Hair dye and chemical straightener use and breast cancer risk in a large US population of black and white women

Carolyn Eberle, MPH

Breast cancer incidence persistent in the United States

Most commonly diagnosed cancer among women in the US

270,000 new female breast cancer cases in 2019

2nd leading cause of cancer-related death

Trends in incidence rates, 1975-2016
Per 100,000, age adjusted to the 2000 US standard population.

Siegel et al, 2020; ACS 2020
Background

Black women at higher risk of aggressive breast cancer subtypes
Hair dye use is widespread in the United States

NCI estimates 1/3 of women and 10% of men over the age of 18 in the US use hair dye

**Oxidative**

Permanent dye
- Colorless precursors, alkalinizing and oxidizing (coupling) agents
- Oxidizing agents react with precursor $\rightarrow$ molecules bind to cortex (inner layer)

**Non-oxidative**

Semi-permanent, Temporary dyes and rinses
- Colored particles bind to cuticle (outer layer) of hair
- Minimal concentrations of oxidizing and alkalinizing agents
Endocrine disrupting activity observed in oxidizing agents

Endocrine disrupting chemicals (EDCs)

2,4-diaminoanisole sulfate and para-Phenylenediamine induce mammary gland tumors in animal models.

4-aminobiphenyal (ABP) adducts were 8 times more likely to be present in breast tissue of women that use hair dye.

Estrogens and EDCs not indicated on labels

Products marketed to black women, darker-colored dyes contain higher concentrations of EDCs

Chemical straightener use common among Black women

More than 60% of Black women, <10% of white women use chemical straighteners

Lye and non-lye hair relaxers

- Lye active ingredients: sodium hydroxide, calcium hydroxide
- Non-lye active ingredients: potassium hydroxide, lithium hydroxide, guanidine carbonate or ammonium thioglycolate
- Scalp burns, hair breakage

Brazilian Keratin Treatments (BKT)

- Active ingredients: Formaldehyde reacts with keratin when heated
- Fewer burns, less breakage

James-Todd et al., 2011; Taylor et al., 2017; Brinton et al, 2018; Llanos et al, 2017; Maneli et al, 2015
Aim 1. Describe the association of hair dye use with breast cancer risk
   Does the association vary by frequency of use, type or color of dye, race, ER or menopausal status?

Aim 2. Describe the association of chemical straightener use with breast cancer risk
   Does the association vary by frequency of use, race, ER or menopausal status?
Study Population & Design

Prospective observational cohort (n=50,884)
Recruitment from 2003-2009

Eligibility criteria
  • Breast cancer-free women
  • Ages 35-74
  • Residents of the U.S. and Puerto Rico
  • Sister diagnosed with breast cancer

Baseline
  • Extensive questionnaires, in-home visits

Follow-up
  • Annual health updates, biennial surveys, study hotline
  • Breast cancer diagnosis confirmed by medical record review with 98% accuracy
  • Pathology reports obtained for ~80% of participants

Sandler et al, 2017; D’Alaisio et al, 2017
Methods

Study Sample

Sister Study Cohort
N=50,844

Completed Questionnaire
N=47,712

Diagnosed before baseline
N=62
Missing Covariates
N=941

Missing personal care product questionnaire
N=3,132

Complete Case Sample
N=46,709

Breast Cancer Cases
September 15, 2016
N = 2,794
Average follow up: 8.3 years
Exposures

**Personal use of hair dye and chemical straighteners**
- Any use in the past 12 months
- Frequency of use in past 12 months
- Duration of use (<5 years, 5+ years)
- Type and color of dye typically used (dark colors, light colors, both)

**Non-professional application of hair dye and chemical straighteners to others**
- Any applications in the past 12 months
- Frequency of applications in past 12 months
Outcomes & Statistical Analysis

Outcomes

Primary outcome: Invasive breast cancer or Ductal Carcinoma in situ (DCIS)

Secondary outcomes: Invasive disease by ER status, Menopausal status at time of diagnosis

Analysis

Cox proportional hazard models

• Age as timescale
• Test for heterogeneity by race
• Adjusted models: Age, race/ethnicity, education, ever oral contraceptive use, BMI, smoking status, parity, age at first birth, age at menarche and menopausal status
Exposure varied by demographic & reproductive characteristics

55% reported permanent hair dye use in past 12 months
   42% of Black women vs. 56% of White women
   Mean age: 54.7 years (users) vs. 56.9 years (non-users)
   60% pre-menopausal vs. 53% post-menopausal

