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### A cross sectional study of hair dye use among doctors and nurses working at a tertiary care centre

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#### ABSTRACT

##### Background

Hair dye products are being extensively used worldwide to enhance an individual outlook. More than two thirds of hair dyes currently contain PPD (paraphenylenediamine) which is a potent allergen and also a carcinogen as demonstrated in experimental studies. With the paucity of existing scientific evidence among the Indian population on hair dye use and in the current scenario safety of hair-coloring agents being a matter of active debate impelled us to take up the present study.

##### Objectives

To assess the prevailing practices, perception and knowledge of hair dye use and also to know the profile of adverse drug reactions to hair dye use.

##### Materials and methods

A cross sectional study was conducted between October 2015- December 2016. A pre validated questionnaire containing 30 questions was administered to doctors and nurses working at Victoria, Vani Vilas, Bowring and Minto hospital attached to Bangalore medical college and research institute. The data tabulated was analyzed using descriptive statistics.

##### Results

A total of 130 doctors and 196 nurses participated in the study with an overall response rate of 79.5%. The age at which the participants started using hair dyes was 21-30 years among doctors and < 20 years among nurses with a frequency of use being  $\geq 5$  times /year in both the groups. 63% of doctors and 80.6% of nurses used the hair dye to cover the gray hairs with the natural hair color being the most preferred option. Most of the participants i.e 64.6% of doctors and 73.97% of nurses used synthetic hair color with synthetic semi-permanent being the most commonly

used hair dye although they opined that natural hair dyes are safe. An alarming issue observed in the study was that 69.2% of nurses and 52.30% of doctors never performed an allergy test prior to its use taking into consideration that PPD is a very potent allergen. Adverse drug reactions (ADR) was reported by 15.9% participants with itching (5.47%), rash (2.43%) and watering from eyes and nose (1.835) being the commonest ADR. 26.9% of the reactions were seen immediately and 19.2% sought medical treatment of whom 1.9% required hospitalization with duration of hospital stay being 1-2 days. There was uncertainty with regards to its safety, risk of cancer and safety during pregnancy and lactation in the medical fraternity.

### Conclusion

Hair dye use was started at an early age and majority used synthetic hair dyes although they perceived that natural ones are safe. Adverse drug reactions noted were minor and provided the potential of PPD to cause life threatening reactions it is essential to increase the awareness regarding its adverse effect profile among the public and health care professionals. Further large scale studies need to be conducted to create a database regarding the hypersensitivity reactions and associated cancer risk which will help governing bodies in cosmetic industry to take appropriate measures in India.

**Keywords:** Hair dye, PPD (paraphenylenediamine), Semi-permanent hair dyes, Permanent hair dyes.

## INTRODUCTION

Hair color, length and style play an important role in ones physical appearance and self perception. [1] Since time immemorial hair phenotypes have contributed disproportionately in human communication imparting information regarding an individual's race, ethnicity, health, gender and age status. [2] In the case of the latter parameter, one experiences significant change in pigmentation in the journey from birth to puberty and through to young adulthood, middle age and beyond. Hair color is attributed to the presence of melanin pigment in the keratinocytes of the hair shaft cortex which are of two types: eumelanin, and pheomelanin. Eumelanin causes shades ranging from brown to black, whilst pheomelanin gives colours in the range of blond to red. Darker hair, therefore, contains more eumelanin. [2] Differing hair colours are merely the consequence of different balances in concentrations of these two pigments, and blond hair is often a result of a low concentration of melanin in general. The hair follicle pigmentary unit is perhaps one of the most visible, accessible and potent aging sensors, with marked dilution of pigment intensity occurring long before even subtle changes are seen in the epidermis. [2] Canities, or hair graying, is a process of chronological ageing and occurs regardless of gender or race. [3] The precise mechanisms responsible for the loss of melanogenically active melanocytes from anagen adult hair follicles with increasing age remain rather speculative. A defective compartmentalization of the biochemically highly reactive process of

melanogenesis, together with a reduced or inefficient antioxidant system, failure of melanocyte stem cell renewal are the proposed hypothesis. [2]

Attitude towards hair color in modern times are influenced by passing trends of the day, perception of self in the society, availability and publicity of hair color products in the market and to some extent geographical location as well. [4] Hair dye products represent one of the most rapidly growing beauty and personal care industries securing nearly a quarter of industry revenue. [5] Today, hair dyes are widely used by both men and women irrespective of their educational or social status either to cover up gray hairs, or simply by those wanting to change their natural hair colour. Indeed, archaeological evidence shows that the use of dyes by humans dates back to the Palaeolithic period. [6] Nowadays, hair dyes are in an important phase of development and since the Second World War, great progress in discoveries and applications of new synthetic dyes has occurred. The strange and subtle chemistry of coloration is constantly evolving, and the desire to re-pigment gray hair as naturally as possible has given birth to radical new approaches. Modification of hair color can be achieved by the following two methods: removal of cortical melanin pigment via bleaching or addition of artificial pigment via application of a hair dye. Hair dyeing systems can be divided into two main categories, oxidative or non-oxidative, and also according to the color durability after the application on hair strands: temporary, semi-permanent, and permanent. [7]

