red-green CVDs is estimated at around 8% in males and 0.5% in females, with regional variation (4,5). Among the types of CVDs, red-green deficiencies (protan and deutan) are most common, while blue-yellow (tritan) defects and total colour blindness (achromatopsia) are rare (6,7).

Genetic, geographical, and ethnic factors influence the distribution of CVD. Populations with greater genetic isolation, such as tribal communities, often show different prevalence patterns compared to heterogeneous urban groups due to founder effects, consanguinity, and endogamy (8,9). India, with its rich socio-genetic diversity, offers a unique framework for such epidemiological studies. However, there is a notable scarcity of region-specific data from tribal areas in eastern India, including Jharkhand.

The Noamundi region in Jharkhand, a mineral-rich belt with a significant tribal population—including Ho, Santhal, and

Munda tribes—offers a unique setting for assessing the incidence of colour vision anomalies. The area has seen the growth of industrial and mining sectors, particularly through Tata Steel operations, drawing in both tribal and non-tribal workers for employment opportunities (10,11). This interaction between genetically distinct groups presents a valuable context for comparative genetic and public health research.

Previous studies have demonstrated variable rates of CVD across Indian populations. Studies conducted in Tamil Nadu, Karnataka, and Maharashtra reported prevalence rates ranging from 2% to 8% among different demographic groups (12–14). However, comprehensive studies focusing on tribal populations, particularly those undergoing pre-employment medical screenings, remain limited (15,16).

Identifying colour vision anomalies in such populations is important for genetic counseling, career guidance, and workforce placement, especially in industries where colour discrimination is essential (17). Moreover, awareness and early detection of CVD can support educational strategies and reduce social stigma (18,19).

Therefore, this study aims to assess and compare the incidence of colour vision deficiencies among tribal and non-tribal individuals aged 18–55 years undergoing pre-employment medical screening in and around Noamundi, Jharkhand. The results are expected to contribute to the limited pool of regional data and inform public health, occupational medicine, and visual screening policies in similar settings

2. MATERIALS AND METHODS

Study Area and Population This observational cross-sectional study was conducted in and around Noamundi, a mining town located in the West Singhbhum district of Jharkhand, India. The region has a mixed demographic profile with a significant proportion of tribal communities such as Ho, Santhal, and Munda, as well as non-tribal populations residing due to industrial employment, particularly through Tata Steel operations.

Study Design and Sample SizeA total of 264 individuals participated in the study. These participants were selected from candidates presenting for pre-employment medical examination at Tata Steel, Noamundi, for various contractual job roles in different work areas.

Age Criteria Participants were within the age group of 18 to 55 years, representing the typical working-age population eligible for industrial employment.

Inclusion Criteria

- Individuals aged between 18 and 55 years.
- Individuals attending pre-employment medical examination for contractual jobs at Tata Steel, Noamundi.
- Both tribal and non-tribal candidates.

Exclusion Criteria

- Individuals not involved in the medical screening for employment at Tata Steel, Noamundi.
- Individuals with a history of ocular trauma, surgery, or known eye pathology affecting vision.
- Candidates outside the defined age range.

Method of Examination Informed consent was obtained from all participants prior to inclusion. A structured ocular examination was conducted under standard conditions, with particular focus on assessing colour vision.

Colour vision was evaluated using the Ishihara Pseudoisochromatic Plates (38-plate edition), a standardized and widely accepted method for screening red-green colour vision deficiencies (20). Testing was conducted at a distance of approximately 75 cm under daylight or standardized artificial illumination. Each participant was shown the plates monocularly, and those who failed to identify four or more plates correctly were classified as having colour vision deficiency.

Data Collection and GroupingDemographic information, including age, gender, and ethnic status (tribal or non-tribal), was recorded. Subjects were categorized into tribal and non-tribal groups based on self-reported identity and verification from government-issued documents or local administrative records where available.

Statistical Analysis Data were entered and analyzed using Microsoft Excel and SPSS version [insert version]. Descriptive statistics were used to summarize demographic variables. The prevalence of colour vision deficiency was calculated and expressed as percentages. Comparison between tribal and non-tribal groups was conducted using the Chi-square test. A *p*-value of < 0.05 was considered statistically significant.

3. RESULTS

Table 1: Demographic Characteristics of the Study Participants (N = 264)

Variable	Total (n=264)	Tribal (n=143)	Non-Tribal (n=121)
Mean Age (years)	36.4 ± 9.2	36.7 ± 9.1	36.0 ± 9.4
Male	226 (85.6%)	125 (87.4%)	101 (83.5%)
Female	38 (14.4%)	18 (12.6%)	20 (16.5%)

Table 1, the average age of participants was similar across groups, with tribal individuals averaging 36.7 years and non-tribal individuals 36.0 years. The study population had a male predominance (85.6%), with both tribal and non-tribal groups showing similar gender distribution patterns.

