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Chemical Hair-Dye Use among Patients with Cataract: A Retrospective Observational Study with an Ayurvedic Perspective

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Abstract

Background: Cataract is a major cause of visual impairment worldwide. In Ayurveda, certain features of cataract have been described under *Kaphaja Kacha*, a condition among the *Drishtigata Netra Rogas*. Chemical hair dyes contain compounds such as para-phenylenediamine (PPD), aromatic amines, and oxidizing agents; however, their potential association with cataract remains inadequately explored.

Objective: To assess the pattern of chemical hair-dye use and evaluate its association with cataract among individuals aged 30–60 years.

Material and Methods: A retrospective observational study was conducted among individuals aged 30–60 years of either gender diagnosed with pre-senile or senile cataract. Participants were recruited from the *Shalakya Tantra* outpatient and inpatient departments and community-based medical camps. Based on exposure history, participants were categorized into an exposed group and a comparison group. The exposed group comprised individuals using permanent or semi-permanent chemical hair dyes at least once every two months for a minimum of four consecutive years, while the comparison group included non-users or individuals with negligible lifetime exposure. Data regarding demographic characteristics, frequency and duration of hair-dye use, ocular findings, and cataract status were collected using a structured questionnaire and analyzed using appropriate statistical methods.

Results: A higher prevalence of cataract, including pre-senile cataract, was observed among habitual chemical hair-dye users compared with non-users. The observed pattern suggested an association between prolonged hair-dye exposure and cataract occurrence, with age, gender, frequency, and duration of exposure considered in the analysis.

Conclusion: Prolonged chemical hair-dye use may be associated with cataract occurrence, including pre-senile cataract. Further well-designed analytical and prospective studies are warranted to establish the strength and nature of this association and to explore potentially modifiable risk factors for cataract.

Keywords: Cataract, Kaphaja Kacha, ammonia, Prevalence of cataract in hair dye users and non-hair dye users, paraphenylenediamine.

Introduction

Cataract is characterized by progressive opacification of the crystalline lens and remains one of the leading causes of visual impairment and blindness worldwide. According to the World Health Organization (WHO), cataract accounts for approximately 94 million cases of moderate-to-severe distance vision impairment or blindness globally [1]. Despite the availability of effective surgical treatment, cataract continues to represent a substantial public health burden, particularly in low- and middle-income countries.

Advancing age is the principal risk factor for cataract; however, several other factors, including diabetes mellitus, ultraviolet radiation, cigarette smoking, corticosteroid exposure, ocular trauma, and other environmental and lifestyle-related factors, have also been implicated in its development. The occurrence of cataract at a relatively younger age, commonly referred to as pre-senile or early-onset cataract, warrants particular attention because of its potential impact on visual function and productivity.

In Ayurveda, *Shalakya Tantra* is one of the eight branches of Ayurveda and encompasses the prevention, diagnosis, and management of disorders affecting the eye and other structures above the clavicle. The importance of vision is emphasized in the classical literature, with Dalhana Acharya stating, *"Sarvendriyanam Madhye Nayanasya Pradhanatwat,"* highlighting the predominance of the eye among the sense organs. Various disorders affecting visual function are described under *Drishtigata Netra Rogas*, among

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which *Kaphaja Kacha* is characterized by disturbances in visual perception. The classical description of objects appearing as though viewed through a thin cloth, *"Tanuchailavratopamam,"* along with *Avila Darshana* (blurred vision), *Guru Bhava* (sensation of heaviness), *Manda Rupa Darshana* (diminished perception of form), and *Shveta Patalata* (whitish appearance), shows certain clinical similarities to the visual manifestations associated with lens opacity. However, *Kaphaja Kacha* should not be considered synonymous with modern clinical cataract without appropriate clinico-pathological correlation.

Chemical hair dyes are extensively used cosmetic products and may contain para-phenylenediamine (PPD), ammonia, aromatic amines, hydrogen peroxide, and other oxidative agents. Depending on the formulation and pattern of use, these substances may result in dermal exposure and systemic absorption. Although the ocular toxicity of individual hair-dye constituents remains incompletely characterized, concerns regarding their possible effects on the crystalline lens have been raised.

