

Knowledge and Awareness of Adverse Effects, Allergy Testing, Carcinogenic Risks, and Safe Use of Hair Dyes among Women in Western Libya

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Abstract

Background: Hair Dyes (HDs) are widely used cosmetic products that are a common procedure among women, allowing them to change or enhance their hair color. Available in various formulations, including permanent, semi-permanent, and temporary dyes. These products often contain chemical ingredients such as paraphenylenediamine (PPD), ammonia, and hydrogen peroxide. While hair dyes offer aesthetic benefits, they also pose potential risks, including allergic reactions, chemical burns, hair damage, and increased risk of cancer. This study aimed to identify side effects of hair dye products, develop strategies to raise awareness and education of chemical dyes, and advise first-trimester pregnant women on safe hair color products.

Materials and Methods: A cross-sectional study was conducted. A total of 179 questionnaires consisting of fifteen questions were distributed to females who used hair dyes, selected randomly from the Western Region in Libya, from November 2023 to April 2024.

Results: A total of 89.9% of females used hair dyes for many reasons, including to have a new and trendy look (53.6%). Most participants were young to middle-aged adults (83.2%), aged 20-40 years, and synthetic hair dyes were the preferred method (79.9%).

Conclusions: The study demonstrated a high prevalence of hair dye use among Libyan women, with synthetic hair dyes being the preferred choice. Given the potential adverse effects associated with chemical hair dyes, increasing public awareness and education on their safe use is essential. Encouraging the use of safer alternatives, particularly during pregnancy, may contribute to better health outcomes and informed decision-making.

Keywords: hair dyes, gray hair, para-phenylene diamine, side effects, risk of cancer.

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INTRODUCTION

Hair is an outgrowth of the epidermis and covers all mammals. It is regarded as an ornament as well. Because it contains melanin, it helps control body temperature and shields the skin and head from the sun ¹. The number of hair fibers on a human scalp ranges from 90,000 to

150,000, with a daily growth rate of 0.3 to 0.5 mm. Hair loss typically ranges from 50 to 100 fibers per day. Depending on personal traits, the hair diameter might range from 15 to 110 µm.

Hair dyes have been used for more than 4,000 years. For instance, it was discovered that Egyptian women used henna to colour their hair.

Additionally, leaden combs soaked in vinegar were frequently used to colour grey hair in the Roman Empire. Millions of people have been utilizing hair dyes lately. Considering the innate human need to look better or alter one's hairdo to stand out in social settings ². These goods have a significant and beneficial impact on our standard of living.

Hair dye systems can be divided into natural hair dyes like henna, Indigo (*Indigofera tinctoria*), and Beet Juice ^{3,4}, and synthetic hair dyes: temporary, semi-permanent, demi-permanent, and permanent ⁵. It involves the permeation of the hair fiber, which is finally incorporated into the matrix ⁶. These types of hair dye are named according to the staying time on hair.

Temporary Non-Oxidative Hair Dyes: Due to their high molecular weight, these dyes leave the hair after the initial shampooing and deposit on the surface of the hair without penetrating the cortex. They also have a shorter permanence life on the fiber.

Semi-Permanent Non-Oxidative Hair Dyes: Low-molecular-weight basic or cationic dyes that are resistant to three to six washings and have a strong affinity for hair keratin are included in these formulations ⁷.

Demi-permanent Oxidative Hair Dyes: Contain 2% hydrogen peroxide and low amounts of alkalinizing agents. Applied like shampoo, left on for 20/30 minutes, and then washed off with water ⁸.

Permanent Oxidative Hair Dyes, which are resistant to shampoo washes, due to the formation of color by complex reactions that occur between precursors in the presence of an oxidizing agent, which prevents molecules formed in the hair from leaving by allowing the reaction to start in the cortex, producing a colorful complex with a high molar mass ⁹.

Gray hair treatment tablets

Recent advancements in nutritional science have identified certain vitamins (B7, B9, and B12), minerals, and botanical extracts (Saw Palmetto and Ginkgo Biloba) ¹⁰ that may support hair health and pigmentation. These supplements are often marketed as solutions for gray hair, focusing on their roles in melanin production, hair growth, and overall hair quality.

Irritation and cancer risk of hair dyes

Ammonia (NH₃) increases trans-epidermal water loss, which causes dryness and irritation of the skin or directly causes burning and erythema. It also disturbs the acidic environment required for enzyme activity and barrier function ¹¹.

Additionally, H₂O₂ can trigger inflammation, resulting in skin redness and oedema. Permanent HD use has been linked to a higher risk of bladder cancer, particularly among barbers and hairdressers who are frequently exposed to these chemicals. Because aromatic amines, which are thought to be carcinogenic and can be absorbed through the skin, are present ^{12, 13}.

