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ORIGINAL ARTICLE *Reproductive epidemiology*

Premature ovarian failure among hairdressers

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BACKGROUND: Hairdressers constitute a major occupational group of female workers who are exposed to chemicals that cause reproductive abnormalities in animal models. The purpose of this study was to examine whether hairdressers are at increased risk of premature ovarian failure (POF) compared with women of similar age in other occupations.

METHODS: This study analyzed data from a population-based sample of 443 hairdressers and 508 women in other occupations, who responded to a mailed survey. POF was assessed in all eligible participants by self-report of a doctor's diagnosis.

RESULTS: Among 443 hairdressers and 508 women in other occupations, 14 (3.2%) and 7 (1.4%) developed POF, respectively. A non-significant increase in the risk of POF was observed among hairdressers compared with non-hairdressers (adjusted relative risk (RR) 1.90; 95% confidence interval (CI) 0.76, 4.72). When limited to Caucasian women only (~85% of respondents), the increased risk was statistically significant (RR 3.24; 95% CI 1.06, 9.91). Among Caucasian women of 40–55 years of age, hairdressers were more than five times as likely to report POF compared with non-hairdressers (RR 5.58; 95% CI 1.24, 25.22).

CONCLUSIONS: Hairdressers may be at increased risk for POF compared with women employed in other occupations.

Key words: chemical exposure / cosmetologists / hairdressers / premature ovarian failure / reproduction

Introduction

Premature ovarian failure (POF) is clinically defined as the spontaneous and irreversible cessation of menses due to ovarian failure prior to the age of 40 years (Gosden *et al*., 2007). Population-based studies estimate that ~1% of women experience POF, with African-American women having a higher risk compared with Caucasian women (Coulam *et al*., 1986; Cramer and Xu, 1996; Luborsky *et al*., 2003). Because of the early loss of ovarian function and the subsequent low levels of circulating estrogens for a prolonged time period, women with POF are at risk of developing a number of adverse health conditions, including cardiovascular disease (Joakimsen *et al*., 2000) and osteoporosis (Harlow and Signorello, 2000). Further, early age at menopause is associated with a significant increase in mortality (Snowdon *et al*., 1989; Rivera *et al*., 2009).

The known causes of POF are heterogeneous; they include genetic factors, ovarian autoimmunity, infection (mumps) and treatment with anticancer drugs (reviewed by Goswami and Conway, 2005). However, the majority of POF cases are idiopathic (Beck-Peccoz and Persani, 2006). Based on animal studies, it is plausible that chemical exposures may be associated with POF (reviewed by Sharara *et al*., 1998); however, no human data supporting this theory exist. Hairdressers constitute a major occupational group of female workers of reproductive age who sustain chemical exposures during their reproductive lifespan. This report presents findings from a large population-based study of hairdressers and women in other occupations on the association between the occupation of hairdresser and the risk of POF.

Materials and Methods

Detailed methods of the Reproductive Outcomes in Salon Employees study are published elsewhere (Gallicchio *et al*., 2009). Briefly, data on reproductive health were collected from 450 hairdressers and 511 women employed in other occupations using a 51-page survey that was mailed to registered female hairdressers and non-hairdressers aged 21–55 years in the Baltimore area and its surrounding counties. Names and addresses of potential participants in the selected occupations and age range were obtained from a commercial mailing house and recruitment proceeded via a mass mailing, which took place in waves from September 2005 through October 2008. Surveys were sent to 3986 hairdressers and 2008 non-hairdressers with valid addresses, of whom 846 (21.1%) and 698 (34.8%) returned the survey, respectively. Those who returned the survey but were not included in the final analytic dataset were excluded due to various reasons, including: not in the

