Use of hair colouring products and breast cancer risk: a case–control study in Connecticut

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Abstract

This case–control study was designed to test the hypothesis that the risk of breast cancer varies by type and colour of the hair colouring products used. A total of 608 cases and 609 controls were included in the study. We found no increased risk associated with the overall use of hair dye products or exclusive use of permanent or temporary types of hair dye products. Among those who reported to have exclusively used semi-permanent types of hair colouring products, some of the ORs were elevated. However, none of the ORs related to age at first use, duration of use, total number of applications, and years since first use, was statistically significant. There was also no increased risk of breast cancer associated with exclusive use of dark or light hair colouring products, or use of mixed types or colours of hair dye products. We also found no increased risk of breast cancer associated with hair dye use based on an individual's reason for using a hair colouring product, such as to cover grey or to change natural hair colour. These data suggest that the use of hair colouring products does not have a major impact on the risk of breast cancer. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Hair colouring products have been shown to contain mutagenic and carcinogenic compounds [1–3]. However, epidemiological studies of hair colouring product use and cancer risk, including breast cancer, have yielded inconclusive results. A recent study by Cook and colleagues [4] from the western Washington state in the United States of America (USA) found that the use of hair colouring products was associated with a 30% borderline significantly increased risk of breast cancer. Among women who used two or more methods of hair colouring applications, ever use of any hair colouring products was associated with a 2-fold increased risk, 3-fold among those who had a total lifetime experience of more than 90 episodes, and almost 6-fold among those who had a total lifetime use of hair colouring applications for more than 2400 min. However, because of the lack of an association between exclusive use of a single type of hair colouring application and breast cancer risk, the authors considered that hair colouring application does not influence breast cancer risk among reproductive-age women.

Considering that mutagenic and carcinogens were historically found in hair dye products [5,6], and the potential carcinogenic effect of hair dye products observed by the recent epidemiological studies [4,7,8], we conducted a detailed examination of the association between breast cancer risk and hair colouring product applications using data from a case–control study conducted in Connecticut in the USA.

2. Patients and methods

2.1. Study population

A description of the study population and methods has been given elsewhere in Ref. [9]. Briefly, cases for

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the case–control study were histologically-confirmed, incident breast cancer patients (ICD-O, 174.0–174.9) who either had breast-related surgery at the Yale-New Haven Hospital (YNHH), in New Haven County, or who were residents of Tolland County, Connecticut, between 1 January 1994 and 31 December 1997. Subjects were restricted to women 30–80 years of age who had no previous diagnosis of cancer, with the exception of non-melanoma skin cancer, and were alive at the time of interview.

We recruited both cases and controls from Tolland County, Connecticut. Newly diagnosed cases with Tolland County addresses were identified from area hospital records by the Rapid Case Ascertainment Shared Resource of the Yale Comprehensive Cancer Center. A total of 238 cases were identified for this study, with 176 of them (74%) completing in-person interviews. Population-based controls with Tolland County addresses were recruited using either random digit dialling methods for those below the age of 65 years, as described by Hartge and colleagues in Ref. [10], or from Health Care Finance Administration files for those aged 65 years and above. A total of 322 controls were randomly selected, and 205 (64%) agreed to participate in this study. Efforts were made to frequency match the cases and controls by age (within 5-year intervals) using a 1:1 ratio by adjusting the number of controls randomly selected in each age stratum every few months.

We also recruited the cases from the area surrounding New Haven, identified using computerised patient information from the YNHH, where records of all newly performed breast-related surgeries are kept. We consecutively selected all breast cancer patients who met the study eligibility requirements as described above. A total of 562 incident breast cancer cases were identified from YNHH, with 432 of them (77%) completing in-person interviews. From the computerised files, we also randomly selected 571 potential control patients who had had breast-related surgery, but were histologically confirmed to be without breast cancer. Of these, 404 (71%) participated in the study. Efforts were made to frequency match the cases and controls by age (within 5-year intervals) using a 1:1 ratio by adjusting the number of controls randomly selected in each age stratum every few months. All the pathological information for the breast cancer cases and for the controls was reviewed by a single reference pathologist for diagnostic confirmation and uniform histological confirmation.