Some dyes contain the suspected carcinogens phenylenediamine and paraphenylenediamine. With greater duration of hair dye use and the use of dark-colored dyes, specific chemicals in hair dyes are also associated with elevated risks of non-Hodgkin lymphoma ¹⁴.

Numerous studies have examined the relationship between HD use and the risk of breast cancer, with varying degrees of success. According to some research, women who started using hair dye early in life or who used it frequently may be at higher risk.

This study aimed to assess the knowledge, awareness, and practices related to hair dye use among women in the western region of Libya, with particular focus on adverse effects, allergy testing, awareness of potential carcinogenic risks, and safe usage practices. The study also aimed to evaluate patterns of hair dye use, commonly reported side effects, and awareness regarding hair dye use during pregnancy.

MATERIALS AND METHODS

A cross-sectional study was conducted among females residing in three cities (Zawia, Sabratha, and Alajelat) in the western region of Libya between November 2023 and April 2024. The study included women aged 20 to 60 years. Participants were recruited through convenience sampling.

A total of 200 questionnaires were distributed, of which 179 were completed and considered valid for analysis, yielding a response rate of 89.5%.

Data were collected using a structured questionnaire that was administered both in paper-based and electronic formats. The

questionnaire consisted of 15 items and was originally developed in English, then translated into Arabic to ensure clarity and accessibility for participants. The questionnaire assessed demographic characteristics, age of initial hair dye use, type and frequency of hair dye usage, reasons for use, safety practices (such as reading instructions and performing allergy tests), and self-reported adverse effects.

The questionnaire was developed based on previously validated studies that evaluated women's knowledge, attitudes, practices, and awareness regarding hair dye use and its associated risks ^{15, 16}. A pilot test was conducted on a small sample to ensure the clarity and appropriateness of the questions.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 27. Descriptive statistics, including frequencies and percentages, were used to summarize the data. The chi-square test was applied to assess associations between categorical variables, with

a p-value of <0.05 considered statistically significant.

RESULTS

Out of the 200 questionnaires distributed, 179 were completed and considered valid for analysis. The results are presented in the following figures (89.9%) of the participants reported using hair dyes, while 10.1% reported no use.

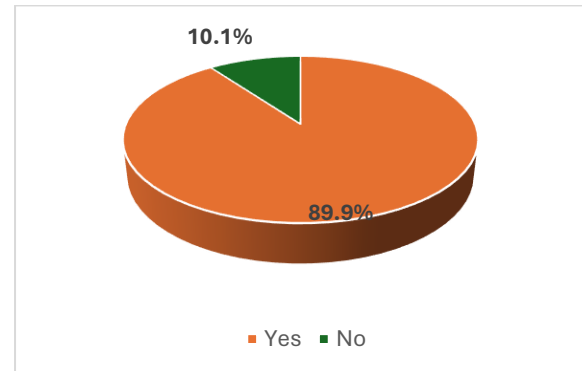


Fig. 1: Hair dye use results.

Table 1: The sample distribution for the age at which participants reported using hair dyes for the first time.

Age	Count	%	Chi square	P-value
Less than 20 years	22	12.3	158.274	< 0.001
From 20 to 30 years	116	64.8		
From 30-40 years	33	18.4		
More than 40 years	8	4.5		
Total	179	100.0		

Table 1 presents the age at which participants reported using hair dyes for the first time. The largest proportion, 64.8%, indicated they began using hair dyes between 20 and 30 years old. A smaller but substantial group (18.4%) started using hair dyes from 30-40 years old. Notably, 12.3% of participants reported using hair dye before the age of 20, suggesting hair dye usage may begin relatively early for some individuals. The smallest group (4.5%) started using hair dyes after 40 years old. The chi-square value of 158.274 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a strong association between age and the initiation of hair dye usage in this sample.

These findings suggest that hair dye usage is most prevalent among young adults, with the majority starting between 20 and 30 years old. However, the substantial proportions who began using hair dyes before 20 and between 30 and 40 years old indicate that hair dye usage spans a wide age range.

Table 2 presents the reported reasons for using hair dyes among the participants. The majority, 53.6%, indicated that they use hair dyes for fashionable purposes and to have a new look. A substantial proportion, 34.6%, reported using hair dyes to get rid of gray hair, which may be more prevalent among older individuals. Notably, only a small percentage (3.9%) cited boosting self-confidence as their primary reason for using hair

dyes. The "other than that" category accounted for 7.8% of responses, suggesting additional unlisted reasons may exist. The chi-square value of 118.318 and p-value < 0.001 indicate a

statistically significant deviation from the expected distribution, suggesting a strong association between the reported reasons and hair dye usage in this sample.

