



Infertility among cosmetologists

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ABSTRACT

Although chemicals used in hair salons have been linked to infertility in animal models, little is known about whether exposures in hair salons are associated with infertility in women. Thus, a survey-based study was performed to investigate infertility in 448 cosmetologists and 508 non-cosmetologists working in Baltimore, Maryland and its surrounding counties. Infertility was assessed with questions addressing time-to-pregnancy (TTP) length (≥ 12 months), consulting a medical professional about fertility problems, and taking medication to become or maintain a pregnancy. Occupational exposure was assessed by job tasks and customers served per week. There were no statistically significant associations between working as a cosmetologist and the odds of TTP ≥ 12 months, consulting a medical professional about infertility, or taking medication to either become or maintain a pregnancy. The data suggest that cosmetologists are not at increased risk for infertility compared to women of the same age working in other occupations.

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1. Introduction

Infertility is a common problem, affecting 1 in 7 married couples and 10–20% of women in the United States [1–5]. In 2002, about 7.3 million American women had a time-to-pregnancy (TTP) of ≥ 12 months, the accepted measurement for infertility, with 2 million women still within their reproductive lifespan remaining infertile even with various forms of alternative reproductive treatment [6]. Infertility in women stems mostly from physical problems in the reproductive system such as retarded oocyte development in the ovary, interrupted transport of the oocyte through fallopian tubes, and improper preparation of the uterine endometrium for implantation. Although in some cases the reason for such physical problems is unknown, some studies suggest that environmental chemicals can cause these types of physical problems in the reproductive system and, thus, may lead to infertility [2,4,7].

Cosmetologists are routinely exposed to various chemical agents, including phthalates, toluene, xylene, formaldehyde, and dimethylaniline, that are present in hair and nail products in salons [8–10]. While some studies have reported possible reproductive problems and adverse pregnancy outcomes, such as miscarriage

and stillbirth, after exposure to dye formulations, dibutylphthalate, formaldehyde, xylene, toluene, and other organic solvents [9–12], few studies have directly focused on the association between occupational chemical exposure and infertility. Further, the results of the few studies that have directly examined this association are equivocal. One large study in Sweden observed a statistically significant 10% decline in successful conception among female cosmetologists compared to women in other professions [12]. Another study in Norway also observed an increased risk of infertility among female cosmetologists [13]. In contrast, other studies in Sweden, Denmark, and the Netherlands have shown no difference in fertility between cosmetologists and non-cosmetologists [4,14,15]. To date, no studies have been published on infertility in cosmetologists in the United States. Thus, we conducted a large survey-based study in Baltimore, Maryland and its surrounding counties to examine the association between working as a cosmetologist and infertility.

2. Methods and materials

2.1. Study sample

This analysis was conducted as part of the Reproductive Outcomes in Salon Employees (ROSE) study. Detailed methods for the ROSE study have been published previously [16]. Briefly, the names and addresses of cosmetologists and non-cosmetologists between 21 and 55 years of age were obtained from a commercial mailing house. This age range was selected to increase the likelihood that women recruited into the study would be within their reproductive lifespan, able to accurately recall exposure and reproductive histories, not be post-menopausal, and not be retired. The non-cosmetologist group of women was selected because their

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socioeconomic status, education level, stress, and workplace environments were similar to cosmetologists, with the exception that they are not regularly exposed at their workplaces to chemicals found in salons.

Each woman whose name and address was obtained from the commercial mailing house was sent a recruitment packet containing an explanation of the study. To minimize selection and response bias, the study was presented as a general health study of working women. The recruitment packet also contained a 51-page questionnaire, a \$1.00 monetary incentive, and a stamped and addressed return envelope.

To be included into the final study sample, a woman had to be between 21 and 55 years of age, have an intact uterus and both ovaries, and to be currently or previously employed as a cosmetologist or in an occupation with similar hours and salary to cosmetologists, but without the chemical exposures.

