Awareness, Prevalence of Hair Smoothing Products that Contain Formaldehyde and Determinants of Their Harmful Effects among Women in Saudi Arabia

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Abstract

Individuals who use hair smoothing products at home or in a salon work environment are at risk of exposure to various chemical compounds. Formaldehyde mixed with keratin as a hair straightening product is in common use by women in Saudi Arabia. The high temperatures used during blow-drying can release gas fumes that have several implications to include irritation of the skin, eyes and respiratory complications. Furthermore, formaldehyde is classified as a known human carcinogen. The aim of this study is to assess the source of keratin hair treatment among women, demonstrate the symptoms related to formaldehyde exposure during keratin hair treatment process and determine the practices that can increase the exposure to formaldehyde and to evaluate the level of formaldehyde in the keratin hair treatment products. A national cross-sectional survey was first conducted during March-April 2017 on Saudi Arabian children and women aged between the age of 12 and 50 years old. A standardized, fully confidential questionnaire was provided to participating members. A total of 330 filled questionnaires were obtained within the study location. Moreover, 30 hair salons that used keratin-based products were visited in 3 different cities in Al Qassim province to check the location of keratin hair treatment, ventilation procedures and take samples of hair products that were later analyzed. Most commonly reported symptom was irritation of the eyes reported by 135 people. Other symptoms described include irritation of throat, burning sensation of the nose, headache and nausea. Argan e Ojon was one of the most famous product tested in this study with formaldehyde levels above 0.2% threshold

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(0.35%). It is worrying that Argan e Ojon does not comply with GSO 1943 and SASO 1953 standards. A majority of salons demonstrated poor ventilation measures and failed to isolate their clients from the general public and salon workers. With the evident complications, more should be done to make people aware of the formaldehyde risks and prevent salons from using these products.

Keywords

Formaldehyde; Keratin; Hair Straightening; Saudi Arabia.

Introduction

The health risk associated with hair-smoothing keratin treatments remains a source of concern for policy makers and healthcare professionals [1, 2]. Despite the overall improvements in the formulas of many salon products, the health risk associated with formaldehyde persist [2]. Physiologically, keratin protein maintains the structure of the hair [3], thus, different mixtures of keratin and formaldehyde (preservative) are used to make the hair smooth, straight and easy to style [4]. However, the high temperature used in the treatment process convert formaldehyde to gas to cause an array of health complication including irritation of the skin, eyes, lung and potential neurological complications [4, 5]. The long-term exposure to formaldehyde gas is linked to permanent damage to the central nervous system and recurrent pulmonary complications [6]. Though the implication of formaldehyde in cancer development remain a controversial issue [7, 8]. Previous study showed a strong link between formaldehyde and cancer [9]. However, the full pathological mechanisms linking exposure to formaldehyde and cancer require further investigation.

The Saudi Food and Drug Authority warned from hair treatment products contain high level of Formaldehyde and considered dangerous if exceeded 0.2% (The permissible concentration by gulf cooperation council standard specifications) [10]. The revelation of the high levels of formaldehyde in hair products and associated health risk resulted in the

offering of non-formaldehyde or low-formaldehyde alternatives by salons and manufactures of hair treatment products. However, there is evidence that the so-called alternatives might mask the real problem of formaldehyde concentration in keratin hair treatment products. For instance, the US occupational safety and health administration found that hair treatments products labeled formaldehyde-free contains levels above 0.2% volume [11]. Similarly, some of the alternatives to formaldehyde used in these products are converted to formaldehyde during the heat application of keratin treatment [12]. Indeed, some of the new products contain formalin, formic aldehyde and methyl derivatives that are known to produce significant levels of formaldehyde during heating. Moreover, there is potential consumer satisfaction aspect to the problem of formaldehyde exposure, as most keratin treatment products free of formaldehyde are thought to be ineffective. Thus, investigation into user perception and awareness is required in the mitigation of the issues of formaldehyde exposure. In general, reduced formaldehyde keratin treatment products are less toxic compared to the formulations used before the recent interest in the potential toxic effects, but they still carry health risks for both the user and the service providers [13, 14].

The health risk associated with these products maybe worsened by the multiple use of products containing formaldehyde and its derivatives within one salon at any given time [12]. The high indoor

levels pose the greatest risk to the hair professionals and their service users. Indeed, recent data showed that significant breathing difficulties and eye irritations are linked to formaldehyde based hair treatment products [15].

Aim of the work

The aim of this study is to assess the source of keratin hair treatment among women, demonstrate the symptoms related to formaldehyde exposure during keratin hair treatment process and determine the practices that can increase the exposure to formaldehyde and to evaluate the level of formaldehyde in the keratin hair treatment products.

