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Disabilities of Children in Correlation to the usage of Hair Dye among Pregnant Women

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Abstract: The aim of this study was to investigate correlation between women using hair dye during their nine month pregnancy and disabled children born within the family. The target population encompassed women in the area of Amman, Jordan who have disabled children within the family. During the year of 2009, 205 women with disabled children from different backgrounds answered a questionnaire which consisted of 15 questions concerning major issues of applying hair dye during their pregnancy. The Statistical Package for Social Sciences (SPSS) analysis program was used to link the disabled children in the family to different parameters regarding the usage of hair dye during the mother's pregnancy. The results of the survey analysis indicated that the type of hair dye used during pregnancy has a direct impact on the number and the severity of disabled children born. Women who gave birth to children with disabilities were using high rates of organic and mineral hair dyes in comparison with mothers who were using natural hair dye during pregnancy. The results of this study indicates that pregnant women who were dyeing their hair using at-home hair color dye had higher statistical frequencies of disabled children with more than one disability in comparison to mothers who have been dyeing their hair at hair salons by hair specialists.

Key words: Pregnancy, questionnaire, henna, trimesters, SPSS, Jordan

INTRODUCTION

Over the course of history hair dye has been used to color hair, in fact women have been using hair dye for centuries. In the past, natural hair dye was the most dominant and the only type used. Today, due to the advancement in the cosmetic industry and the increase of populations around the globe, different types of hair dye have been developed by different industries. It is estimated that 33% of women over the age of 18 and 10% of men over the age of 40 in Europe and North America use some type of hair dye. Permanent hair dyes account for more than 70% of the market consumption worldwide (Van der Walle, 2000). Americans spend over 1.6 billion dollars yearly on at-home hair color as over 54% of American women, ages 16 to 69 dye their hair on regular bases (Kelsh *et al.*, 2008).

The amount of hair dye which is absorbed through the skin might vary from person to person depending on different factors such as: the individual's health, age, gender, the dye's moisture content, the surrounding climate and the environmental conditions (Van der Walle, 2000). Different types of hair dye contain various ingredients and chemicals. Each preparation contains several ingredients that have varied over the years. For example hair dyes containing lead, that used to color the hair black are no longer in use except for lead acetate dyes used in Grecian formula. In addition many formulations

were enhanced since the late 1970's when manufacturers removed additives coupled to the development of cancer in animals (Bolduc and Shapiro, 2001).

Different studies indicated that some ingredients with high concentrations in hair dye chemicals could be unsafe to human health, especially with the misuse of hair dye products as it led to direct accumulation in human bodies. Researchers from the National Cancer Institute in the United States found that rodents that were fed these compounds from coal-tar in certain hair dyes were more likely to develop cancer than rodents that were not fed these compounds. In this study rodents were fed large amounts of these compounds, more than what anyone would ingest. It also did not assess the risks of these components being applied to the skin (Chua-Gocheco *et al.*, 2008). The potential for permanent hair dyes to present a carcinogenic risk has been debated by both toxicologists and epidemiologists, primarily because exposures to certain arylamines in occupational settings have been associated with an increased risk of bladder cancer (Blackmore-Prince *et al.*, 1999).

Manufacturers have stopped making hair dye with these ingredients but many have been replaced with compounds including similar structures. On the other hand, in one study of 12 hair dye formulations (nine oxidations dyes mixed 1:1 with 6% hydrogen peroxide and three semi permanent hair dye) found no evidence of harm or impaired fertility to the fetus after relevant

application in pregnant rats (Van der Walle, 2000). Some hair dye preparations have been associated with birth defects in mice at doses that were usually toxic to the mother (Blackmore-Prince *et al.*, 1999). Research on hair dye and human pregnancy has been minimal therefore not providing enough information to assure whether or not hair dye could be dangerous in human pregnancies.