Survey packets were sent to 4228 registered cosmetologists, of which 242 were returned because of incorrect addresses. Among the remaining 3986 mailed surveys, 452 surveys were completed and returned by women who met the eligibility criteria, and 394 surveys were mailed back by women who did not meet the eligibility requirements or did not want to participate in the study. Four of the women who were classified by the mailing house as cosmetologists and who completed surveys were reclassified as being non-cosmetologists after details in the questionnaire revealed that the participant did not work in a hair salon.

Of the surveys sent to 2118 women in other professions, 115 surveys were returned because of incorrect addresses. Among the remaining 2003 surveys, 189 surveys were mailed back by women who did not meet the eligibility requirements; 509 surveys were completed by women who met the eligibility criteria. Two of the women who were classified by the mailing house as non-cosmetologists and who completed surveys were reclassified as being cosmetologists after details in the questionnaire revealed the women were working as cosmetologists. Thus, 450 cosmetologists and 511 women in other occupations made up the study sample.

2.2. Data collection

All data were self-reported using the mailed survey. This survey obtained detailed demographic, occupational, and reproductive histories. The main outcome variable in this analysis was infertility, which was assessed by questions regarding time-to-pregnancy of ≥ 12 months, whether the women sought and/or acquired diagnoses of infertility from a doctor or nurse, whether the women took medication to become pregnant, or whether she took medication to maintain pregnancy. In addition, the questionnaire collected information on potential confounding variables such as smoking, alcohol use, oral contraceptive use, body mass index (BMI), education, and socioeconomic status.

2.3. Data analysis

Two cosmetologists and three non-cosmetologists were missing information on fertility history and were excluded from this analysis. Characteristics of the cosmetologists and the women in other occupations were compared using chi-square tests for categorical variables and Student's *t*-tests for continuous variables. Multivariate analysis examining the age- and confounder-adjusted associations between occupation and the infertility outcomes was conducted using logistic regression. Potential confounders were selected among the following demographic, health habit, and medical seeking behavior characteristics: race, education, marital status, employment status (full time/part time), BMI, cigarette smoking, current alcohol use, oral contraceptive use, health insurance, and time since last visit to primary care doctor. Variables were included in the final model if they were associated with both infertility and occupation at a significance level of $p < 0.1$. Further, some variables (age, race, BMI, alcohol use, and smoking status) were included in the final model if they did not meet the criteria above because they have been shown in the published literature to be associated with infertility. The final model included age (continuous), race (white/non-white), education (at least some college/no college), BMI (≥ 30 kg/m²/25–29.9 kg/m²/ < 25.0 kg/m²) marital status (married/other), cigarette smoking (current/former/never), and current alcohol use (use of at least 12 alcohol beverages in the past year; yes/no).

A large number of women in the non-cosmetologist sample were working in professions that are thought to be professional (versus non-professional) positions. These women may be more likely to seek treatment for infertility and, therefore, to answer affirmatively to questions pertaining to infertility. Therefore, we sought to compare the cosmetologists to the subset of the non-cosmetologists considered 'non-professionals.' For these analyses, women in the comparison group were categorized as 'professionals' if they reported themselves as professionals, realtors, teachers, nurses, or in the technical (computer) field. Women were categorized as 'non-professionals' if they reported themselves to be administrative assistants or in the service or sales industries. The logistic regression analyses described above were first performed for cosmetologists compared to all non-cosmetologists and then for cosmetologists compared to only the non-professional non-cosmetologists.

Age-adjusted logistic regression models were also constructed to examine whether certain job tasks were associated with infertility among cosmetologists. The independent variable for these analyses was each specific task for which the cosmetologists were queried on the questionnaire; the dependent variable was infertility assessed by TTP > 12 months. Dose–response associations between infer-

tility and the numbers of customers per week serviced on a specific task or the number of hours per week working on a specific task were also examined using the median customers/hours reported by the cosmetologists for that specific task. Because non-cosmetologists were not expected to have performed these tasks in their occupations, they were not asked these questions on the survey and, thus, were not included in this analysis.