Table 2: The sample distribution of participants' reported reasons for using hair dyes.

The reason for using hair dyes	Count	%	Chi square	P-value
Getting rid of gray hair	62	34.6	118.318	< 0.001
Fashionable and having a new look	96	53.6		
Boost self-confidence	7	3.9		
Other than that	4	7.8		
Total	179	100.0		

Table 3: The method used for dyeing hair.

Method used for hair dyeing	Count	%	Chi square	P-value
Natural dyes such as (Henna)	32	17.9	301.022	< 0.001
Synthetic hair dyes	143	79.9		
Oral tablets for gray hair	2	1.1		
Hair spray	2	1.1		
Total	179	100.0		

Table 3 presents data on the methods used by participants to dye their hair. The vast majority, 79.9%, reported using synthetic hair dyes, which are chemically formulated products commonly available in the market. A smaller proportion, 17.9%, indicated using natural dyes such as henna. The remaining responses were split between oral tablets for gray hair (1.1%) and hair

spray (1.1%). The chi-square value of 301.022 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a strong association between the hair dye method and the sample population.

Table 4: A safer method used in dyeing hair, according to participants' opinion.

A safer method used in dyeing hair, according to participants' opinions	Count	%	Chi square	P-value
Natural dyes such as (Henna)	153	85.5	352.732	< 0.001
Synthetic hair dyes	19	10.6		
Oral tablets for gray hair	3	1.7		
Hair spray	4	2.2		
Total	179	100.0		

Table 4 presents data on participants' opinions regarding the safest method for dyeing hair. An overwhelming majority, 85.5%, perceived natural dyes such as henna to be the safer option for hair

dyeing. In contrast, only 10.6% considered synthetic hair dyes to be safer, while the remaining responses were split between oral tablets for gray hair (1.7%) and hair spray (2.2%).

The chi-square value of 352.732 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a

strong association between perceived safety and the hair dye method in this sample.

Table 5: Frequency of hair dye use.

Frequency of hair dye usage	Count	%	Chi square	P-value
Once a year	88	49.2	96.017	< 0.001
Once a month	29	16.2		
Once every two months	61	34.1		
Once a week	1	0.6		
Total	179	100.0		

Table 5 presents data on the frequency of hair dye usage among the participants. The largest proportion, 49.2%, reported using hair dyes once a year. A substantial 34.1% indicated using hair dyes once every two months, suggesting a relatively frequent usage pattern. Additionally, 16.2% of participants used hair dyes once a

month, while only 0.6% reported using them once a week. The chi-square value of 96.017 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a strong association between the frequency of hair dye usage and the sample population.

Table 6: Reasons for repeating hair dyeing.

Reasons for repeating hair dyeing	Count	%	Chi square	P-value
Gray hair appears quickly	70	39.1	115.592	< 0.001
Having a new look	89	49.7		
Other than that	19	10.6		
Total	179	100.0		

Table 6 presents data on the reasons why participants repeat or reapply hair dyes. The most common reason, reported by 49.7% of participants, was "having a new look." This suggests that a significant portion of individuals use hair dyes as a means of changing their appearance or experimenting with different styles. A substantial 39.1% indicated that they repeat hair dyes because "gray hair appears quickly," likely reflecting the need to maintain consistent coverage of gray or white hair as it grows out. While 10.6% selected "other than that," implying additional unlisted reasons. The chi-square value of 115.592 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a strong association between the reported reasons and the frequency of hair dye reapplication in this sample.

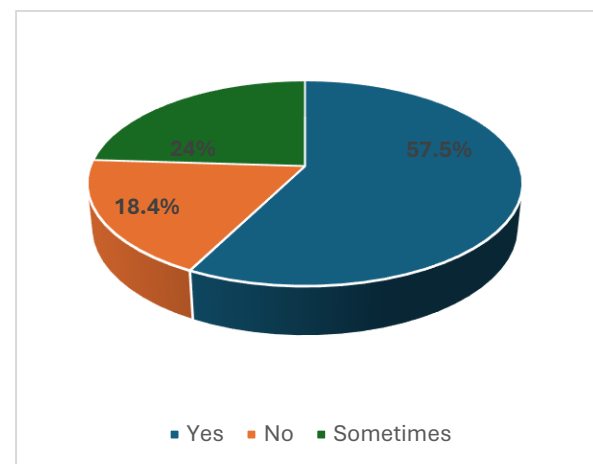


Fig. 2: Data on whether participants read the instructions before using hair dyes.