Commercial oxidative hair colorants are permanent hair colors, which are usually composed of phenylenediamine, 3-aminophenol and isopropyl alcohol, ammonium hydroxide, sodium hydroxide, sodium sulfite, oleic acid, resorcinol, toluene-2, 5-diaminesulphate and propylene glycol (Van der Walle, 2000). The chemicals that are responsible for the attractive forces of the oxidative dyes are the amino and hydroxyl groups. A reactive hair dye consists of main components for polymerization, a coupler for adjusting the color development and an oxidizer (several percentages of hydrogen peroxide and others). Usually, the hair dye components and the coupler are contained in the first bottle and the oxidizer and other compounds contained in the second bottle. For application both fluids in the bottles are mixed just before use (Bolduc and Shapiro, 2001).

During pregnancy, most of the mother's body liquids accumulate around the fetus therefore affected by the toxic liquid which in some cases can be highly concentrated with hair dye use during pregnancy. The first trimester of pregnancy is the most sensitive period where the toxic liquids of hair dye use could negatively effect the formulation of the kidneys, liver, brain and nervous system of the developing fetus (McDowell *et al.*, 2004).

Due to the widespread and increasing use of personal hair dyes, any health risk associated with hair dye use could have a significant public health impact. For some hair conditions hydrogen peroxide is the main key element. The degree of the damage depends on the level of concentration. Due to the possibilities of physical or genetic birth defects induced in the fetus. Some chemicals are known to cause birth defects in pregnant women. Ethically and from the professional prospective it is unacceptable to put pregnant women at risk by experimenting with such substances. As a result, researchers are left with limited methods of investigation. This study investigates through a questionnaire distributed among Jordanian women who already have children with one type of birth defect and works backward through their medical histories to evaluate any pattern of exposure and use of hair dye during pregnancy. When a pattern is found, it is unclear whether that chemical really

caused the birth defects or whether exposure is somehow related to yet another chemical or the woman's genetic background. The result of this study sheds more light on birth defects due to types of hair dye used and any correlation with other factors. Hair dye can be characterized in terms of its effectiveness and ingredients. Effectiveness of hair dye can be divided into three categories:

- Temporary hair color dye which cannot penetrate the cuticle layer and disappears with the first hair wash usually lasting one week
- Semi-permanent hair dye partially penetrating the hair shaft. For this reason, the color will survive repeated washing
- Permanent color hair dye penetrating through the hair shaft entering the skull cortex containing a developer or oxidizing agent and alkalizing agent ammonia

Permanent dye contains the toxic compound such as phenylenediamine or other ingredients. The danger increases if a mercury agent is part of the additives. The Food and Drug Administration in the United States restricted the amount of phenylenediamine and ammonia not to exceed 4% by volume in hair dye.

From the ingredient prospective, hair dye can be divided into three categories:

- **Natural hair dye:** Is extracted from plants and vegetables, the most famous natural hair dye is Henna mixed with mineral salt ingredients (*L. alba*) which is an herb used for cosmetic purposes and folk medicine for the treatment of skin diseases, anti-inflammatory, antipyretic and analgesic agent (Blackmore-Prince *et al.*, 1999). Hair dye companies intentionally add the agent phenylenediamine to the henna powder and label their products as henna hair dye. Generally, henna on its own needs to be applied two or three times for several hours to give the desired color. On the other hand, this can be accomplished with one single application in less than 1 h by adding phenylenediamine to the henna. The toxicity of phenylenediamine, when added to henna occurs through skin absorption
- **Mineral dyes:** Contains cinnabar and lead oxide which can dangerously affect human health and the hair itself
- **Artificial organic hair dyes:** Are the most commonly used and considered to be a permanent hair dye penetrating through the hair shaft and can not easily be removed

MATERIALS AND METHODS

The study area: The survey for this study was conducted in Amman, the Capital of the Hashemite Kingdom of Jordan during the year 2009, the largest city with a population of two million people. The questionnaire was distributed among 205 women with disabled children. Based on the information provided by the 2004 population census, the total number of Jordanians with physical disabilities reached 32,793, amounting to 0.64% of the national population (DOS, 2004). According to the values provided by the DOS, persons with other disabilities represent 1.18% of the Jordanian population. Amman occupies the highest percentages of persons with disabilities across all major governorates in Jordan as it reached 32.3% of the total disabled persons in Jordan (DOS, 2004).