Material and Methods

The study has multiple phases, including survey of keratin hair treatment users, checklist for utilizing keratin hair treatment in salons, and determination of formaldehyde level in keratin hair treatment products. The survey will investigate the demographics data of keratin hair treatment users and their repetitive uses that can increase the exposure to formaldehyde. The second part will involve a visit to salons to obtain the trade names of keratin hair treatment products used, the location of keratin hair treatment and ventilation during treatment. A total number of 30 hair salons were visited in three cities of the Al Qassim province in Saudi Arabia. Majority of hair salons are located in Buraydah (n = 13, 43.3%), 6 (20%) in Unayzah and 11 (36.7%) in AlRass. We got the permission from Municipality for visiting salons and taking sample of the products. Finally, samples of the products collected from the salon and local market have been sent to the laboratory to determine the level of formaldehyde. The study participants will include individuals who have used keratin hair treatments. Women, children and salon not involved with any form of keratin hair treatment will be excluded from the study.

Study design

A national cross-sectional survey was conducted on Saudi women and children aged 12-50 years old in March-April 2017. A standardized, confidential, Internet questionnaire was administered to female members. A total of 330 filled questionnaires were obtained within the study location.

Questionnaire

The questionnaire was designed in English and later translated to Arabic by a professional translator and reviewed for consistency by the investigators. The questionnaire includes the demographics of hair treatment users, the source of getting keratin hair treatment, the symptoms related to formaldehyde exposure and perception of the users to the associated risk and their attitudes towards formaldehyde in the products used.

The questionnaire was pre-tested for validity and reliability. It was tested to check if it was easy for the interviewers to understand the instructions and flow of questions. Prior to pre-testing in the field, the interviewers were undergoing trainings and were provided with instructions about the survey.

Chemical analysis

Keratin hair treatment products collected from visited salon and local market were analyzed for the presence of formaldehyde and its derivatives according to Dar and Naseer [16] method.

Statistical Analysis

The data generated from the user survey were analyzed thematically to understand the practices and perception of the harmful effects of formaldehyde in hair treatment products. The student t-test was used to ascertain the significance of differences between mean values of two continuous variables. Analysis of variance (ANOVA) was performed to test for differences in proportions of categorical variables between 2 or more groups, p-value ≤ 0.05 considered significant. The SPSS Version 22.0 (SPSS

Inc., Chicago, IL) and EpiInfo TM Version (Centers for Disease Control and Prevention, Atlanta, GA, USA) were used for statistical analysis.

Results

Socio-demographic characteristics

Socio-demographic characteristics of 330 children and women who participate in the study are shown in table (1). Fifty percent of the participants were aged between (20-29) years, 24.2% were aged between (30-39) years, 14.2% were (12-19) years, 9.5% were (40-49) years, and 2.1% were 50 years or older.

Most of our participants were educated women 80.6%, 17% were from secondary school, 2.1% were from primary school and only 0.3% was uneducated women. Only 61.2% of the participants haven't children while 38.8% have children.

Table 1.

Table 2 shows that there is no significance differences among women in our participants in all age categories at all questions (F no significant change at $P \geq 0.05$) except for question about allowing hairdresser to see the type of keratin they used in salon ($F = 3.148$, $P = 0.015$) that women in ages between (12-19) years were less interested in knowing the type of keratin used in salon comparing of women in older ages. Also for question about times they do keratin hair treatment ($F = 4.452$, $P = 0.002$) that women in ages (30-49) were do it more frequently than younger women don. For question about presence of children at time of keratin using ($F = 5.719$, $P = 0.000$) we found that younger women were don it in presence more than the older ones (20-49). Also we found significance difference in question about knowing level of Formaldehyde allowed in keratin hair treatments in Saudi Arabia must not exceed 0.2% ($F = 2.977$, $P = 0.019$) that the younger women didn't know this information comparing of older group (20-40).

Table 1. Participants Demographics characteristics.

Characteristics	No.	%
Age		
12-19 years old	47	14.2
20-29 years old	165	50
30-39 years old	80	24.2
40-49 years old	31	9.5
50 years or older	7	2.1
Educational level		
Un educated	1	0.3
Primary school	7	2.1
Secondary school	56	17
University or Postgraduate	266	80.6
Do you have children?		
Yes	128	38.8
No	202	61.2

Table 2. ANOVA results of difference according to age.