Temporary dyes weakly adhere to the hair shaft cuticle via van der Waals forces, but do not penetrate the hair cortex. [7] Semi-permanent dyes coat the hair shaft cuticle in a similar fashion to temporary dyes while also partially infiltrating the cortex. They are retained within the hair shaft by van der Waals forces and are removed in 4 to 12 shampoos without requiring chemical reactions to impart color. They contain an alkaline agent other than ammonia (e.g., ethanolamine, sodium carbonate) with a much lower concentration of hydrogen peroxide than that used with a permanent hair color. Other dyes, such as metallic and vegetable derivatives, are also considered to be semi-permanent dyes and can be used in hair dyeing. [6] Henna is the most widely used vegetable dye and the metallic dyes are derived from silver salts, lead, and bismuth with darkening of the hair strands depending on their concentrations promoting a more natural appearance. Permanent hair dyes are the most important group accounting for more than three-fourth of the market share. They are the most versatile and long lasting and are available in the widest spectrum of shades. Permanent dyes are actually colorless precursors [p-phenylenediamine (PPD), para-toluenediamine etc] and require a developer to impart color. Developers contain hydrogen peroxide, which serves several functions—it bleaches the natural melanin pigment; it causes swelling of the hair cuticle, allowing for diffusion of the colorless precursor into the hair cortex; and it catalyzes the oxidation of the colorless precursor into large colored molecules, which become trapped inside the hair cortex. The hair shaft sustains oxidative damage with permanent hair-dye use. The damage is accentuated with the use of dark colored dyes (black, dark-brown) because darker shades need higher concentrations of precursors. [8]

Given the extensive use of hair dyes scientists have tried to determine the association of hair dye use with health risk. The adverse consequences of hair dyes may range from mild redness, itching to very serious contact dermatitis, anaphylaxis to increased risk of bladder cancer. [9, 10] It is recommended by the cosmetic industry that self-testing for allergy be done before each use. However there exists no uniform or scientifically validated method of self-testing for dye allergy.

There are few studies on hair dye use in Indian population and that too in working class. Given the non-uniformity in package inserts and vigorous promotion of hair dye products, we thought it would be relevant from health point of view to undertake this study to evaluate hair dye use and awareness of hair coloring agents among the doctors and nurses working at a tertiary care centre.

## METHODS

The protocol was approved by the institutional ethics committee. It was a cross sectional study conducted between October 2015-December 2016. The objectives of the study were to assess the prevailing practices, perception and knowledge of hair dye use and also to know the profile of adverse drug reactions to hair dye use. The study included the faculty, post graduates, interns and nursing staff working at Victoria, Vani Vilas, Bowring, Minto hospital attached to Bangalore medical college. Those who had used hair dye (herbal/synthetic) at least once in life time, aged between 18-80 years and willing to give consent were administered a pre validated questionnaire. It contained 30 questions in printed format which had to be filled and returned the same day. Questionnaire included information regarding their educational status, occupation and income, the age at which they first started using hair dyes, type of hair dyes used, frequency of its use, their motive behind coloring their hair, allergy testing before use, adherence to instructions given in the hair dye pack, use during pregnancy and lactation and also details regarding the adverse reactions reactions they suffered and its outcome. Participants could opt for more than one option for few questions. The data tabulated was analysed using proportions/percentages.

## RESULTS

A total of 178 doctors were approached, of which 130 doctors filled the questionnaire and among 232 nurses only 196 were willing to participate in study. The overall response rate was 79.5%.

The baseline demographics of the participants is given in Table 1.