Survey design and implementation: In order to evaluate pregnant women who were using hair dye and gave birth to disabled children in the area of Amman, Jordan a survey in questionnaire form was conducted in the spring of 2009. The aim of this study was to investigate any correlation between using hair dye during pregnancy, type of hair dye, concentrations, application periods, number of hair dye applications during pregnancy and disabled children being born in the family. The survey was distributed among two hundred and thirty women who were using hair dye during their nine month pregnancy and disabled children within the family. Two hundred and five completed surveys were evaluated in this study.

The target population encompassed women in the area of Amman, Jordan who have disabled children within the family. Women with different backgrounds answered the questionnaire which consisted of fifteen questions concerning major issues of applying hair dye during the pregnancy such as: occupation, age when became pregnant with the disabled child, number of times the hair dye was applied during pregnancy, type of hair dye used, number of times the hair was washed during one week period, type and the degree of the child's disability. The questions were in the form of limited multiple choice answers. The questionnaire was evaluated by professionals for its content, clarity of language and appropriateness of length prior conducting the study survey using an initial draft form. Fifty individuals with a variety of backgrounds, education levels and age from the same regional area were chosen for the draft evaluation. The pre-tested sample was excluded from the actual survey. The questionnaire was subsequently evaluated based on the pre-test and revised to its final format. The

Table 1: Results of Chi-square test correlation of the type of hair dye used by pregnant women and the level of disability in children born

Type of hair dye	Level of disability							
	Simple		Moderate		Severe		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Mineral dye	8	20.5	17	30.4	48	45.7	73	36.5
Organic dye	23	59.0	22	39.3	43	41.0	88	44.0
Natural dye	8	20.5	17	30.4	14	13.3	39	19.5
Total	39	100.0	56	100.0	105	100.0	200	100.0
Chi-Q	13.69		Indicator		0.008			

test-retest reliability coefficient Cronpanch Alpha (α) was used to test the reliability of the scale and the internal consistency of the questionnaire, which was calculated to be (0.86). From the statistical perspective this is a reliable result as it exceeds 0.60 (George and Mallery, 2003).

Raw data from the survey was entered into spreadsheets using Excel. Special records were arranged presenting the progress of work in all surveyed categories. The editing process focused on the completeness and consistency of data in order to minimize any data entry errors.

Chi-square analysis regarding colorations among different parameters were conducted on the means of the sample sets indicating if the apparent differences in the means of the data sets were statistically significant at a level of $\alpha = 0.05$. The frequencies values from analysis are shown in Table 1. The Statistical Package for Social Sciences (SPSS) was also applied to the 205 completed questionnaires. Analysis were conducted on different parameters. The SPSS program was used to link the disabled children to the use of hair dye during the pregnancy of their mothers.

RESULTS AND DISCUSSION

According to the results of the survey analysis it is clear that the type of hair dye used during pregnancy has a direct impact on the number of disabled children born. From Table 1, it is evident that women who gave birth to children with disabilities were using high rates of organic and mineral hair dyes in comparison with mothers who were using natural hair dye during their pregnancy. This indicates that the usage of mineral and organic hair dye have serious health effects on mothers and their fetus, since the ingredients of such types of hair dye contain concentrated minerals such as lead, mercury and parafenylene as it penetrates through the blood stream. On the other hand, using natural dyes is safer since these dyes originate from natural sources, however, mineral and industrial agents are added to natural hair dye for the purpose of improving quality and increasing quantities which can lead to kidney failure, body itching, or allergic

Table 2: Results of Chi-square test correlation between the types of hair dye used and the type of disability