This study was approved by the Institutional Review Boards (IRB) at the University of Illinois, Urbana-Champaign and Johns Hopkins University.

3. Results

Compared to women in other professions, cosmetologists were significantly less likely to have a college degree or graduate schooling, to have a household income of at least \$100,000, to be employed full-time, and to have health insurance (Table 1). Conversely, cosmetologists were significantly more likely to report that they were current or former smokers compared to the non-cosmetologists. There were no statistically significant differences between the two groups in terms of race, marital status, BMI, alcohol drinking, ever use of oral contraceptives, and time since last visit to a primary care doctor.

Among the 448 cosmetologists and 508 non-cosmetologists included in the analysis, 73 (16.3%) and 104 (20.5%) reported a TTP of ≥ 12 months, respectively ($p = 0.1$). A small, non-significant decrease in the odds of a TTP ≥ 12 months was observed among cosmetologists compared to the non-cosmetologists after adjustment for age, BMI, marital status, education, smoking habits, and current alcohol use (Table 2; odds ratio (OR) 0.82; 95% confidence interval (CI) 0.57, 1.17). The fully-adjusted OR for TTP ≥ 12 months was close to 1 and not statistically significant when the cosmetologists were compared to the non-professional non-cosmetologist comparison group only (OR 0.98; 95% CI 0.54, 1.78).

Women were also asked in the survey if they sought and/or acquired a diagnosis of infertility from a doctor or nurse. A total of 57 cosmetologists (12.7%) and 94 non-cosmetologists (18.5%) reported that they had consulted a doctor or nurse about infertility ($p = 0.01$). Consistent with the results for TTP ≥ 12 months, a small, non-significant decrease in the odds of obtaining a formal diagnosis of infertility was observed among the cosmetologists compared to the non-cosmetologists after adjustment for age, BMI, marital status, education, smoking habits, and current alcohol use (Table 2; OR 0.76; 95% CI 0.51, 1.12). A similar OR was observed when comparing the cosmetologists to the non-professional non-cosmetologist group only (OR 0.72; 95% CI 0.39, 1.33).

Few cosmetologists and women in the comparison group reported taking a medication to become pregnant or a medication to maintain pregnancy. Although the odds of taking a medication to become pregnant or taking a medication to maintain pregnancy were lower among cosmetologists compared to the entire non-cosmetologist comparison group, the results were not statistically significant after adjustment for age, BMI, marital status, education, smoking habits, and current alcohol drinking (medication to become pregnant: OR 0.70; 95% CI 0.40, 1.24; medication to maintain pregnancy: OR 0.68; 95% CI 0.36, 1.26). In addition, the strength of the ORs for these outcomes was decreased when the cosmetologists were compared to the non-professional non-cosmetologists only (medication to become pregnant: OR 0.84; 95% CI 0.32, 2.20; medication to maintain pregnancy: OR 0.84; 95% CI 0.30, 2.38).

Results from the age-adjusted analysis of job tasks among cosmetologists and TTP ≥ 12 months are shown in Table 3. Handling cleaning supplies was associated with a 70% increase in the risk of TTP > 12 months (OR 1.70; 95% CI 1.01, 2.86); however, there was not a dose–response relationship between hours per week handling cleaning supplies and the investigated outcome. Further, there were no statistically significant associations between the other job tasks in a salon and infertility. For example, cosmetologists who reported bleaching hair of customers did not have significantly different odds

Table 1
Characteristics of cosmetologists and women in other occupations.