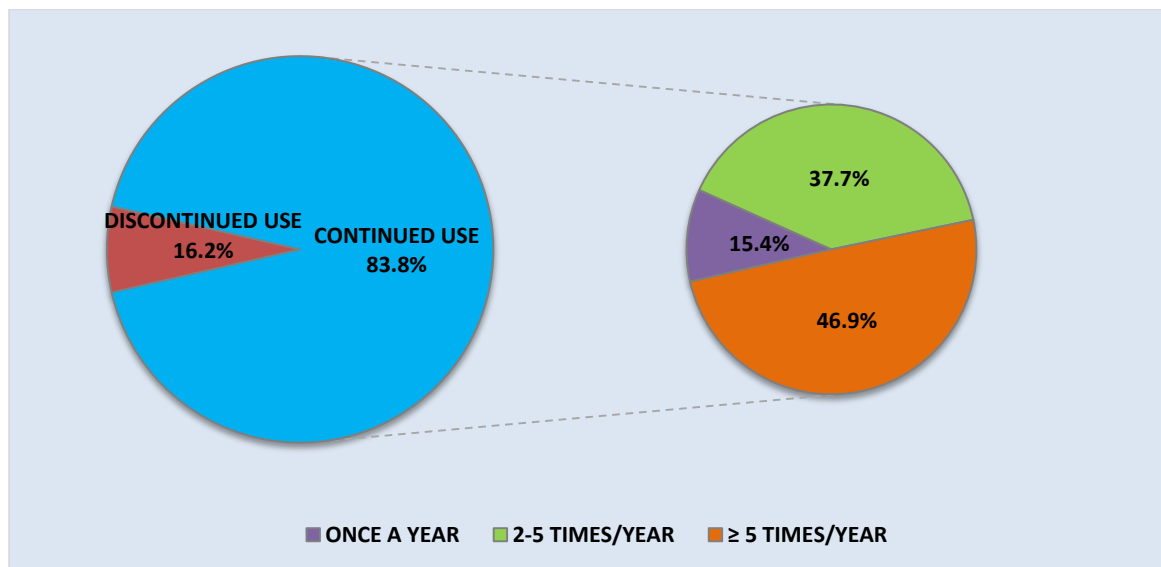
**Table 1: Baseline demographics**

| Variables             | Doctors n=130, n (%) | Nurses n=196, n (%) |
|-----------------------|----------------------|---------------------|
| Age (Mean ± SD)       | 35 ± 9.02            | 41.5 ± 12.06        |
| <b>Sex</b>            |                      |                     |
| • Male                | 53 (40.7%)           | 52 (26.7%)          |
| • Female              | 77 (74.6%)           | 143 (73.3%)         |
| <b>Marital status</b> |                      |                     |
| • Married             | 97 (74.6%)           | 164(84.1%)          |
| • Unmarried           | 33 (25.4%)           | 30 (15.9%)          |
| <b>Education</b>      |                      |                     |
| • College             | -                    | 98 (50.3%)          |
| • Graduate            | 56 (43%)             | 97 (49.7%)          |
| • Post graduate       | 70 (53.8%)           | -                   |
| • Further             | 4 (3.2%)             | -                   |
| <b>Annual income</b>  |                      |                     |
| • < 5 lakhs           | 50 (38.5%)           | 163 (83.5%)         |
| • 5-10 lakhs          | 18 (13.9%)           | 32 (16.5%)          |
| • 10-20 lakhs         | 62 (47.6%)           | -                   |

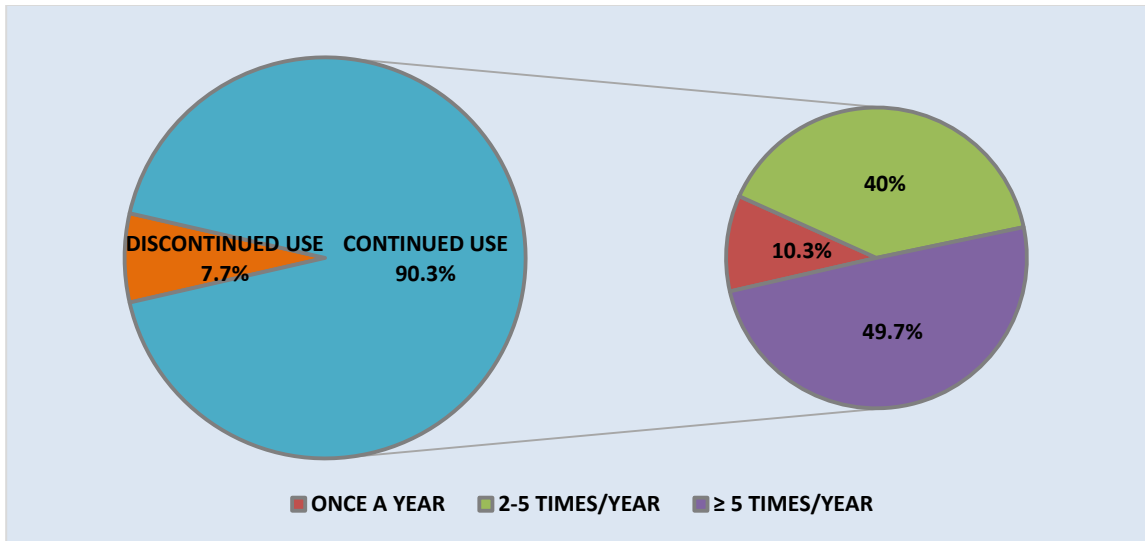
**Practice regarding the hair dye use**

The age at which the participants started using hair dyes was 21-30 years among doctors and less than 20 years among nurses. Among the doctors 83.8% continued to use the hair dye and 16.2%

discontinued its use. 90.35% of the nurses continued to use hair dye and 7.7% discontinued its use. The frequency of hair dye use among doctors and nurses is presented in figure 1 and 2 respectively