Table I Characteristics of study sample

	Hairdressers		Non-hairdressers		*P*-value
	n	%	*n*	%	
Sample size	443		508		
Age, years, mean (SD)	43.7	6.4	42.3	7.9	<0.01
Race					0.08
Caucasian	384	86.7	435	85.6	
African-American	44	9.9	51	10.0	
Other	6	1.4	19	3.7	
Education					<0.01
Some high school	7	1.6	7	1.4	
High school/GED	116	26.2	42	8.3	
Some college/tech	163	36.8	109	21.5	
College/tech degree	120	27.1	130	25.6	
Some graduate school	11	2.5	49	9.6	
Graduate degree	15	3.4	167	32.9	
Marital status					0.44
Single	32	7.2	49	9.6	
Married	324	73.1	369	72.6	
Widowed	10	2.3	6	1.2	
Divorced/separated	48	10.8	63	12.4	
Partners	18	4.1	19	3.7	
Household income					<0.01
<$20 000	27	6.1	14	2.8	
$20 000–49 000	74	16.7	63	12.4	
$50 000–99 000	206	46.5	223	43.9	
≥$100,000	106	23.9	191	37.6	
Employment status					<0.01
Full time	237	53.5	392	77.2	
Part time	191	43.1	100	19.7	
Student	1	0.2	5	1.0	
Medical leave	4	0.9	3	0.6	
Body mass index (kg/m^2)					0.17
<18.5	3	0.7	11	2.2	
18.5–24.9	171	38.6	186	36.6	
25.0–29.9	137	30.9	154	30.3	
≥30.0	111	25.1	147	28.9	
Smoking status					<0.01
Current	94	21.2	83	16.3	
Former	168	37.9	133	26.2	
Never	175	39.5	288	56.7	
Alcohol drinking status					0.14
Current	290	65.5	303	59.6	
Former	123	27.8	171	33.7	
Never	28	6.3	31	6.1	
Oral contraceptive use					0.03
Current	62	14.0	95	18.7	
Former	338	76.3	349	68.7	
Never	41	9.3	62	12.2	

Continued

Table I *Continued*

	Hairdressers		Non-hairdressers		*P*-value
	n	%	*n*	%	
Insurance					0.04
None	33	7.4	18	3.5	
Medicare/Medicaid	9	2.0	7	1.4	
Conventional	253	57.1	315	62.0	
Health maintenance organization	119	26.9	127	25.0	
Other/mixed coverage	25	5.6	39	7.7	
Last visit to regular doctor					0.09
Never	5	1.1	3	0.6	
<1 year ago	313	70.7	323	63.6	
1–2 years ago	84	19.0	120	23.6	
3–5 years ago	20	4.5	35	6.9	
>5 years ago	14	3.2	22	4.3	

targeted age range, reported having a hysterectomy or oophorectomy, not currently employed, and did not complete more than 50% of the survey. Occupation was classified as the current occupation reported by the participant at the time of the survey, and all hairdressers were confirmed to be employed as hairdressers by their responses to detailed work history questions. Teachers comprised ~44% of the comparison group, although women in the medical profession, including nurses, were 21.7% of the comparison group. A woman was considered to have POF if she responded 'yes' to the question of whether she had ever been told by a doctor that she had POF (or early menopause). Data on all variables, including race, were self-reported. The study was approved by the Institutional Review Boards at the University of Illinois Urbana-Champaign and Johns Hopkins University. Informed consent was implied by return of the questionnaire.

There were three non-hairdressers and seven hairdressers who had missing data on POF and they were therefore excluded from this analysis. Characteristics of the hairdressers and the women in other occupations were compared using χ^2 tests for categorical variables and Student's *t*-tests for continuous variables. The unadjusted and confounder-adjusted associations between occupation and POF were examined using Cox proportional hazards regression modeling. The person-years of follow-up for each woman were calculated from age 0 (birth) to either age at menopause for those women who reported having undergone menopause (including those who had been diagnosed with POF) or age at the time of survey completion for those women who were still menstruating. Thus, women who had not undergone menopause at the time of survey completion were censored at their age at the time of the survey. Potential confounders were selected among the following demographic and health-related characteristics: race, education, marital status, household income, employment status (full time/part time), body mass index, current cigarette smoking, current alcohol use, current oral contraceptive use, health insurance and time since last visit to a primary care doctor. Variables were included in the final model if they were associated with both POF and occupation at a significance level of $P < 0.1$. The final model included age (continuous) and current cigarette smoking (self-reported yes/no). Current oral contraceptive use was not significantly associated with POF and, therefore, was not included in the final model. Because exposures in hair salons may differ by race (Blackmore-Prince *et al.*, 1999; Herdt-Losavio *et al.*, 2009) and the majority of the sample was Caucasian, analyses were conducted first among the whole sample and then among Caucasians only. Further analyses were limited to women aged 40 years or older. All analyses were conducted using SAS, Version 9.1 (Cary, North Carolina, USA).