	Cosmetologists		Other occupations		p-Value
	n	%	n	%	
Sample size	448		508		
Current occupation					
Cosmetologist	448	100.0	–		
Professional	–		400	78.7	
Non-professional	–		108	21.3	
Age, years, mean (SD)	43.6	(6.4)	42.3	(7.9)	0.004
Race					0.1
Caucasian	388	86.6	435	85.6	
African-American	43	9.6	51	10.0	
Other	7	1.6	19	3.7	
Education					<0.0001
Some high school	8	1.8	7	1.4	
High school/GED	118	26.3	42	8.3	
Some college/tech	162	36.2	108	21.3	
College/tech degree	122	27.2	129	25.4	
Some graduate school	12	2.7	47	9.3	
Graduate degree	15	3.3	171	33.7	
Marital status					0.4
Single	32	7.1	49	9.6	
Married	330	73.7	371	73.0	
Widowed	10	2.2	6	1.2	
Divorced/separated	47	10.5	62	12.2	
Partners	18	4.0	18	3.5	
Household income					<0.0001
<\$20,000	28	6.3	14	2.8	
\$20,000–49,000	74	16.5	62	12.2	
\$50,000–99,000	209	46.7	222	43.7	
\$100,000+	107	23.9	192	37.8	
Employment status					<0.0001
Full time	240	53.6	393	77.4	
Part time	192	42.9	99	19.5	
Student	1	0.2	5	1.0	
Medical leave	4	0.9	3	0.6	
Body mass index (kg/m ²)					0.2
<18.5	3	0.7	10	2.0	
18.5–24.9	172	38.4	187	36.8	
25.0–29.9	139	31.0	153	30.1	
>30.0	113	25.2	148	29.1	
Smoking status at survey					<0.0001
Current	97	21.7	83	16.3	
Former	168	37.5	132	26.0	
Never	175	39.1	289	56.9	
Smoking pack-year history					<0.0001
≥25 pack years	55	12.3	34	6.7	
<25 pack years	196	43.8	178	35.0	
Never smoked	175	39.1	289	56.9	
Alcohol drinking status					0.1
Current	293	65.4	303	59.6	
Former	124	27.7	171	33.7	
Never	28	6.3	31	6.1	
Ever used oral contraceptives					0.1
Yes	404	90.2	444	87.4	
No	42	9.4	63	12.4	
Insurance					0.04
None	33	7.4	18	3.5	
Medicare/Medicaid	9	2.0	7	1.4	
Conventional	254	56.7	315	62.0	
HMO	120	26.8	126	24.8	
Other/mixed	26	5.8	39	7.7	
Last visit to regular doctor					0.08
Never	5	1.1	3	0.6	
<1 year	315	70.3	323	63.6	
1–2 years	84	18.8	120	23.6	
3–5 years	20	4.5	35	6.9	
>5 years	14	3.1	22	4.3	

Note: percentages for some characteristics may not equal 100% due to missing data.

Table 2
Age- and fully-adjusted odds ratios (ORs) and 95% confidence intervals (95% CI) for infertility outcomes among cosmetologists.