Type of dye	Type of Dis.																			
	Mobility		Deaf		Visual		Mental		Difficulties		Slow learning		Autism		Total					
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%				
Mineral dye	26	54.2	9	40.9	3	17.6	30	38.5	3	14.3	2	25.5	0	0.0	73	36.5				
Organic dye	20	41.7	11	50.0	9	52.9	31	39.7	8	38.1	4	50.0	5	83.3	88	44.0				
Natural dye	2	4.2	2	9.1	5	29.4	17	21.8	10	47.6	2	25.0	1	16.7	39	19.5				
Total	48	100.0	22	100.0	17	100.0	78	100.0	21	100.0	100	8.0	100	6.0	200	100.0				
Chi .Q	31.23		Indicator		0.002															

Table 3: Results of Chi-Square test correlation to the degree of disability and repeated hair washing during pregnancy

Level of Disability	No. of repeated hair washing											
	1-2 Times		3-4 Times		5-6 Times		7-8 Times		8 Times and more		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Simple	6	9.0	12	23.5	8	19.0	11	36.7	3	20.0	40	19.5
Moderate	20	29.9	13	25.5	9	21.4	11	36.7	4	26.7	57	27.8
Severe	41	61.2	26	51.0	25	59.5	8	26.7	8	53.3	108	52.7
Total	67	100.0	51	100.0	42	100.0	30	100.0	15	100.0	205	100.0
Chi .Q	15.62		Indicator		0.048							

reaction to humans which is in a complete agreement with studies made by Deepak *et al.* (2006), who indicated that chemical based dyes can harm health in general. Gill *et al.* (2002) indicated that the mercury agent in hair dye ingredients is able to reach the fetus umbilical cord and penetrates to the nerve system. From Table 1 it is clear that the value of Chi-square reached an indicator level less than (0.05) which amounted to (13.69) with probability value of (0.008). The results in Table 1 is in full agreement with Gill *et al.* (2002) indicating that the usage of mineral hair dye during pregnancy leads to higher frequencies of severe disabilities in children born.

The increase rate of mobility and mental disability is referred to mothers using mineral and organic hair dye as it directly affects the mother's blood and kidney function. This reflects on the blood cells of the fetus as well as the nerve and sense systems, as the organisms of the fetus are still in the developing stages. For example, impurities in the blood system of the fetus cannot be filtered completely by the fetus's kidneys due to the small size especially in the first three months of pregnancy. Different types of disabilities such as mobility, deafness, mental, slow learning and others which might occur is shown in Table 2 with the percentages of disabilities from the obtained survey regarding the types of hair dye. In general, high concentrations of heavy metals in hair dye could cause mental disability (Cook *et al.*, 2004) this is in complete agreement with the outcome of the survey as shown in Table 2.

Table 3 shows that women who fail to wash their hair after the use of hair dye frequently and on regular bases delivered children with severe disabilities, while women who repeatedly wash their hair after the use of hair dye

gave birth to children with moderate disabilities. This is in a full agreement with Zhang *et al.* (2008), who indicated that mothers who washed their hair frequently after dyeing reduced the effects of toxic chemicals and the effects on the fetus. The statistical results shown in Table 3 indicate a Chi-square at the level of statistical significances which reached the indicator level of (0.05) and less which amounted to (15.62) with probability value of (0.048). On the other hand, frequencies of the survey showed that women who were washing their hair at the minimum level (1-2 times) resulted in giving birth to children with disability due to the direct impact of hair dye chemicals, this accounted for 42 children out of 202 of individual mothers who participated in the study. Women who washed their hair repeatedly (8 times and more) with total disability occurrences after one year or more were 12 children born with disability; this indicates that less harmful effects of toxic chemicals if hair is washed frequently. Such action leads to reducing the rate of those chemicals in the mother and the blood of her fetus and thus the emergence of subsequent period of disability after child birth. The value of Chi-square at the level of statistical significances reached an indicator level of (0.05) and less which amounted to (35.27) with probability value of (0.000) as shown in Table 4.