Results

Compared with the non-hairdressers, hairdressers were significantly older and less likely to have: a graduate degree or some graduate schooling, have a household income of $100 000 or greater, be employed full-time, be currently using oral contraceptives, or have health insurance (Table I). Conversely, the hairdressers were significantly more likely to report that they were current smokers compared with their counterparts. There were no statistically significantly differences between the two groups in terms of race, marital status, body mass index, alcohol drinking or time since the last visit to a primary care doctor.

Among the 443 hairdressers and 508 women in other occupations included in the analyses, 14 (3.2%) and 7 (1.4%) developed POF, respectively ($P = 0.06$). In the entire sample, a non-significant increase in the risk of POF was observed among the hairdressers compared with the non-hairdressers after adjustment for age, current cigarette smoking and current alcohol use (Table II; relative risk (RR) 1.90; 95% confidence interval (CI) 0.76, 4.72). When limited to Caucasian women only, the strength of the association was greater and statistically significant (RR 3.24; 95% CI 1.06, 9.91). In addition, among Caucasian women >40 years of age, hairdressers were more than five times as likely to report POF compared with non-hairdressers after adjustment for smoking and alcohol use (RR 5.58; 95% CI 1.24, 25.22).

Discussion

The findings from this study indicate that hairdressers may be at increased risk of POF compared with women of reproductive age in other occupations. To our knowledge, this study is the first study to report results on this association, although one study observed a

Table II RRs and 95% CIs for POF among hairdressers compared with non-hairdressers estimated using Cox proportional hazards regression

	POF cases	Person years[a]	Unadjusted RR (95% CI)	Adjusted RR (95% CI)[b]
All ages				
All races				
Non-hairdressers	7	20 887	1.00 (reference)	1.00 (reference)
Hairdressers	14	18 719	2.06 (0.83, 5.09)	1.90 (0.76, 4.72)
Caucasian women				
Non-hairdressers	4	17 963	1.00 (reference)	1.00 (reference)
Hairdressers	14	16 264	3.53 (1.16, 10.74)	3.24 (1.06, 9.91)
Ages 40–55 years				
All races				
Non-hairdressers	5	14 539	1.00 (reference)	1.00 (reference)
Hairdressers	12	14 232	2.46 (0.87, 6.97)	2.31 (0.81, 6.62)
Caucasian women				
Non-hairdressers	2	12 891	1.00 (reference)	1.00 (reference)
Hairdressers	11	12 352	5.78 (1.29, 25.82)	5.58 (1.24, 25.22)

95% CI = 95% confidence interval; RR = relative risk; POF = premature ovarian failure.
[a]Calculated from age 0 (birth) to either age at menopause for those women who reported having undergone menopause (including those who had been diagnosed with POF) or age at the time of survey completion for those women who were still menstruating.
[b]Adjusted for age and current smoking (yes/no).

significant increase in the risk of amenorrhea (absence of menstruation for 6 months) among hairdressers compared with clothing saleswomen in the Netherlands (Blatter and Zielhuis, 1993). Hairdressers are exposed to a number of chemicals used in the workplace that have the potential to be associated with an increased risk of adverse reproductive outcomes (Moorman *et al*., 2000); these chemicals include solvents, bleaches, hair dyes, non-lye relaxers, alcohols, ethylene glycol, methacrylate and phthalates (Moorman *et al*., 2000).

In the current study, we did not measure specific chemicals present in hairdressers versus the non-hairdressers. However, it is possible that solvent exposure may be associated with the observed POF in hairdressers because they are routinely exposed to solvents and some studies have shown an association between solvent use and adverse reproductive outcomes (Eskenazi *et al*., 1991; Sharara *et al*., 1998). In one study, women who reported solvent use during painting had an increased risk of infertility compared with women who did not use solvents (OR 1.74; 95% CI 1.11, 8.3) (Eskenazi *et al*., 1991). In additional studies, organic solvents were found to be associated with reduced fecundability (reviewed by Sharara *et al*., 1998).