Question	Sum of Squares	Df	Mean Square	F	Sig.
Did hair dresser allow you to see the type of keratin?					
Between Groups	8.087	4	2.022		0.015
Within Groups	141.273	220	0.642	3.148	
Total	149.360	224			
How many times do you perform keratin hair treatment process whether at home or in salon?					
Between Groups	18.108	4	4.527	4.452	0.002
Within Groups	330.465	325	1.017		
Total	348.573	329			
Do you perform keratin hair treatment process with children presence whether at home or salon?					
Between Groups	3.664	4	0.916	5.719	0.000
Within Groups	52.060	325	0.160		
Total	55.724	329			
Do you know that the level of Formaldehyde allowed in keratin hair treatments in Saudi Arabia must not exceed 0.2%?					
Between Groups	2.679	4	0.670	2.977	0.019
Within Groups	73.127	325	0.225		
Total	75.806	329			

Table 3 shows that there is no significant differences among women in our participants in all education levels at all questions (F values shows no significant change at $P \leq 0.05$). Except question about performing keratin hair treatment with presence of children ($F = 10.340$, $P = 0.000$) which means that women who have high education level didn't do it with presence of their children than less educated ones. Another question was about feeling throat irritation and cough ($F = 4.526$, $P = 0.012$) that women who has low education more feeling of that symptom than high educated ones. Also symptom headache ($F = 4.902$, $P = 0.008$) we found that women who has low education more feeling of that symptom than high educated ones.

Table 3. ANOVA results of difference according to education level.

Question	Sum of Squares	Df	Mean Square	F	Sig.
Do you perform keratin hair treatment process with children presence whether at home or salon?					
Between Groups	3.314	2	1.657	10.340	0.000
Within Groups	52.410	327	0.160		
Total	55.724	329			
Throat irritation and cough					
Between Groups	1.811	2	0.905	4.526	0.012
Within Groups	65.414	327	0.200		
Total	67.224	329			
Headache					
Between Groups	1.373	2	0.686	4.902	0.008
Within Groups	45.782	327	0.140		
Total	47.155	329			

The present study shows no significance differences among women in our participants in all questions according to differences in having children or not, except in times they perform keratin hair treatment process where ($t = 3.812$, $P \leq 0.00$) which

means that women who have children are more doing it more than women who haven't children (**Table 4**).

Table 4. T-test results of difference according to having children.

Question	N	Mean	Std. Deviation	Std. Error Mean	t	Sig
Times do you perform keratin hair treatment process whether at home or in salon?						
Having children	128	1.8750	1.26740	.11202	3.812	0.000
Didn't having children	202	1.4406	.80356	.05654		

Knowledge about the risk related to Formaldehyde exposure

Table 5 shows that only 21.5% of our participants were perform keratin hair treatment process with children presence. Two hundred forty-one (73%) of our participants thought that there is a relation between percentage in keratin hair treatment and the symptoms they feel it. One hundred eighteen (35.8%) of the participants knowing that the level of formaldehyde allowed in keratin hair treatments in Saudi Arabia must not exceed 0.2%. Two hundred ninety-one (88.2%) of the participants knowing that poor ventilation increases health risk associated with formaldehyde during keratin hair treatment.

Table 5. Knowledge about the risk related to Formaldehyde exposure

Characteristics	No. of yes	%
Perform keratin hair treatment process with children presences whether at home or in salon	71	21.5
The relationship between its percentage in keratin hair treatment products and the symptoms mentioned earlier	241	73
The level of Formaldehyde allowed in keratin hair treatments in Saudi Arabia must not exceed 0.2%	118	35.8
Poor ventilation increases health risk associated with formaldehyde during keratin hair treatment	291	88.2

Table 6. Attitude towards keratin hair treatment.

Characteristics	No.	%
Times do you perform keratin hair treatment process whether at home or in salon?		
Once or twice only	205	62.1
Three or four times only	92	27.9
Periodically, every 2-3 months	6	1.8
Periodically, every 4-6 months	11	3.3
Periodically, every 7 months or more	16	4.9
you think that commercials are one of the reasons for women to use keratin hair treatment	279	84.5

Attitude towards keratin hair treatment

Table 6 demonstrates approximately 62.1% of the participants do it once or twice only, 27.9% were do it three or four times only, while who do it at periodically times were less than 10 % of the participants.

Two hundred seventy-nine (84.5%) of women in our study thought that one of the most important reasons to use keratin hair treatment was commercial advertisements.

Practice of keratin hair treatment

Table 7 shows that the participants in this study used keratin hair treatment and most of them (65.2%) thought that their hair needs it.

Table 7. Practice of keratin hair treatment among women.