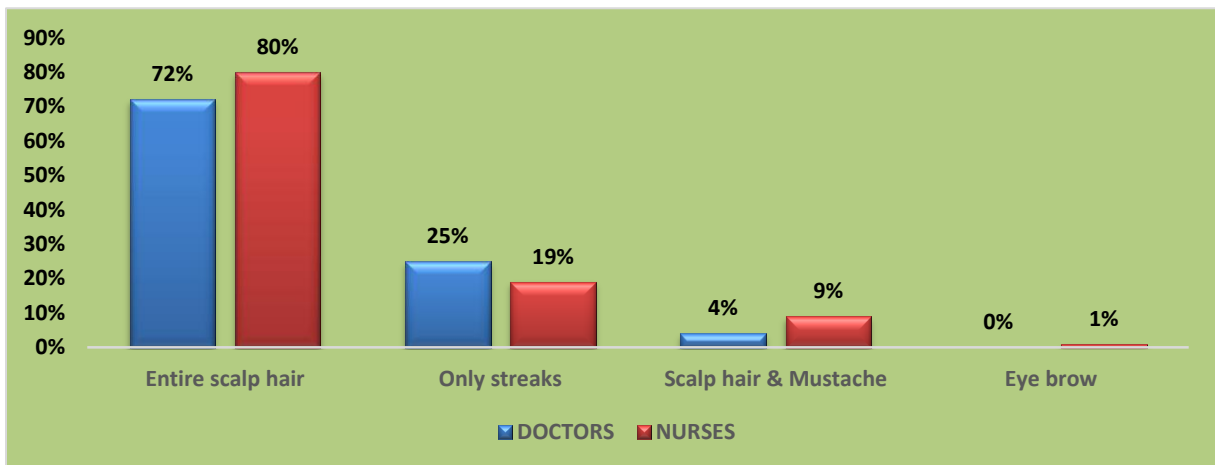


**Figure 1: Frequency of hair dye use – Doctors**



**Figure 2: Frequency of hair dye use – Nurses**

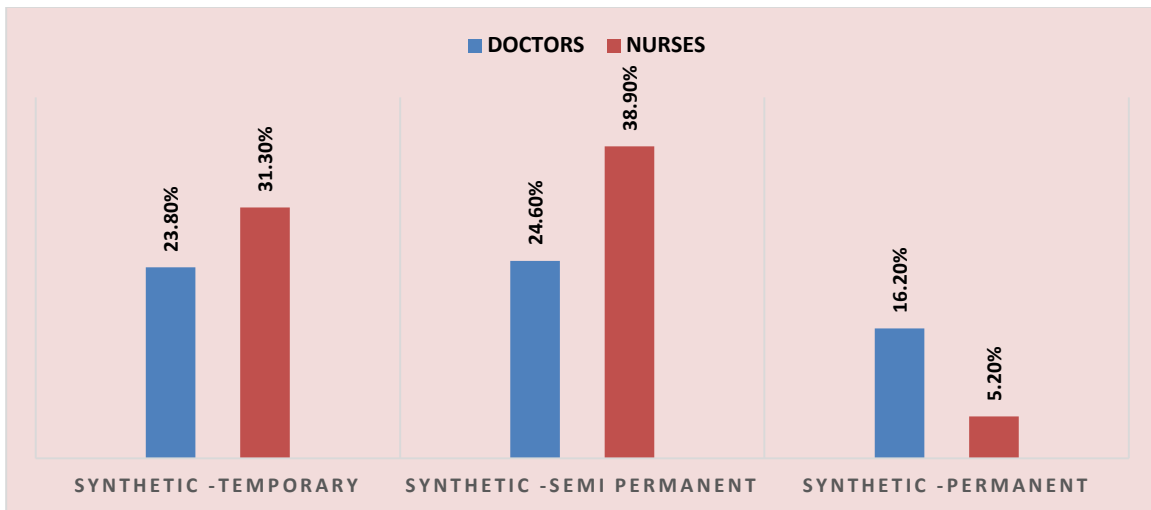
The sites of hair dye application is depicted in figure 3.13 (10%) amid the doctors and 18 (9.2%) amid the nurses applied hair dye at multiple sites.



**Figure 3: Sites of hair dye application amongst doctors and nurses.**

Amongst the doctors natural type of hair dye was used by 46 (35.4%) and synthetic hair dye was used by 84 (64.6%) of them. 50 (25.51%) and 145 (73.97%) nurses used the natural and synthetic hair

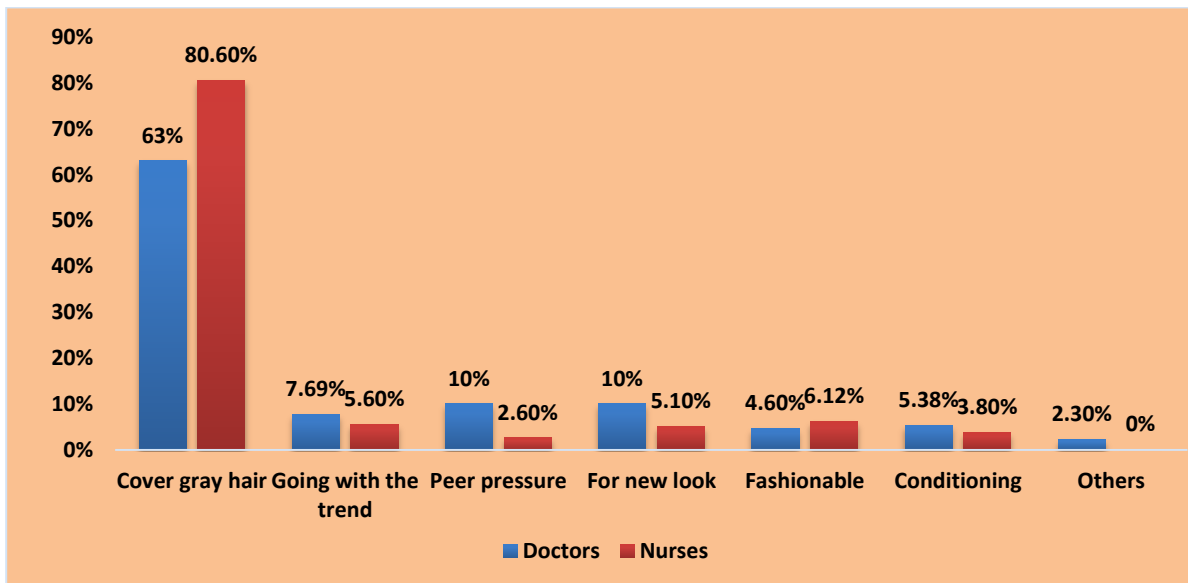
dye respectively. synthetic hair dye was 145 (73.97%). The types of the synthetic hair dye that was used is depicted in figure 4.