Although studies have not examined whether other chemicals used in hair salons are associated with POF in women, studies indicate that several of these chemicals destroy ovarian follicles and reduce female fertility in animal models (Marsman, 1995; Bolon *et al*., 1997; Moorman *et al*., 2000). For example, Bolon *et al*. (1997) showed that 2,2 bis(BM)1,3-propanediol significantly decreases follicle numbers in a dose-dependent manner in CD-1 mice. Studies from the National Toxicology Program indicate that *N*-methylolacrylamide significantly reduces ovarian weight in rats (an indirect indicator of follicle loss) (National Toxicology Program, 1989). Fort *et al*. (2001) showed that ethylene glycol monomethyl ether significantly reduces oocyte counts in Xenopus laevis. In addition, Davis *et al*. (1994) and Lovekamp-Swan and Davis (2003) have shown that phthalates significantly reduce the number of large pre-ovulatory follicles and thus, ovulations in rats. Given the ability of such chemicals to destroy ovarian follicles and the use of these chemicals by hairdressers, future studies should determine whether hairdressers have high levels of selected chemicals and whether such chemicals mediate the association between hairdressers and POF.

Although, to our knowledge, this study is the first to report results pertaining to hairdressers and POF, findings from other studies have also indicated poorer reproductive health among hairdressers compared with women in other occupations, when using other end-points. For example, a recent publication by Halliday-Bell *et al*. (2009) showed that, in the Finnish population from 1990 to 2004, hairdressers and cosmetologists had an increased risk of having a low birthweight child and a preterm delivery compared with teachers of the same age. Similarly, Herdt-Losavio *et al*. (2009) found a positive association between working as a cosmetologist and having low birthweight baby, among women of reproductive age in New York State. Results from these studies are consistent with some of the other published research, including studies from the Netherlands (Kersemaekers *et al*. 1997) and Sweden (Rylander and Kallen, 2005); however, other investigations have shown that hairdressers are not at increased risk for adverse reproductive health outcomes. In a study examining pregnancy outcomes among female hairdressers who participated in the Danish National Birth Cohort, Zhu *et al*. (2006) reported no significant differences in fetal loss, preterm birth, small-for-gestational age, congenital malformations or achievements of developmental milestones among the children of hairdressers and shop assistants. In addition, a published analysis from the present study showed no statistically significant associations between being a cosmetologist/hairdresser and adverse pregnancy outcomes (Gallicchio *et al*., 2009).

Although this study is the first to report a significant increase in the risk of POF among hairdressers compared with working women in other occupations of similar ages, several study limitations must be considered when interpreting the results. First, the association could be due to an unmeasured confounder, as it is possible that hairdressers differ from the comparison group on characteristics or exposures unrelated to occupation for which data were not collected. In the majority of POF cases, the etiology is unknown; collection of data in this study was limited to known risk factors for POF such as cigarette smoking. There is also the potential for residual confounding for those factors that were included in the regression models in the study; for instance, cigarette smoking was based on self-report, thus increasing the likelihood of misclassification, and in the regression analysis it was treated as a dichotomous variable. Additionally, because of the small number of POF cases, we were not able to examine hairdresser occupation and POF among African-American women only or among women of other races. There may be inherent genetic and salon-related chemical exposure differences by race (Blackmore-Prince *et al*., 1999; Herdt-Losavio *et al*., 2009); this should be further explored in future studies.

Finally, as with many survey-based studies, the response rate of this survey was low among both the hairdressers and the non-hairdressers. The women who were mailed the questionnaire and completed it are likely to differ from those who did not complete the questionnaire; if this is the case, our results are generalizable only to those hairdressers and non-hairdressers who are likely to be study participants. In this study, no data on the non-responders were collected and, therefore, we were not able to compare the responders to the non-responders in terms of demographic or occupational characteristics. It is also possible that women not completing the questionnaire were more likely to be diagnosed with POF than those who did complete the questionnaire. If this differed by occupation such that hairdressers not responding to the mailed survey were more likely to be diagnosed with POF than those who completed the questionnaire and non-hairdressers who did and did not respond had an equal likelihood of being diagnosed with POF, the risk estimates reported in this manuscript could be biased towards the null.

The results presented in this study suggest hairdressers may be at increased risk for POF compared with women of the same age employed in other occupations. Future research should be conducted to elucidate the cause of this association, focusing specifically on the chemical exposures that have been shown in animal models to destroy ovarian follicles.

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