

Spontaneous Abortions among Cosmetologists

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To examine the relation between adverse pregnancy outcomes and work in cosmetology during pregnancy, we conducted a mail survey in North Carolina among 8,356 licensed female cosmetologists 22-36 years of age. We identified pregnancies between 1983 and 1988 by a brief screening questionnaire, followed by a more detailed mail questionnaire. Seventy-four per cent of eligible cosmetologists responded to each inquiry. We restricted the main analysis to 96 cosmetologists with a spontaneous abortion and 547 cosmetologists with a single livebirth who worked full-time in cosmetology or in other jobs during the first trimester of

pregnancy. With adjusted odds ratios ranging from 1.4 to 2.0, we found associations between spontaneous abortion and the number of hours worked per day in cosmetology, the number of chemical services performed per week, the use of formaldehyde-based disinfectants, and work in salons where nail sculpturing was performed by other employees. We found no important associations among full-time cosmetologists who performed few chemical services and among cosmetologists who worked less than 35 hours per week. (Epidemiology 1994;5:147-155)

Keywords: spontaneous abortion, work during pregnancy, chemicals, hairdressers, cosmetology, alcohol, formaldehyde, working conditions.

Cosmetology, a predominantly female occupation comprising over half a million women in the United States,¹ has received little attention with regard to potential adverse reproductive outcomes. Cosmetologists (also called hairdressers, stylists, or beauticians) have daily contact with cosmetic products and thus are routinely exposed through inhalation or dermal absorption to a wide range of chemicals, including established toxins such as dyes and solvents,²⁻⁴ and they generally perform their work in a standing position. Exposure to chemicals during pregnancy has been associated with increased spontaneous abortion risk in various occupations.⁵⁻⁸ Little is currently known about the effect of prolonged standing on spontaneous abortion risk.⁹ Epidemiologic data are scant on adverse reproductive outcomes among cosmetologists. Several studies found no association between spontaneous

abortion and work in cosmetology,¹⁰⁻¹⁴ and findings on the association with stillbirth are inconsistent.^{15,16} Exposure assessment in these studies was based on job title only, and the numbers of cosmetologists studied tended to be small. Given these limitations, we conducted a more detailed study to assess whether work in cosmetology during the first trimester of pregnancy is associated with an increased risk of spontaneous abortion.

Methods

STUDY POPULATION

The study population was identified through the North Carolina cosmetology license registry. In April 1988, the registry included 34,737 cosmetologists with active licenses who were state residents. We were able to locate the licensing records for an estimated 92% of all cosmetologists listed in the computerized license registry, and through record review, we identified 8,356 female cosmetologists between the ages of 22 and 36 years, who were invited to participate in the study.

In the first phase of the study, we sent to all eligible cosmetologists a two-page screening questionnaire to identify cosmetologists who had recently been pregnant. Nonrespondents were followed up with a reminder postcard and two replacement questionnaires. To reduce potential selection and information bias, the survey was introduced as the North Carolina Cosmetology Health Study. To reduce potential bias

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associated with a long recall period, we restricted eligibility to the most recent pregnancy for which the last menstrual period before the pregnancy had occurred between April 1983 and March 1988. We estimated the date of the last menstrual period based on the self-reported duration of the pregnancy. Women were eligible for inclusion in the study if they had experienced a spontaneous abortion of less than 20 weeks gestation after the last menstrual period between 1983 and 1988. If multiple spontaneous abortions occurred during the 5-year period, only the most recent was included. Women without a spontaneous abortion during the 5-year period were eligible for inclusion in the study if the most recent pregnancy between 1983 and 1988 resulted in a single livebirth.

In the second phase of the study, we sent to cosmetologists with an eligible pregnancy a questionnaire that requested more detailed information on the outcome of the pregnancy, work exposures during pregnancy, and other risk factors for adverse pregnancy outcomes, such as reproductive history and maternal and paternal life-style factors. Nonrespondents were followed up with reminder letters and telephone calls.