Characteristics	No. of yes	%
You see that the nature of your hair in necessary need to use keratin hair treatment	215	65.2
You use keratin hair treatment services offered by salons	225	68.2
You perform keratin hair treatment at home	138	41.8
You use personal protective equipment such as a protective mask and gloves while using keratin hair treatment	253	76.7
Vapors and strong odors evaporate during keratin hair treatment procedure	305	92.4

The present study showed that 68.2% of our participants use keratin hair treatment services offered by salons, also 41.8% were do it by themselves at home. While who use it in both situations were 10% only.

Most of the women who using keratin hair treatment services offered by salons don't interest in knowing the bottle of treatment 24.5%, while 22.7% mentioned that the hair dresser doesn't allow them to see the bottle, only 20.9% were see it before using it.

Most of the women in our survey (76.7%) were used personal protective equipment such as a protective mask and gloves while using keratin hair treatment. While almost 23.3% of women didn't use mask and gloves while using keratin. Three hundred five (92.4%) of the participants had vapours and strong odours evaporate during keratin hair treatment procedure.

Symptoms related to Formaldehyde exposure

Table 8 and **Figure 1** show that eyes irritations are the most mild symptom happen during or after

Table 8. Mild Symptoms related to Formaldehyde exposure.

Symptoms	No.	%
Eyes irritation	135	28.1
Burning sensation in the nose	71	14.8
Throat irritation and cough	94	19.6
Nausea	19	4
Headache	57	11.8

Figure 1: Mild symptoms of keratin using.

using keratin treatment, second were throat irritation and cough 19.6%, third burning sensation in the nose 14.8%, fourth headache in 11.8%, and nausea by 4%.

Also, **Table 9** and **Figure 2** show that scalp inflammation 13.5%, and Shortness of breath 8.1% are the most serious symptoms of using keratin hair treatment while they didn't mention that they had unconsciousness during or after using hair treatment.

Table 9. Serious Symptoms related to Formaldehyde exposure.

Symptoms	No.	%
Shortness of breath	39	8.1
Unconsciousness	0	0
Scalp inflammation	65	13.5

Figure 2: Serious symptoms of keratin using.

Sources of keratin hair treatment Products used at home

Figure 3 demonstrates several sources of keratin hair treatment products used at home, most of them 18.5% were coming from online markets, while

Figure 3: Percent of sources of keratin.

8.8% each were get it from pharmacies and local markets, and 5.8% only have another sources of it

Checklist for hair smoothing treatment practices in salons

The checklist results of 30 hair salons were visited in three cities of the Al Qassim province is shown in **Table 10**. Only 16.7% of hair salons have good ventilation and 26.67% of hair salons perform keratin hair treatment in separate location from other salon services (**Figure 4 & 5**).

Figure 4: Percent of Good Ventilation.

Figure 5: Percent of Separate Location.

Table 10. Names of keratin hair treatment used among Saudi women.

Characteristics	No.	%
Brazilian Blowout	5	4.3
Amazon Keratin	12	10.3
Brasil Cacau	5	4.3
Cadiveu acai therapy	8	6.8
Cadiveu glomour pluse	1	0.9
Inoar	12	10.3
Matrix	3	2.6
Keratin cure gold and honey	8	6.8
Global keratin	3	2.6
lasio	2	1.7

Characteristics	No.	%
Agi max	1	0.9
W one brazil	2	1.7
Mohair plus	2	1.7
Rioskill	2	1.7
Brazilian Keratin	28	23.9
I Don't Know	23	19.7

Names of keratin hair treatment used among Saudi women

In **Table 10** shows that, all samples in yellow color have level of formaldehyde more than 0.2% and should not be used.

Level of formaldehyde in different Keratin hair treatment products

The present study showed the keratin hair treatment product Argan e Ojon- AtivoRedutor that has been analyzed for the presence of formaldehyde and its derivatives using SASO 2185 testing method.

The test of product Argan e Ojon for the determination of formaldehyde shows that product does not comply with GSO 1943 and SASO 1953 Standards (exceed the allowed level). As per the standards the formaldehyde content should not be more than 0.2%.Whereas, The product Amazonliss The Real Brazilian Keratin for the determination of formaldehyde shows that product within the limited concentration by GSO 1943 and SASO 1953 Standards (= 0.2%).

However, 3-18 contains high level of formaldehyde (>0.2%) according to SFDA analysis.

Discussion

This study highlights that formaldehyde is linked to many health complications including irritation of the eyes, breathing difficulties and scalp inflammation. Emerging evidence shows that the levels found in keratin hair treatment products could be exposing hair professionals and their service users to these risks.