**Figure 4: Types of hair dye used – Doctors & Nurses**

The foremost motive behind the hair dye use among the doctors was to cover the gray hairs- 82 (63%) with a similar trend noted among the nurses

158 (80.6%) also. The other motives behind hair dye use are represented in figure 5.

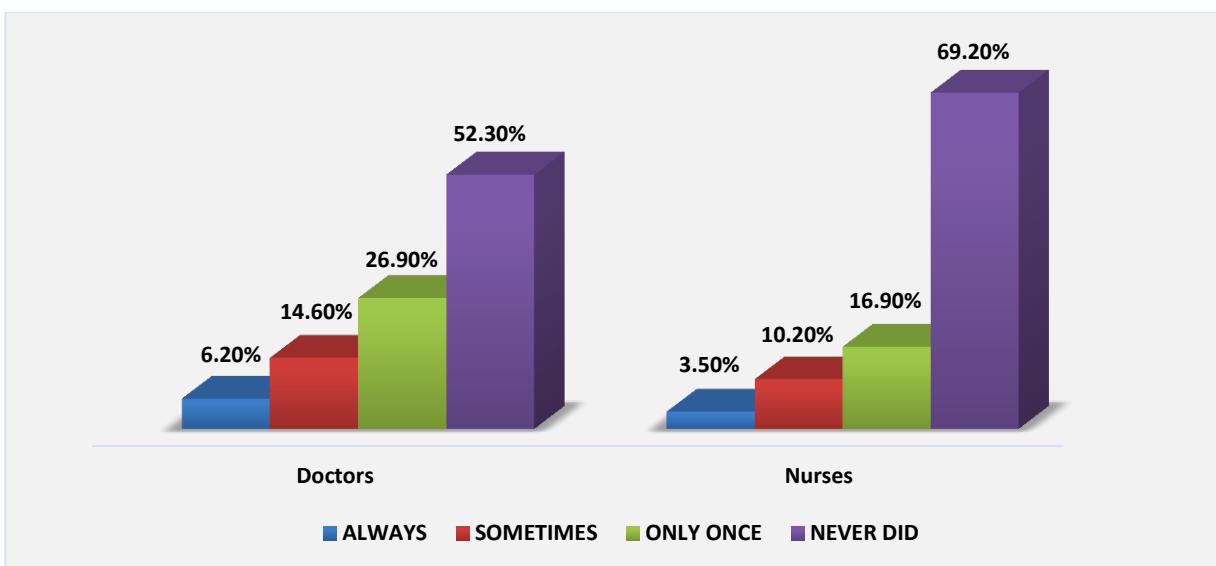


**Figure 5: Motive for hair dye use – Doctors & Nurses**

**The other practice related questions are tabulated in table 2.**

|   | <b>Doctors</b> | <b>Nurses</b> |
|---|----------------|---------------|
| <b>Dye it:</b>  |                |               |
| • Self  | 78 (60%)       | 144 (73.8%)   |
| • Saloon  | 31 (23.8%)     | 34 (17.4%)    |
| • Both  | 21 (16.2%)     | 18 (8.8%)     |
| <b>Follow the instructions strictly that comes with hair dye pack:</b>        |                |               |
| • Most of the time  | 58 (44.6%)     | 50 (25.5%)    |
| • Always  | 25 (19.2%)     | 45 (22.9%)    |
| • Sometime  | 35 (26.9%)     | 53 (27%)      |
| • Never did   | 12 (9.2%)      | 48 (24.4%)    |
| <b>Waiting time before washing hair dye :</b>                                 |                |               |
| • <30 min   | 53 (40.7%)     | 107 (54.6%)   |
| • 30-60 min   | 52 (40%)       | 66 (33.7%)    |
| • 60-120 min  | 17 (13.1%)     | 16 (8.2%)     |
| • >120 min  | 08 (6.2%)      | 07 (3.8%)     |
| <b>Wear gloves while handling dye:</b>  |                |               |
| • Yes   | 98 (75.4%)     | 122 (62.2%)   |
| • No  | 32 (24.6%)     | 73 (37.2%)    |
| <b>Use recommended shampoo to wash your hair after dyeing</b>                 |                |               |
| • Yes   | 81 (62.3%)     | 84 (42.8%)    |
| • No  | 49 (37.7%)     | 111 (56.6%)   |
| <b>Test for allergy (patch test) before use: (Figure 6)</b>                   |                |               |
| • Every time  | 08 (6.2%)      | 07 (3.6%)     |
| • Sometime  | 19 (14.6%)     | 20 (10.2%)    |
| • Only once   | 35 (26.9%)     | 35 (17.9%)    |
| • Never did   | 68 (52.3%)     | 134 (68.36%)  |
| <b>Site of application for allergy testing among those who did the test :</b> |                |               |
| • Forearm   | 35 (56.5%)     | 16 (25.8%)    |
| • Cubital fossa   | 01 (1.61%)     | 10 (16.1%)    |
| • Behind the ears   | 24 (38.7%)     | 33 (53.2%)    |
| • Others  | 02 (3.2%)      | 03 (4.8%)     |