EXPOSURE ASSESSMENT

We categorized the woman's work status during the first trimester of the index pregnancy as work in cosmetology, cosmetology student, work in other jobs, or work as a full-time homemaker. We classified women who worked in both cosmetology and other jobs as working in cosmetology. Women who worked in other jobs or as full-time homemakers and reported doing cosmetology work for family and friends were classified according to their main occupation.

The construction of cosmetology-related exposure variables was derived from information on self-reported work characteristics, including the number of hours worked per week, the number of hours per day spent standing and sitting, the number of customers per week, the number of specific services performed per week, the type of disinfectants used, and the wearing of protective gloves. Since cosmetologists may be exposed to air contaminants produced by other employees, we also constructed exposure variables derived from information on salon characteristics, including the number of cosmetologists working in the salon and the performance of manicuring or nail sculpting by other employees.

DATA ANALYSIS

We compared women with a spontaneous abortion with those with a livebirth regarding occupational

exposures during the first trimester of pregnancy. To eliminate any inherent differences among full-time workers, part-time workers, and homemakers, we restricted the main analysis to licensed cosmetologists who worked full-time (35 or more hours per week) in cosmetology or in other jobs during the first trimester of pregnancy. In all comparisons, we used licensed cosmetologists who worked full-time in other jobs during the first trimester of pregnancy as the unexposed reference group. To assess whether spontaneous abortion risk increased with exposure intensity, we categorized work characteristics thought to be indicative of exposure, such as the number of customers and chemical services per week and the number of hours per day spent standing, into approximate tertiles. The tertiles were defined by the distribution among women with a livebirth who worked full-time in other jobs during the first trimester of pregnancy. We also conducted separate analyses defining the exposed group as women who worked less than 35 hours per week in cosmetology.

We computed odds ratios (OR) and 95% confidence intervals (CI) to estimate the relative risk of spontaneous abortion associated with cosmetology-related work exposures. To assess confounding by other potential risk factors (that is, mother's age at conception, race, and education, family income, previous pregnancy loss, mother's alcohol consumption, cigarette smoking, and personal use of hair dyes and permanents during the first trimester of pregnancy), we performed stratified analyses and computed adjusted odds ratios (aOR) and 95% CI using the Mantel-Haenszel approach. Individual adjustment for potentially confounding variables did not appreciably alter the odds ratio estimates. We used unconditional logistic regression analysis to compute adjusted odds ratios simultaneously controlling for previous pregnancy loss, mother's age at conception, and mother's cigarette smoking during the first trimester of pregnancy. To estimate the independent contribution of each exposure measure to the risk of spontaneous abortion, we restricted the analysis to women who worked full-time in cosmetology during the first trimester of pregnancy and computed the odds ratio for each exposure measure while adjusting for other work exposures.

Results

ENUMERATION OF ELIGIBLE PREGNANCIES

Of the 8,356 screening questionnaires sent, 748 (9%) were returned because of an incorrect address (N = 740) or because the addressee was deceased (N = 8) (Table 1). After up to four mailings, 6,054 screening

SPONTANEOUS ABORTIONS AMONG COSMETOLOGISTS

TABLE 1. Response to Screening and Detailed Questionnaires

	Number	%*
Screening questionnaires sent	8,356	100.0
Deceased	8	0.1
Incorrect address	740	8.9
Completed mail questionnaire	6,054	72.5
Completed telephone screening	148	1.8
Refusal (by mail or phone)	118	1.4
No response	1,288	15.4
Detailed questionnaires sent	1,696	100.0
Incorrect address	7	0.4
Completed mail questionnaire	1,228	72.4
Completed phone interview	21	1.2
Completed questionnaire for wrong pregnancy	10	0.6
Refusal	41	2.4
No response	389	22.9

* Percentages do not total 100.0 because of rounding.

questionnaires were completed and returned. For a subset of nonrespondents, we obtained telephone numbers, and 148 of them agreed to a brief screening interview by telephone. Screening therefore was completed for 6,202 (82%) of the 7,608 cosmetologists who presumably received the questionnaire, or 74% of the screening population. Among respondents, 1,866 cosmetologists reported one or more eligible pregnancies. With eligibility restricted to one pregnancy per woman, the screening questionnaire identified 267 eligible spontaneous abortions (145 of most recent pregnancies and 122 of previous pregnancies) and 1,429 eligible livebirths, or 1,696 eligible women in total.