Limited epidemiological evidence has explored the relationship between chemical hair-dye exposure and cataract. An earlier clinical and experimental study involving hair-dye users reported a higher frequency of lenticular changes among exposed individuals compared with controls and observed a relationship between lenticular changes and the duration and amount of dye exposure. Experimental observations in the same study also suggested potential lens toxicity associated with para-phenylenediamine. [2] However, these findings are historical and do not establish a causal relationship between hair-dye exposure and cataract.

Given the widespread use of chemical hair dyes and the limited epidemiological evidence concerning their potential ocular effects, further investigation of this association is warranted. Therefore, the present study was undertaken to assess the pattern of chemical hair-dye use and examine its association with cataract among individuals aged 30–60 years, with particular emphasis on pre-senile cataract and associated ocular clinical features. The Ayurvedic clinical descriptions of *Kaphaja Kacha* were considered as a conceptual framework for correlating the observed ocular manifestations with classical descriptions.

Review of Literature

1. Cataract

Cataract is an opacity of the crystalline lens or its capsule that may result in progressive impairment of visual acuity. The term is derived from the Greek *katarraktes*, meaning "waterfall." Cataract remains one of the leading causes of blindness and visual impairment globally. The World Health Organization (WHO) estimates that cataract accounts for approximately 94 million cases of moderate-to-severe distance vision impairment or blindness worldwide. Cataract-related visual impairment remains particularly important in low- and middle-income countries, where access to timely cataract surgery may be limited. [1]

Cataract is broadly classified into congenital, developmental, traumatic, complicated, secondary, and age-related forms. Age-related cataract is the most common form and generally occurs in older adults. However, cataract occurring at a relatively younger age is increasingly recognized as an important clinical and public health concern. Established risk factors include increasing age, diabetes mellitus, cigarette smoking, ultraviolet radiation, ocular trauma, corticosteroid exposure, nutritional factors, and socioeconomic and environmental factors. [3, 4]

Early cataract may be asymptomatic and may be detected incidentally during routine ophthalmic examination. With progression, patients may develop painless diminution of vision, blurred or cloudy vision, glare, halos around lights, impaired night vision, altered colour perception, frequent changes in refractive correction, and monocular diplopia. The clinical appearance varies according to the anatomical location and morphology of the lens opacity, with nuclear, cortical, and posterior subcapsular cataracts being common morphological patterns.

Cataract extraction with intraocular lens implantation remains the definitive treatment for visually significant cataract. Although cataract surgery is highly effective and generally considered one of the most cost-effective interventions in ophthalmology, barriers to accessing surgery persist, particularly in rural and underserved populations. [1]

2. Presenile Cataract

Presenile or early-onset cataract refers to lens opacity occurring at an age younger than that typically expected for age-related cataract. Although definitions vary among studies, cataract occurring before approximately 50 years of age is frequently categorized as presenile cataract in epidemiological research.

The development of presenile cataract is multifactorial. Reported risk factors include diabetes mellitus, smoking and tobacco exposure, corticosteroid use, ultraviolet radiation, ocular trauma, metabolic abnormalities, nutritional factors, occupational exposures, and genetic predisposition. A case-control study conducted in India reported significant associations between presenile cataract and tobacco exposure, hypercholesterolaemia, fuel exposure, and lower socioeconomic status. [3]

Patients with presenile cataract may present with gradual, painless diminution of vision, glare, difficulty with night vision, halos around lights, impaired colour perception, and frequent changes in refractive correction. Clinical examination demonstrates lens opacity corresponding to the specific morphological type of cataract. Because presenile cataract occurs during the economically productive years, its impact may extend beyond visual disability to occupational functioning, quality of life, and socioeconomic productivity.