Majority of the participants ie 52.3% of doctors and 69.2% of the nurses never performed allergy testing as depicted in figure 6.



**Figure 6- Information on allergy testing-Doctors & Nurses**

Most of the participants -111 (85.4%) of the doctors and 185 (94.38%) of the nurses were satisfied with the hair color after dyeing. The participants amid doctors who agreed that they felt compelled to continue hair dye use was 70 (53.8%), undecided were 28 (21.5%) and disagreed were 32 (24.6%). The participants amid the nurses who were inclined towards continuing hair dye was 115 (58.67%), who were undecided were 73 (37.2%) and who disagreed were 8 (4.1%).

#### **Attitude towards hair dye use**

Majority of the doctors 120 (92.3%) and nurses 174 (88.78%) preferred the natural color with the exotic color preference being 10 (7.69%) and 22

(11.22%) among the doctors and nurses respectively. 122 (93.8%) of the doctors and 186 (94.9%) of the nurses thought natural hair dyes were safe. Of the synthetic hair dyes, synthetic temporary was thought to be safe by doctors and nurses accounting to 4 (3.07%) and 7 (3.57%) respectively.

#### **Knowledge towards hair dye use**

Majority of the doctors 120 (92.3%) and nurses 176 (89.79%) knew the brand name of the hair dye that they used with few failing to recall it. The proportion of doctors and nurses who agreed, disagreed and were undecided regarding the safety of hair dyes from health point of view is depicted in figure 7.



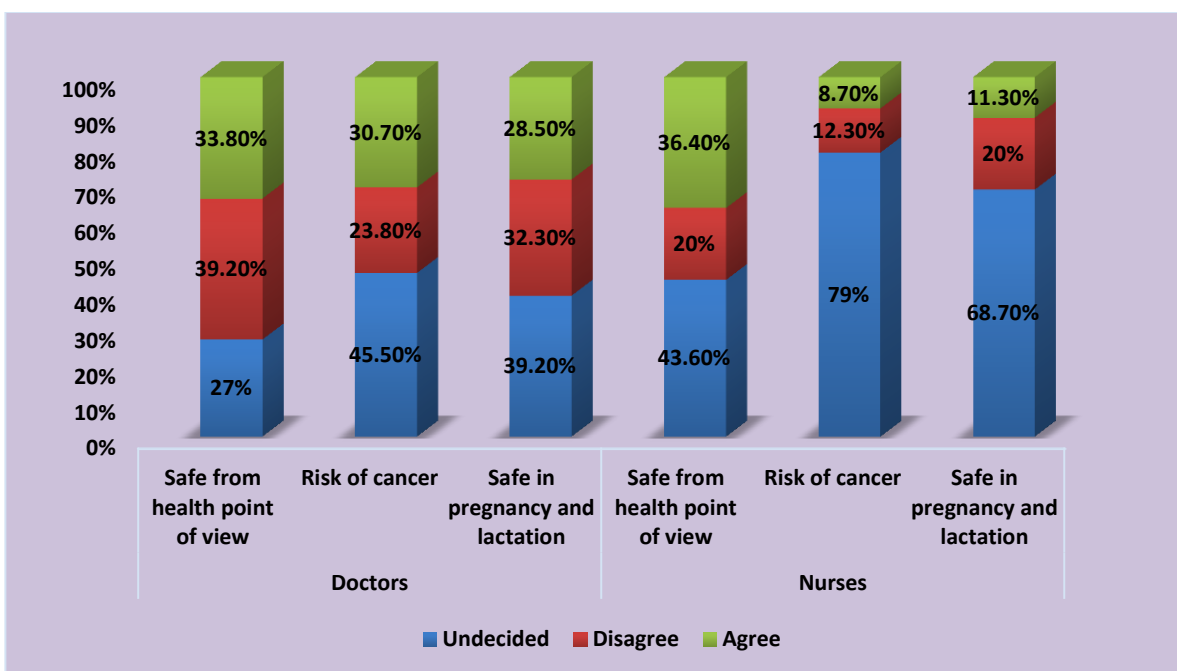


Figure 7: Knowledge regarding hair dye safety

52 (15.9%) participants in the study reported adverse drug reactions. The adverse drug reactions profile for all the participants which included doctors and nurses is represented in figure 8. Most of the reactions were experienced later i.e 32 (61.5%) compared to those which were seen immediately- 20

(38.5%). 14 (26.9%) experiencing it each time, 19 (36.5%) experiencing it sometimes and 18 (34.6%) did not experience it each time. Only 10 (19.23%) sought medical treatment of whom 1(1.9%) required hospitalization with during of hospital stay being 1-2 days.