Seventy-four per cent of cosmetologists with an eligible pregnancy completed the more detailed questionnaire (Table 1), yielding data on 191 spontaneous abortions (72% response) and 1,058 livebirths (74% response). Three spontaneous abortions were considered uncertain and were excluded from the analysis since neither a positive pregnancy test nor medical care following the spontaneous abortion was reported. Of the remaining 188 spontaneous abortions, 81% occurred during the first 12 weeks of pregnancy. The mean gestational age was 9.8 weeks. Ninety-two per cent of women reported that they were absolutely sure about having had a spontaneous abortion. Other reported characteristics include bleeding (73%), hospitalization (42%), dilation and curettage (64%), and ultrasound (47%). Only 7% of pregnancies ending in a spontaneous abortion were confirmed solely by a home pregnancy test.

MATERNAL CHARACTERISTICS

Most respondents to the detailed questionnaire were

white (87%), had a high school education (92%), and had a family income of less than \$20,000 (65%). Forty-three per cent were less than 25 years of age at conception, with a mean age of 25.9 years, and 52% worked full-time (35 hours or more per week) during the first trimester of pregnancy, either in cosmetology (N = 430) or in other jobs (N = 215); 65 respondents attended cosmetology school during the first trimester.

Table 2 presents characteristics of women working full-time in cosmetology or in other jobs that were included in the main analysis. Women with a spontaneous abortion were similar to those with a livebirth with regard to race, education, age, family income, alcohol consumption, and personal use of hair dyes and permanents during the index pregnancy. Gravidity of three or higher, a history of pregnancy loss, and cigarette smoking were more frequently reported by women with a spontaneous abortion than women with a livebirth.

COSMETOLOGY AND SPONTANEOUS ABORTION RISK

Compared with women employed full-time (35 or more hours per week) in jobs outside cosmetology during the first trimester of pregnancy, full-time cosmetologists had only a slightly increased risk of spontaneous abortion (Table 3). Part-time work (less than 35 hours per week) in cosmetology and full-time work as a homemaker were not associated with increased spontaneous abortion risk. Women who attended cosmetology school during the first trimester of pregnancy had more than double the risk of a spontaneous abortion (adjusted OR = 2.3).

For full-time work in cosmetology, adjusted odds ratios associated with the highest levels of specific exposures ranged from 1.4 to 2.0 (Table 3). Compared with full-time work in other jobs, increased odds ratios were found for cosmetologists working more than 40 hours per week and standing more than 8 hours per day. Odds ratios increased with the number of customers per week and the number of chemical services, bleaches, and permanents performed per week. No strong increase in the odds ratios was observed for the weekly number of hair dyes. Elevated odds ratios were associated with the use of formaldehyde- and alcohol-based disinfectants, work in small salons with fewer than four employees, and work in salons where nail sculpturing was performed by other employees. Except for hair dyes, the adjusted odds ratios were lower among women who reported wearing protective gloves always or most of the time. Among women working less than 35 hours per week in cosmetology, none of the exposure measures was strongly associated with

TABLE 2. Characteristics of Women with Eligible Pregnancies Who Worked Full-Time (≥ 35 Hours) in Cosmetology or Other Jobs