2.2. Interviews

A standardised, structured questionnaire was used to obtain information on the use of hair colouring products. First, respondents were asked whether they had used hair colouring products regularly at any time in their lives. If their responses were affirmative, they were asked to provide information related to each period in which they had used a hair colouring product, with a period defined as use of the same type/colour product (without specifying a minimum duration of each period). If either changed, it was considered to be another period. Specifically, for each period of hair dye use, subjects were asked to provide information regarding the type and colour of the hair colouring product used, their age at first/each use, age when they stopped use, the number of years of use, and the frequency of use per year during those years of reported use. The respondents in our study were also asked for their main reason for using a hair colouring product, such as to cover grey or to change natural hair colour. The study interviewers were trained to use pictures of hair product labels for the interview.

The questionnaire also obtained information on other potential risk factors, including menstrual and reproductive history, family cancer history, occupation, diet and demographic factors. Information on usual diet in the year prior to being interviewed was collected using a scannable semi-quantitative food frequency questionnaire developed and validated by the Fred Hutchinson Cancer Research Center. The questionnaire was specifically designed to optimise estimation of fat intake. The majority of the cases and controls were interviewed within 3 months either after being ascertained by the Rapid Case Ascertainment system at the Yale Cancer Center or as selected by the study.

2.3. Data analysis

The relationship between use of hair colouring products and breast cancer risk was assessed by type (permanent, semi-permanent and temporary) and colour (dark: black, red, and brown/brunette or light: blonde, and silver). For each type and colour, the risk was assessed by age at first use, duration of use and years since first use.

Some subjects reported using a particular type or colour of hair dye product across different periods of life, with varying frequencies in each period. The average frequency of use for a product was not necessarily representative of the use in any one period, since the frequency of use was likely to vary over a lifetime. Therefore, instead of calculating an average frequency of lifetime use, we calculated the total number of times a specific type or colour of hair dye product was used, similar to the approach of Koenig and colleagues in Ref. [11]. Calculation of the total number of times a specific type or colour of hair dye was used was performed in two steps: first by calculating the number of times used for each period by taking the product of years of use (duration) and frequency of uses per year, and then taking the total over the lifetime. Since the study subjects were recruited from two counties, we also

stratified the data by study site to ensure that the results were similar for the two counties.

Unconditional logistic regression was used to estimate the association between hair colouring product use and breast cancer risk, and to control for potential confounders. Potential confounding variables included in the final model were age (<45, 45–54, 55–64, ⩾65 years), race (whites, blacks and others), and age at menopause. Study site (YNHH, and Tolland County) was also adjusted when the relationship was considered for the entire population. Adjustment for other factors (such as family breast cancer history, history of lactation, body mass index and dietary fat intakes) did not result in any material changes to the odds ratios (ORs), therefore, these variables were excluded from the final model. ORs and 95% confidence intervals (CI) were calculated using SAS statistical software [12]. Tests for trend were conducted by using a likelihood ratio statistic in a logistic regression model.

3. Results

Cases were slightly older than controls despite frequency matching. Therefore, age was controlled in all subsequent analyses so as to reflect the study design. Women with a later age at first full-term pregnancy showed a significantly increased risk (Table 1). In comparison to those less than age 20 years at first full pregnancy, the ORs were 1.6 (95% CI 1.1–2.4) and 1.8 (95% CI 1.1–2.7) for those having first full-term pregnancy at ages 20–25 years and over age 25 years, respectively. Women who lactated more than 12 months during their lifetimes experienced a reduced risk (OR = 0.8, 95% CI 0.5–1.1) compared with those who never lactated. Women with a first-degree relative with breast cancer had a non-significantly increased risk of breast cancer (OR = 1.2, 95% CI 0.9–1.6). Dietary fat intake at the second tertile, but not the third tertile, showed a 40% increased risk. Increased body mass index was associated with an elevated risk of breast cancer. These observations are generally consistent with what is known about breast cancer aetiology.