	n	%	Age-adjusted OR (95% CI)	Fully-adjusted OR (95% CI) ^a
Time-to-pregnancy ≥ 12 months				
All non-cosmetologists	104	20.5	1.0 (ref)	1.0 (ref)
Cosmetologists	73	16.3	0.76 (0.54, 1.06)	0.82 (0.57, 1.17)
Non-professional non-cosmetologists				
Professional non-cosmetologists	85	21.3	1.27 (0.73, 2.21)	1.26 (0.69, 2.30)
Cosmetologists	73	16.3	0.92 (0.53, 1.61)	0.98 (0.54, 1.78)
Consult doctor or nurse about infertility				
All non-cosmetologists	94	18.5	1.0 (ref)	1.0 (ref)
Cosmetologists	57	12.7	0.65 (0.45, 0.93)	0.76 (0.51, 1.12)
Non-professional non-cosmetologists				
Professional non-cosmetologists	76	19.0	1.20 (0.68, 2.12)	0.93 (0.50, 1.73)
Cosmetologists	57	12.7	0.75 (0.42, 1.35)	0.72 (0.39, 1.33)
Medication to become pregnant				
All non-cosmetologists	46	9.1	1.0 (ref)	1.0 (ref)
Cosmetologists	21	4.7	0.49 (0.29, 0.84)	0.70 (0.40, 1.24)
Non-professional non-cosmetologists				
Professional non-cosmetologists	39	9.8	1.59 (0.69, 3.67)	1.25 (0.49, 3.17)
Cosmetologists	21	4.7	0.72 (0.30, 1.76)	0.84 (0.32, 2.20)
Medication to maintain pregnancy				
All non-cosmetologists	37	7.3	1.0 (ref)	1.0 (ref)
Cosmetologists	18	4.0	0.55 (0.31, 0.98)	0.68 (0.36, 1.26)
Non-professional non-cosmetologists				
Professional non-cosmetologists	32	8.0	1.90 (0.72, 5.02)	1.30 (0.47, 3.59)
Cosmetologists	18	4.0	0.94 (0.34, 2.60)	0.84 (0.30, 2.38)

^a Adjusted for age (continuous), race (white/non-white), education (at least some college/no college), BMI (≥ 30 kg/m²/25–29.9 kg/m²/ <25.0 kg/m²) marital status (married/other), cigarette smoking (current/former/never), and current alcohol use (use of at least 12 alcohol beverages in the past year; yes/no).

of TTP ≥ 12 months than cosmetologists who reported not bleaching hair of customers (OR 0.76; 95% CI 0.45, 1.26). Additionally, there was no evidence of a dose–response relationship between the number of customers served per week on a specific task or the number of hours per week working in a specific task and TTP ≥ 12 months.

4. Discussion

Recent studies have shown that environmental exposures to chemicals such as selenium, ethylene glycol monomethyl ether, and phthalates may be associated with poor reproductive function and, therefore, reduced fertility [15]. As cosmetologists are occupationally exposed to many chemicals in various job tasks in a salon, they may be at increased risk for infertility. However, findings from this survey-based cross-sectional study, which is one of the first studies in the United States and one of the few studies in the world to examine fertility among cosmetologists, indicate that cosmetologists are not at an increased risk for infertility compared to women of the same age working in other occupations. These results were consistent when using different infertility outcomes (TTP ≥ 12 months, talking with a doctor or nurse about infertility, taking medication to become pregnant, and taking medication to maintain a pregnancy) and different comparison groups (all non-cosmetologists and non-professional non-cosmetologists only).

Similar to the results of our study, a Danish study showed no significant difference in the number of hospital visits due to infertility, as coded in the Danish Hospital Register, among hairdressers compared to shop assistants [4]. While the results of this study were similar to ours, the Danish study had a number of limitations, including the use of a control group that may have been exposed to similar amounts of salon chemicals as the hairdressers and the lack of detailed data on specific job tasks. Another study in the Netherlands also indicated no association between the hairdressing occupation and having a TTP ≥ 12 months [14]. This study was

questionnaire- rather than registry-based and had participant characteristics similar to those in our study. The investigators did not obtain information about different job tasks.

In contrast to the findings from our study, several published studies have reported a statistically significant association between infertility and some chemicals that are present in salon products. Smith et al. [11], while not investigating chemical exposure in hair salons or cosmetologists directly, reported finding an association of infertility among women exposed to toluene, xylene, hairspray, other paint-related solvents, and volatile organic solvents. Axmon et al. [12] also reported that hairdressers were less successful than non-hairdressers in conceiving, though the results were only significant when TTP was considered as a continuous variable (fecundability ratio = 0.91, 95% CI 0.83, 0.99). The percentage of women who had a TTP ≥ 12 months was only slightly higher in hairdressers ($N = 113$; 7%) compared to non-hairdressers ($N = 91$; 6%). When women who became pregnant within 1 month of trying were excluded from the analysis (“birth control bias”) the difference between hairdressers and non-hairdressers was no longer significant (fecundability ratio = 0.96, 95% CI 0.87, 1.07). When hairdressers who were exposed to chemicals in salons with certainty were compared to the non-hairdressers, there was no longer a significant difference of TTP (fecundability = 0.95, 95% CI 0.87, 1.03). Further, Baste et al. [13] showed a significant increase in infertility among hairdressers compared to non-hairdressers and also shop assistants. The results were not only attributed to potential occupational chemical exposures in a hair salon, but also to physical demands on hairdressers while working such as standing upright and walking most of the day. Nonetheless, further adjusted analyses controlling for standing and walking most of the day indicated that chemical exposure was the key problem concerning infertility.