Usually, a specialist, or hairdresser at beauty salons would choose the suitable hair dye and perform the process in more professional and timely manner than the use of at-home hair color dye conducted by the woman herself (Hueber-Becker *et al.*, 2007). The results of this study, Table 5 indicates that pregnant women who were dyeing their hair using at-home hair color dye had higher statistical frequencies of disabled children who have more

Table 4: Results of Chi-square test correlation between the number of times of repeated hair wash and when the disabilities occurred

	Disability occurrence											
	1-2 Times		3-4 Times		5-6 Times		7-8 Times		8 and more Times		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Congenital	42	63.6	16	32.0	12	28.6	6	20.0	2	14.3	78	38.6
First year	21	31.8	23	46.0	22	52.4	14	46.7	6	42.9	86	42.6
Years after	3	4.5	11	22.0	8	19.0	10	33.3	6	42.9	38	18.8
Total	66	100.0	50	100.0	42	100.0	30	100.0	14	100.0	202	100.0
Chi. Q	35.27		Indicator		0.000							

Table 5: Chi-square test correlation of the places pregnant women dyed their hair and the occurrences of more than one disability in children born

More other disabilities	Place of hair dye					
	Home		Hair salons		Total	
	Freq.	%	Freq.	%	Freq.	%
Yes	48	43.3	30	30.3	78	38.0
No	58	54.7	69	69.7	127	62.0
Total	106	100.0	99	100.0	205	100.0
Chi. Q	4.87		Indicator		0.027	

Table 6: Results of Chi-square test correlations of the time of disability occurrence and the place where the hair was dyed

	Disability occurrence					
	Home		Hair salons		Total	
	Freq.	%	Freq.	%	Freq.	%
Congenital	51	48.1	27	28.1	78	38.6
First year	47	44.3	39	40.6	86	42.6
Years after	8	7.5	30	31.3	38	18.8
Total	106	100.0	96	100.0	202	100.0
Chi. Q	20.42		Indicator		0.000	

than one disability, this is in comparison to the mothers who have been dyeing their hair at hair salons by hair specialists. The statistical significances for these results reached an indicator level of (4.87) with probability value of (0.027) as shown in Table 5.

Mothers who have being dyeing their hair at home gave birth to disable children directly after delivery in comparison with mothers who have been dyeing their hair at hair saloons. This can be attributed to the severity and direct negative results of mislead usage of hair dye at home. Mothers experienced in making the best use of hair dye chemicals are limited in comparison with a hair salon specialist. Mothers tend to care more about the color of their hair resulting from dye materials, the negative impacts of non-compliance in the quantities or the time the dye should remain on the hair while pregnant could have a direct influence on the type and severity of disabled children born. The results shown in Table 6 is in full agreement with the above statement as the value of Chi square at the level of statistical significances reached the indicator level of (0.05) and less which amounted to (20.42) with probability value of (0.000).

Table 7: Results of Chi-square test in relation between the occurrence of disabilities and the type of hair dye used.

Types of hair dye	Congenital disability		Disability after the 1st year of birth		Disability after few years of birth		Total disabilities	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
	Mineral	39	52.0	24	28.2	9	23.7	72
Organic	25	33.3	44	51.8	19	50.0	88	44.4
Natural	11	14.7	17	20.0	10	26.3	38	19.2
Total	75	100.0	85	100.0	38	100.0	198	100.0
Chi. Q	13.47		Indicator		0.009			

The severity of disabilities occurs during pregnancy due to the direct impact of input chemicals on the fetus as the mother is the main and only source of nutrition for complete growth of the child. Table 7 shows that mothers who used mineral hair dye gave birth to disabled children, while others who used organic or natural hair dye gave birth to children whose disabled symptoms occurred after the first year of birth or beyond. This indicates the direct impact and harmful effect of chemicals in hair dye on pregnant women and their fetus. It is clear from Table 7 that the value of Chi square is at a level of statistical significance reaching the indicator level of (0.05) and less which amounted to (13.47) with probability value of (0.009).