No increased risk was found for hair colouring product use overall or by study site (Table 2). The risk was also not increased with the exclusive use of permanent types (Table 3) or temporary types of hair colouring products (data not shown). Among those who reported to have exclusively used semi-permanent types of hair colouring products (Table 3), some of the ORs were elevated. However, none of the ORs related to age at first use, duration of use and total number of applications was statistically significant.

There was also no increased risk among women associated with exclusive use of darker (red, black and brown/brunette) hair colouring products or light

(blonde and silver) hair colouring products (Table 4), or the use of mixed types or colours of hair dye products (data not shown).

We also did not find an increased risk of breast cancer associated with hair dye use based on an individual's reason for using a hair colouring product, such as to cover grey or to change natural hair colour (data not shown).

4. Discussion

In this case–control study, we found no overall association between hair colouring product use and breast

Table 1
Selected characteristics of breast cancer cases and controls

Characteristics	Cases (*n* = 608)	Controls (*n* = 609)	OR[a]	95% CI
Age at menarche (years)				
⩾15	67	66	1.0	
13–14	245	259	1.0	0.7–1.2
<13	290	283	1.1	0.8–1.6
Unknown	6	1	6.1	0.7–53.6
Age at first full pregnancy (years)				
<20	54	73	1.0	
20–25	260	240	1.6	1.1–2.4
⩾26	209	198	1.8	1.1–2.7
Nulliparous	85	98	1.4	0.8–2.3
Lifetime lactation (months)				
0	390	366	1.0	
1–6	96	101	0.8	0.6–1.2
7–12	46	50	0.9	0.5–1.3
⩾13	76	92	0.8	0.5–1.1
Family breast cancer history				
No	463	485	1.0	
Yes	145	124	1.2	0.9–1.6
Fat intake (g/day)				
<46	173	207	1.0	
46–71	230	199	1.4	1.1–1.9
⩾72	186	183	1.2	0.9–1.7
Unknown	19	20	1.2	0.6–2.4
BMI (kg/m²)				
<21.0	80	105	1.0	
21.0–24.9	238	234	1.3	0.9–1.9
⩾25.0	290	270	1.3	0.9–1.8
Race				
Whites	551	557	1.0	
Blacks	38	35	1.2	0.7–2.1
Others	19	17	1.2	0.6–2.4
Annual income ($)				
<20 000	354	343	1.0	
20 000–24 999	46	60	0.7	0.4–1.0
⩾25 000	102	119	0.8	0.6–1.1
Unknown	106	87	1.1	0.8–1.5

95% CI, 95% confidence interval; BMI, body mass index.
[a] Odds ratios for each selected characteristic were adjusted for all other selected characteristics listed in Table 1.

Table 2
Hair colouring product use and risk of female breast cancer by study site