This current study had several strengths. First, this study was specifically designed to examine associations between cosmetologists and fertility in the general population. Secondly, the

Table 3
Age-adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for the associations between cosmetologist's job tasks and time to pregnancy (TTP) \geq 12 months.

Cosmetologist job task	Age-adjusted OR (95% CI)
Wait on customers	
No	1.0 (ref)
Yes	0.95 (0.54, 1.68)
<27 h/week	0.94 (0.50, 1.79)
\geq 27 h/week	0.96 (0.51, 1.82)
Handle cash	
No	1.0 (ref)
Yes	1.37 (0.78, 2.42)
\leq 8 h/week	1.53 (0.81, 2.87)
>8 h/week	1.22 (0.64, 2.35)
Handle cleaning supplies	
No	1.0 (ref)
Yes	1.70 (1.01, 2.86)
<3 h/week	1.80 (0.95, 3.42)
\geq 3 h/week	1.63 (0.91, 2.95)
Wash hair	
No	1.0 (ref)
Yes	0.86 (0.49, 1.53)
<20 customers/week	1.10 (0.59, 2.07)
\geq 20 customers/week	0.67 (0.35, 1.30)
Dye/color/highlight hair	
No	1.0 (ref)
Yes	0.87 (0.50, 1.52)
<10 customers/week	0.92 (0.47, 1.79)
\geq 10 customers/week	0.84 (0.46, 1.55)
Bleach hair	
No	1.0 (ref)
Yes	0.76 (0.45, 1.26)
<5 customers/week	0.91 (0.49, 1.68)
\geq 5 customers/week	0.65 (0.36, 1.19)
Perm hair	
No	1.0 (ref)
Yes	0.72 (0.41, 1.24)
<5 customers/week	0.74 (0.39, 1.41)
\geq 5 customers/week	0.69 (0.37, 1.29)
Straighten hair	
No	1.0 (ref)
Yes	0.67 (0.37, 1.23)
\leq 1 customers/week	0.68 (0.32, 1.45)
>1 customers/week	0.66 (0.28, 1.56)
Texturize hair	
No	1.0 (ref)
Yes	0.61 (0.35, 1.07)
<10 customers/week	0.79 (0.38, 1.66)
\geq 10 customers/week	0.50 (0.24, 1.03)
Apply hair conditioning treatments	
No	1.0 (ref)
Yes	0.73 (0.44, 1.23)
<10 customers/week	0.54 (0.27, 1.07)
\geq 10 customers/week	0.88 (0.50, 1.56)
Apply hair relaxers	
No	1.0 (ref)
Yes	0.71 (0.38, 1.34)
\leq 1 customers/week	0.72 (0.32, 1.59)
>1 customers/week	0.71 (0.29, 1.77)
Cut/style/blow dry hair	
No	1.0 (ref)
Yes	0.80 (0.45, 1.42)
<30 customers/week	0.76 (0.39, 1.48)
\geq 30 customers/week	0.83 (0.44, 1.56)
Spray hair with hairspray	
No	1.0 (ref)
Yes	0.80 (0.45, 1.43)
<30 customers/week	0.74 (0.38, 1.42)
\geq 30 customers/week	0.87 (0.46, 1.64)
Makeup/skin care	
No	1.0 (ref)

Table 3 (Continued).