	Spontaneous Abortions (N = 96) %	Single Livebirths (N = 547) %
Mother's race		
White	91.3	89.7
Black or other	8.7	10.3
Mother's education		
Some high school	4.2	3.3
High school and/or some college	95.8	91.4
College graduate		5.3
Family income (\$)		
<20,000	28.9	33.3
20,000-29,999	38.9	35.9
30,000-39,999	22.2	18.2
$\geq 40,000$	10.0	12.6
Mother's age at conception (years)		
<20	5.2	2.0
20-24	45.8	46.1
25-29	33.3	37.7
30-36	15.6	14.3
Gravidity		
1	50.0	53.9
2	22.9	34.0
3-4	24.0	11.3
≥ 5	3.1	1.0
Previous pregnancy loss		
0	68.8	94.7
1	24.0	4.4
≥ 2	7.3	1.0
Nausea*		
Yes	28.3	43.7
No	71.7	56.3
Alcohol*		
Never	82.8	87.8
< once per week	12.9	10.2
\geq once per week	4.3	2.0
Cigarettes per day*		
Never	64.2	76.2
1-10	20.0	12.5
11-20	13.7	9.6
≥ 21	2.1	1.7
Personal use of hair dyes*		
No	81.7	82.7
Yes	18.3	17.3
Personal use of permanents*		
No	72.3	71.5
Yes	27.7	28.5

* During the first trimester of pregnancy.

increased spontaneous abortion risk (data not shown).

Restricting the analysis to women who worked full-time in cosmetology, Table 4 presents odds ratios for each exposure measure adjusted for the other exposure measures and other risk factors. The odds ratios re-

mained essentially the same for the number of hours worked per week, the number of chemical services and permanents performed per week, use of formaldehyde-based disinfectants, and work in salons where nail sculpturing was performed by other employees,

SPONTANEOUS ABORTIONS AMONG COSMETOLOGISTS

TABLE 3. Adjusted Odds Ratios for Spontaneous Abortion by Work Status and Specific Work Exposures during the First Trimester of Pregnancy

	Number of Spontaneous Abortions	Number of Single Livebirths	aOR*	95% CI
Other jobs: ≥ 35 hours†	26	187	1.0	Referent
Other jobs: < 35 hours	8	34	1.4	0.6-3.5
Full-time homemaking	31	195	0.9	0.5-1.7
Cosmetology school	17	48	2.3	1.1-4.8
Cosmetology: < 35 hours	34	224	1.0	0.6-1.8
Cosmetology: ≥ 35 hours	69	356	1.4	0.8-2.3
Hours worked per week				
35-40	46	275	1.2	0.7-2.0
≥ 41	23	81	2.0	1.0-4.0
Hours standing per day				
< 7	22	120	1.2	0.6-2.3
7-8	27	156	1.3	0.7-2.4
≥ 9	19	73	1.9	1.0-3.9
Customers per week				
< 35	18	120	1.1	0.6-2.3
35-49	20	107	1.2	0.6-2.4
≥ 50	26	120	1.6	0.8-3.0
Chemical services per week‡				
< 8	14	114	0.7	0.3-1.5
8-12	24	111	1.7	0.9-3.2
≥ 13	29	114	1.9	1.0-3.5
Hair dyes per week				
< 2	16	112	1.1	0.5-2.2
2-3	25	107	1.6	0.8-3.0
≥ 4	26	126	1.4	0.7-2.6
Bleaches per week				
0	18	116	1.1	0.5-2.1
1	24	130	1.3	0.7-2.4
≥ 2	25	95	1.9	1.0-3.7
Permanents per week				
< 5	18	115	1.0	0.5-2.0
5-9	23	127	1.3	0.7-2.4
≥ 10	26	105	1.9	1.0-3.6
Wearing of gloves§				
≥ 2 hair dyes per week				
Low glove use	6	35	1.1	0.4-2.9
High glove use	45	190	1.6	0.9-2.8
≥ 2 bleaches per week				
Low glove use	8	24	2.3	0.9-6.0
High glove use	17	68	1.7	0.9-3.4
≥ 10 permanents per week				
Low glove use	18	72	2.1	1.0-4.5
High glove use	5	20	1.4	0.4-4.9
Disinfection product use				
Formaldehyde-based				
No	16	132	0.8	0.4-1.6
Yes	51	219	1.7	1.0-3.0
Alcohol-based				
No	53	298	1.3	0.7-2.2
Yes	14	53	1.9	0.9-4.1
Beauty salon characteristics				
Number of other cosmetologists in salon				
< 4	30	124	1.7	0.9-3.2
4-5	13	94	1.1	0.5-2.3
≥ 6	24	122	1.3	0.7-2.4