Hair dye use	YNHH			Tolland			All		
	Ca/co[a]	OR[b]	95% CI	Ca/co[a]	OR[b]	95% CI	Ca/co[a]	OR[b]	95% CI
Never	103/96	1.0		60/60	1.0		163/156	1.0	
Ever	329/308	1.0	0.7–1.4	116/145	0.8	0.5–1.3	445/453	0.9	0.7–1.2
Age at first use (years)									
<26	94/101	0.9	0.6–1.4	26/51	0.5	0.3–1.0	120/152	0.8	0.5–1.1
26–40	115/110	1.0	0.7–1.5	38/49	0.9	0.5–1.5	153/159	0.9	0.6–1.2
⩾41	119/97	1.0	0.7–1.5	51/44	1.1	0.6–2.0	170/141	1.0	0.7–1.4
Duration of use (years)									
<7	92/106	0.8	0.6–1.2	44/50	0.9	0.5–1.7	136/156	0.8	0.6–1.2
7–18	105/95	1.0	0.7–1.6	38/51	0.7	0.4–1.3	143/146	0.9	0.7–1.3
⩾19	132/107	1.1	0.7–1.5	34/43	0.8	0.4–1.5	166/150	0.9	0.7–1.3
Total number of applications									
<25	91/97	0.9	0.6–1.4	38/53	0.8	0.4–1.4	129/150	0.8	0.6–1.2
25–99	105/103	1.0	0.7–1.4	39/43	0.9	0.5–1.7	144/146	0.9	0.6–1.2
⩾100	128/106	1.0	0.7–1.5	39/47	0.8	0.5–1.5	167/153	0.9	0.7–1.3
Years since first use									
<10	84/85	1.0	0.7–1.6	33/28	1.3	0.7–2.5	177/113	1.0	0.7–1.5
10–19	71/72	0.9	0.6–1.4	30/37	0.8	0.4–1.5	101/109	0.8	0.6–1.2
20–29	73/68	1.0	0.6–1.6	28/32	0.9	0.5–1.8	101/100	0.9	0.6–1.3
⩾30	100/83	1.0	0.6–1.5	24/47	0.5	0.3–1.0	124/130	0.8	0.5–1.1

[a] No. of cases and no. of controls.
[b] Odds ratio adjusted for age (<45, 45–54, 55–64 ⩾65 years), race (whites, blacks and others) and age at menopause. Never use is the referent category for all odds ratios.

cancer risk. While there was a suggestion of an increased risk of breast cancer among those who used semi-permanent hair dye products, none of the ORs were statistically significant, and there was no clear pattern of an increased risk with increased duration and extent of use. Therefore, chance alone may account for the observed results for semi-permanent colour use. We also did not find an association between hair dye use and risk of breast cancer based on an individual's reason for using a hair colouring product as suggested by others [13]. These observations, together with the majority of the earlier studies, suggest that personal hair colouring product use is unlikely to be a major cause of human breast cancer [14–22].

Several strengths and potential limitations of the study design must be considered in interpreting our findings. In this relatively large case-control study, we collected detailed information on duration, frequency and type and colour of hair dye product use for each period of use, that allowed the study to quantitatively evaluate the association by major characteristics of hair dye use. Standardised structured questionnaires were administered through face to face interviews with the subjects; no surrogate interviewing was used, which minimised misclassification of exposure.

The questionnaire used to collect information on hair dye use in this study was modified from a National Cancer Institute (NCI) questionnaire assessing hair dye product use and risk of non-Hodgkin's lymphoma

Table 3
Hair colouring product use and risk of female breast cancer by type of products

Hair dye use	Permanent			Semi-permanent		
	Ca/co[a]	OR[b]	95% CI	Ca/co[a]	OR[b]	95% CI
Never	163/156	1.0		163/156	1.0	
Ever	237/248	0.9	0.7—1.2	102/76	1.2	0.9–1.8
Age at first use (years)						
<26	77/84	0.9	0.6–1.3	9/14	0.7	0.3–1.6
26–40	78/91	0.8	0.6–1.2	37/25	1.6	0.8–2.5
⩾41	82/73	0.9	0.6–1.4	56/37	1.3	0.8–2.1
Duration of use (years)						
<7	59/77	0.7	0.5–1.0	50/43	1.2	0.8–1.8
7–18	70/81	0.8	0.5–1.1	31/22	1.4	0.8–2.4
⩾19	108/90	1.0	0.7–1.3	21/11	1.9	0.9–4.0
Total number of applications						
<25	60/82	0.7	0.5–1.0	45/34	1.4	0.9–2.2
25–99	67/75	0.8	0.5–1.2	38/31	1.2	0.7–2.0
⩾100	106/90	0.9	0.7–1.3	19/11	1.6	0.7–3.4
Years since first use						
<10	50/57	0.9	0.6–1.4	40/32	1.2	0.7–2.1
10–19	53/67	0.8	0.5–1.2	21/15	1.3	0.6–2.6
20–29	53/57	0.9	0.6–1.4	28/14	1.8	0.9–3.6
⩾30	81/67	1.0	0.7–1.5	13/15	0.7	0.3–1.6

[a] No. of cases and no. of controls.
[b] Odds ratio adjusted for age (<45, 45–54, 55–64 ⩾65 years), race (whites, blacks and others), and age at menopause and study site (YNHH and Tolland county). Never use is the referent category for all odds ratio.