3. Ayurvedic Description of Kacha

In Ayurveda, disorders affecting vision are described under *Drishtigata Netra Rogas*. *Kacha* is described among these ocular disorders in the classical texts. Acharya Sushruta describes 12 *Drishtigata Rogas*, whereas Acharya Vagbhata provides a more extensive classification of ocular diseases. [5, 6]

The classical description of *Kacha* includes disturbances in visual perception, progressive diminution of vision, and alteration in the appearance or perception of objects. The description of objects appearing as though viewed through a thin cloth, *"Tanuchailavratopamam,"* together with manifestations such as *Avyakta Darshana* and other forms of altered visual perception, has been considered relevant when attempting to correlate the classical description with modern disorders associated with impaired vision.

Acharya Dalhana discusses the progression of *Timira* and its relationship with *Kacha*, particularly in the context of changes involving the visual field and progressive visual impairment.[5] Acharya Vagbhata describes the involvement of vitiated *Doshas* reaching the ocular structures through the relevant

channels and localizing at a site of susceptibility (*Khavaigunya*), resulting in disorders of *Drishti*. [6]

In *Kaphaja Kacha*, classical descriptions include diminished perception of the lustre of bright objects such as the sun, moon, and lamp, together with whitish changes associated with the visual field or *Drishtimandala*. [6] These features have prompted attempts to correlate *Kaphaja Kacha* with certain manifestations of lens opacity.

However, *Kacha* should not be regarded as synonymous with modern cataract. Modern cataract is an objectively demonstrable structural opacity of the crystalline lens, whereas the classical diagnosis is based on clinical features and Ayurvedic concepts of pathogenesis. Therefore, any correlation between *Kacha* and cataract should be regarded as a clinico-symptomatic and conceptual correlation, rather than a direct diagnostic equivalence.

4. Correlation of Kaphaja Kacha with Cataract

Certain clinical features described in *Kaphaja Kacha* may show similarities with manifestations encountered in cataract, particularly progressive blurring of vision, altered perception of objects, diminution of visual clarity, and whitish visual changes. Descriptions such as *Tanuchailavratopamam* may be interpreted as having a clinical resemblance to the visual experience associated with progressive lens opacity.

The comparison is particularly relevant in the context of *Kaphaja Kacha*, in which descriptions of diminished visual clarity and altered perception of bright objects may resemble some clinical manifestations of cataract. Nevertheless, the correspondence is not complete and should not be interpreted as evidence that the classical entity represents the same pathological condition as modern cataract.

This distinction is important in contemporary research because Ayurvedic descriptions can provide a conceptual framework for clinical interpretation, whereas diagnosis of cataract should be established using standard ophthalmological examination and objective assessment of the crystalline lens.

5. Hair Dyes: Classification and Composition

Hair dyes are widely used cosmetic preparations and can be classified according to their duration of colour retention and chemical mechanism. Temporary and semi-permanent products generally rely on non-oxidative colourants, whereas permanent hair dyes predominantly employ oxidative chemistry. [7]

Temporary dyes generally contain water-soluble colourants that are deposited primarily on the surface of the hair and are readily removed by washing. Semi-permanent dyes contain preformed colour molecules that interact with the hair shaft and are gradually removed with repeated washing. Permanent hair dyes involve oxidative reactions and generally contain three principal components: dye precursors, coupling agents, and an oxidizing agent, commonly hydrogen peroxide in an alkaline medium. [7]

Para-phenylenediamine (PPD) is an important aromatic amine used as a precursor in many permanent hair-colouring formulations. Other ingredients may include toluene-2,5-diamine, aminophenols, resorcinol derivatives, ammonia or alternative alkalizing agents, hydrogen peroxide, and other colouring compounds. The precise composition varies considerably between products and formulations. [7]

6. Potential Health Effects of Hair-Dye Exposure

The toxicological effects of hair dyes depend on the individual chemical constituents, their concentration, route of exposure, frequency of application, duration of exposure, and individual susceptibility. PPD is particularly recognized as a potent skin sensitizer and has been associated with allergic contact dermatitis and other hypersensitivity reactions. [7, 9]

A comprehensive review of hair-dye ingredients reported that oxidative hair dyes may contain aromatic amines and other compounds with documented toxicological effects. Experimental studies have demonstrated mechanisms involving oxidative stress, cellular toxicity, and immune sensitization for some constituents. However, the toxicological profile of the complete hair-dye formulation cannot be inferred solely from the effects of an individual chemical constituent. [7]

Ocular irritation has also been reported with exposure to certain hair-dye ingredients. Nevertheless, evidence concerning chronic ocular toxicity and specifically the development of cataract in humans remains limited. Consequently, the possibility of an association between long-term exposure and ocular morbidity warrants further epidemiological investigation rather than being considered an established causal relationship.