A majority (57.5%) report that they do read the instructions before using hair dyes. However, a notable proportion (18.4%) indicated that they do not read the instructions, while (24.0%)

responded "sometimes," suggesting inconsistent adherence to instructions.

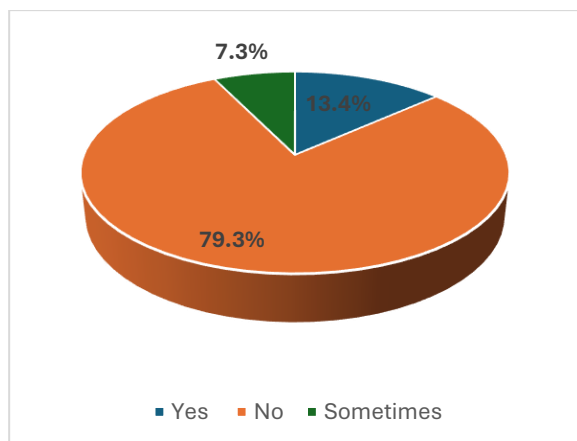


Fig. 3: presents data on whether participants performed an allergy test before using hair dyes.

A concerning majority, 79.3%, reported that they do not perform an allergy test before using hair dye. Only 13.4% indicated that they do conduct an allergy test, while 7.3% responded "sometimes," suggesting inconsistent adherence to this safety precaution.

Table 7 presents data on the symptoms experienced by participants when using hair dyes. The most commonly reported symptom was "hair loss, breakage, or dryness," experienced by 55.3% of participants. A substantial proportion (35.8%) indicated experiencing "other than that," suggesting unlisted symptoms not captured in the survey options.

Table 7: Symptoms related to hair dye usage.

Symptoms related to hair dye usage	Count	%	Chi square	P-value
Redness \ itching \ skin ulcers	11	6.1	421.447	< 0.001
Hair loss \ breakage \ dryness	99	55.3		
Swelling and redness of the eyes	5	2.8		
Other than that	64	35.8		
Total	179	100.0		

Additionally, 6.1% reported "redness, itching, or skin ulcers," while 2.8% experienced "swelling and redness of eyes." The chi-square value of 421.447 and p-value < 0.001 indicate a statistically significant deviation from the expected distribution, suggesting a strong association between the reported symptoms and hair dye usage in this sample.

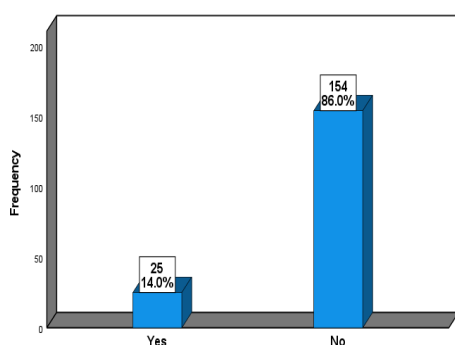


Fig. 4: presents data on the use of hair dyes during the first trimester of pregnancy.

The majority of participants (86.0%) reported not using hair dyes during the first trimester of pregnancy. However, a notable (14.0%) indicated that they did use hair dyes during this critical period of fetal development as shown in figure 4.

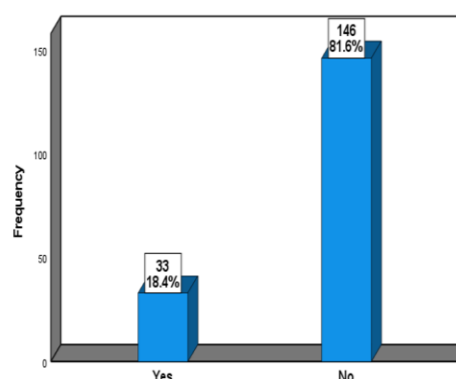


Fig. 5: presents data on whether participants had information about the potential carcinogenic effects of hair dyes.

An overwhelming majority (81.6%) reported that they did not have any information about whether hair dyes can cause cancer. In contrast, only (18.4%) indicated having such information as shown in figure 5.

DISCUSSION

Through this study, (89.9%) of females used some types of HDs, while (10.1%) may have allergies or sensitivities that lead them to prefer alternatives. The primary reasons are to be different and keep up with the latest fashions, with a percentage (53.6%), which may be more prevalent among young adults^{17,18}, and (34.6%) reported using hair dyes to cover up gray hair, which could be more common in middle-aged adults^{19,20} and (3.9%) cited boosting self-confidence.