(NHL), multiple myeloma and lymphocytic leukaemia [23]. While we have no direct measures of validity in this study, other research relating hair dye use and risk of breast cancer [14–22], NHL [23–25], multiple myeloma [26,27], leukaemia [23,28] and bladder cancer [8] suggests that women generally are able to report hair dye use characteristics (such as duration, timing, frequency type and colour).

In a reliability study, Shore and colleagues [17] reported a correlation coefficient (r) of 0.86 for duration of hair dye use from two interviews one year apart, with the coefficients for the cases and controls separately being nearly identical. The correlation coefficient for reported frequency of use was $r = 0.92$. However, while the results may indicate that hair dye information collected through self-report was reliable, differential over-reporting of hair colouring product use among breast cancer patients may still occur if patients believe that hair dye use or a specific type (or colour) of hair dye use may increase a person's breast cancer risk. The lack of an overall association between hair dye use and breast cancer risk argues against differential recall playing a major role for the results of our study.

Despite the large number of subjects (608 cases and 609 controls), statistical power may be limited for analyses by the type or colour of the products used. Therefore, chance may be a potential explanation for the elevated ORs among those exclusively using semi-permanent hair dye products.

Another potential limitation of our study concerns the use of benign breast disease patients as part of the control group for the New Haven study site. If benign breast diseases were associated with hair colouring product use, a weak association between use of hair colouring products and breast cancer risk could be obscured. However, this explanation does not seem to be highly likely because the results stratified by study site (Table 2) reached essentially the same conclusions as in the combined analyses.

In summary, in this case–control study, we found no overall association between hair dye use and breast cancer risk based on detailed information regarding lifetime use of hair dye products. Based on the results from this study and from earlier epidemiological studies, we consider it is unlikely that personal hair dye use contributes significantly to an increase in breast cancer risk.

Acknowledgement

Table 4
Hair colouring product use and breast cancer risk by colour of the products

Hair dye use	Dark colour products only[a]			Light colour products only[b]		
	Ca/co	OR[c]	95% CI	Ca/co	OR[c]	95% CI
Never	163/156	1.0		163/156	1.0	
Ever	251/234	1.0	0.7–1.3	166/176	0.9	0.6–1.2
Age at first use (years)						
<26	38/48	0.8	0.5–1.3	61/76	0.8	0.5–1.2
26–40	69/70	1.0	0.7–1.5	43/45	0.9	0.6–1.5
≥41	144/116	1.1	0.8–1.5	62/55	1.0	0.6–1.5
Duration of use (years)						
<9	112/103	1.1	0.8–1.5	48/62	0.8	0.5–1.2
≥9	139/130	1.0	0.8–1.3	118/114	1.0	0.7–1.3
Total number of applications						
<25	83/73	1.1	0.8–1.6	43/64	0.7	0.5–1.0
25–99	91/84	1.0	0.7–1.4	46/47	1.0	0.6–1.5
≥100	75/76	0.9	0.6–1.3	75/64	1.0	0.7–1.5
Years since first use						
<10	83/67	1.2	0.8–1.8	27/35	0.8	0.5–1.4
10–19	62/66	0.9	0.6–1.3	37/37	1.0	0.6–1.7
20–29	55/38	1.3	0.8–2.1	38/52	0.7	0.4–1.1
≥30	47/59	0.7	0.4–1.0	64/51	1.1	0.7–1.7

[a] Dark colour: black, red and brown/brunette.
[b] Light colour: blonde and silver.
[c] Adjusted for the same variables as in Table 3.

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