7. Hair-Dye Exposure and Cataract

The possible relationship between hair-dye exposure and cataract has received comparatively limited investigation. One of the earliest studies specifically examining this question was conducted by Jain *et al*. In their clinical and experimental investigation, 200 hair-dye users were examined and lenticular changes were reported in 89% of exposed individuals compared with 23% of controls. The authors reported that the observed lenticular changes were related to the duration and amount of hair-dye exposure and individual susceptibility. Experimental investigations in animals were also reported to demonstrate lens changes following exposure to PPD. [2]

Although this study provides an important historical basis for investigating a possible relationship between hair-dye exposure and lens changes, its findings should be interpreted cautiously. The study was conducted several decades ago, and differences in hair-dye formulations, exposure patterns, diagnostic methods, and study design limit direct extrapolation to contemporary populations. Furthermore, evidence from experimental studies cannot by itself establish causality in humans.

More recent reviews of hair-dye toxicology have focused predominantly on dermatological, systemic, genotoxic, and carcinogenic effects, while relatively little epidemiological evidence has specifically addressed cataract development. [7, 8] This represents an important gap in the current literature.

Cataract occurring during the productive years of life has important clinical and socioeconomic implications. Although established risk factors for presenile cataract have been investigated, the potential contribution of repeated exposure to chemical hair dyes remains insufficiently characterized. The widespread use of permanent and semi-permanent hair dyes, together with the presence of chemically active compounds such as PPD and other aromatic amines, provides a rationale for further investigation.

At present, available evidence is insufficient to conclude that chemical hair-dye exposure causes cataract. However, the historical clinical and experimental observations, together with the biological activity of several hair-dye constituents, support the need for well-designed observational studies to explore this potential association. [7, 2]

The present study therefore focuses on individuals aged 30–60 years and evaluates the pattern of chemical hair-dye exposure in relation to cataract, with particular attention to duration and frequency of use, age, gender, and the occurrence of presenile cataract. The clinical manifestations are considered alongside the Ayurvedic description of *Kaphaja Kacha*, thereby providing a comparative framework between contemporary ophthalmological findings and classical Ayurvedic descriptions.

Materials and Methods

Study Design and Setting: A retrospective observational study was conducted to evaluate the association between prolonged chemical hair-dye exposure and cataract among individuals aged 30–60 years. Participants were recruited from the *Shalakya Tantra* outpatient and inpatient departments and through community-based medical camps.

Sample Size: A total of 100 subjects diagnosed with cataract were included in the study.

Participant Selection: Subjects of either sex aged 30–60 years with a clinical diagnosis of cataract, including pre-senile and senile cataract, were considered eligible for the study. Participants were enrolled after fulfilling the predefined inclusion and exclusion criteria and providing informed consent.

Inclusion Criteria

Participants were included if they:

i). Were aged 30–60 years, irrespective of sex.
ii). Had a clinical diagnosis of cataract, including pre-senile or senile cataract.
iii). Had documented baseline lens status.
iv). Were willing to participate and provide informed consent.

Exclusion Criteria

Participants were excluded if they had:

i). A history of cataract surgery in either eye.
ii). Use of herbal hair dyes.
iii). Occupational exposure to hair-dye chemicals, including professional hairdressers.
iv). Congenital cataract.
v). Significant ocular trauma or ocular comorbidities predisposing to cataract.
vi). Systemic diseases or conditions considered important potential confounders for cataract, as specified in the study protocol.
vii). Tobacco use, alcohol dependence, or other substance use considered relevant to cataract risk.

Exposure Classification

Participants were classified according to their history of chemical hair-dye exposure. The exposed group comprised individuals who had used permanent or semi-permanent chemical hair dyes at least once every two months for a minimum of four consecutive years. The comparison group comprised non-users or individuals with negligible lifetime exposure to hair dyes.