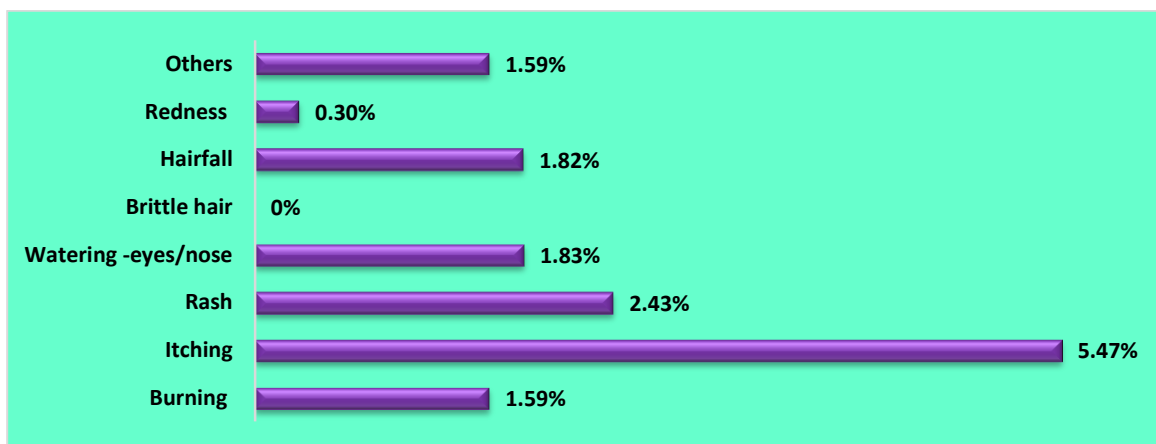


Figure 8 - Adverse drug reactions – Doctors/Nurses

## DISCUSSION

Many advances in the cosmetic industry have increased our ability to enhance youth and beauty. Hair coloring products are one such innovation. Over the past several decades, a significant amount of work has been dedicated to understanding the possible long-term side effects associated with hair-dye use, specifically looking at cancer risk. In the United States, the United States Food and Drug Administration (FDA) regulates the safety of cosmetic products. Additionally, the Cosmetic Ingredient Review (CIR) program established in 1976 now known as the Personal Care Products Council provides an independent expert assessment of product safety. [7] Commercially available hair-dye formulations contain chemical ingredients that are similar to banned ingredients by FDA in 1980 and hence the causal relationship between the potentially toxic ingredients in various hair dyeing products raises an important public health concern. Therefore an attempt was being made to strengthen the existing evidence regarding hair dye use and the above study was planned. [11]

In the present study the age at which the participants started using hair dyes was 21-30 years among doctors and less than 20 years among nurses while it was 27 years in a study by Patel et al., conducted among the Indian population. A study conducted on Danish adult population, Korean population and a study in Riyadh showed it to be 16 years, 40-49 years and 15 years respectively. [4, 9]

The results of the present study indicate that the use of hair dye is very common among females (65.4%) which is line with a study done in Denmark which reported it to be 74.9%. The results of the survey conducted by AlGhamdi KM et al., also indicated that the use of Hair dye is very common among females in Saudi Arabia with 82.6% of the participating females having dyed their hair at some point in their lives. It has also been estimated that more than one-third of women over age 18 and about 10% of men over age 40 use some type of hair dye. Natural color was preferred by most of the participants compared to exotic colors. This finding correlates with the study findings of AlGhamdi KM et al., wherein 95.3% of the participants colored their hair with natural hair color compared to exotic colors whose usage was only 4.7%. The frequency of hair dye was more than 5 times a year which contrasts the

study by Patel., et al in which most of them used 3-5 times/year. [4, 9]

The synthetic hair dyes were most commonly used although majority were of the opinion that natural hair dyes are safe reflecting the lacunae in translating the knowledge into practice. This finding diverges from the study by Zaid et al., wherein 38.9% of the females preferred natural dyes. [12] Among the synthetic ones synthetic temporary and synthetic semi-permanent was used on par with synthetic permanent being least used. A study by AlGhamdi KM et al., showed that 7.8% (36/461) used temporary dyes, 15.4% (71/461) used semi-permanent dyes, and 76.8% (354/461) used permanent dyes. [4]

The most common motive being the hair dye use was to cover the gray hairs followed by peer pressure and new look among the doctors. To cover gray hair was also the foremost motive among the nurses followed by fashionable look and going with the trend. This highlights the attempt by the consumers to project a youthful look. The above findings correlate with study done by Kim JE., et al where the principle reasons for hair dye usage were to look younger and to maintain a good impression. A study by Zaid et al., showed that the major motivation for hair dyeing was to simply have a change of color and follow new trends (52.3%); other reasons were to improve the outlook by 24.2% and to hide gray hair by 23.5% which contrasts the present study findings. [12] The type of hair dye used and the motive can explain the increased frequency of hair dye use noted in the present study. Most of them were satisfied with the hair color after dyeing and felt compelled to continue its use.