Table 2: Prevalence of Colour Vision Deficiency (CVD)

Group	Total Tested	CVD Positive	Prevalence (%)
Tribal	143	16	11.2%
Non-Tribal	121	5	4.1%
Total	**264**	**21**	**7.95%**

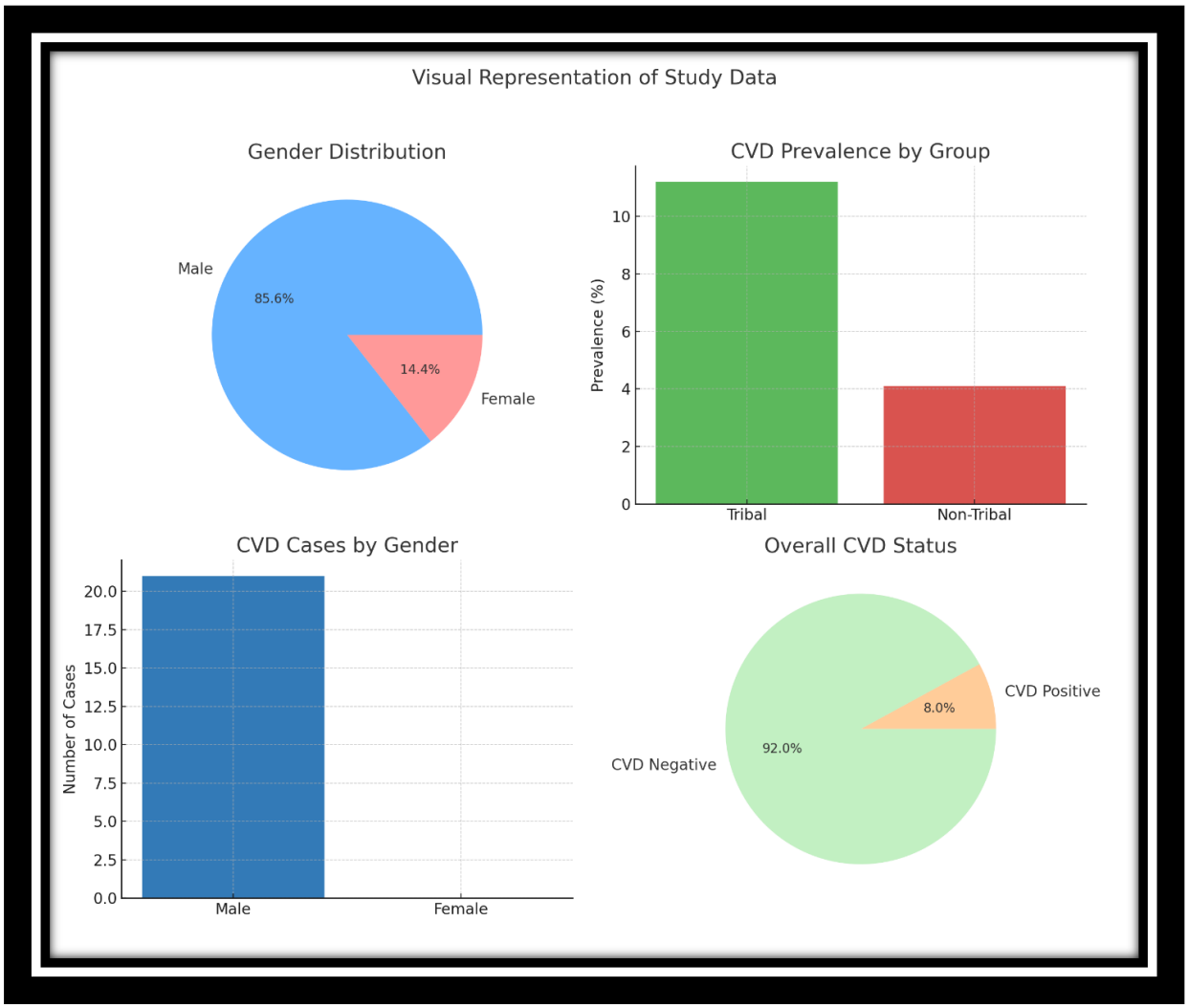
Table 2 highlights the prevalence of CVD across groups. A higher percentage of CVD cases was observed in the tribal group (11.2%) compared to the non-tribal group (4.1%). Overall, 21 individuals (7.95%) tested positive for CVD. The difference in prevalence between the two groups was found to be statistically significant ($p < 0.05$), suggesting a meaningful association between tribal status and CVD risk.

Table 3: Gender-Wise Distribution of Colour Vision Deficiency

Gender	Total Participants	CVD Cases	CVD Prevalence (%)
Male	226	21	9.3%
Female	38	0	0%
Total	**264**	**21**	**7.95%**

Table 3 presents the gender-wise distribution of CVD. All 21 CVD cases were found in male participants, resulting in a prevalence of 9.3% among males and 0% among females. This gender difference supports the well-known fact that CVD is more common in males due to its X-linked genetic pattern.