TABLE 3. Continued

	Number of Spontaneous Abortions	Number of Single Livebirths	aOR*	95% CI
Manicuring performed by other employees				
No	37	201	1.3	0.8-2.4
Yes	28	132	1.5	0.8-2.7
Nail sculpturing performed by other employees				
No	40	242	1.2	0.7-2.1
Yes	25	89	1.9	1.0-3.7

* Odds ratios adjusted for previous pregnancy loss, mother's age at conception, and mother's cigarette smoking during first trimester.

† Unexposed reference category.

‡ Number of hair dyes, bleaches, and permanents.

§ High glove use: always or most of the time wore gloves; low glove use: never or seldom wore gloves.

with the adjusted odds ratios ranging from 1.6 to 2.6 for these exposure measures.

Discussion

To our knowledge, this is the first study to examine the relation between specific occupational exposures in cosmetology and the risk of spontaneous abortion. Among the licensed cosmetologists who responded to the screening questionnaire, 25% worked in other jobs, and 11% worked as full-time homemakers at the time of screening. Our study population thus included women who left work in cosmetology, but who kept their license active. License renewal is inexpensive and avoids the need to retake the licensing examinations before re-entering the profession at a later time. In occupational studies of adverse reproductive outcomes, selection bias is of particular concern. Women with livebirths may be more likely to leave the work force than women with adverse pregnancy outcomes,^{17,18} a phenomenon that may bias odds ratio estimates away from the null for working women. On the other hand, women who suspect that their adverse pregnancy outcome may be related to occupational exposures may be more likely to leave their job to ensure a healthy pregnancy. The extent to which cosmetologists who were licensed in 1988 provide an unbiased sample of women ever licensed over the period 1983-1988 is unknown, but a large amount of attrition is unlikely.

Since the license register includes both active and inactive cosmetologists, we had the opportunity to use an internal unexposed reference group. Thus, women with exposed and unexposed pregnancies in our study were likely to be similar with regard to social and economic factors related to their decision to obtain cosmetology licenses. To account for potential differences between full-time workers, part-time workers, and homemakers,^{18,19} we restricted the main analysis to women who worked full-time in cosmetology or in other jobs during the first trimester of pregnancy.

Despite screening nearly 8,400 cosmetologists in the reproductive age group for eligible pregnancies, our analyses were based on a relatively small number of spontaneous abortions ($N = 96$) among full-time working women. The response to the screening (74%) and detailed (74%) questionnaire was relatively high compared with other mail surveys conducted in the United States.²⁰ Potential response bias, however, is of concern, since the pattern of nonresponse could distort measures of association.

Pregnancy outcome was ascertained by self-report and could not easily be validated against medical records for this state-wide study population. Among our relatively young respondents to the screening questionnaire, spontaneous abortions accounted for 7.8% of the most recent pregnancies, a finding that is consistent with estimates from cross-sectional studies.²¹ To enhance the reliability of the self-reported spontaneous abortions and to minimize the potential for overreporting, we required positive evidence that the pregnancy or its termination actually occurred based on a positive pregnancy test, bleeding, or seeking of medical care after the pregnancy was lost. Among women who worked full-time in cosmetology, compared with those in other jobs, the proportion of spontaneous abortions of less than 7 weeks gestational age was identical (19%), a result that indicates that our findings are unlikely to be due to an excess of the more ambiguous early pregnancy losses among exposed women.