Information regarding hair-dye exposure, including type, frequency, and duration of use, was obtained using a structured questionnaire.

Data Collection

Data were collected through a structured, interviewer-administered questionnaire. Information recorded included sociodemographic characteristics, history and pattern of hair-dye use, duration and frequency of exposure, and relevant ocular and clinical findings related to cataract.

Clinical information regarding lens status and cataract diagnosis was obtained from clinical examination and available medical records. The collected data were systematically documented and subsequently analysed.

Statistical Analysis

Data were entered, tabulated, and analysed using appropriate statistical methods. Continuous variables were summarized using mean and standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Appropriate inferential statistical tests were used to assess the association between chemical hair-dye exposure and cataract and to compare relevant demographic and clinical characteristics between the exposure groups. Results were presented using tables and graphical representations, including bar graphs and pie charts. A P value <0.05 was considered statistically significant, where applicable.

Results

A total of 100 participants aged 30–60 years with clinically diagnosed cataract were included in the study. Of these, 81(81.0%) were hair-dye users and 19(19.0%) were non-users.

Sociodemographic Characteristics

- The study population comprised 58(58.0%) males and 42(42.0%) females. The predominant age group was 51–60 years (58.0%), followed by 41–50 years (26.0%) and 31–40 years (16.0%).
- Among the hair-dye users, 50(61.7%) were aged 51–60 years, 20(24.7%) were aged 41–50 years, and 11(13.6%) were aged 31–40 years. Among non-users, 8(42.1%) were aged 51–60 years, 6(31.6%) were aged 41–50 years, and 5(26.3%) were aged 31–40 years.
- Male participants accounted for 45(55.6%) of the hair-dye users, while females accounted for 36(44.4%). Among non-users, 13(68.4%) were male and 6(31.6%) were female.
- The majority of participants were married (94.0%). With regard to education, 31.0% had graduate-level education or above, 30.0% had secondary education, 14.0% had completed high school, 13.0% were illiterate, and 12.0% had primary education.

Type of Hair Dye Used

Among the 81 hair-dye users, 51(63.0%) reported using chemical-based permanent hair dyes, while 30(37.0%) reported using mixed hair dyes containing chemical and natural components.

Frequency of Hair-Dye Application

Monthly application was the most frequently reported pattern of hair-dye use. Among the 81 users, 43(53.1%) applied hair dye once a month, 26(32.1%) once every 2–3 months, and 12(14.8%) once every 6 months.

Duration of Hair-Dye Use

The duration of hair-dye exposure varied among the 81 users. 43(53.1%) had used hair dye for 1–5 years, 29(35.8%) for 6–10 years, 5(6.2%) for less than 1 year, and 4(4.9%) for more than 10 years.

Thus, among hair-dye users, a duration of 1–5 years was the

most frequently reported exposure period.

Mode of Hair-Dye Application and Protective Measures

Among the respondents, 52 participants (64.2%) reported self-application at home, 16(19.8%) reported professional application at a salon/parlour, and 12(14.8%) reported application by a family member or friend. One response was recorded as missing among the hair-dye users.

Regarding protective measures during hair-dye application, 68 participants reported using protective measures, whereas 12 reported not using them. The dataset contained some missing responses for this item.

Ocular Symptoms Following Hair-Dye Application

Among the 81 hair-dye users, ocular symptoms following hair-dye application were assessed using a multiple-response questionnaire. Eye irritation was the most frequently reported ocular symptom, occurring in 70 participants (86.4%), followed by blurred vision in 52(64.2%), watering in 48(59.3%), pain in the eyes in 15(18.5%), haloes in front of the eyes in 10(12.3%), and redness in 8(9.9%).

Because participants could report more than one symptom, the percentages exceed the number of participants when summed and should therefore be interpreted as multiple-response frequencies.

Other Symptoms Following Hair-Dye Application

Other symptoms following hair-dye application were recorded for 80 participants. Scalp irritation was reported by 57 participants (71.3%), followed by heaviness of the head in 53(66.3%), burning sensation in 49(61.3%), headache in 38(47.5%), and giddiness in 20(25.0%).