Previous study investigated that hair-straightening treatments in Portland (Oregon) using the formaldehyde-free Brazilian Blowout Smoothing Solution. Out of 105 samples analyzed from 12 various hair-straightening products, nine had measurable formaldehyde with higher levels measured when using flat iron and blow-drying. Another study conducted task-specific formaldehyde monitoring in three salons and reported that the highest short-term exposures for the stylist occurred during blow-drying [17]. Pierce et al., [11] measured short-term formaldehyde concentration in the breathing zone of a stylist who performed a Brazilian Blowout Acai treatment on a mannequin human hair wig. They took a series of real time formaldehyde concentration measurements at the stylists' workstation and demonstrated a continuously increasing levels with application which further increased during blow-drying process.

The checklist shows that a majority of salons in Al Qassim demonstrated poor ventilation measures and failed to isolate their clients from the general public and salon workers. As stated by the PKSC, local source capture ventilation is the best method of ventilation in salons. The PKSC investigated the levels of formaldehyde and concluded that the highest levels were measured during blow-drying of hair, in particular that of high temperature [18]. These systems were not in place in the majority of salons investigated. It is apparent that salon businesses need to be further educated on the dangers of formaldehyde.

The Saudi Food and Drug Authority (SFDA) took caution from hair products that contained high level of Formaldehyde and considered treatments as dangerous if exceeded 0.2%. This is in line with the permissible concentrations set by gulf cooperation council standard specifications) [10].

Argan e Ojon was one of the two products tested in this study with formaldehyde levels above 0.2% threshold (0.35%). These levels were simi-

larly recorded in Veloce by La Brasiliana hair product and at this concentration; this product has demonstrated side effects [19]. However, Amazonliss demonstrated levels of 0.2%. Despite it being at the acceptable threshold, it is apparent that manufacturers and distributors must recognize formaldehyde on any product that contains more than 0.1% formaldehyde. This may be either gas or in a solution that can release formaldehyde at a concentration of 0.1ppm or higher. This suggests that even at levels less than 0.2%, risk of side effects are still likely. It may be that the exposure time is relevant too in addition the formaldehyde concentration levels [20].

This study shows that the most common mild symptoms reported were eye irritation (40.91%), throat irritation and cough (28.48%), burning sensation in the nose (21.52%), headache (17.27%) and nausea (5.76%). In agreement with this study Mathur and Rastogi demonstrated a strong association between formaldehyde exposure and respiratory symptoms such as cough, breathlessness and chest tightness [21].

Formaldehyde is known as mucous membrane irritant that can cause excess lacrimation and conjunctivitis. Eye irritation has always been a common complaint by hair salon staff [22]. This has been again been observed in this study. In addition, this study shows that the most common serious symptoms reported were scalp inflammation (19.70%) and Shortness of breath (11.82%). The Agency for Toxic Substances & Disease Registry similarly reports that formaldehyde can cause coughing, difficulty breathing or shortness of breath [20].

The Saudi Food and Drug Authority have instructed consumers to not use the aforementioned products with a particular batch number. They have advised that all such samples must be destroyed and not sold by salons to customers. It is vital to source products from reliable companies [10]. Despite the Saudi Food and Drug Authority addressing local authorities to recall products and ban of entry of

such products to Saudi Arabia, this study evidently demonstrates that such hair treatment products are still on the salon shelves and local markets. The products could be of another batch order however, their risks are still apparent.

As with all research projects, limitations commonly exist that may significantly affect the results.

The limitations of this study were as follows:

Only the province of Al Qassim was investigated and reported. This risk geographical bias that may have skewed the study results. In the future with more time and resources, it may be necessary to investigate more provinces across Saudi Arabia to reproduce results from a larger cohort.

Salons were chosen in terms of proximity to my location. If I were to carry out this research project again, I would ideally prefer to randomly located salons to reduce the risk of selection bias.

Conclusion

The results of the present study demonstrated that formaldehyde has the ability to maintain hair straight and silky appearance. However, it has harmful risks and side effects this includes irritation of the eyes, burning sensation of the nose, headaches and nausea. These symptoms and other more severe consequences such as cancer however, products with formaldehyde continue to be manufactured and sold globally. This may be through false advertisement or via chemicals that have the capability to convert itself to formaldehyde. From the investigations on the formaldehyde levels in hair products within one province in Saudi Arabia, it is evident that Argan e Ojon had levels of more than 0.2%. This does not comply with GSO 1943, and SASO 1953 standards, which suggest otherwise that lower levels are safer to use. Additionally, more needs to be done by hair salons in regards to ventilation of their businesses. This study concludes that hair products of dangerously high levels of formaldehyde are still being sold and used in

Saudi Arabia despite their apparent side effects, and hence more must be done to restrict its use in the country.

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