Most of the instructions in the hair dye pack were followed except performing an allergy test prior to use of a new hair dye product. The percentage following the instructions was 58% among the doctors and 50% among the nurses. This could be due to the fact that the participants in the study were health care professionals. This may contrast the findings that would have aroused if the study participants were general population depicting a totally different scenario overall. In a study by AlGhamdi KM., et al 40% of the participants followed instructions with majority (64%) failing to perform an allergy test which is line with present study findings. The study findings are also comparable with study of Patel et al., which also showed that allergy test was performed by only 10%

of the participants. This practice is a cause for concern because 6.4% of HD users suffer allergy symptoms following hair dyeing.

The safety of hair-coloring agents is a matter of active debate. Hair coloring involves the use of chemicals capable of removing, replacing, and/or covering up pigments naturally found inside the hair shaft. For more than 100 years aromatic amine family have been the main agents used in permanent hair dyes, and more than two thirds of hair dyes currently contain PPD. [13] This compound forms the key ingredient in most of the hair dyes owing to its low molecular weight, its ability to penetrate the hair shaft and follicle, its strong protein binding capacity, and its rapid polymerization in the presence of a coupler (a kind of catalyst) and an oxidizing agent. These properties PPD an ideal contact allergen and, indeed, it is among the most potent. [8, 12, 14, 15] Use of these chemicals can result in a range of adverse effects, including temporary skin irritation and allergy, hair breakage, skin discoloration and unexpected hair color results. A full-blown reaction does not occur immediately after use. In many cases, reaction is mild and will sometimes start with an itchy scalp or body, but as the days move on, it can begin to escalate. Studies have shown that 0.1-1% of the patients are sensitized to PPD and this sensitization is what triggers the allergic reaction. [16] This can lead to swelling, and an intensely burning, itching sensation spreading across the skin. Serious reactions to PPD can result in life threatening reactions such as urticaria, anaphylaxis, rhabdomyolysis, laryngeal edema, severe metabolic acidosis and acute renal failure. [17, 18] In addition, PPD can leave one with permanent scars and permanent sensitivity to chemicals. To help prevent or limit allergic reactions, the majority of hair color products recommend that the client conduct a patch test before using the product. This involves mixing a small quantity of tint preparation and applying it directly to the skin for a period of 48 hours. If irritation develops, manufacturers recommend not to use the product. In the present study adverse reactions were noted in 15.9% of the study participants. The spectrum consisted of rashes, burning, brittle hair, hair fall, watering from nose and ears with itching being the commonest. In a study by Zaid et al., 20.4% of the women reported allergic reactions with itching and redness of the scalp being the commonest and these findings are similar to the

present study findings. [12] Study by Kim JE et al., showed the prevalence of the side effects due to hair dye was 23.8%. [10] The low prevalence of allergic reactions could be due to the fact that mild symptoms induced by hair dyeing may be under-recognized or overlooked as was reported in the above mentioned studies. Adverse reactions were 42% with itching, redness and pigmentation of the scalp, hair loss, hair breakage, conjunctivitis and headache being the common adverse reactions in a study conducted by Patel et al. [9]

Over 5,000 different chemicals are used in hair dye products, some of which are reported to be carcinogenic. Given the widespread use of hair dye products, even a small increase in risk may have a considerable public health impact and this has prompted scientists to determine whether exposure to the chemicals in hair coloring products is associated with an increased risk of cancer in people. The results of the epidemiologic studies which evaluated the cancer risk and teratogenic effects are inconclusive. In the present study 30.7% of doctors and 8.7% of nurses agreed that hair dye is associated with cancer risk compared to a previous study by Zaid et al., in which 21.5% agreed. [12] In a study from Saudi Arabia, 36% believed that hair dyes could cause cancer. Regarding the opinion on whether hair dye use is safe in pregnancy and lactation 28.5% of doctors and 11.3% of the nurses agreed with 39.25 and 68.7% of the participants being undecided with regards to its safety. [4] Nearly 96% expressed hair dyeing was unsafe during pregnancy, lactation in a study conducted by Patel et al. [9] With limited studies evaluating the risk of hair dye use in pregnancy and lactation, the use of Hair dye during pregnancy is not recommended and might be associated with future health problems in children.

The present study also highlights the extensive use of hair dye in the modern society. Although it was a cross sectional study the data can help to strengthen the existing evidence on hair dye use and its risk. Focus should be targeted on the safety of commercial hair dyes and chemical substances they contain. It is important that there is labeling of the ingredients of hair dye packs with possible side effects and date of manufacture, expiry. Additionally, for the people who experience side effects of hair dye products, a patch test for the main substances that cause contact dermatitis may be helpful to select hair dye products and to decrease the side effects of them.

Independent regulation and research at the governmental and organizational levels should be encouraged and the manufacturers of hair dye products should be provided with detailed guidelines and restrictions for development and manufacture. With many facts remaining unclear regarding the safety issues more studies are needed to help clarify this issue.

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