These symptoms were also recorded as multiple responses; therefore, individual percentages are not mutually exclusive.

Characteristics of Non-Hair-Dye Users

Among the 19 non-users, the most frequently reported reason for not using hair dye was lack of need or interest, reported by 16 participants (84.2%). Two participants (10.5%) reported concern regarding possible side effects, while one participant (5.3%) reported both lack of need/interest and concern regarding side effects.

Two of the 19 non-users (10.5%) reported indirect exposure to chemical-based hair dye, such as helping another person during application, while 16(84.2%) reported no such exposure. One response was not available.

Visual Symptoms among Non-Hair-Dye Users

Among the 19 non-hair-dye users, 10(52.6%) reported blurring of vision, while 9(47.4%) did not. Dimness of vision at night was reported by 15(78.9%), while 4(21.1%) did not report this symptom.

Halos around lights were reported by 7 of 18 respondents (38.9%), whereas 11(61.1%) did not report halos. Sensitivity to light or glare was reported by 16 participants (84.2%), while 3(15.8%) did not report this symptom.

None of the 19 non-hair-dye users reported double vision. The need for brighter light during reading or similar activities was reported by 18 participants (94.7%), while 1(5.3%) did not report this requirement.

In this study of 100 participants with clinically diagnosed cataract, 81.0% reported a history of hair-dye use and 19.0% reported no hair-dye use. Among the hair-dye users, chemical-based permanent dyes were the predominant type, and monthly application was the most common frequency of use. The most frequently reported duration of use was 1–5 years.

Ocular symptoms reported following hair-dye application were predominantly eye irritation, blurred vision, and watering. Other commonly reported symptoms included scalp irritation, heaviness of the head, and burning sensation.

Among non-hair-dye users, visual symptoms commonly reported included the need for brighter illumination during reading, sensitivity to glare, and dimness of vision at night.

The present findings describe the distribution of hair-dye exposure and clinical symptoms among participants with cataract. The observed proportion of hair-dye users among cataract patients should not, by itself, be interpreted as evidence that hair-dye exposure increases the risk of cataract. Assessment of such an association requires comparison with an appropriate non-cataract population or a suitably designed comparative analysis, together with measures of association and statistical significance.

Table 1

Duration	n	%
<1 year	5	6.2
1-5 years	43	53.1
6-10 years	29	35.8
>10 years	4	4.9
Total	81	100

Discussion

The present observational study evaluated the pattern of chemical hair-dye exposure among individuals aged 30–60 years with clinically diagnosed cataract, with particular emphasis on cataract occurring at a relatively younger age. The study further assessed the type, frequency, and duration of hair-dye use and documented ocular and other symptoms reported following hair-dye application.

Among the 100 participants included in the study, 81(81.0%) reported a history of hair-dye use, whereas 19(19.0%) reported no history of hair-dye use. As all participants in the present cohort had clinically diagnosed cataract, these findings represent the distribution of hair-dye exposure among participants with cataract and do not represent the prevalence of cataract among hair-dye users or non-users. Similarly, these data do not permit estimation of relative risk or determination of a causal relationship between hair-dye exposure and cataract.

Age and Sex Distribution

The largest proportion of participants belonged to the 51–60-year age group (58.0%), followed by the 41–50-year (26.0%) and 31–40-year (16.0%) age groups. The predominance of participants in the older age group is consistent with the established association between advancing age and cataract. The inclusion of participants aged 30–50 years was relevant to the assessment of cataract occurring at a relatively younger age.

Males constituted 58.0% of the study population, while females constituted 42.0%. This finding describes the sex distribution within the study cohort and does not establish a sex-specific difference in cataract occurrence. Differences in environmental, occupational, behavioural, and healthcare-related factors may contribute to the observed distribution.

Pattern of Hair-Dye Exposure

Among the 81 hair-dye users, 63.0% reported using chemical-

based hair dyes, whereas 37.0% reported using mixed hair dyes containing chemical and natural components. The predominance of chemical-based products indicates that exposure to synthetic hair-dye formulations was common among the participants reporting hair-dye use.