In previous occupational surveys of spontaneous abortion that included cosmetologists, exposure assessment was based on job title only.¹⁰⁻¹⁴ Given the large proportion of cosmetologists who work part-time and the large variation in the number and type of services provided, job title alone is a poor surrogate measure for chemical exposures, particularly in this occupation, and therefore would tend to dilute any true association

SPONTANEOUS ABORTIONS AMONG COSMETOLOGISTS

TABLE 4. Odds Ratios for Spontaneous Abortion and Full-Time Work in Cosmetology, Adjusted for Other Work Exposures and Maternal Characteristics*

	Number of Spontaneous Abortions	Number of Single Livebirths	cOR†	95% CI	aOR‡	95% CI
Hours worked per week§						
35-40	41	247	1.0	Referent	1.0	Referent
≥41	20	68	1.8	1.0-3.2	1.8	0.9-3.8
Hours standing per day§						
<7	20	112	1.0	Referent	1.0	Referent
7-8	25	137	1.0	0.5-1.9	0.9	0.4-1.9
≥9	16	66	1.4	0.7-2.8	1.0	0.4-2.6
Chemical services per week§						
<8	11	107	1.0	Referent	1.0	Referent
8-12	23	101	2.2	1.0-4.8	2.6	1.1-6.1
≥13	27	107	2.5	1.2-5.2	2.4	1.1-5.6
Hair dyes per week						
<2	13	104	1.0	Referent	1.0	Referent
2-3	25	96	2.1	1.0-4.3	1.6	0.7-3.5
≥4	23	115	1.6	0.8-3.3	0.9	0.4-2.1
Bleaches per week						
0	15	105	1.0	Referent	1.0	Referent
1	23	124	1.3	0.6-2.6	1.1	0.5-2.4
≥2	23	86	1.9	0.9-3.8	1.4	0.6-3.2
Permanents per week						
<5	15	104	1.0	Referent	1.0	Referent
5-9	21	116	1.3	0.6-2.6	1.3	0.6-2.8
≥10	25	95	1.8	0.9-3.7	1.9	0.8-4.3
Use of formaldehyde-based disinfectants§						
No	14	118	1.0	Referent	1.0	Referent
Yes	47	197	2.0	1.1-3.8	2.1	1.0-4.3
Use of alcohol-based disinfectants§						
No	49	267	1.0	Referent	1.0	Referent
Yes	12	48	1.4	0.7-2.7	1.2	0.6-2.7
Nail sculpturing performed by other employees§						
No	38	230	1.0	Referent	1.0	Referent
Yes	23	85	1.6	0.9-2.9	1.6	0.9-3.1

* Analysis restricted to women who worked full-time in cosmetology without missing data on work exposures and maternal characteristics.
 † Crude odds ratios.
 ‡ Adjusted odds ratios.
 § Odds ratios adjusted for other work exposures (that is, hours worked, hours standing, chemical services, formaldehyde-based disinfectant, alcohol-based disinfectant, and nail sculpturing) and maternal characteristics (that is, previous pregnancy loss, age, and smoking during the first trimester).
 || Odds ratios adjusted for other work exposures (that is, hours worked, hours standing, hair dyes, bleaches, permanents, formaldehyde-based disinfectant, alcohol-based disinfectant, and nail sculpturing) and maternal characteristics (that is, previous pregnancy loss, age, and smoking during the first trimester).

of occupational exposures in cosmetology with adverse reproductive outcomes. Only when we considered specific work activities and more intense exposure levels did we identify increased risks of spontaneous abortion. The assessment of specific exposures through self-reported work and salon characteristics in this study is therefore an improvement over previous studies. We cannot, however, exclude the possibility of exposure misclassification, since all exposure informa-

tion relied on self-report. Since odds ratios increased with the weekly number of hours worked, customers, and chemical services, recall bias would also have to follow a dose-response pattern to account for the results.