Cosmetologist job task	Age-adjusted OR (95% CI)
Yes	0.65 (0.22, 1.90)
\leq 5 customers/week	0.29 (0.04, 2.17)
>5 customers/week	1.14 (0.31, 4.18)
Trim and file fingernails/toenails	
No	1.0 (ref)
Yes	1.42 (0.79, 2.55)
\leq 8 customers/week	0.88 (0.35, 2.18)
>8 customers/week	2.01 (0.99, 4.08)
Apply polish to fingernails/toenails	
No	1.0 (ref)
Yes	1.64 (0.94, 2.86)
<10 customers/week	1.83 (0.87, 3.85)
\geq 10 customers/week	1.49 (0.73, 3.05)
Apply/fill acrylic nail enhancements	
No	1.0 (ref)
Yes	1.68 (0.89, 3.19)
<10 customers/week	2.66 (1.14, 6.23)
\geq 10 customers/week	1.12 (0.46, 2.70)
Apply/fill gel nail enhancements	
No	1.0 (ref)
Yes	0.88 (0.32, 2.43)
<10 customers/week	0.75 (0.16, 3.45)
\geq 10 customers/week	1.00 (0.27, 3.76)
Remove acrylic nail enhancements	
No	1.0 (ref)
Yes	1.15 (0.52, 2.56)
<4 customers/week	1.75 (0.65, 4.71)
\geq 4 customers/week	0.69 (0.20, 2.41)

study included detailed questions in the survey about reproductive history, occupational history, and specific job tasks in salons. Additionally, this study was not limited only to hairdressers but instead expanded the study to cosmetologists, which included hairdressers. Further, this study collected information on known potential confounders such as age, race, socioeconomic status, education level, BMI and health habits (smoking and alcohol use) by including questions about them in the survey. Finally, the comparison groups were women with similar race, BMI, stress, and workplace environments to cosmetologists, but without exposure to chemicals used regularly in salons.

Despite these strengths, the study also has some limitations. Other studies obtained information about cosmetologists and non-cosmetologists from national registries of economically active people based on keywords relating to cosmetologists and job titles [4,13,14]. Our study was survey-based and relied on self-reported information. Thus, there may have been some misclassification with regards to job description and types of exposures, although we have no reason to believe that the participants in the study were not accurate in reporting their current job titles or the chemicals that they are exposed to in salons. A second limitation is that information about specific exposures at the time of infertility was not collected; this precluded our ability to examine whether cases of infertility were directly associated with chemical exposures.

Furthermore, although mailed surveys typically produce low response rates [17], the response rate in this study was lower than other studies using mailed surveys. The low response rate may be due to the fact that certain occupational groups such as cosmetologists are less likely to participate in survey-based studies. While this has not been documented in the literature and information from non-responders was not available in our study, what has been shown is that middle-age women, minorities, and people within low-income ZIP codes are less likely to respond to questionnaires [17]. Some of these characteristics are similar to those comprising

the groups in our study. Finally, there is the possibility that women with fertility problems were less likely to participate in the study. Thus, the prevalence estimates of infertility among cosmetologists and among the comparison group could have been underestimated. Further, if participation among those with fertility problems differed by study group, the observed estimates of associations could be biased.

The data suggest that cosmetologists are not at increased risk for infertility compared to women of the same age working in other occupations. Future studies should examine whether cosmetologists are at an increased risk for other adverse reproductive health outcomes compared to non-cosmetologists.

Conflict of interest statement

Drs. Flaws, Miller, and Zacur, and Ms. Greene and Peretz do not have any potential conflicts of interest to disclose. Dr. Lisa Gallicchio is a paid consultant for Procter & Gamble. Procter & Gamble did not have anything to do with this study, but they may make some of the products used by cosmetologists.

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