Regarding frequency of application, 53.1% reported monthly application, 32.1% reported application once every 2–3 months, and 14.8% reported application once every 6 months. Monthly application was therefore the most frequently reported exposure pattern in the study cohort. However, the present data do not establish that more frequent application is associated with a higher risk of cataract because the study did not include an appropriate non-cataract comparison group.

With respect to duration of exposure, 53.1% of hair-dye users reported use for 1–5 years, 35.8% for 6–10 years, 6.2% for less than 1 year, and 4.9% for more than 10 years. These findings demonstrate variation in the duration of reported hair-dye exposure within the study population. A dose–response relationship cannot be inferred from these descriptive data alone.

Ocular Symptoms Reported Following Hair-Dye Application

Among hair-dye users, eye irritation was the most frequently reported ocular symptom (86.4%), followed by blurred vision (64.2%) and watering of the eyes (59.3%). Other reported symptoms included ocular pain (18.5%), haloes around lights (12.3%), and ocular redness (9.9%).

The frequent reporting of ocular irritation may indicate ocular discomfort associated temporally with hair-dye application. Certain hair-dye constituents are known to have irritant or sensitizing properties. Nevertheless, the questionnaire-based nature of symptom assessment and the absence of objective exposure measurements prevent attribution of these symptoms specifically to hair-dye exposure.

Other Symptoms Reported Following Hair-Dye Application

Among hair-dye users, the most frequently reported non-ocular symptoms were scalp irritation (71.3%), heaviness of the head (66.3%), burning sensation (61.3%), headache (47.5%), and giddiness (25.0%).

The relatively frequent reporting of scalp irritation is consistent with the possibility of local irritant or sensitizing effects of some hair-dye ingredients. However, these symptoms are nonspecific and may have multiple causes. Therefore, they should be interpreted as symptoms reported following hair-dye use rather than as evidence of a direct adverse effect.

Findings among Non-Hair-Dye Users

Among the 19 non-hair-dye users, the principal reported reason for not using hair dye was lack of perceived need or interest, while some participants reported concerns regarding possible adverse effects.

Visual symptoms were also documented among non-hair-dye users. The most frequently reported symptoms were the need for brighter illumination during reading or similar activities (94.7%), sensitivity to light or glare (84.2%), and dimness of vision at night (78.9%). Blurring of vision was reported by 52.6% of participants, while haloes around lights were reported by 38.9%. No participant reported double vision.

The occurrence of these symptoms among non-hair-dye users indicates that visual symptoms were not exclusive to participants with a history of hair-dye exposure and may be related to the underlying cataract or other ocular factors.

Comparison of Hair-Dye Users and Non-Users

The study included a greater number of hair-dye users than non-users among participants diagnosed with cataract. However, this difference in numbers cannot be interpreted as evidence of an increased risk or prevalence of cataract associated with hair-dye exposure, because all participants in the study population had cataract.

Similarly, the greater frequency of monthly hair-dye application cannot be interpreted as evidence of a dose–response relationship. Establishment of such a relationship would require comparison of cataract occurrence across different exposure categories using appropriate denominators and adjustment for potential confounding variables.

Potential Biological Considerations

Chemical hair-dye formulations may contain paraphenylenediamine (PPD), aromatic amines, ammonia, hydrogen peroxide, and other dye-forming or oxidizing agents. Several of these constituents are recognized for their potential to cause local irritation or sensitization. Previous experimental and clinical literature has also raised the possibility of ocular and lens effects associated with certain hair-dye constituents.

Oxidative stress has been proposed as a potential mechanism through which environmental or chemical exposures may contribute to lens damage. However, the evidence directly linking routine hair-dye exposure with cataract formation remains limited. The findings of the present study should therefore be regarded as observational and hypothesis-generating rather than confirmatory.

Relevance to Cataract at a Relatively Younger Age

The inclusion of individuals aged 30–60 years enabled assessment of cataract occurring across younger and older adult age groups. Participants aged 31–40 and 41–50 years constituted a proportion of the study cohort, indicating the presence of cataract at relatively younger ages.