Since cosmetology involves exposure to chemical mixtures from multiple sources, it is difficult, if not impossible, to identify effects associated with specific chemical agents. We found that several work charac-

teristics were independently associated with an increased risk of spontaneous abortion, including the number of chemical services performed per week, the use of formaldehyde-based disinfectants, and work in salons where nail sculpturing was performed by other employees. Although based on small numbers, glove use was associated with lower risk among women who performed 10 or more permanents or two or more bleaches per week, which may suggest an exposure pathway through dermal absorption rather than inhalation.

There is evidence that certain chemicals used in cosmetology may adversely affect reproductive outcomes. Occupational exposure to solvents has been linked to spontaneous abortion,^{8,22} although uncertainties remain about fetotoxic effects of specific solvents. Many cosmetic products contain solvents,^{3,23} several of which have been associated with increased spontaneous abortion risk in other occupations.^{22,24,25} Hair dyes can be dermally absorbed^{26,27} and have been associated with mutagenic and carcinogenic effects^{28,29} and female infertility,³⁰ but in our study, the risk of spontaneous abortion did not increase with the number of hair dyes performed per week. Formaldehyde-containing fumigants (paraformaldehyde tablets or formalin solutions), which are commonly used in cosmetology, have been found to generate airborne formaldehyde concentrations that exceed the Occupational Safety and Health Administration short-term exposure limits.^{31,32} The effect of formaldehyde on spontaneous abortion risk is unknown. Among nurses, associations between use of formaldehyde-containing disinfectants and spontaneous abortion are inconsistent.^{33,34}

Future research based on larger study populations, improved assessment of occupational exposures, and validated reproductive outcomes is warranted to replicate our findings and identify any specific reproductive hazards in cosmetology.

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References

1. Current Population Survey 1991 Annual Survey. vol. 39. Employment and Earnings. Washington DC: Department of Labor, Bureau of Labor Statistics, 1992.
2. National Institute for Occupational Safety and Health. Potential Occupational Hazards. vol. III. Industrial Processes: Hairdressing and Barbering. DHEW Pub. No. (NIOSH)81-148-827. Rockville, MD: National Institute for Occupational Safety and Health, 1980.
3. Brown NJ. Health Hazard Manual for Cosmetologists, Hairdressers, Beauticians and Barbers. Ithaca, NY: Department of Industrial and Labor Relations, Cornell University, 1990.
4. Ostton DD, Weir J, Thornton P. Hazardous Substances in the Cosmetology Workplace. Sacramento: California Board of Cosmetology, 1988.
5. Lindbohm ML, Taskinen H, Hemminki K. Reproductive health of working women: spontaneous abortions and congenital malformations. *Public Health Rev* 1985;13:55-87.
6. Kline J. Maternal occupation: effects on spontaneous abortions and malformations. In: Stein ZA, Hatch MC, eds. *Reproductive Problems in the Workplace*. Philadelphia: Hanley and Belfus, 1986.
7. Rosenberg MJ, Feldblum PJ, Marshall EG. Occupational influences on reproduction: a review of recent literature. *J Occup Med* 1987;29:584-591.
8. Taskinen HK. Effects of parental occupational exposures on spontaneous abortion and congenital malformation. *Scand J Work Environ Health* 1990;16:297-314.
9. Goulet L, Theriault G. Association between spontaneous abortion and ergonomic factors. *Scand J Work Environ Health* 1987;13:399-403.
10. Hartz SC, Jacques PF. Occupational Health Surveillance of Reproductive Outcomes: A Case-Control Study. Final Report. (NIOSH)210-78-0057. Cincinnati: National Institute for Occupational Safety and Health, 1978.
11. Shilling S, Lalich NR. Maternal occupation and industry and the pregnancy outcome of U.S. married women, 1980. *Public Health Rep* 1984;99:152-161.
12. Silverman J, Kline J, Hutzler M, Stein Z, Warburton D. Maternal employment and the chromosomal characteristics of spontaneously aborted conceptions. *J Occup Med* 1985;27:427-438.
13. Kline J, Stein Z, Hatch M. Surveillance of Parental Employment and Spontaneous Abortion. Final Report. (NIOSH)210-81-5002. Cincinnati: National Institute for Occupational Safety and Health, 1982.
14. McDonald AD, McDonald JC, Armstrong B, Cherry N, DeLorme C, D-Nolin A, Robert D. Occupation and pregnancy outcome. *Br J Ind Med* 1987;44:521-526.
15. Goulet L, Theriault G. Stillbirth and chemical exposure of pregnant workers. *Scand J Work Environ Health* 1991;17:25-31.
16. Vaughan TL, Daling JR, Starzyk PM. Fetal death and maternal occupation. *J Occup Med* 1984;26:676-678.
17. Axelsson G. Selection bias in studies of spontaneous abortion among occupational groups. *J Occup Med* 1984;26:525-528.
18. Lemasters GK, Pinney SM. Employment status as a confounder when assessing occupational exposures and spontaneous abortion. *J Clin Epidemiol* 1989;42:975-981.
19. Savitz DA, Whelan EA, Rowland AS, Kleckner RC. Maternal employment and reproductive risk factors. *Am J Epidemiol* 1990;132:933-945.
20. Dillman DA. *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley, 1978.
21. Kline J, Stein Z, Susser M. *Conception to Birth: Epidemiology of Prenatal Development*. New York: Oxford University Press, 1989.
22. Lindbohm ML, Taskinen H, Sallmen M, Hemminki K. Spontaneous abortions among women exposed to organic solvents. *Am J Ind Med* 1990;17:449-463.
23. Hazard Evaluation System and Information Service. *Artificial Fingernail Products: A Guide to Chemical Exposures in the Nail Salon*. Berkeley: California Occupational Health Program, 1989.
24. Taskinen H, Lindbohm ML, Hemminki K. Spontaneous abortions among women working in the pharmaceutical industry. *Br J Ind Med* 1986;43:199-205.