According to the age group, the largest number was between 20 and 30 years, where their percentage was (64.8%). This is due to increased societal pressure and changing fashion trends²¹, which lends credence to this, with a percentage of (53.6%) in our results.

A smaller but substantial group (18.4%) started using hair dyes between the ages of 30 and 40 years, who may use HDs to cover gray hair, which could be more common in middle-aged adults²¹. Notably, (12.3%) of participants reported using hair dyes before the age of 20 (15- 18 years). This is due to being more sensitive to allergens in HDs, such as para-phenylenediamine (PPD), which cause severe allergic reactions, and the effect on our community.^{22,23}

About 49.2% of women who use hair dyes once a year reported that they aim to change their appearance and achieve a new look. On the other hand, the results showed that a proportion of women use hair dye more frequently, with 34.1% dyeing their hair monthly and 16.2% every two months. This may be attributed to the rapid appearance of gray hair (39.1%).

The results also indicated that only 57.5% of participants read the instructions before using hair dye. In addition, a very small proportion (13%) performed a skin allergy test before application, while the majority (79.3%) did not. The skin allergy test (SAT) is recommended 48 hours before use to prevent contact allergic reactions^{24, 25}.

Among the side effects reported by participants, hair loss, breakage, or dryness was the most frequent, accounting for 55.3%, and may be attributed to chemical damage caused by ammonia²³.

Which can strip natural oils, leading to dryness and increased brittleness, also Hydrogen Peroxide, which can weaken the hair shaft, making it more prone to breakage and loss²⁰. Frequent dyeing can lead to cumulative damage affecting the integrity of the hair. Allergic reactions with PPD, leading to inflammation of the scalp, which may contribute to hair loss²⁶. PH imbalance, as the high pH of many HDs may disrupt the natural equilibrium of the scalp and hair, causing breakage and dryness²⁷. However, a significant percentage (35.8%) reported "other than that," which may indicate additional symptoms such as headaches, fever, rhinitis, and dandruff²⁸. Other side effects included "redness, itching, or skin ulcers," and "swelling and redness of eyes," with percentages (6.1%) (2.8%), respectively, which may be caused by several ingredients in HDs.

It was found that among women in the first trimester, approximately 86% reported not using HDs. This finding indicates a high level of awareness and concern regarding fetal safety among pregnant women. Several studies suggest that toxic chemicals in hair products may be absorbed through the scalp in sufficient amounts to increase the risk of adverse health effects in women and their infants²⁹. Furthermore, some studies have reported an association between maternal use of hair dyes and an elevated risk of certain cancers, such as neuroblastoma, in offspring³⁰.

While (14%) used HDs during pregnancy in the first trimester. Studies on the teratogenic effects of chemical hair dyes are inconclusive. Hair dyes are probably safe to use during pregnancy because so little dye is absorbed through the skin. However, it is still important to be cautious^{31, 32}; therefore, many healthcare providers recommend that pregnant women not use permanent hair dyes during the first three months. While the absorption through the skin is minimal, the concern is that breathing fumes during the process could be harmful to the developing baby. Permanent hair dyes contain ammonia, which has a strong chemical fume. The

recommendation is to avoid hair dyes that contain ammonia³³.

Most participants (81.6%) lacked sufficient information about potential carcinogenic effects, which may be attributed to limited awareness and inadequate education regarding associated risk¹⁶.

CONCLUSION

This study highlights the widespread use of hair dyes among women in the western region of Libya, particularly among young adults. The findings revealed that synthetic hair dyes are the most commonly used type, despite a high prevalence of self-reported hair-related side effects, including hair loss, dryness, and breakage.

Importantly, the study identified gaps in safe usage practices. A considerable proportion of participants did not perform allergy testing before use, and many demonstrated limited awareness regarding the potential health risks associated with hair dye products, including possible long-term effects. Furthermore, limited awareness of the potential carcinogenic risks from repeated exposure to certain hair dye ingredients underscores the need for enhanced public health education and safer cosmetic practices.

The results also showed that while most participants perceived natural dyes as safer alternatives, synthetic dyes remain the dominant choice. This discrepancy highlights the need for improved education and behavioral change strategies.

Additionally, although the majority of participants avoided hair dye use during pregnancy, a notable proportion still reported use during the first trimester, indicating the need for targeted education among women of reproductive age.

Overall, these findings emphasize the importance of raising awareness about the safe use of hair dyes. Public health interventions should focus on promoting safer practices, such as conducting patch tests, carefully reading product instructions, and encouraging the use of less harmful alternatives. Future research is recommended to further explore the relationship between hair dye use and adverse health outcomes using more robust analytical approaches.

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