However, the present study does not establish whether hair-dye exposure is independently associated with cataract occurring at a younger age. Future studies specifically addressing this question should account for established cataract risk factors, including diabetes, corticosteroid exposure, smoking, ultraviolet radiation, ocular trauma, metabolic disorders, and other relevant environmental and lifestyle factors.

Ayurvedic Perspective

From the Ayurvedic perspective, *Kaphaja Kacha* is described under *Drishtigata Netra Rogas* and is characterized by disturbances in visual clarity and perception. Certain clinical descriptions, including progressive blurring of vision and altered perception of objects, may be considered comparable to selected clinical manifestations of cataract.

In the present study, *Kaphaja Kacha* is considered as an Ayurvedic conceptual and clinico-symptomatic correlate of cataract, rather than as a direct diagnostic equivalent of modern cataract. This distinction is important because Ayurvedic disease classification and contemporary ophthalmological diagnosis are based on different conceptual and diagnostic frameworks.

The study provides descriptive information regarding the type, frequency, and duration of hair-dye use among individuals with cataract and documents ocular and other

symptoms reported following hair-dye application. The inclusion of participants across the 30–60-year age range also permits description of cataract occurring at relatively younger ages.

Several limitations should, however, be considered. First, the sample size was relatively small and participants were recruited from clinical settings and community-based medical camps, which may limit generalizability. Second, the observational nature of the study precludes determination of causality. Third, information regarding hair-dye exposure and symptoms was obtained through participant reporting and may therefore be subject to recall and reporting bias. Fourth, the study population consisted of participants with cataract and did not include a non-cataract control group; consequently, cataract prevalence and measures of relative risk associated with hair-dye exposure cannot be estimated from the present dataset. Finally, potential confounding by established cataract risk factors should be considered when interpreting the findings.

The present study demonstrates that a substantial proportion of the cataract patients evaluated reported a history of hair-dye use. Chemical-based hair dyes and monthly application were the most frequently reported exposure patterns. Ocular irritation, blurred vision, and watering of the eyes were commonly reported among hair-dye users, while visual symptoms were also observed among non-hair-dye users.

These findings provide a basis for further investigation of a possible association between repeated chemical hair-dye exposure and cataract, particularly cataract occurring at a relatively younger age. However, the present study does not establish that hair-dye exposure causes cataract or that hair-dye users have a higher risk of developing cataract.

Future case–control or prospective cohort studies with larger sample sizes, appropriate non-cataract comparison groups, objective assessment of lens status, detailed characterization of hair-dye formulations and cumulative exposure, and adjustment for established cataract risk factors are warranted to determine whether prolonged chemical hair-dye exposure is independently associated with cataract.

Conclusion

The present observational study describes the pattern of chemical hair-dye exposure among individuals aged 30–60 years with clinically diagnosed cataract. Among the 100 participants, 81% reported a history of hair-dye use, with permanent chemical hair dyes and relatively frequent use being common exposure patterns. Ocular and non-ocular symptoms such as eye irritation, blurred vision, watering, scalp irritation, burning, and headache were frequently reported among hair-dye users.

However, as all participants included in the present study had cataract, the observed distribution of hair-dye exposure does not establish an increased prevalence or risk of cataract among hair-dye users, nor does it demonstrate a causal relationship between chemical hair-dye exposure and cataract formation. The findings should therefore be interpreted as descriptive and hypothesis-generating.

From an Ayurvedic perspective, the clinical features of cataract may be considered in relation to the classical description of *Kacha*, particularly *Kaphaja Kacha*, under *Drishtigata Netra Rogas*. This provides a conceptual framework for understanding progressive visual impairment, although *Kaphaja Kacha* should not be considered directly equivalent to modern cataract.

The findings highlight the need for further well-designed analytical studies, particularly case-control or prospective cohort studies incorporating non-cataract controls, objective assessment of lens changes, detailed characterization of hair-dye formulations and cumulative exposure, and appropriate adjustment for established cataract risk factors. Such studies may help clarify whether long-term chemical hair-dye exposure has any independent association with cataract development or progression.

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