9.9% reported chemical straightener use in the past 12 months
   74% of Black women vs. 3% of white women
   13.3% pre-menopausal vs. 7.9% post-menopausal
   11.5% in overweight or obese vs. 6.7% normal/underweight
# Results

**Permanent hair dye use associated with all breast cancer**

<table>
<thead>
<tr>
<th></th>
<th>All participants</th>
<th>Non-Hispanic White</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Adjusted HR (95% CI)</td>
<td>Events</td>
</tr>
<tr>
<td>Personal use in the 12 months before enrollment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use†</td>
<td>1,235</td>
<td>Ref</td>
<td>1,064</td>
</tr>
<tr>
<td>Any use</td>
<td>1,559</td>
<td>1.09 (1.01, 1.17)</td>
<td>1,338</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>634</td>
<td>1.08 (0.98, 1.19)</td>
<td>524</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>925</td>
<td>1.09 (1.00, 1.19)</td>
<td>814</td>
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<tr>
<td><strong>p for trend</strong></td>
<td><strong>0.05</strong></td>
<td></td>
<td><strong>0.1</strong></td>
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Dye color

<table>
<thead>
<tr>
<th></th>
<th>All participants</th>
<th>Non-Hispanic White</th>
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<tbody>
<tr>
<td></td>
<td>Events</td>
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<td>Events</td>
</tr>
<tr>
<td>None</td>
<td>1,235</td>
<td>Ref</td>
<td>1,064</td>
</tr>
<tr>
<td>Light colors only</td>
<td>713</td>
<td><strong>1.12 (1.02, 1.23)</strong></td>
<td>664</td>
</tr>
<tr>
<td>Dark colors only</td>
<td>683</td>
<td><strong>1.08 (0.98, 1.19)</strong></td>
<td>529</td>
</tr>
<tr>
<td>Light and dark colors</td>
<td>144</td>
<td>0.96 (0.81, 1.14)</td>
<td>133</td>
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</tbody>
</table>
Light-colored dye associated with premenopausal breast cancer

<table>
<thead>
<tr>
<th></th>
<th>Pre-Menopausal</th>
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<th>Post-Menopausal</th>
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<tbody>
<tr>
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<td>Events</td>
<td>Adjusted HR (95% CI)</td>
<td>Events</td>
<td>Adjusted HR (95% CI)</td>
</tr>
<tr>
<td>Personal use in the 12 months before enrollment</td>
<td>519</td>
<td></td>
<td>2,270</td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>199</td>
<td>Ref</td>
<td>1,035</td>
<td>Ref</td>
</tr>
<tr>
<td>Any use</td>
<td>320</td>
<td>1.12 (0.94, 1.34)</td>
<td>1,234</td>
<td>1.08 (0.99, 1.18)</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>164</td>
<td>1.14 (0.92, 1.40)</td>
<td>467</td>
<td>1.06 (0.95, 1.19)</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>156</td>
<td>1.11 (0.90, 1.37)</td>
<td>767</td>
<td>1.09 (0.99, 1.20)</td>
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<tr>
<td></td>
<td></td>
<td><em>p for trend</em>  0.3</td>
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<td>0.07</td>
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Dye color

<table>
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<tr>
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<th>Pre-Menopausal</th>
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<th>Post-Menopausal</th>
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<tr>
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<td>Events</td>
<td>Adjusted HR (95% CI)</td>
<td>Events</td>
<td>Adjusted HR (95% CI)</td>
</tr>
<tr>
<td>None</td>
<td>199</td>
<td>Ref</td>
<td>1,035</td>
<td>Ref</td>
</tr>
<tr>
<td>Light colors only</td>
<td>142</td>
<td><strong>1.30 (1.04, 1.62)</strong></td>
<td>570</td>
<td>1.08 (0.98, 1.20)</td>
</tr>
<tr>
<td>Dark colors only</td>
<td>149</td>
<td>1.11 (0.89, 1.37)</td>
<td>530</td>
<td>1.07 (0.67, 1.20)</td>
</tr>
<tr>
<td>Light and dark colors</td>
<td>27</td>
<td>0.70 (0.47, 1.05)</td>
<td>117</td>
<td>1.06 (0.88, 1.29)</td>
</tr>
</tbody>
</table>
## Results