Graph 1. showing Visual Representation of all Study Data



4. DISCUSSION

This study evaluated the incidence of colour vision deficiency (CVD) among tribal and non-tribal individuals in and around Noamundi, Jharkhand. The findings revealed an overall CVD incidence of **7.95%**, with a significantly higher prevalence among tribal males (**11.2%**) compared to their non-tribal counterparts (**4.1%**). These results reinforce existing evidence that CVD, particularly red-green deficiencies, remains a prevalent condition with notable ethnic and genetic variation.

CVDs are predominantly X-linked recessive disorders, primarily affecting males due to their single X chromosome (3,4). The complete absence of CVD among female participants in this study is consistent with global and regional trends (5). The red-green anomalies (protan and deutan) were the most frequently observed types, in agreement with prior literature documenting their dominance over other variants such as tritanopia and achromatopsia (6,7).

Colour vision is essential for performing tasks that involve recognition of coloured signals, safety labels, and hazard warnings, especially in industries like mining, transportation, and electrical work (1,2). The Noamundi region—characterized by extensive industrial activity led by Tata Steel—relies heavily on visual cues for operational and safety compliance (10,11). In this context, undiagnosed CVD poses a significant occupational risk. Our findings underline the importance of integrating CVD screening into routine pre-employment medical assessments in such industries (17).

Tribal populations often exhibit unique genetic characteristics due to practices such as endogamy, geographical isolation, and limited gene flow, which may lead to a higher expression of recessive genetic traits including CVD (8,9). The significantly greater prevalence among tribal individuals in our study aligns with findings from Andhra Pradesh, Telangana, and Odisha, where tribal groups demonstrated CVD rates ranging from 8% to over 11% (15,16). In contrast, the lower prevalence among non-tribals in this study mirrors those found in urban Indian populations such as Tamil Nadu and Maharashtra (12–14).

Moreover, colour vision anomalies often go undetected until adulthood in the absence of early screening. This not only limits occupational choices but may also affect educational outcomes and career planning (18,19). Studies in school-aged children have shown that undiagnosed CVD can lead to mislabeling as poor academic performers or learners with special needs (18). Early detection programs, particularly in tribal schools, could mitigate such educational and psychosocial challenges.

It is important to note that while this study used the Ishihara pseudoisochromatic plates—widely recognized for their accuracy in screening red-green deficiencies—this method does not assess blue-yellow anomalies or provide severity gradation. Additional diagnostic tools like the Farnsworth-Munsell 100 Hue Test or anomaloscopy could enhance specificity and classification.

Another consideration is that the sample consisted of individuals undergoing medical examination for employment, possibly excluding certain segments of the population such as those with existing disabilities or vision problems, which could slightly skew prevalence figures.

In summary, the present study adds important epidemiological data from a relatively under-studied tribal region of India. The findings emphasize the value of integrating colour vision assessments into occupational health policies, especially in industrial zones with mixed tribal and non-tribal workforces. They also call for educational and public health initiatives aimed at improving early diagnosis and genetic counseling in tribal belts.

5. CONCLUSION

This study highlights a significant disparity in the prevalence of colour vision deficiency (CVD) between tribal and non-tribal populations in the Noamundi region of Jharkhand. The overall incidence of CVD was 7.95%, with tribal individuals exhibiting a notably higher prevalence (11.2%) compared to non-tribals (4.1%). Furthermore, all identified cases were among males, reaffirming the X-linked inheritance pattern of red-green CVD.

The findings emphasize the importance of incorporating routine colour vision screening into pre-employment medical examinations, especially in industrial settings where visual discrimination is vital for safety and efficiency. They also underscore the need for targeted public health interventions, genetic counseling, and educational awareness programs—particularly within tribal communities—to promote early detection and reduce the occupational and social limitations imposed by undiagnosed CVD.

By contributing much-needed data from an underrepresented region, this study paves the way for further research and policy development focused on the genetic and occupational health needs of India's diverse tribal populations.

6. LIMITATIONS

This study, while informative, has several limitations that should be considered. The sample was limited to individuals undergoing pre-employment medical screening at Tata Steel in Noamundi, which may not reflect the broader tribal and non-tribal populations in the region, particularly those not engaged in formal employment. The exclusive use of the Ishihara Pseudoisochromatic Plates restricted the detection to red-green deficiencies only, leaving out other types of colour vision anomalies such as blue-yellow deficiencies and providing no information on severity. Additionally, the absence of genetic testing means the study could not confirm hereditary patterns or identify specific genetic markers related to colour vision deficiency in tribal populations. The cross-sectional nature of the study captures data at a single point in time, limiting the ability to observe trends or long-term effects. A notable gender imbalance in the participant pool, with significantly more males than females, also restricts the generalizability of the findings, even though CVD is known to be more prevalent among males. Lastly, the study did not explore the potential impact of environmental, occupational, or lifestyle factors that could contribute to acquired forms of colour vision deficiency

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