Hair dye is usually absorbed through the scalp and into the body identified through urine tests. Some medical experts are hesitant to give carte blanche to hair coloring during all stages of pregnancy. Often, many physicians advise holding off coloring hair with permanent dyes during the first trimester when pregnant woman and the fetus is undergoing important neurological developments. Coloring can then be resumed in the second or third trimester. The results of the statistical analysis in this research is in full agreement with the above statements as shown in Fig. 1, the earlier the application of hair dye during pregnancy the more harm and more risk on the fetus development with disabilities. The value of Chi-square is at level of statistical significances reaching the indicator level of (0.05) and less which amounted to (22.13) and a probability value of (0.014), indicating a direct relationship between the period of hair dye used during pregnancy and the severity of the disability.

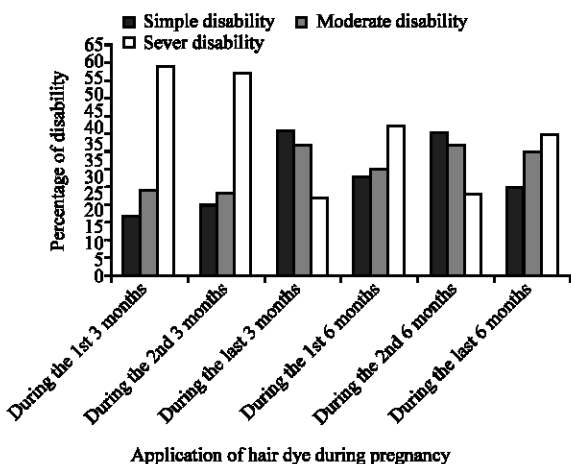


Fig. 1: The degree of disability of born children and the time mothers used hair dye during pregnancy

DISCUSSION

The results of the survey analysis indicated that women who gave birth to children with disabilities were using high rates of organic and mineral hair dyes in comparison with mothers who were using natural hair dye during pregnancy. The type of hair dye used during pregnancy (organic, mineral, or natural) has a direct impact on the number and severity of disabled children born. The statistical analysis of the study revealed that the earlier the application of hair dye during pregnancy (first trimester, second trimester, etc.) the more harm and more risk on the fetus development with disabilities. Women who fail to wash their hair after the use of hair dye frequently and on regular bases delivered children with severe disability, while women who repeatedly washed their hair after the use of hair dye gave birth to children with moderate disability. Mothers who have been dyeing their hair at home gave birth to disable children directly after delivery in comparison with mothers who have been dyeing their hair at hair salons. The results of this study indicates that pregnant women who were dyeing their hair using at-home hair color dye had higher statistical frequencies of disabled children who have more than one disability, this is in comparison to the mothers who have been dyeing their hair at hair salons by hair specialists.

As a result of this research and in order to prevent the possibilities of disabled children born due to the mother's usage of hair dye during pregnancy the following recommendations are provided:

- Avoid using any type of hair dye during pregnancy
- Use natural hair dye such as henna or *L. alba*, rather than organic and mineral hair dye during pregnancy

- It is advisable to avoid using hair dye during the first trimester of pregnancy
- Pregnant women who use at-home hair dye should wear protective gloves during application and avoid inhaling hair dye fumes
- Pregnant women who use at-home hair dye should not leave hair dye on scalp for longer period than recommended in instruction leaflet
- Pregnant women should choose a hair dye that requires the least amount of time to stay on the scalp
- It is advisable for pregnant women to highlight or frost the hair instead of full hair dye as the chemicals will not be directly applied to the scalp and less hair dye will be absorbed through the skin
- Rinsing the hair after coloring and washing dyed hair on regular bases reduces the chances of chemicals penetrations through the blood stream

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