Chemical straightener use associated with all breast cancer

<table>
<thead>
<tr>
<th></th>
<th>All participants</th>
<th>Non-Hispanic White</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Adjusted HR (95% CI)</td>
<td>Events</td>
</tr>
<tr>
<td>Personal use in the 12 months before enrollment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use†</td>
<td>2,543</td>
<td>Ref</td>
<td>2,334</td>
</tr>
<tr>
<td>Any use</td>
<td>251</td>
<td>1.18 (0.99,1.41)</td>
<td>68</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>107</td>
<td>1.07 (0.86, 1.34)</td>
<td>37</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>144</td>
<td>1.31 (1.05, 1.63)</td>
<td>31</td>
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<tr>
<td></td>
<td></td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Applied to others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>2,716</td>
<td>Ref</td>
<td>2,380</td>
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<tr>
<td>Any use</td>
<td>78</td>
<td>1.27 (0.99,1.62)</td>
<td>22</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>62</td>
<td>1.35 (1.03,1.77)</td>
<td>19</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>16</td>
<td>1.03 (0.62,1.70)</td>
<td>3</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>p for trend</td>
<td></td>
<td>0.2</td>
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*Ref* indicates the reference group for the adjusted HR calculations.
Chemical straightener use associated with breast cancer risk in post-menopausal women

<table>
<thead>
<tr>
<th></th>
<th>Pre-menopausal</th>
<th>Post-menopausal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Hazard ratios (95% CI)</td>
</tr>
<tr>
<td></td>
<td>519</td>
<td>Ref</td>
</tr>
<tr>
<td><strong>Personal use in the 12 months before enrollment</strong></td>
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<td>2,085</td>
</tr>
<tr>
<td>No use†</td>
<td>453</td>
<td>1.05 (0.75,1.46)</td>
</tr>
<tr>
<td>Any use</td>
<td>66</td>
<td>1.15 (0.77,1.70)</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>33</td>
<td>0.93 (0.30,1.44)</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>33</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Applied to others</strong></td>
<td></td>
<td>2,216</td>
</tr>
<tr>
<td>No use†</td>
<td>495</td>
<td>1.18 (0.75,1.84)</td>
</tr>
<tr>
<td>Any use</td>
<td>24</td>
<td>1.29 (0.79,2.10)</td>
</tr>
<tr>
<td>&lt;4 times per year</td>
<td>19</td>
<td>--</td>
</tr>
<tr>
<td>Every 5-8 weeks, 1+ per month</td>
<td>5</td>
<td>--</td>
</tr>
</tbody>
</table>

*p for trend*
Hair dye use and breast cancer risk summary

**Permanent hair dye use associated with all breast cancer risk**
- ↑ Frequent users
- ↑ Black women
- ↑ Light-colored dye (all breast cancer, white women, and pre-menopausal)
- ↑ Dark-colored dye (Black women)
  
  No associations in ER status specific stratum

**Semi-permanent and temporary dye use not associated with breast cancer risk**

**Semi-permanent application to others associated with all breast cancer risk**
- ↑ ER +, post-menopausal
Chemical straightener use and breast cancer risk summary

**Personal use and application to others associated with all breast cancer**

↑ Frequent users

↑ Post-menopausal women

Non-significant suggestion that ER- breast cancers were driving association

Risk did not vary by race; prevalence of exposure varied significantly

**Similar findings in recent studies of chemical straightener use and breast cancer**

**Women’s Circle of Health**

All breast cancer, white women: OR = 1.74, 95%CI (1.11,2.74)

ER- breast cancer: OR = 2.56, 95%CI (1.06,6.16)

**Ghana Breast Health Study**

Current users OR = 1.39, 95% CI (1.00, 1.93)

Former users OR = 2.22, 95% CI (1.56, 3.16)

Llanos et al, 2017; Brinton et al, 2018
Controversy surrounding Brazilian Keratin Treatments

2010 Oregon OSHA investigation

- 105 keratin treatment samples from 54 salons
- Formaldehyde concentration: 6.4% - 11.8%

Formaldehyde exposure and breast cancer risk not studied

IARC Class 1 carcinogen for nasopharyngeal cancer

Washington Post, October 17, 2011

Health & Science

Straight hair at what cost? Treatments using formaldehyde may pose a risk.
**Strengths**

- Large national sample
- Prospective cohort
- Extensive exposure information
- 90% + follow up retention
- Sufficient sample to estimate effect in black and white women

**Limitations**

- Self-reported data
- Product formulations not known
- Exposure limited to past 12 months, use during follow up not captured

**Future Directions**

- Assessing types of chemical straightener or relaxer
- Early life exposure in Sister Study
Acknowledgements

Thank you to the Sister Study participants!

Co-authors
Lexie White PhD, MSPH
Kyla Taylor PhD, MPH
Dale Sandler PhD, MPH

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