SPONTANEOUS ABORTIONS AMONG COSMETOLOGISTS

25. Kyyronen P, Taskinen H, Lindbohm ML, Hemminki K, Heironen OP. Spontaneous abortions and congenital malformations among women exposed to tetrachloroethylene in dry cleaning. *J Epidemiol Community Health* 1989;43:346-351.
26. Kiese M, Rauscher E. The absorption of p-toluenediamine through human skin in hair dyeing. *Toxicol Appl Pharmacol* 1968;13:325-331.
27. Maibach HI, Leaffer MA, Skinner WA. Percutaneous penetration following use of hair dyes. *Arch Dermatol* 1975;111:1444-1445.
28. Ames BN, Kammen HO, Yamasaki E. Hair dyes are mutagenic: identification of a variety of mutagenic ingredients. *Proc Natl Acad Sci USA* 1975;72:2423-2427.
29. Searle CE, Harnden DG, Venitt S, Gyde OH. Carcinogenicity and mutagenicity tests of some hair colourants and constituents. *Nature* 1975;255:506-507.
30. Rachootin P, Olsen J. The risk of infertility and delayed conception associated with exposures in the Danish workplace. *J Occup Med* 1983;25:394-402.
31. Almaguer D, Blade LM. Health Hazard Evaluation Report. (HETA)88-153-2072. Cincinnati: National Institute for Occupational Safety and Health, 1990.
32. Almaguer D, Klein M. Health Hazard Evaluation Report. (HETA)89-170-2100. Cincinnati: National Institute for Occupational Safety and Health, 1991.
33. Hemminki K, Mutanen P, Saloniemi I, Niemi ML, Vainio H. Spontaneous abortions in hospital staff engaged in sterilising instruments with chemical agents. *Br Med J Clin Res Ed* 1982;285:1461-1463.
34. Stucker I, Caillard JF, Collin R, Gout M, Poyen D, Hemon D. Risk of spontaneous abortion among nurses handling antineoplastic drugs. *Scand J Work Environ Health* 1990;16:102-107.